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PPPO-02-1610776-13

Mr. Jon Richards
Remedial Project Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
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Dear Mr. Mullins and Mr. Richards:

TRANSMITTAL OF THE REMEDIAL INVESTIGATION FEASIBLITY STUDY FOR CERCLA WASTE DISPOSAL ALTERNATIVES EVALUATION AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY, DOE/LX/07-0244&D2

Please find enclosed for your review the certified D2 *Remedial Investigation Feasibility Study for CERCLA Waste Disposal Alternatives Evaluation at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0244&D2. Included also are comment response summaries for comments received from the U.S. Environmental Protection Agency on September 6, 2012, and October 29, 2012; comments from the Kentucky Department for Environmental Protection received on September 12, 2012; and a file with other changes. To aid in the review, a redline version of the document is included. Throughout the redline document, regulatory agencies' comments are identified in the margin near the corresponding redline text.

If you have any questions or require additional information, please contact me at (270) 441-6820.

Sincerely,

Jennifer Woodard

Jennifer Woodard
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosures:

1. Certification Page
2. Responses to EPA technical comments received September 6, 2012
3. Responses to EPA legal comments received October 29, 2012
4. Companion file to EPA legal comments received October 29, 2012
5. Responses to KDEP comments received September 12, 2012
6. D2 CERCLA WDA RI/FS Report
7. D2 CERCLA WDA RI/FS Report, Redline
8. Other changes file

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CERTIFICATION

Document Identification: ***Remedial Investigation Feasibility Study for CERCLA Waste Disposal Alternatives Evaluation at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,*** **DOE/LX/07-0244/D2**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

LATA Environmental Services of Kentucky, LLC

Mark J. Duff, Paducah Project Manager — 7-25-13 Date Signed

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

U.S. Department of Energy (DOE)

Rachel H. Blumenfeld, Acting Paducah Site Lead
Portsmouth/Paducah Project Office — 7-25-13 Date Signed

DOE/LX/07-0244&D2
Primary Document

Remedial Investigation/Feasibility Study Report for CERCLA Waste Disposal Alternatives Evaluation at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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DOE/LX/07-0244&D2
Primary Document

Remedial Investigation/Feasibility Study Report for CERCLA Waste Disposal Alternatives Evaluation at the Paducah Gaseous Diffusion Plant Paducah, Kentucky

Date Issued—July 2013

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
LATA ENVIRONMENTAL SERVICES OF KENTUCKY, LLC
managing the
Environmental Remediation Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC30-10CC40020

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ACRONYMS

AEA	Atomic Energy Act
amsl	above mean sea level
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
ARRA	American Recovery and Reinvestment Act
AT123D	Analytical, Transient 1-2-3-Dimension Model
BGOU	Burial Grounds Operable Unit
bgs	below ground surface
BP	before present
CA	contamination area
CAB	Citizens Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CIP	Cascade Improvement Program
COC	contaminant of concern
COE	U.S. Army Corps of Engineers
COPC	chemical of potential concern
CUP	Cascade Uprating Program
DAF	dilution attenuation factor
DCE	dichloroethene
D&D	decontamination and decommissioning
DO	dissolved oxygen
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DSHA	deterministic seismic hazard analysis
DMSA	DOE Material Storage Area
DUSTMS	Disposal Unit Source Term-Multiple Species
DWGIS	Data Warehouse GIS Viewer
EEI	Electric Energy, Inc.
EIC	Environmental Information Center
ELCR	excess lifetime cancer risk
EMWMF	Environmental Management Waste Management Facility
EOW	edge of waste
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ET	evapotransport
ETTP	East Tennessee Technology Park
FEMA	Federal Emergency Management Agency
FFA	Federal Facility Agreement
FML	flexible membrane liner
fps	ft per second
FR	*Federal Register*
FS	feasibility study
FY	fiscal year
g	acceleration due to gravity
GCL	geosynthetic clay liner
GDP	gaseous diffusion plant
GIS	geographic information system

GWOU	Groundwater Operable Unit
HDPE	high-density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
HI	hazard index
HU	hydrogeologic unit
INEEL	Idaho National Engineering and Environmental Lab
JEB	James E. Beavers Consultants
KAR	*Kentucky Administrative Regulations*
KDWM	Kentucky Division of Waste Management
KRS	*Kentucky Revised Statutes*
LCB	life cycle baseline
LLW	low-level waste
M_W	moment magnitude
MCL	maximum contaminant level
MDC	minimum detectable concentration
MDL	method detection limit
MLLW	mixed low-level waste
mcy	million cubic yards
MOCVD	metal organic chemical vapor deposition
mya	million years ago
NAL	no action level
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NMSZ	New Madrid Seismic Zone
NNSS	Nevada National Security Site
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NRDA	Natural Resource Damage Assessment
NSDD	North-South Diversion Ditch
ORR	Oak Ridge Reservation
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PGA	peak ground acceleration
PGDP	Paducah Gaseous Diffusion Plant
POA	point of assessment
PORTS	Portsmouth
PPE	personal protective equipment
PQL	practical quantitation limit
PSHA	probabilistic seismic hazard analysis
PWAC	preliminary waste acceptance criteria
QA	quality assurance
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
REI	Risk Engineering, Inc.
RGA	Regional Gravel Aquifer
ROD	record of decision
RI	remedial investigation
SM&M	surveillance, maintenance, and monitoring
SSL	soil screening level
SWMU	solid waste management unit

SWOU	Surface Water Operable Unit
Tc-99	technetium-99
TBC	to be considered
TCE	trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
T&E	threatened and endangered
TRU	transuranic
TSCA	Toxic Substances Control Act
TVA	Tennessee Valley Authority
UCL	upper confidence limit
UCRS	Upper Continental Recharge System
UF_6	uranium hexafluoride
USC	*United States Code*
USEC	United States Enrichment Corporation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	waste acceptance criteria
WBS	work breakdown structure
WCS	Waste Control Specialists
WDF	waste disposal facility
WKWMA	West Kentucky Wildlife Management Area
WP	work plan
WVSZ	Wabash Valley Seismic Zone
ZVI	zero-valent iron

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EXECUTIVE SUMMARY

This remedial investigation/feasibility study report (RI/FS) has been prepared to evaluate waste disposal alternatives for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) waste that will be generated from environmental restoration of operable units (OUs) and from future decontamination and decommissioning (D&D) activities at the Paducah Gaseous Diffusion Plant (PGDP). This document was developed in accordance with Section IV of the Federal Facility Agreement (FFA) to satisfy applicable requirements of CERCLA and the Resource Conservation and Recovery Act (RCRA). It provides information that has been gathered to develop and evaluate disposal alternatives.

As a federal facility on the National Priorities List (NPL), the U.S. Department of Energy (DOE) must confirm and quantify the nature and extent of contamination, then implement appropriate response actions to remedy releases or threatened releases of hazardous substances to the environment. The general compliance approach that incorporates these requirements is termed the CERCLA remedy selection process, the ultimate goal of which is to provide the rationale for decision makers to identify and select a remedy to reduce risk found at a contaminated site. The CERCLA remedy selection process defined by the U.S. Environmental Protection Agency (EPA) in 40 *CFR* § 300.430(d) and (e) was utilized to evaluate the disposal alternatives and identify the most appropriate alternative for near-term and long-term disposal of CERCLA-generated waste. The selected alternative must be protective of human health and the environment and also must be compliant with applicable or relevant and appropriate requirements (ARARs).

In addition to satisfying CERCLA requirements, this RI/FS Report addresses environmental concerns through incorporation of values outlined in the National Environmental Policy Act (NEPA), in keeping with DOE's Secretarial Policy on NEPA (DOE 1994), and integrates the Natural Resource Damage Assessment process with overall site cleanup. NEPA requires federal agencies to evaluate and document the effect their proposed actions would have on the quality of the human environment. Further, NEPA requires agencies to consider both the adverse and beneficial environmental impacts of alternatives during the planning and decision making stages. DOE is required to assess the potential consequences of its activities on the human environment in accordance with Council on Environmental Quality NEPA regulations (40 *CFR* §§ 1500-1508) and the DOE NEPA Implementing Procedures (10 *CFR* § 1021).

SOURCES AND VOLUMES OF CERCLA WASTES

Various hazardous, nonhazardous, and low-level radioactive waste resulting from past and ongoing operations has been generated and disposed of at PGDP. Solid waste management units (SWMUs) and areas of concern (AOCs) at PGDP have been combined into the following five media-specific OUs:

- Surface Water OU (SWOU)
- Soils OU
- Burial Grounds OU (BGOU)
- Groundwater OU (GWOU)
- D&D OU

Site cleanup activities are expected to generate a variety of CERCLA waste, totaling an estimated 3.6 million cubic yards (mcy) from 2014 to 2039. Waste types are anticipated to include the following:

- Low-level waste (LLW) [defined in the Atomic Energy Act (AEA)]
- Hazardous waste (defined in *KRS* 224 and RCRA Subtitle C)
- Mixed low-level waste (MLLW, defined and regulated as a hazardous waste and LLW)
- Toxic Substances Control Act (TSCA) waste (defined and regulated as a TSCA waste)
- TSCA/LLW waste (defined and regulated as a TSCA waste and LLW)
- Nonhazardous solid waste [defined by RCRA Subtitle D and meets the waste acceptance criteria (WAC) of the on-site C-746-U Landfill]

High-level, transuranic, and spent nuclear fuel as defined in DOE Order 435.1 are not expected to be generated and are not included in the CERCLA waste volume. These waste types, if generated during cleanup, will be disposed of off-site no matter which alternative is chosen, because regulations prescribe disposal in special repositories.

Waste types and volumes were estimated for the evaluation of disposal alternatives using information available at the beginning of modeling efforts performed to support this RI/FS [i.e., volumes included in the 2007 approved life cycle baseline (LCB)];[1] these modeling efforts are involved, and it is not practicable to revise the modeling for each waste forecast update. To account for the uncertainty in waste volumes, this RI/FS is prepared using a range of waste volumes. The waste forecasts used still aid in developing the waste disposal alternatives by providing probable source areas, waste categories (physical form), waste types (regulatory classification), and waste generation schedules. Waste forecast estimates are based on waste expected to be generated from CERCLA response actions from 2014 to 2039.

The "base case" waste volume (approximately 3.6 mcy) is the summation of the volume of CERCLA generated waste taken directly from the LCB and D&D waste volume estimates (DOE 2006). The base case does not include assumptions that would modify the waste volume through measures such as recycling, reuse, or other waste reduction initiatives. The base case represents the most likely volume that can be predicted to be generated using the 2007 approved LCB information.

High-end and low-end waste volume estimates were developed to model uncertainties associated with the base case waste forecast. Uncertainties include a potential waste volume increase or decrease, the availability of the C-746-U Landfill and whether waste meeting the C-746-U Landfill WAC will be disposed of there, and waste reuse or recycling. This range of waste volumes is intended to address uncertainties in the waste volume for the purposes of assessing the feasibility of the disposal alternatives. The actual volume associated with an alternative may differ for a variety of reasons such as updated waste forecasts or the need for additional fill to facilitate disposal of non-soil waste.

The high-end volume accounts for a scenario when a response action commences and excavation of the lateral area or depth of contamination is greater than what was forecasted. The high-end waste volume assumes that waste meeting the C-746-U Landfill WAC will not be disposed of in the C-746-U Landfill and will require either off-site disposal or disposal in a newly-constructed on-site disposal facility. The high-end waste volume scenario accounts for a situation in which the C-746-U Landfill is unavailable due

[1] The 2007 approved LCB is used for planning purposes; the schedule and volume estimates used are subject to change.

to economic, technical, or regulatory issues. This high-end volume also assumes that no potential volume-reducing activities such as recycling, reuse, or other waste reduction initiatives would be implemented.

The low-end waste volume scenario includes assumptions that reduce the base case forecast based on the following:

- Up to 75% of the forecasted scrap metal would be recycled (~550,000 yd^3).
- Up to 75% of the forecasted concrete debris would be recycled/reused (~585,000 yd^3).
- Five buildings in the D&D inventory (C-100, C-101, C-102, C-103, and C-720) would be retained (DOE 2011a) for ongoing use (~185,000 yd^3).

The following remaining waste volumes have been accounted for as follows:

- Other waste volumes are 10% less than the base case forecast.
- Nonhazardous solid waste would be disposed of in the C-746-U Landfill (~552,000 yd^3).

DESCRIPTION OF ALTERNATIVES

This RI/FS Report provides the technical evaluation of three waste disposal alternatives:* No Action, Off-Site, and On-Site.

The No Action Alternative involves the continuation of coordinated project-by-project disposal for CERCLA waste. For the purposes of the evaluation, it is assumed that the on-site C-746-U Landfill will continue to operate and receive waste that meets its WAC. Waste not meeting the C-746-U Landfill WAC will be disposed of off-site. Under CERCLA, a No Action Alternative is required to provide a baseline for comparison with other alternative actions. The No Action Alternative, if selected, would require no changes to current waste disposal practices. The No Action Alternative serves as the base case volume for the Off-Site Alternative.

The Off-Site Alternative involves project-by-project disposal of CERCLA waste and is evaluated using three waste volumes (1) the base case (same as the No Action Alternative); (2) a high-end waste volume scenario for which all CERCLA waste is assumed to be shipped off-site; and (3) a low-end waste volume scenario, which assumes various waste reduction actions, continued use of the C-746-U Landfill for a portion of the waste meeting the WAC of the C-746-U Landfill, and off-site disposal of CERCLA waste that does not meet the C-746-U Landfill WAC. These waste volume ranges are intended to address uncertainties in the waste volume for the purposes of assessing the feasibility of the disposal alternatives.

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*The C-746-U Landfill can accept certain nonhazardous solid waste generated by CERCLA activities at PGDP. Nonhazardous solid waste generated under CERCLA would be eligible for disposal at either a potential on-site WDF or the C-746-U Landfill. Waste disposal decisions will be made on a project-by-project basis. It is anticipated that PGDP CERCLA projects typically will dispose of nonhazardous solid waste at the C-746-U Landfill; however, in some cases, projects may dispose of solid waste at a potential on-site WDF based on project efficiency and operational considerations such as managing project waste characterization and segregation resources; maximizing operational efficiencies at the C-746-U Landfill and a potential on-site WDF; and efficiently utilizing air space at the C-746-U Landfill and a potential WDF. For purposes of this RI/FS, each of the remedial action alternatives is assumed to utilize this approach.

The actual volume associated with an alternative may differ for a variety of reasons, such as updated waste forecasts or the need for additional fill to facilitate disposal of non-soil waste.

The On-Site Alternative involves the disposal of CERCLA waste into a newly constructed on-site waste disposal facility (WDF) located on DOE-owned property. The On-Site Alternative includes the same waste volume scenarios as the Off-Site Alternative: (1) the base case, which assumes continued use of the C-746-U Landfill for disposal of waste meeting that facility's WAC, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in a newly constructed on-site disposal facility; (2) a high-end waste volume scenario for which CERCLA waste would be disposed of in a newly constructed on-site disposal facility; and (3) a low-end waste volume scenario, which assumes various waste reduction actions, continued use of the C-746-U Landfill for disposal of waste meeting that facility's WAC, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in a newly constructed on-site disposal facility.

For evaluation of the low-end, base, and high-end volume scenarios, the air space capacity of the proposed on-site disposal facility is assumed to be equal to the projected waste volumes. Correspondingly, the air space capacity of the proposed on-site landfill ranges from 1.5 to 4 mcy. The high end capacity plus the remaining 1.5 mcy of the C-746-U Landfill provides 5.5 mcy of air space capacity. Optimizing the design and configuration of the proposed on-site disposal facility may further increase the airspace capacity. The capacity of the proposed on-site disposal facility may increase in the event more waste is encountered or it is determined that additional fill is needed to facilitate the placement of non-soil debris.

As described in the Work Plan (DOE 2011a), the PWAC are based on groundwater transport of contaminants and the exposure scenario of a residential groundwater user drawing water from a well located at the edge of waste, the waste disposal facility boundary, the property boundary, or surface water outcrop. This receptor was selected because this individual reasonably would be expected to receive the highest cancer risk, hazard, and/or radionuclide dose from most contaminants migrating from the landfill.

The design requirements in the ARARs will be accounted for in the WAC development. Other constraints including, but not limited to, landfill worker protection and operational requirements (i.e., waste form and placement, etc.) are not considered in the development of the PWAC, but are anticipated to be incorporated into the WAC if the On-Site Alternative is selected. Some WAC concentrations also may increase compared to PWAC concentrations as a result of final site selection, final WDF design, etc. Such revisions to the PWAC are expected to occur as part of developing the final WDF design and O&M plan.

Waste not meeting the WAC for an on-site disposal facility would be disposed of at an existing approved, permitted, and operating off-site treatment, storage, or disposal facility. For purposes of the RI/FS evaluation, it is assumed that 5% of the waste volume for each scenario would not meet the on-site facility WAC and would require off-site disposal.

None of the alternatives evaluated directly establish waste treatment requirements. Treatment of waste would be the responsibility of each individual project, as required to meet the WAC of the selected waste disposal facility.

Table ES.1 shows a summary of waste disposal volumes for each OU.

Table ES.1. Baseline Waste Volume Forecast by OU

Project	Fiscal Year	Waste Forecast Volume (yd^3)*
BGOU	2014–2018**	341,550
GWOU	2010–2017***	7,390
SOILS OU—Remedial Action	2014	85,720
SWOU—Off-site	2016	15,670
PGDP D&D OU	2019–2039****	3,142,510
TOTAL		**3,592,840**

*Volume estimates for the BGOU, GWOU, Soils OU Remedial Action, and SWOU Off-Site are from the 2007 approved LCB. Volume estimates for PGDP D&D are from DOE 2006. Total volumes and volumes per year may vary based on deviations from the 2007 approved LCB.
**Volume shown is only for 2014 to 2018.
***Volume shown is only for 2014 to 2017.
****The schedule referenced is derived from the D&D proposed project schedule (DOE 2006).

COMPARATIVE ANALYSIS OF THE ALTERNATIVES

The FS evaluated the alternatives using information assembled for the RI. The detailed analysis evaluated the alternatives individually against the seven threshold and balancing criteria specified in the National Contingency Plan. A comparative evaluation then was conducted to determine the relative strengths and weaknesses of the alternatives. A summary of the evaluation and comparative analysis is provided for the three alternatives for each criterion.

Overall Protection of Human Health and the Environment. All of the alternatives are considered to be protective of human health and the environment. The No Action Alternative represents no change to current practice.

The Off-Site Alternative would protect human health and the environment by removing CERCLA wastes generated at PGDP and isolating them from the environment by disposal in permitted off-site facilities.

The On-Site Alternative would protect human health and the environment by placing waste in an engineered on-site disposal facility specifically sited, designed, constructed, operated, monitored, and maintained to reliably contain the waste. Waste exceeding the on-site facility WAC would be disposed of at a permitted off-site disposal facility.

Compliance with ARARs. Under the No Action Alternative, ARARs would be developed and evaluated for each project-specific CERCLA action. Accordingly, there are no ARARs associated with the No Action Alternative as detailed in the *Work Plan for CERCLA Waste Disposal Alternative Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0099&D2/R1 (DOE 2011a).

The Off-Site Alternative consists of shipment of CERCLA waste to and disposal of in licensed or permitted off-site disposal facilities. It is assumed that individual waste generators would be responsible for treatment before disposal; therefore, ARARs for waste treatment to meet any applicable land disposal restrictions or other treatment requirements under state or federal regulations are not addressed as part of this project (DOE 2011a). Because wastes would be disposed of off-site at appropriately licensed facilities under this alternative, ARARs for waste disposal are not addressed for this alternative (DOE 2011a).

Under the On-Site Alternative, a new on-site waste disposal facility would be sited, designed, and constructed in compliance with ARARs and pertinent to be considered guidance, including DOE orders, with the exception of the TSCA requirement for a 50-ft buffer between the base of the liner and the top of the water table. With the exception of the 50-ft requirement, the facility would meet the design, construction, support facilities, operation, and monitoring requirements for a TSCA chemical waste landfill found at 40 *CFR* § 761.75. An "equivalent standard of performance" CERCLA waiver of this 50-ft requirement would be invoked for the On-Site Alternative in accordance with CERCLA § 1216 (4)(D), allowing waiver of the requirement if the standard of performance being proposed is equivalent to that required under the otherwise applicable regulation. All other aspects of the On-Site Alternative design, construction, support facilities, operations, and closure are expected to comply with ARARs.

Long-term Effectiveness and Permanence. Under the No Action Alternative and the Off-Site Alternative, waste would be shipped off-site for disposal. The off-site disposal options would be protective and permanent in the long-term because the off-site facilities would operate in accordance with their respective WAC, approved construction and operating procedures, and closure/postclosure period requirements.

The Off-Site Alternative would have no additional long-term socioeconomic or land-use impacts at the receiving facilities, as they already are committed to long-term operation, maintenance, and monitoring. Implementing this alternative would not result in any significant cumulative impacts to the environment.

Under the On-Site Alternative, for the purpose of this evaluation, long-term environmental effects are those impacts that may occur following closure of an on-site waste disposal facility. The facility would accept waste through 2039, with final cap closure expected by 2044. Waste meeting the WAC would be placed in a new on-site waste disposal facility. Waste not meeting the WAC would be shipped to an off-site facility for disposal (assumed to be 5% of waste volume for this evaluation).

Both the On-Site and Off-Site Alternatives use proven technologies to protect human health and the environment and meets risk-based targets. Reliance on proven technologies reduces uncertainty associated with these alternatives. The disposal cell and cap would be designed to remain stable under expected environmental conditions, including possible erosion, weathering, and earthquakes. Aside from intentional human disturbance or major global climate changes, no other credible scenarios for exposing human or ecological receptors to the waste have been identified.

For the No Action and Off-Site Alternatives, the Energy*Solutions* and NNSS facilities are located in an arid climate at considerable distances from population centers. Low, long-term risk to human health results from the remote location, very low precipitation, and the absence of a potable aquifer below the sites. The license for the federal waste portion of the Waste Control Specialists (WCS) facility in Andrews County, Texas, was issued on September 18, 2012. As of December 20, 2012, the DOE approval process had not been completed. This facility may be considered and evaluated for future waste shipments after the facility is approved by DOE for waste disposal, as long as the transportation and disposal costs in the RI/FS are representative of WCS cost.

An on-site waste disposal facility located at PGDP also would be designed to isolate waste from the environment, but would be located in a more humid climate and is generally closer to human receptors. The greater amount of rainfall and proximity to human receptors create an environmental setting more conducive to contaminant mobilization and subsequent exposure than at western sites; however, long-term risk at the on-site waste disposal facility is low because of the operational, engineering, and institutional controls at the facility during waste placement and following closure.

Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment. Because this RI/FS was initiated solely for the purpose of evaluating disposal alternatives and treatment options were not considered, this criterion is not used to evaluate the preferred alternatives. Decisions regarding the treatment of waste generated by the various OUs would be made on a project-specific basis.

Short-term Effectiveness. Under the No Action and Off-Site Alternatives, transportation risk for off-site transport of waste would be a significant short-term impact to workers and the public during remedial action. Off-site disposal presents a much greater risk of accident, injury, and death than disposal on-site because of the long transportation routes to the off-site facilities expected to be utilized. Potential risks from exposure to waste during incident free transport or as the result of an accidental spill are very low.

The primary risks to workers for the On-Site Alternative would result from construction, waste handling, and disposal activities. Insignificant risk would result from transport of small volumes of waste off-site. These activities would be conducted by trained personnel in accordance with transportation requirements, DOE requirements, and approved health and safety plans. Worker exposure would be minimized by compliance with U.S. Department of Transportation and DOE waste packaging, transport, and handling requirements; the use of shielding and personal protective equipment; limits on work schedules; and other operational restrictions, such as spacing and distancing. The overall risk to site workers for this alternative would be low.

Environmental impacts resulting from the construction of an on-site waste disposal facility could include disturbance or destruction of potential wetlands areas and potential critical habitat areas for the endangered Indiana bat; these impacts would need to be mitigated if encountered. Land use at off-site facilities already is committed to waste disposal and would not be impacted further.

There would be no short-term adverse socioeconomic impacts from either an on-site waste disposal facility or off-site facility. Waste handling/preparation work force requirements would be approximately the same for each of the alternatives. For the On-Site Alternative, local disposal facility construction jobs would be created, in addition to jobs for facility operation, security, and closure. For off-site transport and disposal, there would be local manpower requirements at PGDP, and personnel at the receiving facilities are already in place. Transportation jobs would be created for off-site waste disposal, but the geographical location of those jobs is not known.

Because the census tracts closest to PGDP do not report a higher proportion of minorities or low-income populations than the national average, there would be no disproportionate or adverse environmental justice impacts for on-site disposal.

Implementability. All of the alternatives are implementable. Services and materials required for all elements of on-site and off-site waste disposal are readily available. The On-Site Alternative is technically feasible because the containment technologies are readily available and proven to be reliable at other waste disposal facilities across the country. The No Action and Off-Site Alternatives are likewise technically feasible because there are licensed and permitted facilities with suitable capacity to accept the waste volume expected, and truck and rail transport systems to these facilities are readily available.

Cost. The estimated present value costs for the No Action and Off-Site Alternatives vary, primarily according to the waste volume scenario being estimated; however, for the comparable waste volume scenarios evaluated for the On-Site Alternative, on-site disposal is substantially less costly. The cost of on-site disposal is not heavily dependent on the particular site chosen for locating a facility, with the cost differential falling well within the level of accuracy of FS cost estimate. Construction components of a designed facility would be essentially the same for either of the prototype sites, and the cost of long-term monitoring and institutional controls also would be essentially the same. Minor site-specific differences are expected as a result of site development concerns, such as overhead power transmission line relocation, road distances, wetland mitigation, and cell configuration.

Table ES.2 provides present value costs for the base case waste volume for the three alternatives, assuming use of Site 11 for representative costs for the On-Site Alternative.

Table ES.2. Alternatives Cost Comparison

Waste Disposal Facility	No Action Alternative	Off-site Alternative (No Action Alternative)	On-site Alternative***
Recycling	0	0	0
C-746-U Landfill	1.1	1.1	1.1
Off-Site Facility	2.5	2.5	*
New On-Site Facility	0	0	2.5
Total Managed Volume	3.6	3.6	3.6
Total Present Value Cost—Operations	$1,310,982,000	$1,310,982,000	$374,927,000
Total Present Value Cost—Capital	$0	$0	$390,451,000
Cost ($)/cy**	$364	$364	$213

*Assumes 5% of the waste will not meet the WAC and will be disposed of off-site. Conceptual design assumes Total Volume.
**Cost ($)/cy based on Total Present Value Cost/Total Managed Volume.
***Site 3A Costs used for the On-Site Alternative.

SUMMARY

The On-Site Alternative provides the lowest cost of the alternatives evaluated by a substantial margin. The CERCLA-generated waste, however, would remain on-site. The on-site disposal facility would be compliant with ARARs. The final configuration and volume of the on-site disposal facility is anticipated to be similar to that presented throughout this RI/FS Report, but may differ as a result of the design process, site configuration, updates in the forecasted waste volumes, or the need for additional fill to facilitate placement of non-soil debris.

Both the No Action and Off-Site Alternatives would be more costly to implement than the On-Site Alternative, and future disposal capacity availability is uncertain (although disposal capacity is available in the short-term). Both the No Action and Off-Site Alternatives would result in larger transportation risks, but the CERCLA-generated waste would be removed from the PGDP site.

The PWAC were developed using the methodology presented in the Work Plan (DOE 2011a). Because this methodology considers only groundwater transport and exposure, it is recognized that some of the final calculated PWAC values may have other criteria that will be applied to the WAC, such as worker safety or restrictions on waste types (e.g., TRU waste would not eligible to be placed in an on-site WDF), etc. Additionally, the PWAC also should be used to inform the design of an on-site WDF. As a result of any design changes, if the On-Site Alternative is chosen, some WAC concentrations may increase compared to the final PWAC concentrations (Table 5.20). See Appendix C, Attachment 11 for further discussion.

1. INTRODUCTION

The Paducah Gaseous Diffusion Plant (PGDP) site is located on a 3,556-acre reservation that contains an active uranium enrichment facility and surrounding support facilities. The PGDP is owned by the U.S. Department of Energy (DOE), and the uranium enrichment facilities are currently leased to and operated by the United States Enrichment Corporation (USEC). DOE is conducting environmental restoration (ER) activities at PGDP in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 *USC* 9601 *et seq.* 1980). PGDP was placed on the National Priorities List (NPL) in 1994. DOE, the U.S. Environmental Protection Agency (EPA), and the Commonwealth of Kentucky (Kentucky) entered into a Federal Facility Agreement (FFA) in 1998 (EPA 1998) that established the regulatory framework for CERCLA projects at PGDP. In accordance with Section IV of the FFA, this Remedial Investigation/Feasibility Study (RI/FS) Report was developed to satisfy applicable requirements of CERCLA and the Resource Conservation and Recovery Act (RCRA) (42 *USC* 6901 *et seq.* 1976).

This report details the evaluation of waste disposal alternatives for CERCLA wastes that will be generated under the PGDP FFA during ER of the operable units (OUs) and from the future PGDP decontamination and decommissioning (D&D) activities. Solid waste management units (SWMUs) and areas of concern (AOCs) at PGDP have been combined into the following five media-specific OUs:

- Surface Water OU (SWOU)
- Soils OU
- Burial Grounds OU (BGOU)
- Groundwater OU (GWOU)
- D&D OU

Site cleanup activities are expected to generate a variety of CERCLA waste, including both contaminated media and debris, totaling an estimated 3.6 million cubic yards (mcy) from 2014 to 2039. Waste types are anticipated to include the following:

- Low-level waste (LLW) [defined in the Atomic Energy Act (AEA)]
- Hazardous waste (defined in *KRS* 224 and RCRA Subtitle C)
- Mixed low-level waste (MLLW, defined and regulated as a hazardous waste and LLW)
- Toxic Substances Control Act (TSCA) waste (defined and regulated as a TSCA waste)
- TSCA/LLW waste (defined and regulated as a TSCA waste and LLW)
- Waste meeting the waste acceptance criteria (WAC) of the C-746-U Landfill

High-level, transuranic, and spent nuclear fuel, as defined in DOE Order 435.1, are not expected to be generated and are not included in the CERCLA waste volume. These waste types, if generated during cleanup, will be disposed of off-site no matter which alternative is chosen, because regulations prescribe disposal in special repositories.

This RI/FS follows the RI/FS decision documentation process required by CERCLA. Three disposal alternatives[*] were evaluated: No Action, Off-Site Disposal, and On-Site Disposal.

- The *No Action Alternative* involves the continuation of coordinated project-by-project disposal for CERCLA waste.[2] This would include off-site disposal for the waste that does not meet the WAC of the on-site C-746-U Landfill and continued use of the C-746-U Landfill for disposal of waste that meets that facility's WAC. Evaluation of this alternative assumes there would be no sitewide efforts to reduce waste volumes. Under CERCLA, a No Action Alternative is required to provide a baseline for comparison with other alternatives. The No Action Alternative, if selected, would require no changes to current waste disposal practices.

- The *Off-Site Disposal Alternative* involves project-by-project disposal of CERCLA waste and includes two waste volume scenarios for comparison purposes: (1) a high-end waste volume scenario for which CERCLA waste is assumed to be shipped off-site and that the C-746-U Landfill is not available; and (2) a low-end waste volume scenario, which assumes various waste reduction actions, use of the C-746-U Landfill for waste that meets that facility's WAC, and off-site disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill.

- The *On-Site Disposal Alternative* involves the disposal of CERCLA waste into a newly constructed on-site waste disposal facility located on property owned by DOE.[3] Evaluation for the On-Site Alternative includes a base case and both high- and low-end waste volume scenarios. The base case represents the most likely volume that can be predicted to be generated using the 2007 approved life cycle baseline (LCB).[4] The base case also considers continued use of the C-746-U Landfill for disposal of waste that meets that facility's WAC, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in a newly constructed on-site disposal facility. The high-end waste volume scenario assumes CERCLA and waste that would otherwise go to the C-746-U Landfill would be disposed of in a newly constructed on-site facility. The low-end waste volume scenario assumes various waste reduction actions, continued use of the C-746-U Landfill for disposal of waste that meets the facility's WAC, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in a newly constructed on-site disposal facility. It is also assumed for the purposes of the RI/FS that 5% of the waste volume would require off-site disposal.

The "base case" waste volume (approximately 3.6 mcy) consists of all CERCLA-generated waste taken directly from the LCB and D&D waste volume estimates, but does not take into account recycling, reuse, or other waste-reduction initiatives. The base case represents the most likely volume that can be predicted to be generated using information from the 2007 approved LCB.

High-end and low-end waste volume estimates are variations of the base case. They were developed to address uncertainties associated with the base case waste forecast; potential waste volume increase or

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[*]The C-746-U Landfill can accept certain nonhazardous solid waste generated by CERCLA activities at PGDP. Nonhazardous solid waste generated under CERCLA would be eligible for disposal at either a potential on-site WDF or the C-746-U Landfill. Waste disposal decisions will be made on a project-by-project basis. It is anticipated that PGDP CERCLA projects typically will dispose of nonhazardous solid waste at the C-746-U Landfill; however, in some cases, projects may dispose of solid waste at a potential on-site WDF based on project efficiency and operational considerations such as managing project waste characterization and segregation resources; maximizing operational efficiencies at the C-746-U Landfill and a potential on-site WDF; and efficiently utilizing air space at the C-746-U Landfill and a potential WDF. For purposes of this RI/FS, each of the remedial action alternatives is assumed to utilize this approach.

[2] Any material generated as waste during a CERCLA response action conducted under the FFA for PGDP.

[3] The property owned by DOE is defined as within the boundaries of DOE PGDP-owned property (3,556 acres), including property licensed to the West Kentucky Wildlife Management Area (WKWMA).

[4] The 2007 approved LCB is used for planning purposes; the schedule and volume estimates used are subject to change.

decrease; availability of the C-746-U Landfill in the future, and whether waste meeting the WAC of the C-746-U Landfill will be disposed of there; and waste reuse or recycling. These waste volume ranges are intended to address uncertainties in the waste volume for the purposes of assessing the feasibility of the disposal alternatives. The actual volume associated with an alternative may differ for a variety of reasons such as updated waste forecasts or the need for additional fill to facilitate disposal of non-soil wastes.

These are the high-end assumptions.

- An increase of 10% from the base case volume to account for excavating more contamination than expected in individual response actions.
- The C-746-U Landfill is unavailable due to economic, technical, or regulatory issues; therefore, waste meeting the WAC of the C-746-U Landfill will require disposal off-site or disposal in a newly-constructed on-site disposal facility.
- No potential volume-reducing activities such as recycling, reuse, or other waste reduction initiatives would be implemented.

These are the low-end assumptions:

- Up to 75% of the forecasted scrap metal would be recycled (~550,000 yd^3).
- Up to 75% of the forecasted concrete debris would be recycled/reused (~585,000 yd^3).
- Five buildings in the D&D inventory (C-100, C-101, C-102, C-103, and C-720) would be retained (DOE 2011a) for ongoing use (~185,000 yd^3).

The following remaining waste volumes have been accounted for:

- Other waste volumes are 10% less than base case volumes.
- Waste meeting the WAC of the C-746-U Landfill would be disposed of in the C-746-U Landfill (~552,000 yd^3).

Table 1.1 provides a summary of the CERCLA waste disposal alternatives to be evaluated.

Table 1.1. CERCLA Waste Disposal Alternatives Summary

Waste Disposal Facility	No Action Alternative (Base Case Waste Volume)	Off-Site Alternative			On-Site Alternative*		
		High-End Waste Volume	Base Case Waste Volume (No Action Alternative)	Low-End Waste Volume	High-End Waste Volume	Base Case Waste Volume	Low-End Waste Volume
C-746-U Landfill	✓		✓	✓		✓	✓
Off-Site Facility	✓	✓	✓	✓			
New On-Site Facility					✓	✓	✓

*Waste that does not meet the WAC of an on-site facility would be disposed of off-site. For this RI/FS, it is assumed that 5% of the waste volume would require off-site disposal.

1.1 PURPOSE AND ORGANIZATION OF REPORT

This RI/FS Report combines the RI and FS processes into a single report. The purpose of the RI is to collect information to develop the waste disposal alternatives, and the FS is performed to evaluate and screen the alternatives. The CERCLA remedy selection process defined by EPA in 40 *CFR* § 300.430(d) and (e) was utilized to evaluate the disposal alternatives and identify the most appropriate alternative for disposal of CERCLA-generated waste. The selected alternative must be protective of human health and the environment and also must be compliant with applicable or relevant and appropriate requirements (ARARs) or invoke a CERCLA ARAR waiver. By following the CERCLA RI/FS process, the information presented can be used to support an informed decision regarding the remedy that is most appropriate for this site.

This document is organized consistent with the outline provided in Appendix H of the RI/FS Work Plan (WP) (DOE 2011a). The outline in the RI/FS WP was tailored based on the outlines in the FFA, which were developed for documents that support characterization of and remedy selection for contaminant release sites. This RI/FS Report has been tailored to focus on development of information necessary to evaluate disposal alternatives for PGDP CERCLA-generated waste and to enable an informed decision by DOE, regulators, and stakeholders.

The remaining chapters of this RI/FS Report include the following:

- Environmental Setting—Chapter 2
- Evaluation of Seismic Conditions—Chapter 3
- Waste Inventory and Characterization—Chapter 4
- Detailed Description of Alternatives—Chapter 5
- Detailed Evaluation of Alternatives—Chapter 6
- Comparative Analysis of Alternatives—Chapter 7
- References—Chapter 8

The following appendices are included to support the RI/FS Report:

- Appendix A—Summary of Seismic Conditions
- Appendix B—Waste Forecast
- Appendix C—PWAC Modeling Supporting Information
- Appendix D—Waste Characterization
- Appendix E—Siting Study
- Appendix F—Conceptual Design
- Appendix G—ARARs
- Appendix H—No Action and Off-Site Cost Estimate
- Appendix I—On-Site Cost Estimate

1.2 BACKGROUND INFORMATION

This section provides a general history of PGDP and a summary of relevant background information.

1.2.1 General History

PGDP is a DOE-owned uranium enrichment plant consisting of a diffusion cascade system and associated support facilities. Effective July 1, 1993, DOE leased the plant production facilities to USEC.

DOE began construction of the plant in 1951 and initiated operation in 1952. The plant currently enriches uranium-235, the second most abundant isotope in naturally occurring uranium, from its natural abundance of 0.72% to almost 5.5%. Enrichment of uranium-235 is necessary because the most abundant isotope of uranium, uranium-238 (> 99% of naturally occurring uranium), is not a fissile material. The enrichment process requires extensive support facilities. Some of the facilities currently active at PGDP include a steam plant, four major electrical switchyards, four sets of cooling towers, process buildings, a building for chemical cleaning and decontamination, a water treatment plant, and maintenance and laboratory facilities. Several inactive facilities also are located on the plant site.

From 1953 until 1977, most of the uranium hexafluoride (UF_6) used by PGDP was produced from feedstock in the feed plant, which was designed to process both natural uranium and uranium from reactor tails. The reactor tails included uranium that had been returned for reenrichment from the plutonium production reactors at the DOE Hanford and Savannah River plants.[5] As a result of nuclear reactions in the plutonium production reactors, the reactor tails contained traces of technetium-99 (Tc-99) and are believed to be the sole source of Tc-99 released to the environment at PGDP. Since 1977, PGDP has been supplied with UF_6 feedstock from commercial converters, such as Honeywell in Metropolis, Illinois, and from foreign sources. Since the plant's construction, trichloroethene (TCE) was used as a cleaning solvent. The use of TCE as a degreaser ceased on July 1, 1993. Polychlorinated biphenyls (PCBs) were used extensively as an insulating, nonflammable, thermally conductive fluid in electrical capacitors and transformers at PGDP. PCB oils also were used as flame retardants on the gaskets of diffusion cascades and in other sections of the plant and as hydraulic fluid.

Various hazardous, nonhazardous, and radioactive wastes resulting from ongoing operations have been generated and disposed of at PGDP. Site investigations have determined that TCE and Tc-99 in groundwater, as well as uranium and PCBs in surface water and sediment, are the four primary environmental contaminants of concern (COCs) at the facility (CH2M HILL 1991; CH2M HILL 1992).

1.2.2 RI/FS Scoping Document and Work Plan

In April 2008, the CERCLA Waste Disposal Evaluation RI/FS Scoping Document (Scoping Document) (DOE 2008) was prepared. Information in the Scoping Document was used in a series of project scoping meetings with representatives from EPA, Kentucky, and DOE. The purpose of the scoping meetings was to lay the groundwork for the RI/FS process and, specifically, to facilitate the development of the RI/FS WP. During the scoping meetings, several topics such as seismic issues, groundwater modeling, and siting criteria were discussed, and potential data gaps were identified.

The approved RI/FS WP described the data that would be collected to develop disposal alternatives for CERCLA waste and proposed methods to address identified data gaps regarding seismic issues, hydrogeologic data, and geotechnical data (DOE 2011a). The RI/FS WP also presented proposed methods to conduct groundwater modeling to support preliminary WAC (PWAC) development, develop analytical profiles (i.e., waste characterization), and perform site screening to identify potential sites for the On-Site Alternative. The PWAC provides an estimate of the average contaminant concentrations allowed in the total waste volume. Individual loads could be higher or lower, but the total mass of any one constituent present in the landfill will not exceed the PWAC inventory mass. As such, the PWAC establishes the total contaminant amount allowed in the landfill, such as maximum curies permitted in the cell or the single contaminant limit per COPC. As described in the WP, the PWAC development considers the total estimated volume of the Waste Disposal Facility. As the PWAC involves only release of contaminants through migration of water from the proposed landfill and subsequent groundwater fate and transport

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[5] Reactor tails received after 1975 were placed in storage rather than being processed.

through the underlying aquifer, the PWAC considers only mobile forms of contaminants; therefore, the contaminant inventory limits defined by the PWAC apply only to mobile forms of a contaminant (e.g., nickel as a component of soil that is capable of dissolving into percolating water, etc.). Wastes placed in a nonmobile form, such as nickel ingots, etc., will not be subject to the contaminant inventory limits defined by the PWAC.

As described in the Work Plan (DOE 2011a), the PWAC are based on groundwater transport of contaminants and the exposure scenario of a residential groundwater user drawing water from a well located at the edge of waste, the waste disposal facility boundary, the property boundary, or surface water outcrop. This receptor was selected because this individual reasonably would be expected to receive the highest cancer risk, hazard, and/or radionuclide dose from most contaminants migrating from the landfill.

The design requirement in the ARARs will be accounted for in the WAC development. Other constraints including, but not limited to, landfill worker protection and operational requirements (i.e., waste form and placement, etc.) are not considered in the development of the PWAC, but are anticipated to be incorporated into the WAC if the On-Site Alternative is selected. Some WAC concentrations also may increase compared to PWAC concentrations as a result of final site selection, final waste disposal facility (WDF) design, etc. Such revisions to the PWAC are expected to occur as part of developing the final WDF design and O&M plan.

1.2.3 Waste Volume Reduction

DOE has conducted a waste materials recycling and reuse evaluation for PGDP, that is outlined in Section 4.1.4, that explored opportunities for reuse, recycling, and melting of waste materials generated. The evaluation addresses the feasibility and costs associated with the reuse or recycling of materials that otherwise would be disposed of as waste in the current CERCLA waste forecast. DOE’s commitment to waste volume reduction and the possible steps involved in a scrap metal recycling effort are discussed in connection with the low-end waste volume scenario outlined in Section 4.1.4.

Reuse and/or recycling of material or waste is an important DOE initiative and may lead to benefits that include the following:

- Reduce the overall volume of waste requiring disposal,
- Provide cost savings for the disposal alternatives,
- Create new jobs for the community, and
- Provide benefits to other programs.

1.2.4 Waste Treatment

Treatment of the forecasted waste is not included in the RI/FS waste disposal evaluation. While it is recognized that some of the wastes will require chemical or physical treatment prior to disposal, the project generating the waste will be responsible for the evaluation of treatment alternatives in project-specific CERCLA documentation. The volume of waste that may require treatment is projected to be a very small fraction of the total volume of CERCLA waste (i.e., less than 2% of the forecasted waste by volume). It is not necessary to develop a centralized waste treatment approach within the scope of this waste disposal alternatives evaluation, since the current plan is that any necessary treatment will be performed by the project generating the waste.

1.3 SITING STUDY

A site screening study was conducted to determine the best location at PGDP to represent the On-Site Alternative for the waste disposal evaluation (DOE 2001). The site screening process evaluated the 12 candidate sites presented in the RI/FS Work Plan. Threshold Criteria were based on minimum technical requirements, floodplain and wetland considerations and a minimum area of 110 acres, based on the facility conceptual design. The Threshold Criteria were applied on a pass-fail basis. Five of the 12 candidate sites passed the Threshold Screening and were carried forward for the Secondary Screening. (Sites 1, 3A, 5A, 9, and 11).

While all five sites that passed the Threshold Criteria are considered technically adequate for construction of an on-site waste disposal facility, the Secondary Criteria were applied. The Secondary Criteria were weighted according to relative importance. Secondary Criteria also were identified as either inherent factors, which are permanent site features, or "logistical factors," which are more short-term, constructability considerations. This distinction was made to ensure the best site was defined based on long-term factors and not on relatively short-term factors of constructability convenience. The total score for each criterion for each site was the product of weighting factor times the score.

Once the Secondary Criteria were established, each of the five sites was scored. The individual scores then were compiled and provided to the team members for discussion. Sites 3A and 11 are referred to as "prototype" sites and are discussed in detail throughout the report. Site 3A, is within the boundary in the southern hydrogeologic setting; and Site 11, in the northern hydrogeologic setting, is located north of the current C-746-U Landfill.

1.4 OVERVIEW OF THE ENVIRONMENTAL COMPLIANCE PROCESS

This section summarizes the compliance framework for ER at PGDP, including the major regulations driving the response actions. This section also explains how this RI/FS Report satisfies the documentation requirements of CERCLA, the National Environmental Policy Act (NEPA), the Natural Resource Damage Assessment (NRDA) process, and the public involvement process.

1.4.1 Major Laws, Regulations, and Controlling Documents

Section 105(a)(8)(B) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act, requires EPA to promulgate a list of national priorities among the known or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States. On June 30, 1994, EPA placed PGDP on the NPL [59 *FR* 27989 (May 31, 1994)]. The NPL lists sites across the country that are designated by EPA as high priority sites for remediation under CERCLA. As the lead agency under CERCLA, DOE is responsible for conducting cleanup activities at PGDP in compliance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). CERCLA is not the only driver for cleanup at PGDP. RCRA also requires corrective action for releases of hazardous constituents from a SWMU.

Section 120 of CERCLA requires federal facilities listed on the NPL to enter into an FFA. The purpose of an FFA is to coordinate the CERCLA remedial action and RCRA corrective action process into a set of comprehensive requirements for site remediation. The FFA requires that DOE develop and submit an annual Site Management Plan (DOE 2013) to EPA and Kentucky. The Site Management Plan provides the overall strategic approach for site cleanup and establishes schedules and milestones for implementation. The disposal of waste generated during site cleanup is part of the overall site strategic approach and is evaluated in this report.

The intent of NEPA is to promote a decision making process that results in minimization of adverse impacts to human health and the environment. On June 13, 1994, the Secretary of Energy issued a Secretarial Policy (Policy) on NEPA that addresses NEPA requirements for actions taken under CERCLA. Section II.E of the Policy states that DOE CERCLA documents will incorporate NEPA values to the extent practicable, such as analysis of cumulative, ecological, cultural, and socioeconomic impacts. NEPA values are incorporated into this RI/FS Report consistent with DOE policy. Table 1.2 presents specific NEPA values and the sections of this RI/FS Report that incorporate these elements. NEPA requires federal agencies to evaluate and document the effect that proposed actions would have on the quality of the human environment. Further, NEPA requires agencies to consider both the adverse and beneficial environmental impacts of alternatives during the planning and decision making stages. DOE is required to assess the potential consequences of its activities on the human environment in accordance with the Council on Environmental Quality, NEPA regulations (40 *CFR* §§ 1500-1508), and the DOE NEPA Implementing Procedures (10 *CFR* § 1021).

Table 1.2. NEPA Integration into the RI/FS for CERCLA Waste Disposal Alternatives Evaluation

NEPA Element	RI/FS Section
Summary	Executive Summary
Proposed Action, including ancillary elements	Section 1.1 Purpose and Organization of Report
Purpose and Need for Action	Chapter 1. Introduction
Affected Environment Land Use Socioeconomics Environmental Justice Transportation Noise Cultural Resources Geology and Soils Water Resources and Water Quality Ecological Resources Wetlands and Floodplains Threatened and Endangered Species Climate and Air Quality Alternatives	Chapter 2. Environmental Setting Section 2.2 Demography and Land Use Section 2.2 Demography and Land Use Section 2.2 Demography and Land Use Section 2.2.1 Transportation Section 2.2.1 Transportation Section 2.2.2 Cultural Resources Section 2.3 Geology and 2.3.7 Surficial Deposits/Soil Section 2.5 Hydrogeology and 2.6 Surface Water Hydrology Section 2.7 Ecological Setting Section 2.7.3 Wetlands and Floodplains Section 2.7.4 Threatened and Endangered Species Section 2.8 Climatology and Meteorology Chapter 5. Detailed Description of Alternatives
Environmental Consequences (direct and indirect impacts, mitigative measures, and unavoidable adverse impacts) Land Use Climate and Air Quality Geology and Soils Water Resources and Water Quality Wetlands and Floodplains Ecological Resources Threatened and Endangered Species Cultural Resources Socioeconomics Environmental Justice Transportation Noise Human Health	Chapter 6. Detailed Evaluation of Alternatives —Overall Protection of Human Health and Environment —Long-term Effectiveness and Permanence —Short-term Effectiveness

Table 1.2. NEPA Integration into the RI/FS for CERCLA Waste Disposal Alternatives Evaluation (Continued)

NEPA Element	RI/FS Section
Irreversible and Irretrievable Commitment of Natural Resources	Chapter 6. Detailed Evaluation of Alternatives—Irreversible and Irretrievable Commitment of Natural Resources
Cumulative Impacts	Chapter 6. Detailed Evaluation of Alternatives—Cumulative Environmental Impacts
Environmental Permits and Regulations	Chapter 6. Detailed Evaluation of Alternatives—Compliance with ARARs

In addition to satisfying CERCLA requirements, this RI/FS Report addresses environmental concerns through incorporation of values outlined in NEPA, in keeping with DOE's Secretarial Policy on NEPA (DOE 1994) as well as continued progress toward overall site cleanup in support of implementing the NRDA process.

1.4.2 CERCLA RI/FS Process

EPA has developed procedural and documentation requirements for characterizing and cleaning up hazardous waste sites under CERCLA. This process is designed to be flexible and can be customized to fit the specific circumstances at each site. RI/FS documents must be prepared in accordance with the requirements of CERCLA, as codified in the NCP (40 *CFR* § 300). Under CERCLA Section 120, PGDP, as a federal facility on the NPL, must confirm and quantify the nature and extent of contamination, then implement appropriate response actions to remedy releases or threatened releases of hazardous substances to the environment. The general compliance approach that incorporates these requirements is the RI/FS process. The following are the primary elements of a typical RI/FS:

- The RI collects data to characterize site conditions, determine the nature and extent of contamination, and assess the risks to human health and the environment.

- The FS develops, screens, and evaluates technologies and alternatives for site remediation and presents potential cleanup criteria.

This RI/FS Report presents the results of these primary elements in a single document. Because this RI/FS addresses sitewide waste disposal options for anticipated wastes, there has been no field sampling to establish the nature and extent of specific contamination. Instead, the RI element is based on existing information from the waste inventory (waste volumes, waste types, and waste characteristics) that has been developed for source-specific or media-specific OUs at PGDP. After the waste inventory was compiled, a waste profile (characterization) was developed using the available data. RI tasks for the On-Site Alternative included reviewing and assessing existing information related to seismic considerations, hydrogeologic, and geotechnical data; conducting a site screening; preparing conceptual designs; and developing a PWAC.[6] For the Off-Site Alternative, the RI included evaluating potential off-site waste disposal facilities, modes of transportation, transportation risks, and shipping container types.

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[6] The PWAC are used to assess the viability of the On-Site Alternative as well as to inform the design of an on-site WDF, if the On-Site Alternative is selected, as it progresses from the conceptual level to final design.

Since this RI/FS is evaluating disposal options, a baseline risk assessment for human health and the environment was not performed. The FS evaluates the alternatives for disposal of CERCLA waste, but does not address site cleanup criteria or waste treatment for specific OUs.

The objective of the RI/FS process is to gather information sufficient to support an informed risk management decision regarding which remedy appears to be the most appropriate for a given site. The remedy selection, while not formally a part of the RI/FS process, has its own requirements and can begin concurrently with or subsequent to the FS. Documents prepared during remedy selection are the proposed plan (identifies the preferred alternative based on information from the RI/FS) and a record of decision (ROD) (announces the selected remedy and documents responses from public comments).

1.4.3 Public Involvement

DOE has involved the public during the scoping for this project through public information exchanges. Additionally, regular briefings for PGDP Citizen's Advisory Board (CAB), a citizens panel advising the DOE Environmental Management Program, have been conducted. The CAB has provided feedback to DOE on its environmental management program since 1995.

DOE, EPA, and Kentucky encourage the public to review this report and other relevant documents in the Administrative Record to gain an understanding of PGDP's environmental cleanup projects. DOE opened the Paducah Environmental Information Center (EIC) in 1993 to provide residents of western Kentucky and southern Illinois a convenient way to participate in ER decisions and to learn more about the agency's environmental work at PGDP. A copy of this RI/FS Report, as well as the entire Administrative Record, is located at the Paducah EIC.

2. ENVIRONMENTAL SETTING

This chapter summarizes the environmental setting at PGDP, describes the location of PGDP, and details the demography and land use, seismicity, hydrogeology, surface water hydrology, ecology, and climatology at and near PGDP.

2.1 LOCATION

PGDP is located approximately 10 miles west of Paducah, Kentucky, and 3.5 miles south of the Ohio River in the western part of McCracken County (Figure 2.1). The plant is located on a 3,556-acre DOE-owned site: approximately 650 acres are within a fenced security area around the PGDP itself, approximately 800 acres are located outside the security fence, and the remaining 1,986 acres are licensed to the Commonwealth of Kentucky as part of the West Kentucky Wildlife Management Area (WKWMA). Bordering the PGDP Reservation to the northeast, between the plant and the Ohio River, is a Tennessee Valley Authority (TVA) reservation on which the Shawnee Fossil Plant is located (Figure 2.2).

The topographic features in the vicinity of the PGDP include nearly level to gently sloping dissected plains and the floodplain of the Ohio River. The elevations of the stream valleys in the dissected plains are up to 100 ft lower than the adjoining uplands (Figure 2.3).

Local elevations range from 290 ft above mean sea level (amsl) along the Ohio River to 450 ft amsl southwest of PGDP near Bethel Church Road. The topography in the PGDP area slopes toward the Ohio River at an approximate gradient of 27 ft per mile (CH2M HILL 1992). Ground surface elevations vary from 360 to 390 ft amsl within the PGDP boundary and 340 to 420 ft amsl within the DOE-owned property.

2.2 DEMOGRAPHY AND LAND USE

PGDP is surrounded by WKWMA and some sparsely populated agricultural lands. The closest communities are Heath, Grahamville, and Kevil, all of which are located within 3 miles of DOE site boundaries (Figure 2.1). PGDP is located 5 miles southwest of Metropolis, Illinois; approximately 10 miles west of Paducah, Kentucky; and approximately 40 miles southeast of Cape Girardeau, Missouri.

Historically, the economy of Western Kentucky has been based on agriculture, although there has been increased industrial development in recent years. PGDP employs approximately 1,400 people, and the TVA Shawnee Fossil Plant employs an additional 260 people. The total population within the 32 counties that lie within a 50-mile radius of PGDP is approximately 534,000, and approximately 66,000 people live within the three counties that contain the 10 mile radius of the plant (Massac County, Illinois, and Ballard and McCracken Counties, Kentucky) (U.S. Department of Commerce 2011). The population of McCracken County is estimated to be approximately 65,565. The estimated population of Paducah, Kentucky, is approximately 25,661. No census tracks near the site include a higher proportion of minorities or low-income populations than the national average.

In addition to the residential population surrounding the plant, WKWMA draws thousands of visitors each year for recreational purposes. This area is used by visitors primarily for hunting and fishing, but other activities include horseback riding, dog trials, hiking, and bird watching.

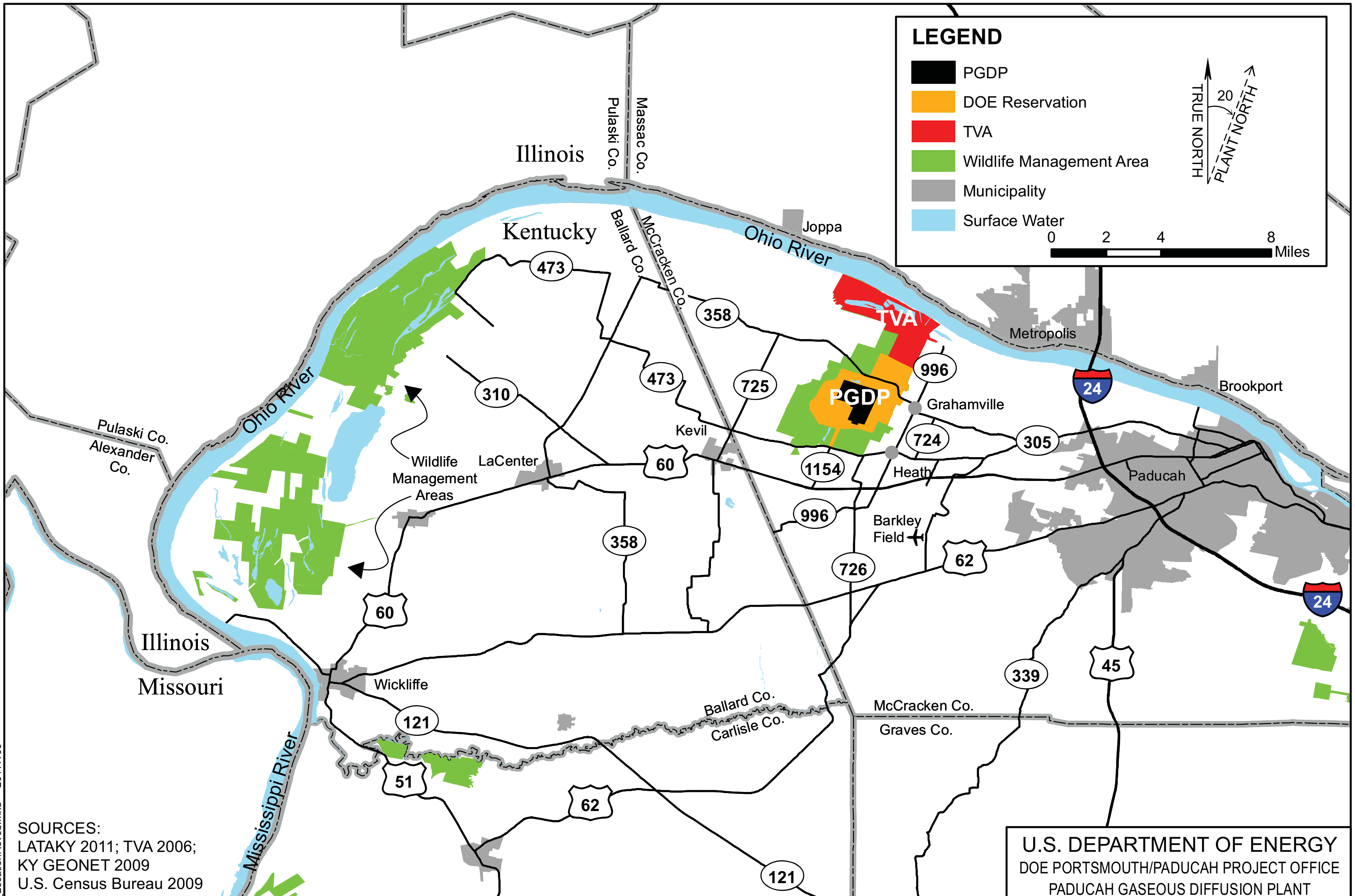

Figure 2.1. PGDP Vicinity Map

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC

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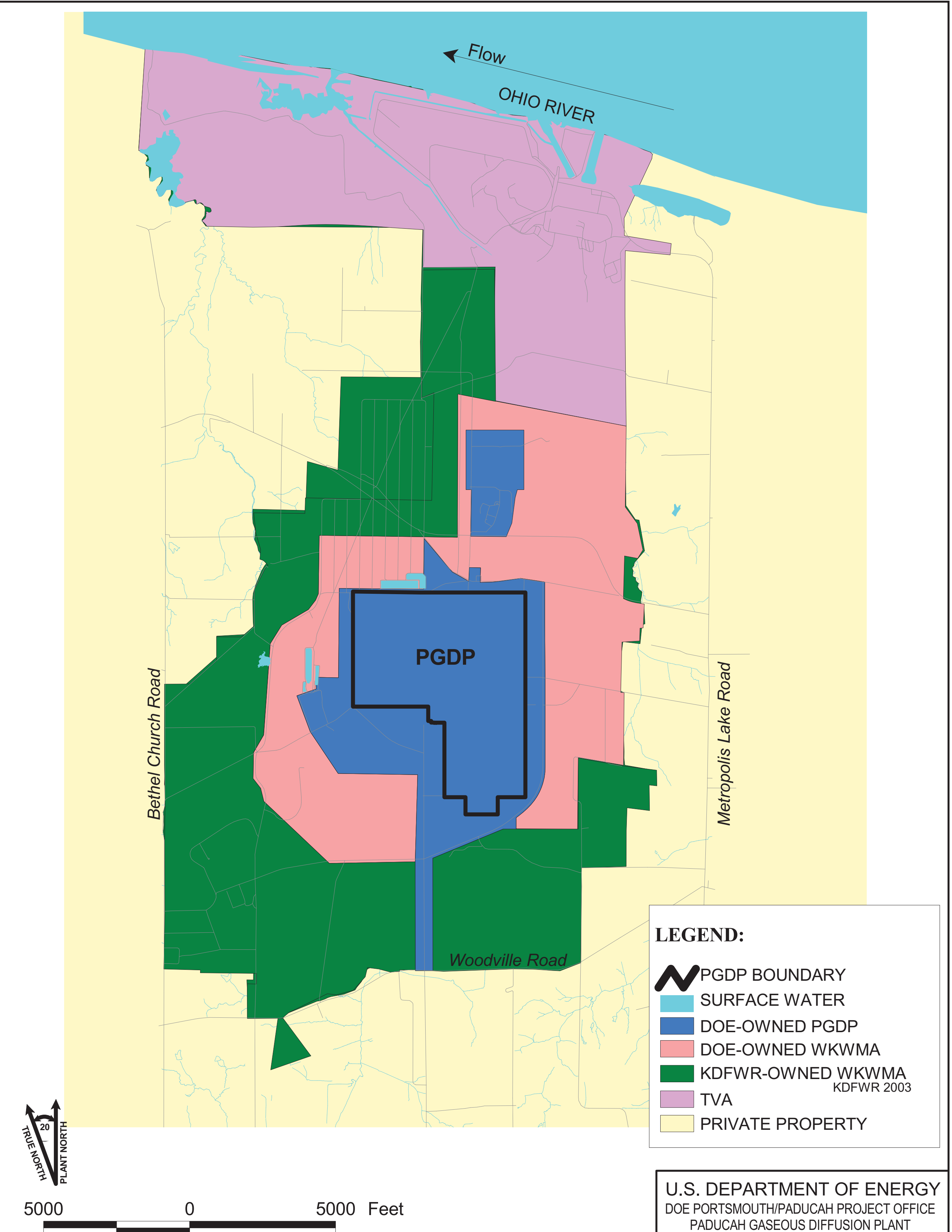

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

Figure 2.2. PGDP Land Ownership Map

LATA Environmental Services of Kentucky, LLC

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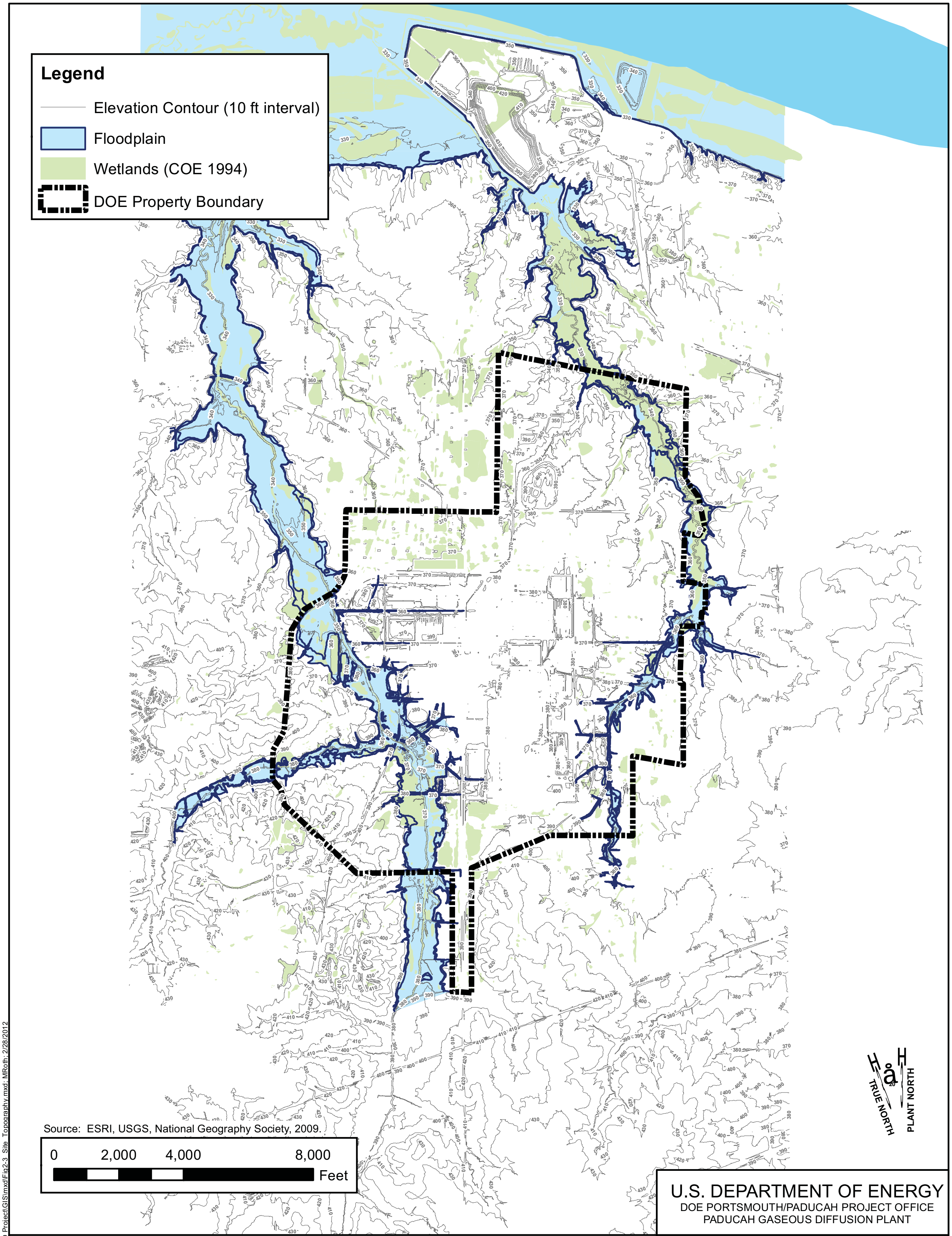

Figure 2.3. Ground Surface Topography in Vicinity of PGDP

2.2.1 Transportation

There are four federal highways (U.S. 45, 51, 60, and 62) and one interstate highway (I-24) in the vicinity of PGDP (Figure 2.1). Highway 60 is used most frequently by plant personnel for access to PGDP. This portion of Highway 60 is functionally classified by the Federal Highway Administration (1989) as "rural-principal arterial."

Traffic surrounding PGDP chiefly consists of visits by recreationists, PGDP personnel, and WKWMA personnel traveling on gravel roads in the area. Ogden Landing Road (Highway 358 shown in Figure 2.1) is the only road frequently used by the public within the DOE property boundary.

The railways within DOE property and continuing south to Woodville Road are owned by DOE. These railways connect to the Paducah & Louisville Railway, Inc., rail lines and extend east to the VMV Enterprise rail yard in Paducah. From the rail yard, connections are available to the Burlington Northern, Canadian National, and Louisville and Nashville rail lines. Rail traffic near PGDP is minimal.

The closest commercial airport is Barkley Regional Airport, approximately 5 miles southeast of PGDP. Barkley Regional Airport is owned jointly by the city of Paducah and McCracken County and operated by the Paducah Airport Corporation.

Noise associated with plant activities generally is restricted to areas inside on-site buildings. Sources of noise beyond the security fence are limited to wildlife, hunting, traffic moving through the area, and operation and maintenance activities located close to the security fence.

2.2.2 Cultural Resources

The COE (1994) survey of cultural resources near PGDP did not identify any archaeological or historical resources in the vicinity of candidate disposal facility sites. If archaeological or historical artifacts or sites were to be discovered during construction, necessary measures (e.g., site mapping, artifact, and data collection) would be performed in accordance with ARARs.

2.3 GEOLOGY

PGDP is located in the Jackson Purchase region of western Kentucky, which represents the northernmost extent of the Mississippi Embayment portion of the Coastal Plain Province. The stratigraphic sequence in the region consists of Cretaceous [144 to 65 million years ago (mya)], Tertiary (65 to 1.8 mya), and Quaternary (1.8 mya to today) sediments unconformably overlying Paleozoic (543 to 248 mya) bedrock (Paleozoic strata younger than Mississippian are not present at the site). Subsequent sections briefly discuss the formations represented in Figure 2.4.

2.3.1 Bedrock

Mississippian (354 to 323 mya) carbonates, consisting of a dark gray limestone with some interbedded chert and shale, underlie the footprint of PGDP (see Figure 2.4) at depths varying from 340 to 400 ft. The thickness of these carbonates is estimated to be greater than 500 ft.

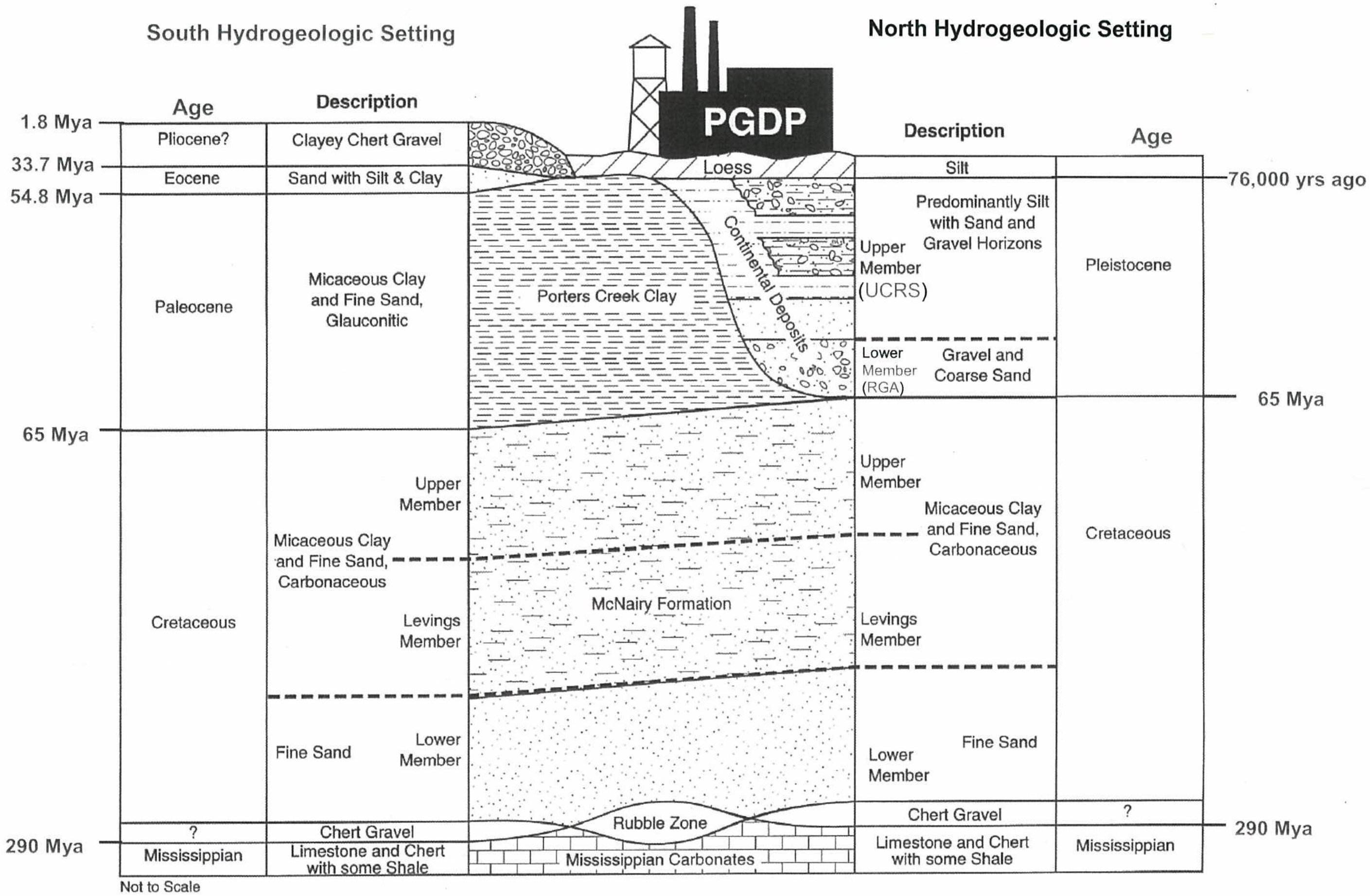

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Figure 2.4. Stratigraphy in the Vicinity of PGDP

2.3.2 Rubble Zone

A rubble zone of chert gravel is commonly encountered in soil borings at the top of the bedrock. The age and continuity of the rubble zone are undetermined. Where it is present, the rubble zone ranges from approximately 5 to 20 ft in thickness.

2.3.3 McNairy Formation

The McNairy Formation consists of Upper Cretaceous sediments of gray to yellow to reddish-brown, very fine- to medium-grained sand interbedded with grayish-white to dark gray, micaceous silt and clay. A basal sand member also is present at PGDP. The total thickness of the McNairy Formation ranges from 200 to 300 ft.

2.3.4 Porters Creek Clay/Porters Creek Terrace Slope

The Paleocene (65 to 54.8 mya) Porters Creek Clay occurs in the southern portions of the site and consists of dark gray to black silt with varying amounts of clay and fine-grained micaceous, commonly glauconitic, sand. In the southern portions of the site it can be as thick as 200 ft. The Porters Creek Clay subcrops along a buried terrace slope that extends east–west across the site. This subcrop is the northern limit of the Porters Creek Clay and the southern limit of the Pleistocene (1.8 mya to 12,000 years) Lower Continental Deposits under PGDP.

2.3.5 Eocene Sands

Eocene (54.8 to 33.7 mya) sands are present south of PGDP above the Porters Creek Clay and can be found in the extreme southwestern part of the DOE Reservation. This unit includes undifferentiated quartz sand and interbedded and interlensing silt and clay of the Claiborne Group and the Wilcox Formation (Olive 1980). The Eocene sands thicken south of PGDP. The Claiborne Group ranges up to 200 ft in thickness and the Wilcox Formation may be up to 100 ft thick.

2.3.6 Continental Deposits

Continental sediments [Pliocene(?)[7] (5.3 to 1.8 mya) to Pleistocene (1.8 mya to 12,000 years ago)] unconformably overlie the Cretaceous through Eocene strata throughout the area. These continental sediments were deposited on an irregular erosional surface consisting of several terraces, and have a total thickness from near 0 to about 120 ft. The thicker Continental Deposits sections represent Pleistocene valley fill sediments that comprise a fining-upward cycle. The continental sediments have been divided into the following two distinct facies.

<u>Lower Continental Deposits</u>. The Lower Continental Deposits is a gravel facies consisting of chert, ranging from pebbles to cobbles, in a matrix of poorly sorted sand and silt. Gravels of the Lower Continental Deposits overlie three distinct terraces in the PGDP area.

- The upper terrace of the Lower Continental Deposits consists of Pliocene(?) gravel units, ranging in thickness from near 0 to 30 ft, occurring in the southern portion of the DOE site at elevations greater than 350 ft amsl. This gravel unit overlies the Eocene sands and Porters Creek Clay (where the Eocene sands are missing).

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[7] A question mark indicates uncertain age.

- Pliocene(?) gravels of the Lower Continental Deposits are also present on an intermediate terrace eroded into the Porters Creek Clay at an elevation of approximately 320 to 345 ft amsl in the southeastern and eastern portions of the DOE site. The thickness of this unit typically ranges from 15 to 20 ft.

- The Lower Continental Deposits of the upper and intermediate terraces are collectively referred to as the Terrace Gravel.

- The third and most prominent of the Lower Continental Deposits members consists of a Pleistocene gravel deposit resting on an erosional surface at an elevation of approximately 280 ft amsl. This gravel underlies most of the plant area and the region to the north, but pinches out under the south side of PGDP along the subcrop of the Porters Creek Clay. The Pleistocene member of the Lower Continental Deposits averages approximately 30 ft in thickness. Trends of greater thickness, as much as 50 ft, fill deeper scour channels that trend east-west across the site.

Upper Continental Deposits. The Upper Continental Deposits is a Pleistocene age, fine-grained facies that commonly overlies the Lower Continental Deposits. This unit ranges in thickness from 15 to 55 ft. The Upper Continental Deposits includes three general horizons beneath PGDP: (1) an upper silt and clay interval; (2) an intermediate interval of common sand and gravel lenses (sand and gravel content generally diminishes northward); and (3) a lower silt and clay interval. The upper silt and clay interval consists of the Peoria Loess and Roxana Silt (DOE 2004; KRCEE 2006). The Peoria Loess and Roxana Silt blanket the entire PGDP area and range from zero to about 40 ft in thickness.

2.3.7 Surficial Deposits/Soils

The surficial deposits found in the vicinity of PGDP are Pleistocene loess and Holocene (10,000 to 12,000 years ago to present) alluvium. Both units commonly consist of clayey silt or silty clay and range in color from yellowish-brown to brownish-gray or tan, making field differentiation difficult.

Loess deposition probably occurred in upland areas during all stages of the glaciation that extended into the Ohio and Mississippi River Valleys.

The soil map for Ballard and McCracken Counties delineates three soil associations within the vicinity of PGDP: the Rosebloom-Wheeling-Dubbs association, the Grenada-Calloway association, and the Calloway-Henry association (USDA 1976). Inside the fenced area of the plant, many of the characteristics of these soil types have been changed due to construction and maintenance activities.

2.4 SEISMICITY

The seismic setting of PGDP is a key consideration in the feasibility, siting, and design of an on-site waste disposal facility for the On-Site Alternative. Three seismic sources have the potential to affect PGDP: the New Madrid Seismic Zone centered near the juncture of Kentucky, Missouri, and Tennessee; the Wabash Valley Seismic Zone in southeast Illinois and southwest Indiana; and background seismicity, which is not associated with any known seismic zone (KRCEE 2007). Of these, the New Madrid Seismic Zone presents the most prominent seismic hazard to PGDP. Four or five major earthquakes are believed to have occurred in the New Madrid Seismic Zone in late 1811 and early 1812 (Nuttli 1982). The most significant earthquakes during this period (December 16, 1811, and January 23 and February 7, 1812) are estimated to have had a magnitude between M7.0 and 7.5 (Hough et al. 2000; Hough and Martin 2002).

Chapter 3 provides a summary of seismic conditions in the region and at PGDP. Appendix A contains summaries of seismic investigations, analyses, and other supporting information relative to seismic hazard at PGDP. If the On-Site Disposal Alternative is selected, further seismic stability analysis would be performed in the final design to fully address seismic conditions.

2.5 HYDROGEOLOGY

The significant geologic units relative to shallow groundwater flow at PGDP include the Terrace Gravel and Porters Creek Clay (south sector of the DOE site) and the Pleistocene Continental Deposits and McNairy Formation (underlying PGDP and adjacent areas to the north). Figure 2.5 illustrates the water level trends in geologic units of the shallow groundwater flow systems at PGDP. Groundwater flow in the Pleistocene Continental Deposits is a primary pathway for transport of dissolved contamination from PGDP. The following paragraphs describe the shallow groundwater flow system at PGDP.

Terrace Gravel Flow System. The Porters Creek Clay is a confining unit to downward groundwater flow south of PGDP. A shallow water table flow system is developed in the Terrace Gravel where it overlies the Porters Creek Clay south of PGDP. Discharge from this flow system provides baseflow to Bayou Creek and underflow to the Pleistocene Continental Deposits to the east of PGDP.

The elevation of the top of the Porters Creek Clay is an important control to the area's groundwater flow trends. A distinct groundwater divide is centered in hills located approximately 9,000 ft southwest of PGDP (USGS 1966), where the Terrace Gravel [horizontal hydraulic conductivity of approximately 1 ft/day (MMES 1992)] and Eocene sands [horizontal hydraulic conductivity of approximately 45 ft/day (USGS 1973)] overlie a "high" on the top of the Porters Creek Clay (vertical hydraulic conductivity of approximately 5.5×10^{-4} ft/day (DOE 2004)]. In adjacent areas where the top of the Porters Creek Clay approaches land surface, as it does immediately south of PGDP and near the subcrop of the Porters Creek Clay to the west of the security-fenced area, the majority of groundwater flow discharges into surface streams (gaining reaches) and little underflow occurs into the Pleistocene Continental Deposits (DOE 1997).

To the east of PGDP, the Terrace Gravel overlies a lower terrace and a thick sequence of Terrace Gravel is adjacent to the Pleistocene Continental Deposits, allowing significant underflow from the Terrace Gravel. Surface drainages in this area typically discharge (losing reaches). Figure 2.6 presents hydraulic potential trends for the Terrace Gravel flow system (DOE 1997). The water table contours are based on information in the United States Geological Survey (USGS) Hydrologic Atlas of the Heath Quadrangle (USGS 1966), stream elevations, and water levels in abandoned gravel pits, although there is uncertainty due to limited monitoring well data from the area depicted in Figure 2.6.

Upper Continental Recharge System (UCRS). The UCRS is the upper stratum where infiltration of surface water occurs and is the location of the water table in the Upper Continental Deposits in the northern PGDP. Groundwater flow is generally downward in the Upper Continental Deposits. A plot of elevation of water level versus midpoint of well screen for UCRS wells at PGDP (Figure 2.7) demonstrates that steep vertical hydraulic gradients are characteristic of the UCRS (DOE 1997). Vertical hydraulic gradients generally range from 0.5 to 1 ft/ft, as measured in wells completed at different depths in the UCRS. The UCRS is composed of silt, clay, and sand members with a large range of horizontal hydraulic conductivity. Overall, the depth-averaged UCRS horizontal hydraulic conductivity is estimated to be approximately 0.005 ft/day.

Beneath PGDP and adjacent land to the north, the water table is present within the UCRS. Water table trends are best understood in the immediate plant vicinity and in the area of the C-746-U Landfill.

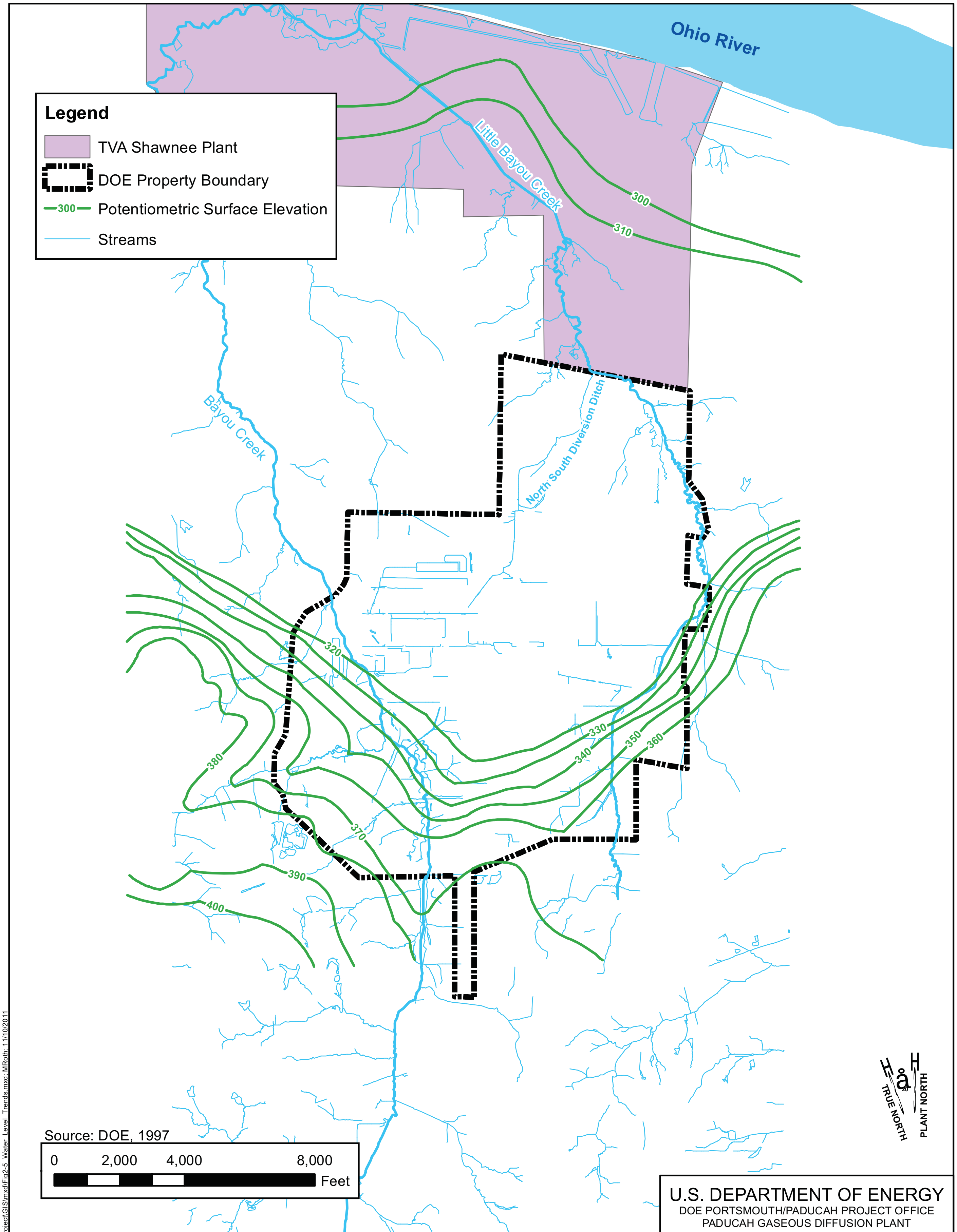

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Figure 2.5. Water Level Trends and Geological Components of the Shallow Groundwater Flow Systems in the Vicinity of PGDP

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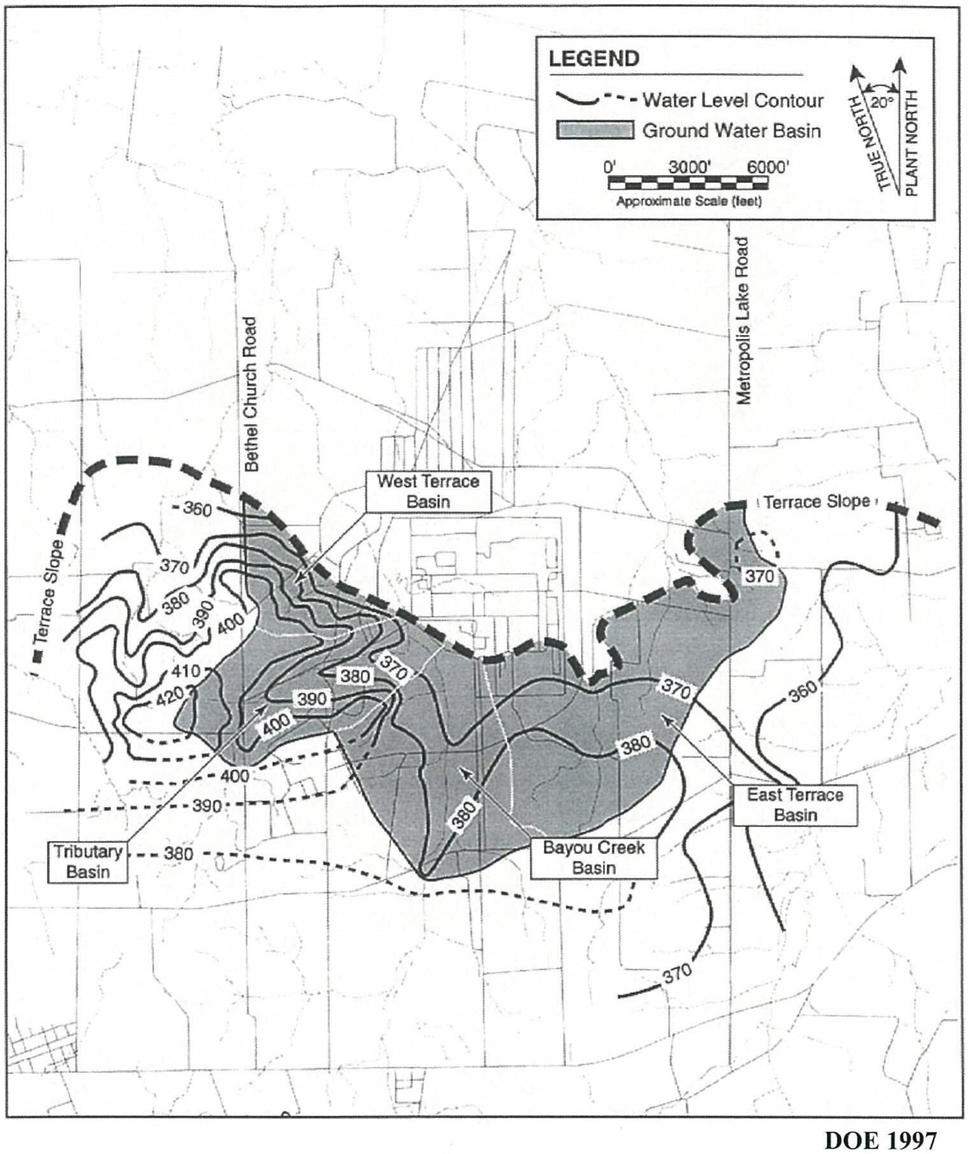

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Figure 2.6. Water Table Trends in the Terrace Deposits South of PGDP

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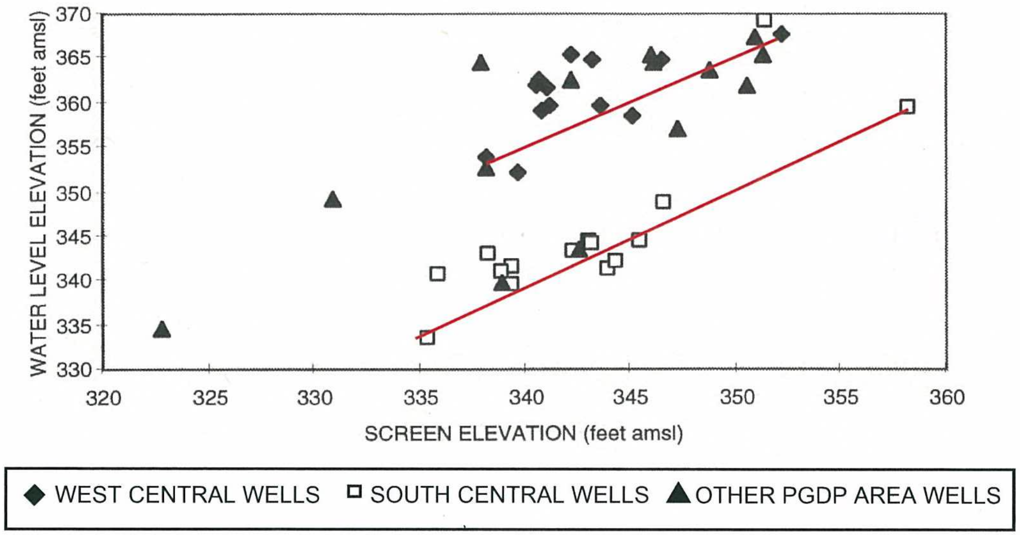

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Figure 2.7. Plot of Water Level Versus Well Screen for Upper Continental Recharge System Wells

Within the west plant area, the elevation of the water table is controlled by the bottom of drainage ditches and the water level in the bordering Bayou Creek. The water table is as shallow as 5 to 10 ft in some localities and less than 20-ft deep throughout the west plant area. Depth to the water table is much greater (as much as 40 ft) in the northeast plant area, where a storm sewer system is present to control storm runoff. Here, the water table slopes east toward Little Bayou Creek.

At the C-746-U Landfill, on the north end of PGDP, groundwater trends and the elevation of the water table are controlled by water levels in the North-South Diversion Ditch (NSDD) on the south side of the landfill and by water levels in Little Bayou Creek on the east and north sides. The water table slopes northward toward Little Bayou Creek at depths of 20 to 40 ft.

In general, the water table in the UCRS slopes away from areas of tributaries and higher land surface toward Bayou and Little Bayou Creeks. The depth to the water table is very shallow in the vicinity of tributaries, and wetlands are present on the highlands and in the vicinity of the creeks.

Regional Gravel Aquifer (RGA). Infiltrating water from the UCRS moves vertically downward into a basal sand member of the Upper Continental Deposits and the Pleistocene gravel member of the Lower Continental Deposits and then laterally north toward the Ohio River. This lateral flow system is called the RGA. The RGA is the shallow aquifer beneath PGDP and contiguous lands to the north.

Hydraulic potential in the RGA declines toward the Ohio River, which is the control for base level of the region's surface water and groundwater systems. The RGA potentiometric surface gradient beneath PGDP is commonly 10^{-4} ft/ft, and increases by an order of magnitude near the Ohio River. Vertical gradients are not well documented, but are believed to be small. Vertical gradients measured at nested wells at the C-404 Burial Ground, for example, range from 0.001 to 0.01 ft/ft, but are not consistently upward or downward.

The hydraulic conductivity of the RGA varies spatially. Pumping tests have documented that the hydraulic conductivity of the RGA ranges from 53 ft/day (EDGe 1990) to 5,700 ft/day (LMES 1996). The overall flow in the RGA is northward to the Ohio River. Observed flow patterns in the RGA are based on hydraulic head relationships associated with natural and anthropogenic recharge, unconfined shallow groundwater flow, response to local and regional base flow (Little Bayou Creek and the Ohio River respectively), and the geometry of the fluvial channel-fill sequence of the RGA as deposited on the erosional surface of the McNairy Formation. Based on groundwater modeling, flow rates generally increase from south to north in the RGA, ranging from approximately 0.5 ft/day in the plant area to over 5.0 ft/day near the Ohio River. Locally, in the vicinity of the plant site, velocities are estimated to range up to 3 ft/day due to heterogeneities in the RGA and the effects of localized anthropogenic recharge.

McNairy Flow System. Groundwater flow in the fine sands and silts of the McNairy Formation is called the McNairy Flow System. The overall McNairy groundwater flow direction in the area of PGDP is northward to the Ohio River, similar to that of the RGA. Hydraulic potential in the McNairy Flow System beneath PGDP is less than in the RGA. Area monitoring well clusters document an average downward vertical gradient of 0.03 ft/ft. Because the RGA has a steeper hydraulic potential slope toward the Ohio River than does the McNairy Flow System, the vertical gradient of the McNairy Flow System reverses nearer the Ohio River. The "hinge line," which is where the vertical hydraulic gradient between the RGA and McNairy Flow System changes from a downward vertical gradient to an upward vertical gradient, parallels the Ohio River near the northern DOE property boundary.

The contact between the Lower Continental Deposits and the McNairy Formation is a hydraulic properties boundary. Representative lateral and vertical hydraulic conductivities of the upper McNairy Formation in the area of PGDP are approximately 0.02 ft/day and 0.0005 ft/day, respectively. Vertical infiltration of groundwater into the McNairy Formation beneath PGDP is on the order of 0.1 inch per year As a result, little interchange occurs between the RGA and McNairy Flow System.

2.5.1 Hydrogeologic Settings

The site is predominantly located over the ancestral Tennessee River channel. The ancestral Tennessee River channel is filled with thick sand and gravel deposits overlaid by a sequence of silts and clays. Southward advance of the ancestral Tennessee River during the Pleistocene Epoch eroded away the Porters Creek Clay immediately beneath and north of the PGDP. The presence of the Porters Creek Clay south of PGDP and the absence of the Porters Creek Clay beneath PGDP and to the north define the two hydrogeologic settings (see Figure 2.4).

2.5.1.1 South hydrogeologic setting

South of the PGDP, a shallow water table system is developed in the Pliocene(?) gravels and Eocene sands where they overlie the Porters Creek Clay. Groundwater flow in the shallow water table system discharges as baseflow to Bayou Creek and its tributaries. Groundwater flow in this shallow system also can migrate across the buried terrace as underflow to the UCRS/RGA flow system. South of PGDP, a thickening wedge of Eocene sands transmits groundwater flow southward. Vertical groundwater flow is restricted to the sediments above the Porters Creek Clay.

2.5.1.2 North hydrogeologic setting

Beneath the PGDP and north, shallow groundwater flows downward through the silts and clays (UCRS) until it encounters the RGA sand and gravel deposit. Once in the RGA, groundwater flow is generally north, toward the Ohio River. Lateral flow in the RGA dominates this hydrologic regime, with comparatively little groundwater migrating downward into the underlying Cretaceous McNairy Formation. Lateral groundwater flow in the RGA is approximately 1 to 3 ft/day.

2.5.2 Hydrogeologic Units

Five hydrogeologic units (HUs) are commonly used to describe the shallow groundwater flow system beneath the DOE property and the contiguous lands to the north. In descending order, as shown on Figure 2.8, the HUs are as follows:

Loess Deposits

- HU 1 (UCRS): Loess that covers most of the site.

Upper Continental Deposits

- HU 2A and HU 2B (UCRS): Discontinuous sand and gravel lenses in a clayey silt matrix.

- HU2 Confining Unit (UCRS): Discontinuous silt unit.

- HU 3 (UCRS): Relatively impermeable unit that acts as the upper semiconfining-to-confining layer for the RGA. The lithologic composition of HU 3 varies from clay to fine sand, but is predominantly silt and clay.

- HU 4 (RGA): Near-continuous sand unit with a clayey silt matrix that forms the top of the RGA.

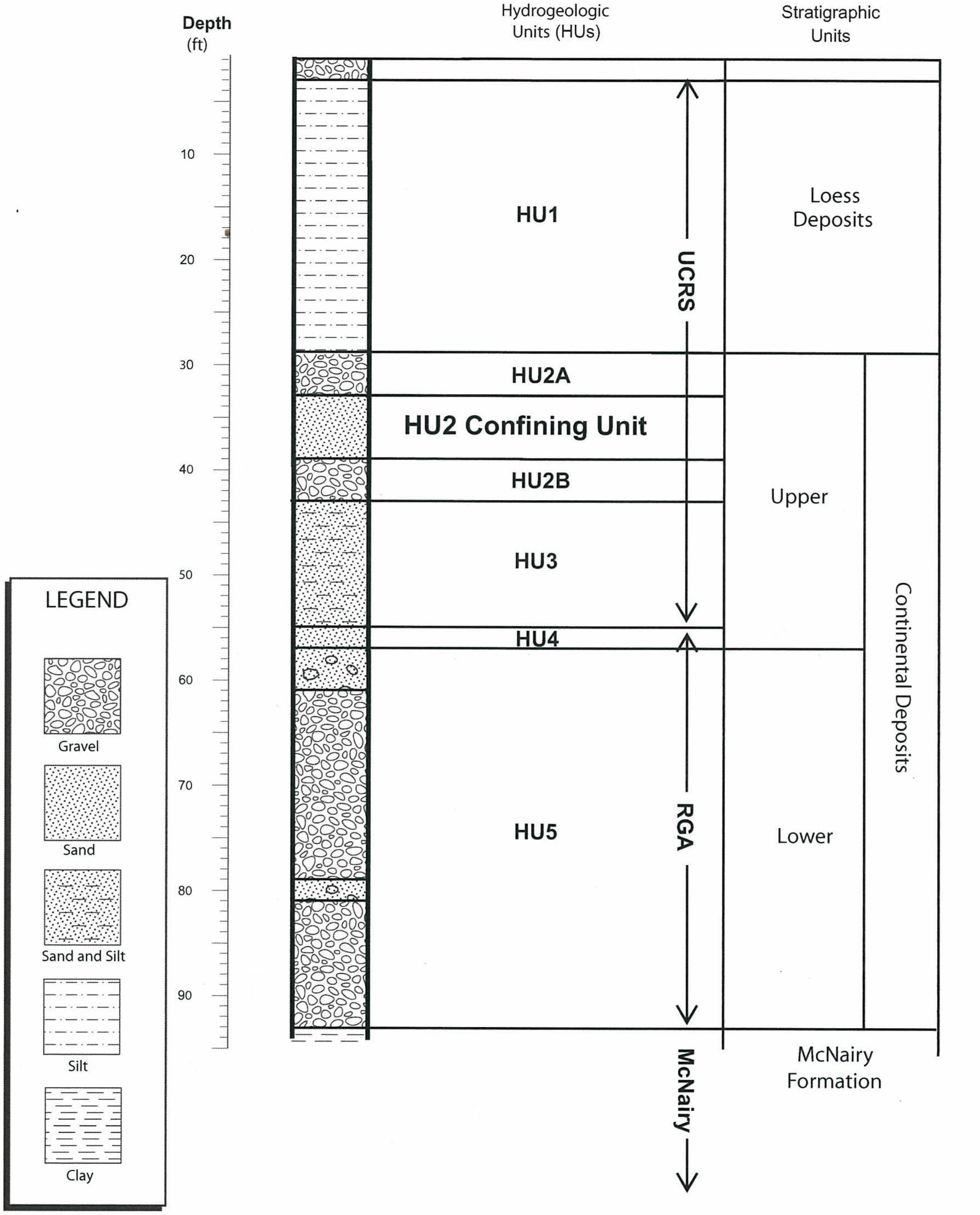

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Figure 2.8. Major Hydrogeologic Units Beneath PGDP

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Lower Continental Deposits

- HU 5 (RGA): Gravel, sand, and silt.

2.6 SURFACE WATER HYDROLOGY

PGDP is situated in the western portion of the Ohio River basin, approximately 15 miles downstream of the confluence of the Ohio River with the Tennessee River, and approximately 35 miles upstream of the confluence of the Ohio River with the Mississippi River. Locally, PGDP is within the drainage areas of the Ohio River, Bayou Creek (also known as Big Bayou Creek), and Little Bayou Creek.

The Ohio River is located approximately 3.5 miles north of PGDP (Figure 2.1). It is the most significant surface water feature in the region, carrying over 25 billion gal/day of water through its banks. Several dams regulate flow in the Ohio River. The Ohio River stage near PGDP is measured at Metropolis, Illinois, by a USGS gauging station. River stage typically varies between 293 and 335 ft amsl over the course of a year. Water levels on the lower Ohio River generally are highest in late winter and early spring and lowest in late spring and early summer. The entire PGDP is above the historical high water floodplain of the Ohio River (CH2M HILL 1991) and above the local 100-year flood elevation of the Ohio River (333 ft) (see Figure 2.3).

The plant is situated on the divide between Little Bayou and Bayou Creeks (Figure 2.9). Surface flow is east-northeast toward Little Bayou Creek and west-northwest toward Bayou Creek. Bayou Creek is a perennial stream on the western boundary of the plant that flows generally northward, from approximately 2.5 miles south of the plant site to the Ohio River along a 9-mile course. An 11,910-acre drainage basin supplies Bayou Creek. Little Bayou Creek becomes a perennial stream at the east outfalls of PGDP. The Little Bayou Creek drainage originates within WKWMA and extends northward and joins Bayou Creek near the Ohio River along a 6.5-mile course, within a 6,000 acre drainage basin. Drainage areas for both creeks are generally rural; however, they receive surface drainage from numerous swales that drain residential and commercial properties, including PGDP and the TVA Shawnee Fossil Plant. The confluence of the two creeks is approximately 3 miles north of the plant site, just upstream of the location at which the combined flow of the creeks discharges into the Ohio River.

Until 2010, the USGS maintained gauging stations on Bayou Creek at 4.1 and 7.3 miles upstream of the Ohio River and a gauging station on Little Bayou Creek at 2.2 miles upstream from its confluence with Bayou Creek. Data collected prior to 2010 showed the mean monthly discharges varied from 7.1 to 22 million gal/day on Bayou Creek and from 1.3 to 7.1 million gal/day on Little Bayou Creek. The upper reach of Little Bayou Creek flows as a perennial stream as a result of plant discharges. A network of ditches discharges effluent and surface water runoff from PGDP to the creeks. Plant discharges are monitored at the Kentucky Pollutant Discharge Elimination System outfalls (Figure 2.9) prior to discharge into the creeks.

Other surface water bodies in the vicinity of PGDP include the following: Metropolis Lake, located east of the Shawnee Fossil Plant; several small ponds, clay and gravel pits, and settling basins scattered throughout the area; and a marshy area just south of the confluence of Bayou Creek and Little Bayou Creek. The smaller surface water bodies are expected to have only localized effects on the regional groundwater flow pattern.

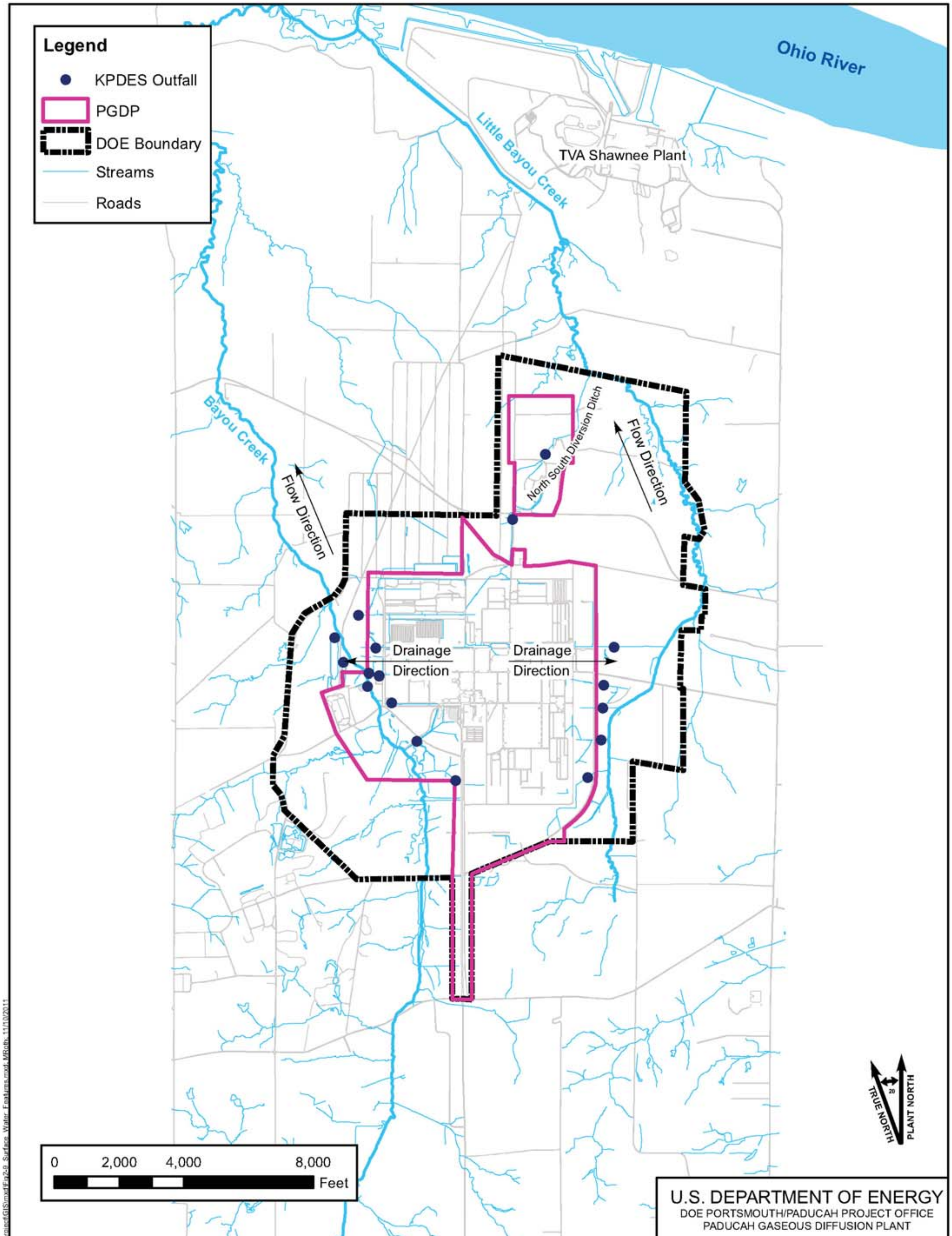

Figure 2.9. Surface Water Features in Vicinity of PGDP

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2.7 ECOLOGICAL SETTING

The following sections give an overview of the terrestrial and aquatic systems at PGDP. A more detailed description, including identification and discussion of sensitive habitats and threatened/endangered species, is contained in *Investigations of Sensitive Ecological Resources Inside the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CDM Federal 1994) and *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky, Volume V: Floodplain Investigation, Part A: Field Results of Survey* (COE 1994).

2.7.1 Terrestrial Systems

The terrestrial component of the PGDP ecosystem includes the plants and animals that use the upland habitats for food, reproduction, and protection. The upland vegetative communities consist primarily of grassland, forest, and thicket habitats with agricultural areas. The main crops grown in the vicinity of the PGDP include soybeans, corn, tobacco, and sorghum. DOE mows much of the grassland habitat adjacent to the plant.

Dominant overstory species of the forested areas include oaks, hickories, maples, elms, and sweetgum. Understory species include snowberry, poison ivy, trumpet creeper, Virginia creeper, and Solomon’s seal. Thicket areas consist predominantly of maples, black locust, sumac, persimmon, and forest species in the sapling stage with herbaceous ground cover similar to that of the forest understory. Wildlife commonly found in the PGDP area consists of species indigenous to open grassland, thicket, and forest habitats. Small mammal surveys conducted on WKWMA documented the presence of southern short-tailed shrew, prairie vole, house mouse, rice rat, and deer mouse. Large mammals commonly present in the area include coyote, eastern cottontail, opossum, groundhog, whitetail deer, raccoon, and gray squirrel. Mist netting activities in the area have captured red bats, little brown bats, Indiana bats, northern long-eared bats, evening bats, and eastern pipistrelles (KSNPC 1991). See Section 2.7.4 for a discussion on threatened and endangered species at the PGDP.

Typical birds of the area include European starling, cardinal, red-winged blackbird, mourning dove, bobwhite quail, turkey, killdeer, American robin, eastern meadowlark, eastern bluebird, bluejay, red-tail hawk, and great horned owl. Examples of amphibians and reptiles present include the cricket frog, Fowler’s toad, common snapping turtle, green tree frog, chorus frog, southern leopard frog, eastern fence lizard, and red-eared slider (KSNPC 1991).

2.7.2 Aquatic Systems

The aquatic communities in and around the PGDP area that could be impacted by plant discharges include two perennial streams [Bayou Creek (named in older documents as Big Bayou Creek) and Little Bayou Creek], the NSDD, a marsh located at the confluence of Bayou Creek and Little Bayou Creek, and other smaller drainage areas. The dominant taxa in surface waters includes several species of sunfish, especially bluegill and green sunfish, as well as bass and catfish. Shallow streams, characteristic of the two main area creeks, are dominated by bluegill, green and longear sunfish, and stonerollers.

2.7.3 Wetlands and Floodplains

A 1994 study of the PGDP area (outside of the fenced industrial area) conducted by the U.S. Army Corps of Engineers (COE) (COE 1994) grouped potential wetlands in the area into 16 vegetative cover types encompassing forested, scrub/shrub, and emergent wetlands. Wetland vegetation consists of species such as sedges, rushes, spikerushes, and various other grasses and forbs in the emergent portions; red maple, sweet gum, oaks, and hickories in the forested portions; and black willow and various other saplings of forested species in the thicket portions. The 1994 COE study identified general areas with features conducive to wetland habitats, such as saturated soils and vegetation types, but did not delineate specific wetlands; therefore, this RI/FS Report refers to these areas identified in the 1994 COE study as “potential wetlands.” COE determined that certain portions of drainage ditches traversing the DOE site inside the plant security fence were jurisdictional wetlands.

Potential wetlands will be delineated, as necessary, prior to construction of an on-site waste disposal facility (WDF), if the On-Site Alternative is selected. Under the Environmental Performance Standards in the Kentucky hazardous waste regulations, a wetland includes land meeting the definition set out in 401 *KAR* 30:005 § 38.[8] If wetlands as defined in 401 *KAR* 30:005 § 38 are identified within the proposed footprint of the WDF, mitigation shall be performed in accordance with ARARs. Measures that mitigate the adverse effects of actions in a wetland may include, but are not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically-sensitive areas; however; any necessary mitigation activities would be identified at a later date.

At PGDP, the Ohio River, Bayou Creek, and Little Bayou Creek cause local flooding during precipitation events. A floodplain analysis performed by the COE (1994) found that much of the built-up portions of the plant lie outside the 100- and 500-year floodplains of the Ohio River and the creeks. In addition, this analysis determined that ditches within the plant area can contain the expected 100- and 500-year discharges. It should be noted that precipitation frequency estimates for the 100- and 500-year events were updated in 2004 in the National Oceanic and Atmospheric Administration’s (NOAA) Atlas 14 (NOAA 2004). In the updated report, the mean precipitation estimate for the 100-year, 24-hour event for the Paducah area is 10.1% to 15% greater than the mean estimate in previous publications. As stated in Atlas 14, in many cases, the mean precipitation estimate used previously is still within the confidence limits provided in Atlas 14; therefore, it is assumed the plant ditches will still contain the 100- and 500-year discharges. Additionally, revised Federal Emergency Management Agency (FEMA) flood risk maps were issued for the PGDP area in November 2011. A comparison of the 2011 FEMA floodplain and the 1994 COE floodplains indicates that in 9 of the 12 candidate sites, the 100- and 500-year floodplains may be smaller than the 1994 COE study found. In comparing the two studies, two of the candidate sites appear to have an increase in floodplain size; however, this is not associated with plant ditches, but rather with creeks that cross the candidate sites. Based on the nature of the project, the more conservative floodplain size will be used for each candidate site (Table 2.1).

Table 2.1. Percentage of Floodplains by Candidate Site

Candidate Site	Percent of Area in COE Floodplain as Shown in D1 RI/FS Report	Percent of Area in FEMA November 2011 Floodplain
1	0%	4%
2	30%	11%
3A	0%	0%
4	24%	7%
5	0%	0%
5A	0%	0%
6	0%	0%

[8] “Wetlands” means land that has a predominance of hydric soils and is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions (401 *KAR* 30:005 § 38).

Table 2.1. Percentage of Floodplains by Candidate Site (Continued)

Candidate Site	Percent of Area in COE Floodplain as Shown in D1 RI/FS Report	Percent of Area in FEMA November 2011 Floodplain
7	21%	25%
8	0%	0%
9	0%	0%
10	29%	13%
11	0%	0%

2.7.4 Threatened and Endangered Species

The only current threatened or endangered (T&E) species with designated critical habitat at the PGDP is the endangered Indiana bat. PGDP is within the Indiana bat Mississippi River Recovery and Mitigation Focus Area and assemblage of maternity colonies in Ballard, Carlisle, Hickman, and McCracken Counties (USFWS 2011). Although the Indiana bat has been captured near PGDP, no Indiana bats have been captured or identified within the boundaries of the PGDP. However, the U.S. Fish and Wildlife Service (USFWS) has designated most of the PGDP as being within a potential maternity habitat area for the Indiana bat.

Table 2.2 lists the endangered, threatened, and candidate species from the USFWS Web site for McCracken County, KY, updated July 30, 2008.

Table 2.2. Endangered, Threatened, and Candidate Species in McCracken County, Kentucky

Group	Species	Common name	Legal Status	Known or Potential
Mammals	*Myotis sodalis*	Indiana bat	E	K
Mussels*	*Potamilus capax*	fat pocketbook	E	K
	Plethobasus cooperianus	orangefoot pimpleback	E	K
	Lampsilis abrupta	pink mucket	E	K
	Obovaria retusa	ring pink	E	K
Mussels*	*Plethobasus cyphyus*	sheepnose	E	P
	Pleurobema clava	clubshell	E	P
	Pleurobema plenum	rough pigtoe	E	P
	Cyprogenia stegaria	fanshell	E	P
	Cumberlandia monodonta	spectaclecase	E	P
	Quadrula c. cylindrica	rabbitsfoot	P	K
Birds*	*Sterna antillarum*	interior least tern	E	K

NOTES:
E = Endangered
K = Known occurrence record within the county.
P = Potential for the species to occur within the county based upon historic range; proximity to known occurrence records; and biological and physiographic characteristics.
*Group and associated species are known or have the potential to be found in McCracken County, Kentucky, but are associated with the Ohio River and are not present at PGDP. As such, these species are not discussed further in this RI/FS Report.

2.8 CLIMATOLOGY

PGDP’s climate is humid-continental. The term “humid” refers to the surplus of precipitation versus evapotranspiration that normally is experienced throughout the year. The average monthly precipitation is 4.11 inches, varying from an average of 3.00 inches in October (the monthly average low) to an average of 5.01 inches in April (the monthly average high). The total precipitation for 2010 was 36.67 inches (NWS 2011), compared to the normal of 49.28 inches (Owenby and Ezell 1992).

The “continental” nature of the local climate refers to the dominating influence of the North American landmass. Continental climates typically experience large temperature changes between seasons. The mean annual temperature for the Paducah area for 2010 was 58.2°F (NWS 2011). The average monthly temperature is 57.2°F: the coldest month is January, with an average temperature of 32.6°F, and the warmest month is July, with an average temperature of 78.8°F (Owenby and Ezell 1992).

Prevailing winds are from the south-southwest at approximately 8.5 miles per hour (Ruffner 1985; NOAA 1974). Historically, stronger winds are recorded when the winds are from the southwest.

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3. EVALUATION OF SEISMIC CONDITIONS

This chapter summarizes (1) regional and site-specific seismic settings as evaluated by the others; (2) the results of past Probabilistic Seismic Hazard Analysis (PSHA) performed by James E. Beavers Consultants (JEB) and their subconsultants; (3) the results of Deterministic Seismic Hazard Analysis (DSHA) that was performed by JEB (2011) in response to the request by Kentucky Division of Waste Management; (4) the results a site response analyses performed by Geosyntec (2011); and the results of a fault rupture propagation study that also was performed by Geosyntec (2011). Both the site response and fault propagation studies were based upon the deterministically evaluated seismic hazard parameters.

Appendix A includes summaries of seismic investigations, analyses, and other supporting information relative to evaluation of seismic hazard parameters at this site.

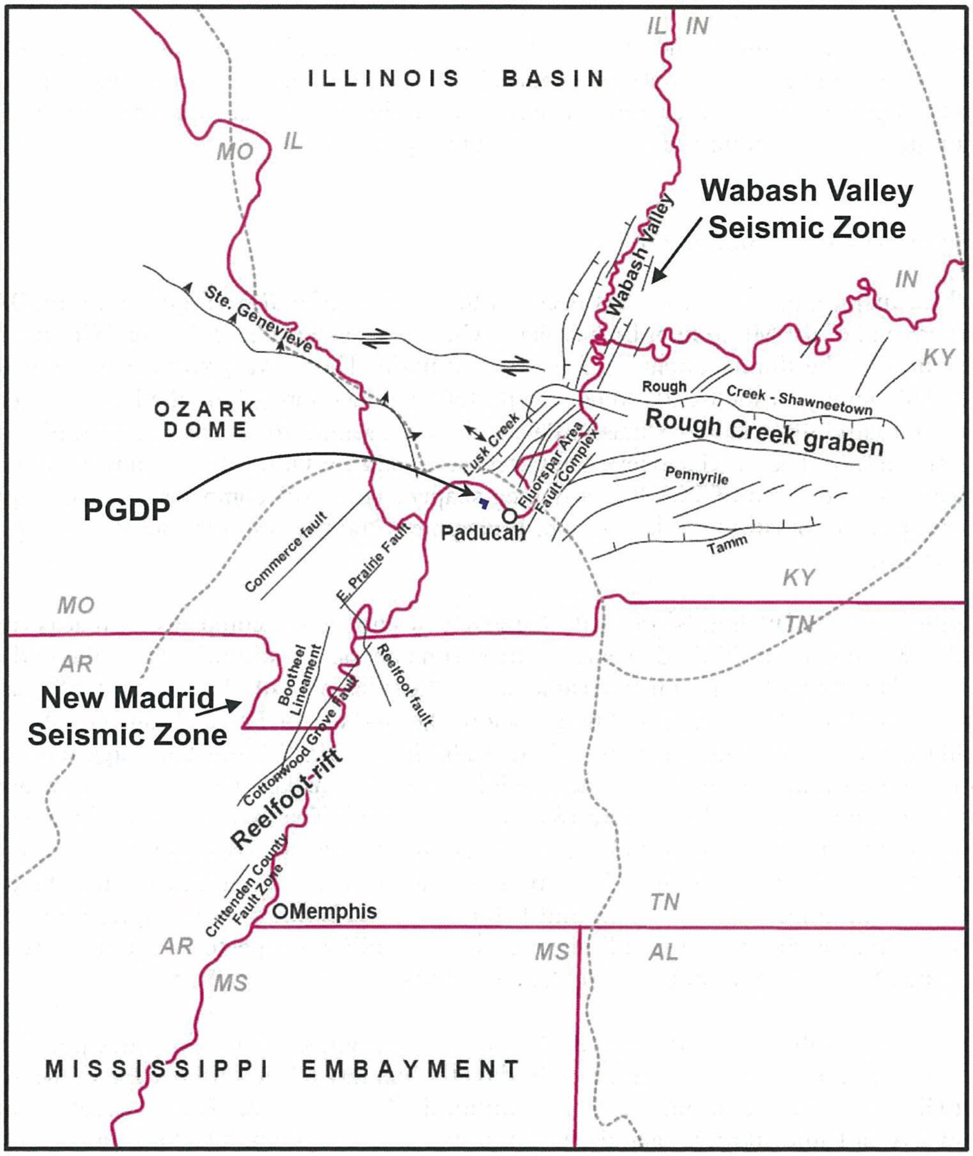
3.1 REGIONAL SEISMIC SETTING

Figure 3.1 shows boundaries of three major tectonic provinces in the relative vicinity of PGDP, including the Illinois Basin, the Mississippi Embayment, and the Ozark Dome. Also shown in Figure 3.1 are the major seismic zones within these provinces: (1) the New Madrid Seismic Zone (NMSZ) that is within the Mississippi Embayment; and (2) the Wabash Valley Seismic Zone (WVSZ) that is within the Illinois Basin. Further included in the former zone is the Flourspar Area Fault Complex that consists mostly of local, seismogenic faults that are further discussed in subsequent section. Similarly, the Moment Magnitudes (M_w) of these and other earthquakes and design seismic events are discussed in subsequent sections.

Several studies, including work by Nelson et al. (1997); Nelson et al. (2002); and Nelson and Denny (2008), indicate that the past and current seismic activity in the relative vicinity of PGDP is not, with the exception of the local faulting, related to Holocene faulting (Holocene faults are faults that show signs of movement of up to 10,000 to 12,000 years before present). The seismicity in the PGDP area is result of tectonic movement within the North American tectonic plate. This intraplate movement, hence seismicity, affects relatively large areas, herein referred to as the “seismic zones.” The seismic zones were the cause of the major historic seismicity in the area, including the 1811-1812 series of strong earthquakes that are collectively referred to as the New Madrid events.

The geometric center of the NMSZ, centered around the Town of New Madrid, MO (Figure 3.1). This town is approximately 60 miles southwest of PGDP. For design, the site-to-source distance (distance from the closest approach of the seismic or fault zone to the site) is used for seismic design. The particular site-to-source is approximately 23 miles.

In addition to seismicity induced by the NMSZ and WVSZ, and local faulting, PGDP may be affected by microseismic activity. This microseismic activity is mostly associated with the Reelfoot rift (see Figure 3.1 for location), but the mechanism of these events is uncertain. This microseismic activity is characterized with relatively small earthquakes (M_w in the range of 2 to 4), with hypocenters at relatively shallow depths (between 2 and 7 miles below the ground surface). The microseismic activity will not be explicitly included in the design (the magnitude/distance pairs are too small/short, compared to the design events), but will be considered as an indication of a potential of local faulting in the immediate vicinity of the site.



LEGEND

.........Faults

.........Physiographic boundary

0 50 mi

0 50 km

(scale is approximate)

N

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Figure 3.1. Regional Tectonic Map

The epicenters and the moment magnitudes of the 1811-1812 series of the New Madrid events remain uncertain. It is known, however, that at least six, and possibly nine, earthquakes with a M_w of 7 or greater occurred in the NMSZ in late 1811 and early 1812. The initial magnitude estimates for two most significant events (December 16, 1811; January 23 and February 7, 1812) initially were 8.0 (Johnston and Schweig 1996; no magnitude scale reported). More recent studies by Hough et al. (2000) and Hough and Martin (2002) estimate M_w for these events ranging from 7.0 to 7.5. The most recent study by JEB in 2011 consulted other recent and relevant sources such as USGS (2009) and Dr. Chris Cramer of the Center for Earthquake Information and Research and established M_w 7.6 as a design magnitude for seismic evaluations based upon NMSZ.

Like for the NMSZ, there is no clear and direct evidence of major historic earthquakes that occurred along a specific mapped fault within the WVSZ (KRCEE 2007). This conclusion was in the most recent update of the Nelson et al. 1997, Nelson et al. 2002, and Nelson and Denny (2008) studies. Several researchers have found geologic evidence that demonstrates that earthquakes greater than M_w 6.0 occurred within the WVSZ as recently as 6,100 ± 200 years ago (REI 1999); therefore, the WVSZ was considered as a significant seismic source for design of PGDP and was evaluated by JEB (2011). JEB assigned M_w 7.0 to WVSZ (2010).

3.2 PGDP SEISMIC SETTING

Faults are a primary expression of past seismic activity. The closest mapped faults at land surface (Figure 3.2) are located approximately 4 miles to the east and 5 miles to the northwest of PGDP (Olive 1980). These structures appear to be Pleistocene (1.8 mya to 10,000 years) or older.

The Barnes Creek Fault Zone of southern Illinois (approximately 7.5 miles northeast of PGDP), if extended sufficiently southward below the Mississippi Embayment, most likely would pass under or near PGDP (on the east side). Nelson et al. (1997; 1999; and 2002) concluded that most movement in the Barnes Creek Fault Zone occurred more than 125,000 years ago, and no movement has taken place within the last 10,000 years. DOE found evidence for Holocene-age faulting, concluding that “faults observed at the Barnes Creek site did extend into Holocene-age deposits” (DOE 2004). This conclusion has not been verified in scientific literature or adopted by seismic hazard practitioners. Evidence used by DOE to develop the Holocene-age faulting hypothesis consisted of a crack in unconsolidated sediment that was interpreted as Holocene in age, using carbon-14 analyses on samples of wood collected from exposures from the stream channel that were accessible. This conclusion was challenged because of the lack of displacement of the sediment and the possibility that the wood samples could have been contaminated by flooding events in the creek. Nelson and Denny (2008) again concluded that the Holocene alluvium had not been faulted at the Barnes Creek location in 2008 (Nelson and Denny 2008).

Another southern Illinois fault zone that could pass below or near PGDP (possibly on the west side) is the Massac Creek Structure of the Hobbs Creek Fault Zone (approximately 8 miles northeast of PGDP). Nelson et al. (1999) interprets this graben in the Hobbs Creek Fault Zone to have formed in Miocene (23.8 to 5.3 mya) to early Pleistocene time.

Two site-specific fault investigations have been conducted at PGDP (Figure 3.3): Site 3A (located immediately south of the PGDP security-fenced area, DOE 2004) and the proposed area of expansion of the C-746-U Landfill (located 1 mile north of the PGDP security-fenced area, KRCEE 2006). Detailed seismic surveys identified subsurface faulting, extending upward into the Upper Continental Deposits, in both locations. Age dating analysis of soil core samples at these locations determined that the latest faulting was pre-Holocene age at both sites. Summaries of these two investigations are included in Appendix A.

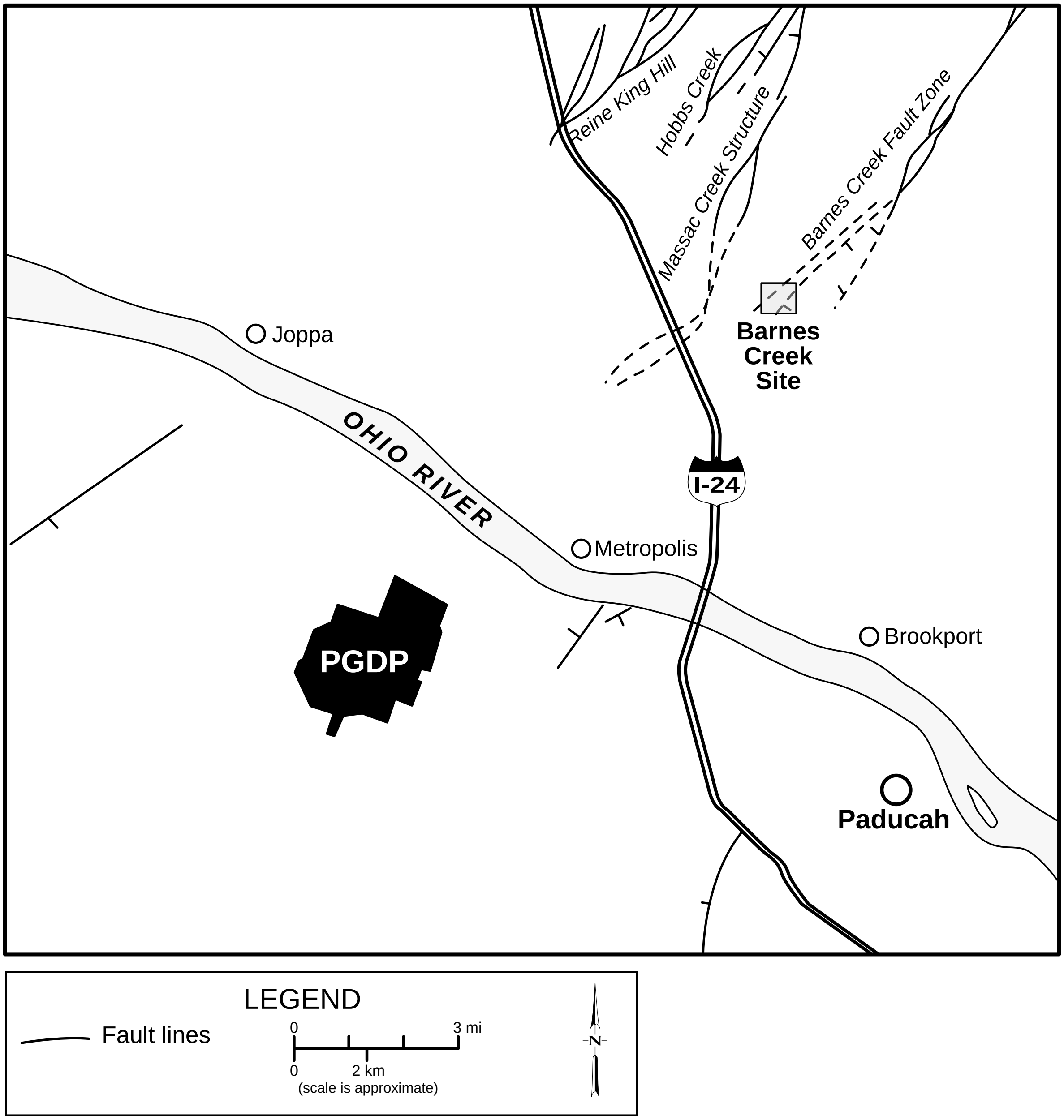

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Figure 3.2. Closest Mapped Faults to PGDP

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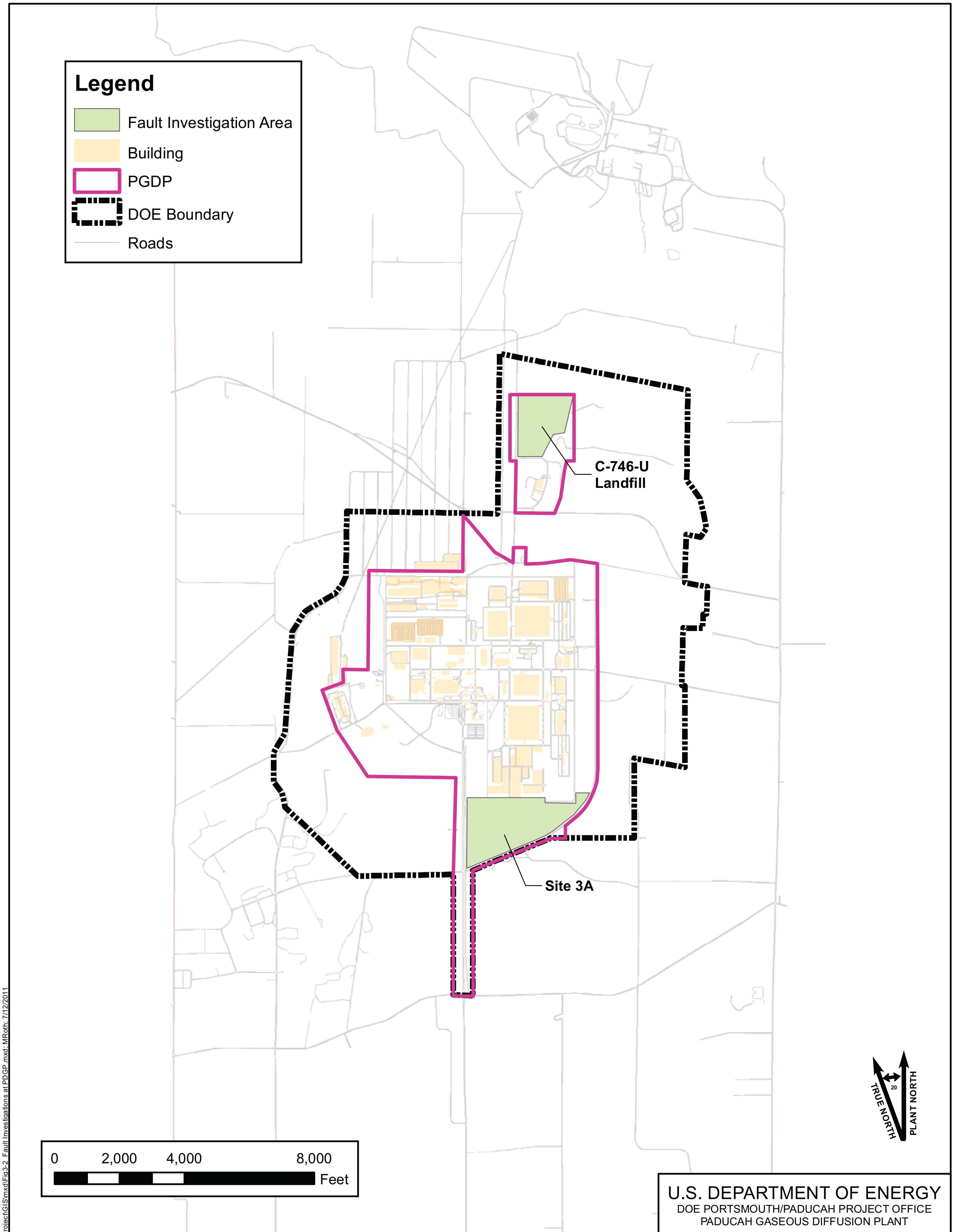

Figure 3.3. Fault Investigations at PGDP

In summary, the current understanding is that faulting mapped on or near PGDP is at least Pleistocene in age (more than 10,000–12,000 years old). Consistent with the other accepted interpretations of faulting in the area, near-surface faulting found during two fault investigations of PGDP site was determined to be Pleistocene in age.

3.3 PGDP SEISMIC HAZARD EVALUATION

3.3.1 General

At DOE sites, seismic hazard parameters are commonly evaluated based upon the results of a PSHA. At DOE sites, the analysis is commonly performed for an event with 2% probability of being exceeded in 50 years. This probability of exceedance corresponds to a seismic event with return period of 2,475 years. The return period of 2,475 years is commonly rounded to 2,500 years, as reported in Section 3.3.2.

In response to request made to DOE by KDWM, seismic hazard parameters for design reevaluation of the C-746-U Landfill have been developed deterministically. The results of the probabilistic seismic hazard analysis, including the seismic hazard parameters, are reproduced herein from historical studies for comparison purposes, only.

3.3.2 Probabilistic Seismic Hazard Analysis

Several PGDP-specific probabilistic seismic hazard studies have been completed within the past 10 years. A 1999 Risk Engineering, Inc., (REI) study based on shear-wave measurements in four deep borehole clusters drilled on the DOE property, evaluated site-specific, peak horizontal ground acceleration for return periods of 250, 500, 1,000 and 5,000 years (REI 1999). Another study interpolated the 1999 REI study results for a return period of 2,500 years and determined the peak ground acceleration (PGA) at PGDP to be approximately 0.8 g at bedrock (located 325 to 425 ft deep) and 0.5 g at the top of soil (Beavers 2001). Further reassessment of the data determined that the peak horizontal ground acceleration was 0.71 g at bedrock and 0.48 g at the top of soil (BJC 2002). Site response analysis was performed at Site 3A (see Figure 3.3; DOE 2004). This modeling used the peak horizontal ground acceleration from BJC 2002 and the shear wave velocity profile for the unconsolidated materials above the bedrock. The site-specific seismic design criteria coefficient for a 2,500-year return period ground motion was determined to be 0.48 g at the top of the soil. This value is consistent with the previous ground motion modeling efforts at PGDP. The relevant results of the past probabilistic seismic hazard studies are summarized in Table 3.1.

Table 3.1. PGDP Site-Specific Probabilistic Seismic Hazard Analyses

Study	Return Period (yrs)	Peak Horizontal Ground Acceleration (g)	
		Bedrock	Top of Soil
REI 1999	2,500	0.78[a]	0.4[b]
Beavers 2001	2,500	0.8	0.5
BJC 2002	2,500	0.71	0.48
DOE 2004	2,500	0.71	0.48
KRCEE 2007	500 to 1,000	0.51[c]	ND[d]

[a] Extrapolated in KRCEE 2007.
[b] Top of soil acceleration not extrapolated in KRCEE 2007; extrapolated from REI 1999.
[c] Median value with one standard deviation is appropriate for determining landfill design criterion.
[d] Top of soil acceleration was not determined in KRCEE 2007.

Additional information on the seismic conditions at PGDP is included in Appendix A, which provides the following:

- Summary of two seismic investigations conducted at PGDP (DOE 2004; KRCEE 2006);
- Responses to comments received from Kentucky on the Seismic Investigation Report (DOE 2004) (Attachment A-1);
- Meeting minutes from a seismic workshop held June 2009 in Oak Ridge, TN, that was arranged to discuss seismic issues identified in the RI/FS WP (Attachment A-2); and
- The results of the bedrock shear-wave sensitivity analysis that was described in the RI/FS WP (Attachment A-3).

3.3.3 Deterministic Seismic Hazard Analysis

In response to request by KDWM, JEB (2011) performed a DSHA for a hypothetical bedrock outcrop at PGDP. JEB considered three representative earthquake scenarios for the area to establish the controlling seismic event for seismic redesign of C-746-U Landfill, the ancillary facilities at the site and for a fault rupture propagation study. The controlling event for seismic design other than fault rupture propagation study was established as a M_w 7.6 event on the New Madrid Fault with a Peak Horizontal Ground Acceleration in a hypothetical bedrock outcrop at the geometric center of C-746-U Landfill of 0.36 g. The design (bedrock) acceleration response spectrum also was established and further used to evaluate design ground motions (accelerograms). The spectrum-compatible design ground motions were used as an input to site response analysis. The appropriate duration of design ground motions was considered as well. The source parameters established for a local seismic event (M_w 6.0, site-to-source distance of 6.0 miles, and reverse style of faulting) were used as an input into a fault rupture propagation study. To provide the maximum protection to the owner, a parametric study of fault rupture propagation was conducted, with an upper-bound M_w of 7.0.

3.3.4 Site Response and Fault Rupture Propagation Analyses

Following the completion of the DSHA, Geosyntec performed site response analysis for C-746-U Landfill (Geosyntec 2011). These analyses were performed not only to evaluate the influence of local soil conditions and landfill on design ground motions applied as bedrock outcrop, also but to provide input for evaluation of soil liquefaction potential at the site, seismic settlement, and ancillary structures at the site. The results of site response analysis were an essential input into a performance-based seismic stability evaluation of C-746-U Landfill waste mass and landfill composite final cover system. Details of this analysis are provided in Geosyntec (2011) and are summarized in Section 3.4.

The fault rupture analysis performed by Geosyntec (2011) consisted of the following evaluations:

- Establish, by reference, the largest local scenario earthquake evaluated by JEB (2011) that could reasonably be expected beneath the site;
- Evaluate whether a displacement associated with local scenario earthquake can be propagated from the seismogenic depth (competent bedrock capable of generating M_w 6.0 event) to the ground surface and landfill composite liner systems;
- Demonstrate that displacement from the local scenario earthquake cannot propagate to the surface, and hence perform a parametric study with simulated earthquakes having M_w as high as 7.0;

- Demonstrate that the present C-746-U Landfill design can withstand the displacement induced by the largest earthquake considered;

- Provide recommended design modifications necessary to enable the landfill containment systems to withstand the predicted ground motions from the largest scenario earthquake; and

- With the exception of the C-746-U Landfill composite final cover system, the landfill, as originally designed, will perform in an acceptable manner during a deterministically evaluated design earthquake. Based upon the results of seismic evaluations with a deterministically evaluated design earthquake, the design of the C-746-U Landfill composite final cover system has been amended to include a double-textured high-density polyethylene (HDPE) geomembrane.

3.4 CONCLUSIONS

The results of seismic evaluations as outlined above indicate that, as with the C-746-U Landfill, when constructed following current design practice, the WDF will perform in an acceptable manner in response to a deterministically evaluated design earthquake scenarios. The C-746-U Landfill composite final cover system, hence the landfill itself, will perform in an acceptable manner during a deterministically evaluated design earthquake. This predicted performance of the C-746-U Landfill indicates that an on-site WDF can be designed to resist the anticipated design earthquake scenarios. The site-specific seismic conditions do not preclude the use of an on-site WDF.

4. WASTE INVENTORY AND CHARACTERIZATION

This chapter provides information on the CERCLA-generated waste forecast for the ER and D&D activities at PGDP.[9] It defines the waste categories, waste types, and waste volumes that are expected to be generated from CERCLA response actions from 2014 to 2039. Because this volume is a forecast containing assumptions and uncertainties, a range of waste volumes is estimated in this evaluation. These include the base case waste volume (the most likely scenario) and the low-end and high-end waste volume scenarios. The waste volumes and characterizations described in this chapter form the basis for evaluation of waste disposal alternatives in this RI/FS. Projects currently not being conducted pursuant to a CERCLA response action, are not included in the waste volume evaluation; however, should circumstances change, it is likely that some or all of these projects will be disposed of as CERCLA waste.

4.1 WASTE INVENTORY

This section defines and details the waste inventory that will require management and disposal in the future. Disposal alternatives for this waste inventory are developed and evaluated in Chapters 5 through 7 of this RI/FS.

4.1.1 Overview of Waste Volume Forecast

To support the long-term planning process associated with implementation of the FFA, DOE has an LCB that serves as the strategic road map for completing site remediation. Each project in the LCB has an associated waste volume forecast providing the as-generated waste by category and type. The forecasts in the LCB are based on the best available information and remediation strategy available at the time of development. Because some of the projects (i.e., OUs, SWMUs, and AOCs) have not been fully characterized, process knowledge was used to estimate the volume of waste to be generated.

The LCB does not contain D&D waste volumes; therefore, an estimate of the waste volume to be generated during D&D was prepared by a separate team (U.S. Army Corps of Engineers–Huntington District; Project Time & Cost, Inc.; TLG Services, Inc.; Project Enhancement Corporation) (DOE 2006). The D&D OU includes a total of 532 structures: 415 facilities (industrial and nonindustrial facilities of various construction types); 26 abovegrade tanks; 76 infrastructure items (e.g., concrete pads, gravel pads); 11 general utility items (e.g., lift stations); and 4 switchyards. Waste volume estimates were derived by multiplying the gross square footage of each facility by a conversion factor. The conversion factor was developed based on the results of similar D&D projects in the Oak Ridge and Portsmouth DOE complexes and also considered facility height and the density of equipment and infrastructure. The D&D waste is scheduled to be generated from 2019 until 2039.

The “base case” waste volume is the summation of the volume of CERCLA-generated waste taken directly from the LCB and D&D estimate and represents the most likely waste volume scenario. The base case does not include assumptions that would increase or reduce the volume, such as recycling, reuse, or waste reduction initiatives. The base case is a reasonable prediction of waste volume using the 2007 approved LCB. To address uncertainties in the waste volume for the purposes of assessing the feasibility of the disposal alternatives, a range of volumes is considered as discussed in Section 4.1.3. The actual

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[9] The schedule referenced is derived from the D&D proposed project schedule (DOE 2006).

volume associated with an alternative may differ for a variety of reasons such as updated waste forecasts or the need for additional fill to facilitate disposal of non-soil wastes.

CERCLA waste will be generated from various SWMUs and AOCs; these are combined into five media-specific OUs (surface water, soils, burial grounds, groundwater, and D&D). By combining the OUs and projects in the LCB, 13 discrete projects (source areas) are identified, as listed in Table 4.1, that will generate waste at PGDP. As noted in Table 4.1, 4 projects included in the LCB are not included in the scope of this RI/FS (or the base case volume) because they are projected to be completed prior to 2014.

In addition to forecasting volume, the waste forecasts provided the following information, used to develop waste disposal alternatives:

- Source areas
- Waste categories (physical form)
- Waste types (regulatory classification)
- Waste generation schedule

Table 4.1. Projected CERCLA Waste-Generating Activities and Corresponding Work Breakdown Structure Descriptions as Outlined in the LCB

Activity Title	WBS Element Description
BGOU	Burial Grounds Operable Unit
D&D—C-340	D&D Operable Unit—C-340[a]
D&D—C-410	D&D Operable Unit—C-410[a]
GWOU—C-400	Groundwater Operable Unit—C-400
GWOU—Dissolved-Phase	Groundwater Operable Unit—Dissolved-Phase Plume
GWOU—Off-site Plume	Groundwater Operable Unit—Groundwater Off-site Plume
GWOU—Pump-and-Treat	Groundwater Operable Unit—Pump-and-Treat Operations
GWOU—Southwest Plume	Groundwater Operable Unit—Southwest Plume[a]
Soils OU	Soils Operable Unit
Soils OU—Remedial Action	Soils Operable Unit—Remedial Action
Soils OU—Removal Action	Soils Operable Unit—Removal Action[a]
SWOU—Off-site	Surface Water Operable Unit Off-site
PGDP D&D	D&D of PGDP facilities and soil remediation during D&D

[a] Waste generated for these activities is not included in the waste volume because the activity is scheduled to be completed prior to 2014, per the 2007 approved LCB.

BGOU = Burial Grounds Operable Unit
DMSA = DOE Material Storage Area
OU = operable unit
SWOU = Surface Water Operable Unit
D&D = decontamination and decommissioning
GWOU = Groundwater Operable Unit
PCB = polychlorinated biphenyl
WBS = Work Breakdown Structure

4.1.2 Schedule of Waste Generation

The waste generation forecast was updated in 2010 to reflect the current project schedule and assumptions for OU remediation. This was necessary because OU project schedules and assumptions have changed since the time the waste forecasts were first developed for the RI/FS WP (DOE 2011a). One change was DOE's additional funding from the American Recovery and Reinvestment Act (ARRA) that has accelerated D&D of facilities. Also, the waste forecast was revised to reflect a waste generation start date of 2014 rather than 2010 to correspond to the proposed CERCLA waste disposal ROD implementation date. The 2014 date was derived based on an assumed final ROD in 2012. There are post-ROD actions related to the On-Site Alternative (e.g., final WAC development; final design data gathering; 30%, 60% and 90% design/review process; development/review of operations and monitoring plans), and CERCLA requires that the ROD begin implementation within 15 months following ROD signatures. Assuming construction would begin 15 months following the ROD, and a minimum 1-year construction period, disposal operations could not begin until 2015. The Off-Site and No Action Alternatives would require very few, if any, post-ROD actions and could be implemented soon after the ROD, but there would be no relevant comparison of the alternatives prior to 2014. The waste volume updates due to the ARRA projects and revised generation start date resulted in a minor impact (reduction of approximately 120,000 yd^3) to the waste forecast, since the majority of waste will be generated beyond 2019, during D&D. Table 4.2 provides the waste forecast for the base case (most likely) waste scenario.

Table 4.2. Baseline Waste Volume Forecast by OU

Project	Fiscal Year	Waste Forecast Volume (yd^3)*
BGOU	2014–2018**	341,550
GWOU	2010–2017***	7,390
Soils OU—Remedial Action	2014	85,720
SWOU—Off-site	2016	15,670
PGDP D&D	2019–2039****	3,142,510
	TOTAL:	**3,592,840**

*Volume estimates for the BGOU, GWOU, Soils OU Remedial Action, and SWOU Off-Site are from the 2007 approved LCB. Volume estimates for PGDP D&D are from DOE 2006. Total volumes and volumes per year may vary based on deviations from the 2007 approved LCB.
**Volume shown is only for 2014 to 2018.
***Volume shown is only for 2014 to 2017.
****The schedule referenced is derived from the D&D proposed project schedule (DOE 2006).

It is recognized that other PGDP projects may be accelerated, which could reduce the forecasted waste volume, or, conversely, new projects may be identified that could increase the waste volume. For the RI/FS, the assumption was to fix the waste volume as shown in Table 4.2 and avoid making minor volume increases or decreases that are not anticipated to impact the disposal alternative evaluation decision. The basis for fixing the waste volumes evolved from a break-even cost analysis that was conducted to determine the volume of waste that would impact a decision for off-site versus on-site disposal. This analysis showed that when the waste volume exceeds approximately 200,000 yd^3, on-site disposal becomes more favorable from a cost standpoint as the waste volume increases. Details of the break-even analysis are provided in Appendix I, Attachment I1.

The waste volumes in the LCB waste forecast and D&D estimates were assigned into six waste categories:

- Asbestos
- Concrete
- General construction debris
- Other dry solids
- Scrap metal
- Soil

"Other dry solids" include items such as personal protective equipment, plastic, and packing material. "Soil" also includes dewatered sediment and sludge. A small volume of the waste (estimated at < 5%) is anticipated to be wood generated during demolition of buildings and cooling towers.

The waste also was characterized by type, which refers to the regulatory classification of the waste. The classifications of waste types are as follows:

- LLW, defined by the AEA
- Hazardous waste (RCRA) (defined under *KRS* 224 and RCRA Subtitle C)
- MLLW (LLW/RCRA) defined and regulated as a hazardous waste and LLW
- TSCA waste (i.e., wastes impacted by PCBs or asbestos as defined under TSCA)
- MLLW/TSCA or LLW/RCRA/TSCA waste (MLLW as a TSCA waste)
- LLW/TSCA waste (LLW as a TSCA waste)
- Waste meeting the WAC of the C-746-U Landfill

Waste meeting the WAC of the C-746-U Landfill would be generated from the same remedial/removal action sources as the LLW/RCRA/TSCA/MLLW waste types. These wastes may include soil and building demolition debris, such as concrete, scrap metal, siding material, and glass. Wastes such as office trash, paper, or other putrescent materials are not included.

The waste forecast also includes a small amount (approximately 5% of the total base case volume) of classified waste.[10] Most of the classified waste at PGDP is in the LLW regulatory waste type and, for the most part, in the form of scrap metal (with limited amounts of soil).

High-level, transuranic, and spent nuclear fuel, as defined in DOE Order 435.1, are not expected to be generated and are not included in the forecasted CERCLA waste volume.

Table 4.3 summarizes the forecasted base case waste volumes by waste category and type.

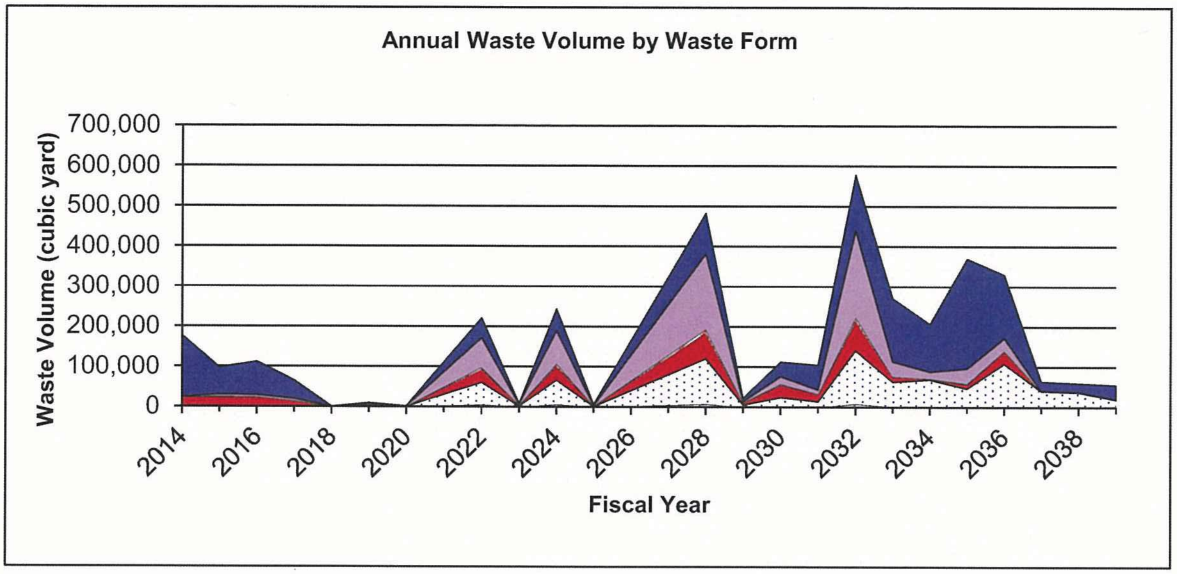
Table 4.3. Base Case Waste Volume by Waste Category and Waste Type

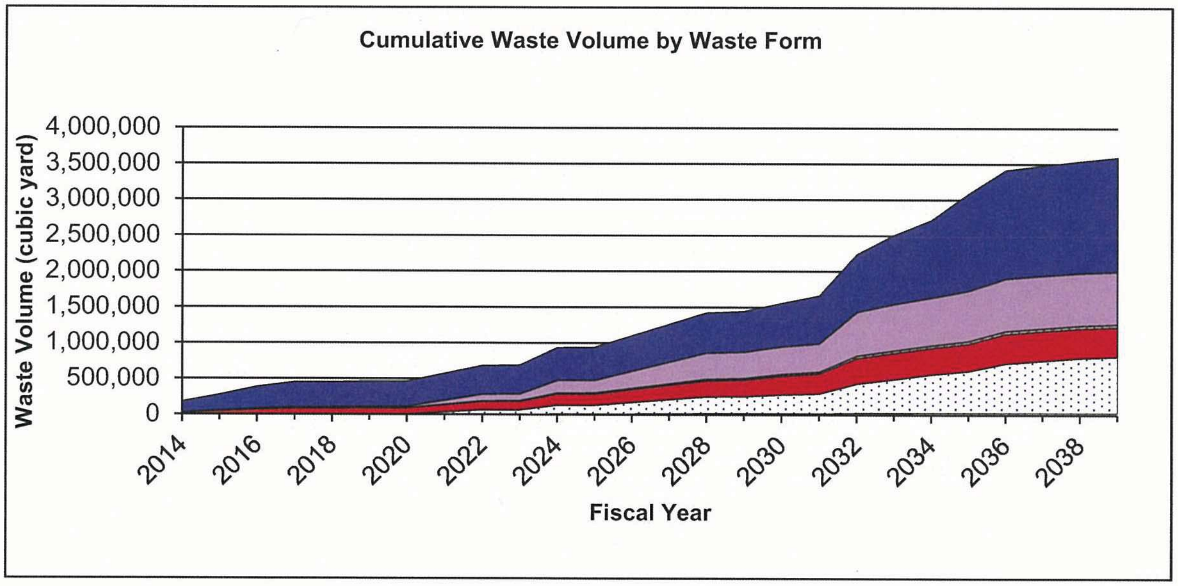
Waste	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid Waste	Total
Asbestos	2,600	0	25,620	0	0	4,100	0	32,300
Concrete	379,490	0	0	0	0	0	401,100	780,590
General Construction Debris	271,920	0	30,340	0	0	10	111,280	413,550
Other Dry Solids	25,320	0	5,430	0	420	790	6,290	38,250
Scrap Metal	559,440	0	0	0	0	1,510	172,040	732,990
Sludge	80	0	0	0	0	0	130	290
Soil	1,176,970	0	5,170	0	70	0	412,640	1,594,850
Total	**2,415,820**	**0**	**66,640**	**0**	**490**	**6,410**	**1,103,480**	**3,592,840**

Volumes are rounded to the nearest hundred and reported in yd^3.
LLW = low-level waste
RCRA = Resource Conservation and Recovery Act
TSCA = Toxic Substances Control Act

The annual and cumulative waste volume by waste category is depicted in Figure 4.1 and the annual and cumulative waste volume by waste type is depicted in Figure 4.2. The waste forecasts for each project and individual building are provided in Appendix B.

[10] The classified waste considered in this RI/FS Report is not classified due to contamination profile, but rather due to the function of the piece of equipment.





Note: Waste volumes were totaled in the FY a project is complete, therefore, some years appear to have little waste being generated.

LEGEND

- Soil
- Concrete
- General Construction Debris
- Other Dry Solids
- Asbestos
- Scrap Metal

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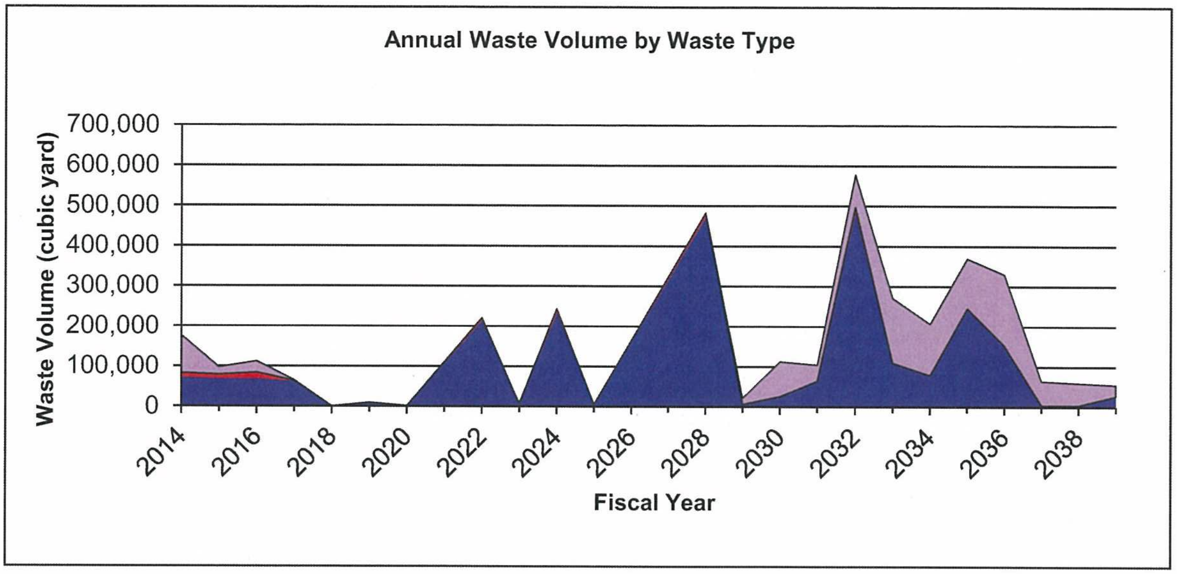
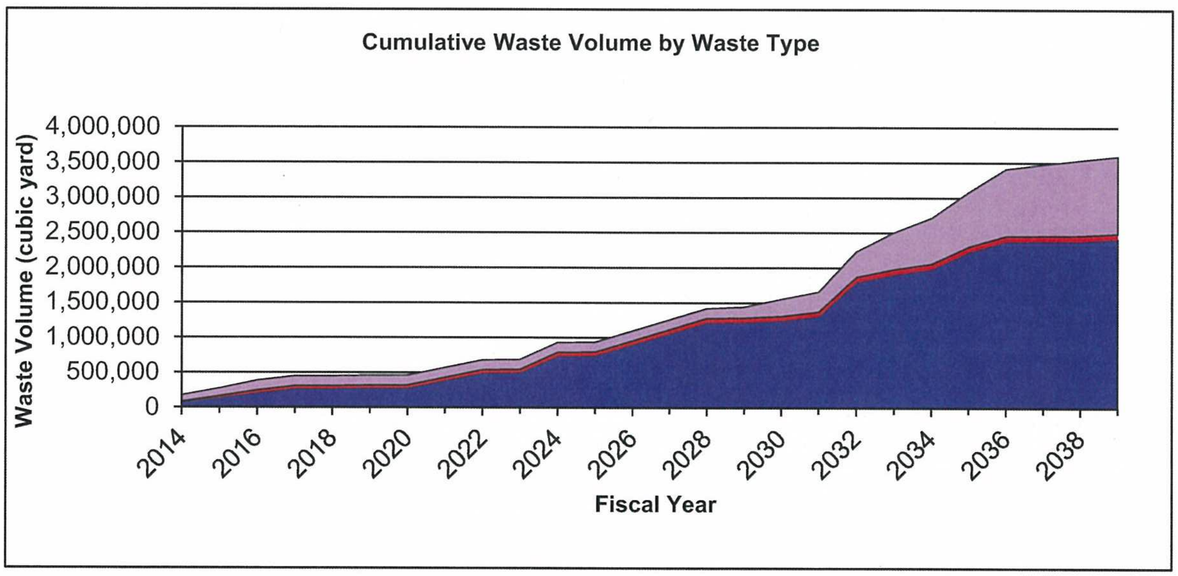
PADUCAH GASEOUS DIFFUSION PLANT

Figure 4.1. Total Waste Volume Generated over Time by Waste Form

LATA Environmental Services of Kentucky, LLC





Note: Waste volumes were totaled in the FY a project is complete, therefore, some years appear to have little waste being generated.

LEGEND

LLW	LLW/RCRA	TSCA	LLW/RCRA/TSCA
	LLW/TSCA	RCRA	Nonhazardous Solid

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DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

Figure 4.2. Total Waste Volume Generated over Time by Waste Type

LATA Environmental Services of Kentucky, LLC

The base case waste volumes shown in Table 4.3 do not include the following:

- Non-CERCLA waste [e.g., DOE Material Storage Area (DMSA)]; waste not associated with DOE's FFA activities;
- Waste prohibited from shallow land disposal (e.g., free liquids); and
- Waste types requiring disposal in special repositories by regulations (e.g., transuranic waste), although these are not anticipated to be generated.

The following general assumptions were used to develop base case waste volume and characteristic projections:

- The WAC for the C-746-U Landfill will not change through final site cleanup;
- Waste treatment performed by the generating project prior to disposal would not significantly change the overall waste volume;
- Soil will swell upon excavation; therefore, calculations made to derive a postexcavation volume include a 25% (average) swell factor;
- Buildings and facilities will undergo D&D and will not be reused in any reindustrialization program;
- Approximately 5% of generated waste will be classified from a security perspective;
- Material generated as waste will not be recycled; and
- Waste generation will occur as shown in Figures 4.1 and 4.2.

4.1.3 Range of Waste Volumes

The base case waste volume detailed in Sections 4.1.1 and 4.1.2 is the most likely scenario, based on information available in the 2007 approved LCB. There are, however, uncertainties inherent in the waste volume estimate and, in turn, the waste disposal evaluation. For this reason, a high-end and low-end volume also were developed for consideration in the disposal alternatives evaluation. These waste volume ranges are intended to address uncertainties in the waste volume for the purposes of assessing the feasibility of the disposal alternatives. The actual volume associated with an alternative may differ for a variety of reasons such as updated waste forecasts or the need for additional fill to facilitate disposal of non-soil wastes.

As an example of uncertainty, the waste volume forecast includes approximately 1.1 mcy of waste that meets the WAC of the C-746-U Landfill. This volume of waste should be eligible for disposal in the operating C-746-U Landfill at PGDP. If this waste is disposed of in the C-746-U Landfill, the base case waste volume is reduced from 3.6 mcy to 2.5 mcy. Another example concerns the disposal of classified waste. The waste volume forecast includes approximately 196,100 yd^3 of classified waste. This volume of waste would be subtracted from the estimate, if it is predominately scrap metal that would be recycled.

Other factors that could significantly change the waste volume include initiatives such as waste recycling and reindustrialization of existing facilities. Decisions regarding (1) continued use of the C-746-U Landfill; (2) which waste will be recycled; and (3) which facilities, if any, will be reused in a reindustrialization program will not be made as part of this RI/FS. Because these decisions could have a significant impact on the disposal waste volume, the RI/FS addresses the associated uncertainties by evaluating a range of waste volumes.

The 2001 LCB waste volume estimate for the Waste Disposal Alternatives (WDA) Project is 3.1 mcy. The 2007 approved LCB waste volume estimate for the WDA project is 3.6 mcy. The 2012 LCB waste volume estimate for the WDA project is 3.4 mcy. The range among these volume estimates illustrates there is uncertainty in the volumes; however, the volumes are relatively stable over an 11 year time frame. The base case volume for the WDA Project is based on the 2007 approved LCB, which is sufficiently accurate for this RI/FS evaluation. High-end and low-end volumes were developed to address uncertainties in waste volume projections as well as other potential uncertainties.

4.1.3.1 Base case waste volume

The "base case" waste volume (approximately 3.6 mcy) consists of all CERCLA-generated waste taken directly from the 2007 approved LCB waste volume estimates, but does not take into account recycling, reuse, or other waste-reduction initiatives. The base case represents the most likely volume that can be predicted to be generated using information available in the 2007 approved LCB.

The most likely volume is the base case waste volume of 3.6 mcy, composed of 2.5 mcy of LLW/RCRA/TSCA/MLLW and 1.1 mcy of waste that meets the C-746-U Landfill WAC. The 1.1 mcy of waste that meets the C-746-U Landfill WAC could be disposed of at the on-site C-746-U Landfill.[11] This facility currently is in operation to receive waste that meets its WAC and has the long-term design capacity to accept the projected volume for the base case of 1.1 mcy.

The remaining volume of 2.5 mcy of LLW/RCRA/TSCA/MLLW then would have different disposal pathways for the Off-Site and On-Site Disposal Alternatives. For the Off-Site Alternative, the LLW/RCRA/TSCA/MLLW would be disposed of at off-site facilities permitted to accept this waste, consistent with current practice. For the On-Site Alternative, the 2.5 mcy would be disposed of at a new on-site disposal facility designed to accept LLW/RCRA/TSCA/MLLW. The 2.5 mcy volume represents a mid-point between the high-end and low-end waste volumes described in Sections 4.1.3.2 and 4.1.3.3.

It currently is projected that 380,000 yd^3 of concrete that would be classified as hazardous waste and 401,000 yd^3 of concrete that would be classified as waste that meets the WAC of the C-746-U Landfill will be generated. The nonhazardous concrete is expected to be composed of a mixture of concrete with some level of contamination and concrete that is free of contamination.

4.1.3.2 High-end waste volume

The high-end waste volume estimate considers scenarios that may increase the base case waste volume.

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[11] The remaining projected design capacity of the C-746-U Landfill is approximately 1.55 mcy (assuming all remaining phases are constructed). Approximately 20% of this airspace will be consumed by daily cover. This leaves approximately 1.24 mcy of airspace for waste. The base case volume scenario assumes 1.1 mcy of waste will be placed in the C-746-U Landfill. This leaves approximately 0.14 mcy of waste capacity. This is approximately 4% of the base case volume. This theoretical reduction is within the volume range used for this RI/FS.

- An increase of 10% from the base case volume to account for excavating more contamination than expected in individual response actions.

- The C-746-U Landfill is unavailable due to economic, technical, or regulatory issues; therefore, waste meeting the WAC of the C-746-U Landfill will require either off-site disposal or disposal in a newly constructed on-site disposal facility.

- No potential volume-reducing activities such as recycling, reuse, or other waste reduction initiatives would be implemented.

Like the base case volume, the high-end volume assumes that no volume-reducing activities such as recycling, reuse, or reindustrialization would be implemented. The base case waste volume of 3.6 mcy was increased by 10% to account for uncertainties which might increase estimated waste volumes. The high-end waste volume is 4 mcy.

4.1.3.3 Low-end waste volume

The low-end waste volume considers scenarios that may reduce the base case waste volume estimate.

- Up to 75% of the scrap metal would be recycled (~550,000 yd^3).

- Up to 75% of the concrete would be recycled/reused (~585,000 yd^3).

- Five buildings in the D&D inventory (C-100, C-101, C-102, C-103, and C-720) would be retained (DOE 2011a) for ongoing use (~185,000 yd^3).

The following are the remaining waste volumes after recycling has been accounted for:

- Other waste volumes are 10% less than the base case volumes.

- Waste meeting the WAC of the C-746-U Landfill would be disposed of in the C-746-U Landfill (552,000 yd^3).

Totaling the impacts of all of these assumptions and subtracting from the 3.6 mcy base case volume results in a low-end waste volume of 1.5 mcy. The total managed volume under the low-end scenario is 3.2 mcy, accounting for the other reductions above results in a low-end waste volume of 1.5 mcy designated for disposal in either a new on-site facility or an off-site facility.

4.1.4 Waste Minimization Program

DOE is committed to waste minimization, including recycling and/or reuse of materials from the PGDP D&D Project, under all of the proposed alternatives (No Action, Off-site, and On-Site). Specific determinations regarding waste minimization, including recycling and/or reuse of materials, will be made on a case-by-case basis at DOE’s discretion. Recycling and/or reuse decisions will be made for discrete materials and waste streams across all phases of the D&D and other CERCLA projects at PGDP. Decisions will be made following an evaluation of relevant factors and considerations. A few of the primary benefits of waste minimization, including material recycling and/or reuse, in the context of this RI/FS, include conserving disposal capacity, regardless of disposal location, and meeting DOE goals for pollution prevention and waste minimization. For the purposes of developing and evaluating remedial action alternatives in this FS, an estimate of up to 75% by volume of the scrap metal and up to 75% by volume of the concrete waste has been included in the On-Site, Off-Site, and No Action Alternatives, based on an initial evaluation of the scope of anticipated waste streams included in the D&D and other CERCLA projects at PGDP. The actual volume to be recycled and/or reused may change as recycling strategies are developed and specific recycling opportunities are identified. Potential ARARs for waste minimization are presented in Table G.3 for Location-Specific ARARs and in Table G.4 for Action-Specific ARARs.

DOE has conducted a waste materials recycling and reuse evaluation to explore potential opportunities for minimization, reuse, recycling, and melting of waste materials anticipated to be generated. The evaluation addresses the feasibility and costs associated with the reuse or recycling of materials that otherwise would be disposed of as waste in the current CERCLA waste forecast. DOE's commitment to waste volume reduction and the possible steps involved in a recycling effort are discussed below.

Minimization of debris material would decrease the waste volume to be disposed of and, therefore, either decrease the size of a disposal cell for the On-Site Alternative or decrease the volume of material to be sent off-site as waste under the No Action and Off-Site Alternatives. Clean-up activities associated with PGDP OUs, during both pre- and post-shutdown phases, are expected to generate a variety of debris (e.g., concrete) and scrap metal, including some amount of copper, nickel, stainless steel, and aluminum. For this RI/FS, the low-end waste volume scenario assumes that the waste minimization program will result in recycling/reusing up to 75% of the scrap metal and up to 75% of the concrete waste. Individual waste stream recycling and/or reuse determinations will be addressed by the generating projects.

The amount of waste minimization is assumed to be the same across alternatives and is, therefore, not a discriminator in the comparison of the alternatives. Because this RI/FS discusses potential technologies and because any selected recycling treatment option would be impact neutral, it is envisioned that a later decision by DOE to implement a large-scale centralized facility would not constitute a significant alteration to the selected waste disposition remedy from a cost, scope, or schedule perspective. Any such later decision would be documented, as necessary, in accordance with the CERCLA process.

Typical waste minimization operations process concrete, metal, wood, plastic, paper and cardboard. The remediation activities at the Paducah site will require the management of concrete, metal, and some wood. Only concrete and metal recycling is evaluated as part of this RI/FS as the quantity of wood to be generated during remediation is anticipated to be small.

During field operations, the concrete and metal intended for recycling would need to be surveyed to assess the material sources (e.g., clean, contaminated, etc.) for segregation purposes. This survey would be performed by the generating project. Surface contamination would be removed as needed using a shot blast system or similar process to remove surface contamination, including hazardous constituents. Volumetrically contaminated metals may be subject to a similar process to reduce volume and prevent void spaces within the disposal cell.

A conceptual concrete processing operation is shown in Figure 4.3. In this conceptual operation, a machine with a breaker would be used to size concrete slabs, foundations, and structural members to fit into a concrete crusher. The concrete pieces would be fed into a portable concrete jaw crusher, for example, which could be located at the work site. The crushed concrete would pass through a magnetic separator to remove steel in the concrete. The removed steel would be managed as part of the metal waste stream. The crushed concrete then would pass through a concrete screening facility. The conceptual operation also includes a lay down area for temporary stockpiling of materials. The crushed concrete could be used in a CERCLA disposal facility as fill material around objects (e.g., minimize/fill voids) or for wet weather access roads. Crushing impacted concrete for use as fill could be advantageous if fill were

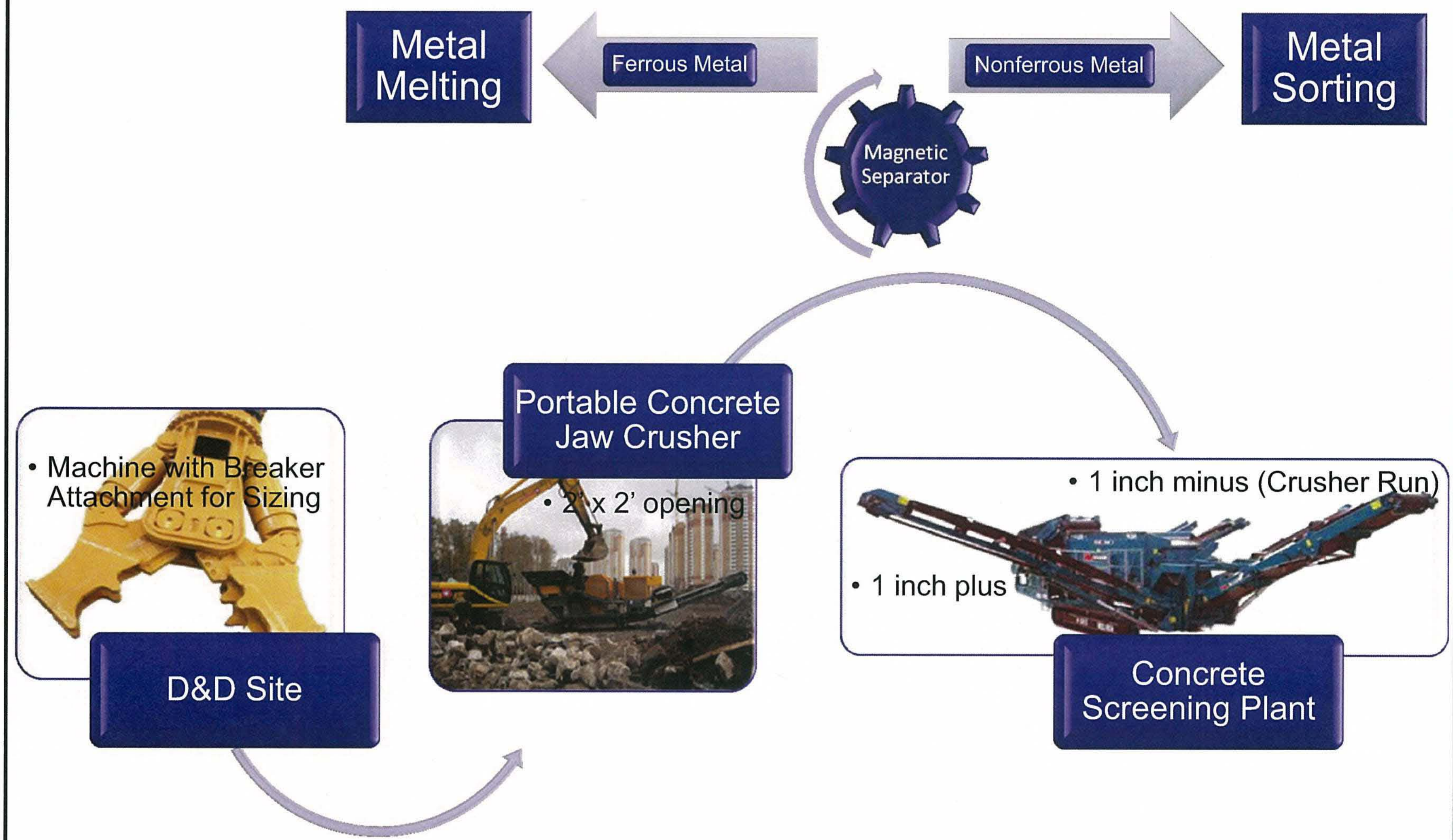

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Figure 4.3. Conceptual Concrete Processing Operation

needed to place debris. By using crushed concrete (either impacted or clean) as fill, the volume of debris to be placed would be decreased thereby decreasing the volume of fill needed to maintain the desired soil to debris ratio. This would result in an overall decrease in size of a disposal cell. Additionally, the crushed concrete substituted for fill reduces the cost associated with purchasing and transporting the fill.

Crushed concrete would be characterized and assessed in accordance with the facility WAC prior to placement within an on-site WDF. Crushed concrete could serve as a source of contamination or result in geochemical changes in leachate that could mobilize or retard other contaminants. Crushing impacted concrete is not as advantageous for either the No Action or Off-Site Alternatives because concrete can be placed uncrushed in the C-746-U Landfill and cannot be used as temporary cover in the C-746-U Landfill. Crushed concrete potentially could be used as void fill with larger debris in transportation containers, resulting in fewer transportation shipments.

A conceptual process to recycle/resize metal is shown in Figure 4.4. In this conceptual process, a machine with a shear attached would be used to size scrap metal to fit into a high capacity hammer millcrusher, which would result in pieces small enough to be efficiently melted or readily disposed of in a CERCLA disposal facility (reducing the amount of material needed to fill voids or potentially being used as void fill). Processing of classified scrap metal could result in it no longer being classified. Clean scrap metal could be recycled with or without size reduction. Recycling of scrap metal would decrease the amount of soil fill needed and decrease the size of the disposal cell for the on-site option and also could decrease the volume of material to be sent off-site as waste. Recycling of scrap metal could be implemented at a relatively low level of effort and should be considered an option for each of the alternatives. In the event uranium scrap metal is considered for recycling, the conceptual process discussed here would be reviewed to determine whether it would be appropriate for uranium recycling. Potential criticality concerns would be assessed and managed prior to processing.

Melting could create ingots for controlled recycling by removing impurities through heating or slagging of the molten metal. In the event that a metal could not be released for general use, other benefits of applying the recycling process to create ingots still would exist. These benefits would include reducing void spaces (reducing the waste volume, increasing the stability of the waste, and potentially increasing packaging efficiency for off-site transportation) or binding contaminants, allowing for their disposal. As with crushing concrete, placing resized metal within a disposal facility (either on-site or off-site) would decrease the volume of fill needed to maintain the desired soil to debris ratio, resulting and an overall decrease in the size of a disposal facility. This in turn would reduce the cost associated with purchasing and transporting the fill.

Multiple melting technologies exist, including conventional technologies and state of the art technologies, such as microwave or plasma heating. Conventional technologies include electronic arc furnace and induction furnace. Preliminary review indicates that induction furnace is preferred for several reasons, including its ability to be cold started, improving overall operational efficiency, and better control of radioactivity. Microwave and plasma heating technologies show promise, but are not wide spread. For the purpose of the ARAR and cost evaluation, an induction furnace is assumed. The steps in a general melting and decontamination process are shown in Figure 4.5. In the conceptual metal melting process, induction furnaces for ferrous and nonferrous materials would be used for melting. Smaller induction furnaces would be used for "clean" versus "contaminated" metals for both the ferrous and nonferrous operations. A treatment system for contamination reduction also is included in the conceptual process. Another option to induction furnace melting of metals such as nickel and copper is metal organic chemical vapor deposition (MOCVD). The MOCVD process employs the decomposition of the metallic items to separate out contaminants and produce pure metals (Terekhov and O'Meara 2000). The three primary steps in the process are (1) production of a volatile organic metal from contaminated metals or metal oxides; (2) purification of the volatile organic metal through fractional distillation; and

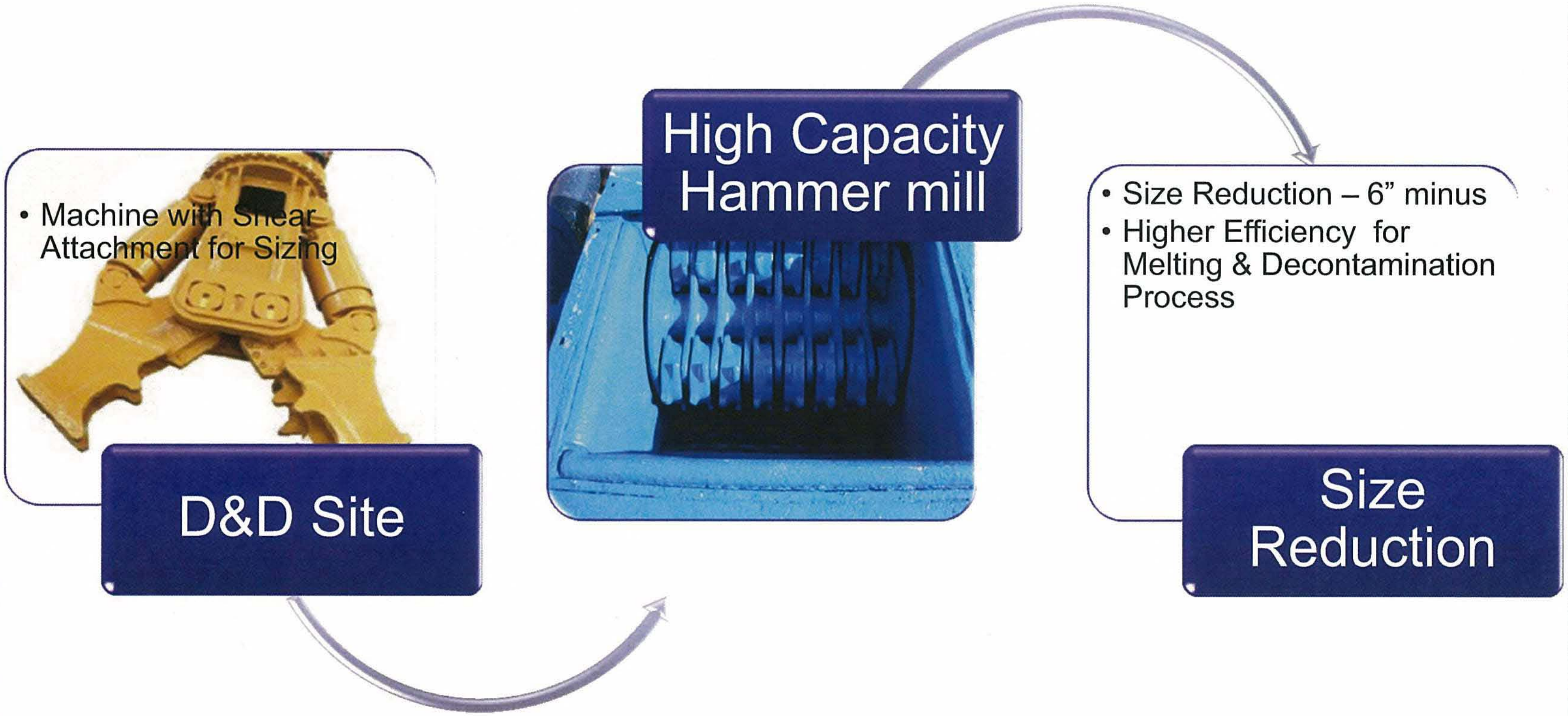

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Figure 4.4. Conceptual Scrap Metal Size Reduction Operation

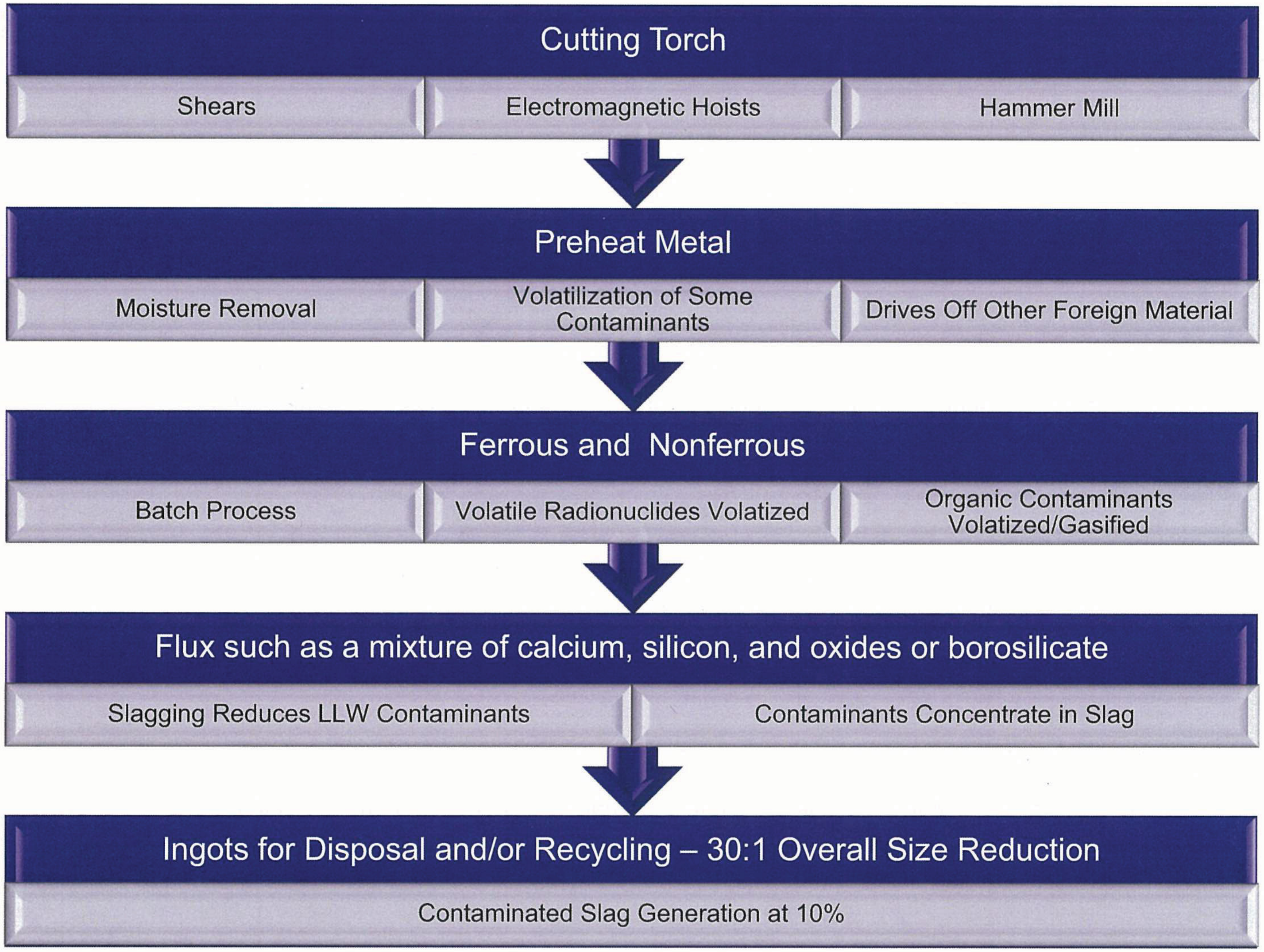

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Figure 4.5. General Melting Process

(3) decomposition of the organic metal into purified metal. The process can be employed by purifying individual metals or by using the fractional distillation to separate the individual metals.

Metal melting could have cost benefits beyond volume reduction, preserving disposal facility airspace, reducing costs for fill soil, and facilitating placement or packaging for transportation if the ingots could be assigned an intrinsic value, which is difficult given the current DOE Moratorium. Even with an intrinsic value, the additional cost-effectiveness related to the intrinsic value would vary with the market price of scrap metal. With the range of historic prices for scrap metal, however, there could be an economic advantage to metal melting. Though there are uncertainties in the value of the metals at the time recycling could occur, metal melting will be retained as an option for each of the alternatives due to other associated benefits, including, but not limited to, reducing volume, preserving disposal facility airspace, reducing costs for fill soil, and facilitating placement or packaging for transportation, and other factors at a date closer to generation of the recyclable materials.

Using crushed concrete as fill material could decrease cost because it could lead to a reduction in size of an on-site disposal facility and could require less clean soil for waste placement. Recycling of scrap metal would decrease costs by reducing the size of an on-site disposal facility and requiring less clean fill for waste placement. Cost reductions related to recycling or reuse would be offset by the construction and operations costs of the metal melting and concrete crushing facilities. For these reasons, concrete crushing and metal recycling will be retained as options for all three waste disposal alternatives. The amount of waste minimization is assumed to be the same across the alternatives and is, therefore, not a discriminator in the comparison of the alternatives. As such, a net zero cost for waste minimization is assumed for this RI/FS.

It should be noted that size reduction of material to be disposed in a CERCLA landfill may need to be accounted for in the WAC development, as the larger surface area to volume of pieces could potentially result in a higher percentage of leaching of contaminants.

Tables 4.4 and 4.5 summarize the present value cost (and value) for the recycling options compared to the No Action Alternative (base case for the Off-Site Alternative) and the On-Site Alternative cost for construction, operation, closure, and postclosure care (see Section 6 for a description of these costs), respectively. Costs for the recycling options are added to the Off-Site Alternative costs (Table 4.4) and the On-Site Alternative cost for construction, operations, closure, and postclosure care (Table 4.5). The recycling costs present value calculations are included in Appendix H and Appendix I. The costs presented in Tables 4.4 and 4.5 below are shown for illustrative purposes and are not intended to be the sole factor in decision making.

Table 4.4. Summary of Present Value Cost/Value for Recycling for the No Action/Off-Site Alternative

Item	Base Case (No Recycling)	Low-End Case (2012 Metal Values)[a]	Low-End Case (Historic 20-Year Average Metal Values)
Off-Site Alternative	$1,310,982,000	$796,473,000	$796,473,000
Concrete Crushing Facility Construction and Operation	NA	$51,195,000	$51,195,000
Metal Melting Facility Construction and Operation	NA	$518,469,000	$518,469,000
Scrap Metal—Direct Recycling	NA	$(25,070,000)	$(15,637,000)
Scrap Metal—On-Site Recycling	NA	$(210,083,000)	$(141,320,000)
Total	$1,310,982,000	$1,130,984,000	$1,209,180,000

NA = Not Applicable
Values shown in parenthesis are subtracted from the costs.
Metal prices obtained from World Bank 2013.
[a] Metal prices were accessed in January 2013 and correspond to December 2012 prices.

Table 4.5. Summary of Present Value Cost/Value for Recycling for the On-Site Alternative*

Item	Base Case (No Recycling)	Low-End Case (2012 Metal Values) [a]	Low-End Case (Historic 20-Year Average Metal Values)
On-Site Alternative Construction, Closure, O&M, and Postclosure Care	$765,378,000	$637,059,000	$637,059,000
Concrete Crushing Facility Construction and Operations	NA	$51,195,000	$51,195,000
Metal Melting Facility Construction and Operations	NA	$518,469,000	$518,469,000
Scrap Metal—Direct Recycling	NA	$(25,070,000)	$(15,637,000)
Scrap Metal—On-Site Recycling	NA	$(210,083,000)	$(141,320,000)
Total	$765,378,000	$971,570,000	$1,049,766,000

NA = Not Applicable
Values shown in parenthesis are subtracted from the costs.
Metal prices obtained from World Bank 2013.
*Site 3A Costs used for the On-Site Alternative.
[a] Metal prices were accessed in January 2013 and correspond to December 2012 prices.

4.2 WASTE CHARACTERIZATION/ANALYTICAL PROFILE

This analytical profile section characterizes the forecasted soil and non-soil waste, develops a list of COCs as a subset of the comprehensive PGDP-wide COPCs based on the waste inventory in Section 4.1, and then estimates the concentration or activity for each COC. The estimated volume of each classification (waste type) of the waste forecast is included in Table 4.3. Also, as discussed in Section 4.1.2, classified waste is a type of LLW and, therefore, would have no effect on waste characterization or groundwater modeling activities for the PWAC. Classified waste was assumed to be a portion of the LLW for the purposes of waste characterization and cost elements. The classified waste considered in this RI/FS Report is not classified due to contamination profile, but rather due to the function of the piece of equipment. By definition, a classified material includes any item or scrap that, due to its composition, structure, or function, reveals restricted data or other classified information, either directly or through analysis, in accordance with DOE CG-SS-4, DOE CG-PGD-5, or other applicable classification guidance. This project did not differentiate classified waste from nonclassified waste; therefore, the waste profile accounts for classified materials. A PWAC[12] that is protective of human health and the environment has been developed (see Section 5.4.6 and Appendix C) for a potential on-site waste disposal facility. The PWAC and this analytical profile are used in this FS to evaluate the On-Site Alternative.

Additionally, the average activity/concentration by COC for a potential on-site waste disposal facility is estimated as a volume-weighted average. The activity/concentration for each contaminant is a weighted average (Eq. 4.1) derived from the sum of the activity/concentration for each COC in the waste profile multiplied by the volume of the specific waste divided by the sum of the entire waste volume. These weighted averages then are compared to the PWAC for each COC. The waste profiles also are used to derive a total contaminant mass in the total volume of waste for use in groundwater models to estimate concentrations at the location of potential receptors.

$$\text{Weighted Average} = ([X_1*Y_1]+[X_2*Y_2]+...+[X_n*Y_n])/(Y_1+Y_2+...+Y_n) \qquad \text{(Eq. 4.1)}$$

where:
X_n = concentration (e.g., in mg/kg) at Facility "n"
Y_n = volume from Facility "n"

The D&D waste generally has not been characterized, and several of the OUs have limited analytical data; therefore, characterization of these wastes uses the best available sources of data as described in Section 4.2.1. Much of this characterization is not based on site-specific data; consequently, it is considered only an estimate for purposes of comparative analysis in the FS.

4.2.1 Sources of Data

Best available data were used to develop waste profiles for each waste type in the base case volume estimate (Table 4.3). Sources include limited PGDP-specific analytical data that are available for many of the projects that contribute to the forecasted waste volume. These data were supplemented with analytical information from site characterization activities obtained through the PGDP Data Warehouse geographic information system (GIS) Viewer (Paducah DWGIS). As PGDP-specific concentration data are not available for all projected waste streams (e.g., D&D, BGOU,[13] etc.), there exists some uncertainty regarding the waste characterization profiles. The High-Volume and Low-Volume Scenarios for the On-Site and Off-Site Alternatives were developed to address uncertainties in volumes and waste characterization that could lead to uncertainties in volumes.

Analytical data available in the Paducah DWGIS provide contaminant concentrations associated with some of the soil and sediments at PGDP. These data are representative of soil, groundwater, and surface water remedial action OUs, and are statistically assessed as described in Section 4.2.4. These data do not represent the BGOU, nor the waste within the D&D scope.

Waste profiles have been prepared to support recent and ongoing PGDP waste disposal operations, although limited wastes have been disposed. Although these profiles do contain relevant characterization

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[12] For the purposes of this RI/FS, the contaminant inventory limits defined by the PWAC apply only to mobile forms of a contaminant (e.g., nickel as a component of soil that is capable of dissolving into percolating water, etc.). Wastes placed in a non-mobile form, such as nickel ingots, etc., will not be subject to the contaminant inventory limits defined by the PWAC.

[13] Although concentration data generally are not available for the BGOU waste, information on the quantities of certain materials placed within individual BGOU SWMUs is available; this information is discussed in Section 4.2.5.

data for disposed wastes, they are not representative of the anticipated base case waste volume, and the detail concerning specific COC concentrations is inadequate to provide much additional value.

Waste profiles from the East Tennessee Technology Park (ETTP) D&D activities at the Oak Ridge Gaseous Diffusion Plant on the DOE-Oak Ridge Reservation (ORR) were used as surrogate information for PGDP D&D in the absence of PGDP-specific information. This surrogate information includes statistical evaluations of COCs for specific waste actually disposed of at the ORR Environmental Management Waste Management Facility (EMWMF). Similarly, waste profiles for the BGOU at ETTP were used as surrogate information for the PGDP BGOU. The profiles from wastes accepted at EMWMF are statistically derived from results of comprehensive waste characterization. Uncertainties associated with this approach are discussed in Section 4.3.

4.2.2 Selection of Contaminants of Concern

The PGDP has a comprehensive list of sitewide COPCs [Table A.1 in the Risk Methods Document (DOE 2011b)] from which a subset of COCs for the forecasted CERCLA waste volume may be derived. Note that the COC list developed for the purposes of this RI/FS does not constitute a list of COCs as defined by the Risk Methods Document (DOE 2011b) (i.e., they are not based on risk characterization results for chemical hazard and risk over all pathways within a use scenario of concern and were not compared to benchmarks of 0.1 and 1E-06, respectively). Rather, the COC list for this RI/FS was developed per the procedures in the RI/FS Work Plan (DOE 2011a). As discussed in Section 4.2.1, characterization data are not available for D&D or BGOU waste. Consequently, waste profiles developed during demolition activities at ETTP were used as surrogates for the waste to be generated during PGDP D&D and BGOU remediation. It is recognized that there were differences between the processes at ETTP and PGDP that could lead to differences in waste characterization; uncertainty associated with this approach is discussed in Section 4.3.

Based on site history, analytical data, and comparison of the PGDP site and gaseous diffusion process with the ETTP, the chemicals in the PGDP sitewide COPCs that are <u>not</u> considered COCs for D&D waste include the following:[14]

- Acrylonitrile
- Benzene
- Carbon tetrachloride
- 1,1-dichloroethene (DCE)
- *trans*-1,2-DCE
- Hexachlorobenzene
- 2-nitroaniline
- N-nitroso-di-N-propylamine
- Dioxins and furans, including these:
    - 2,3,7,8-tetrachlorodibenzo-p-dioxin
    - 2,3,7,8-tetrachlorodibenzo-p-furan
    - 2,3,7,8-pentachlorodibenzo-p-dioxin (isomers)
    - 1,2,3,7,8-pentachlorodibenzo-p-furan
    - 2,3,4,7,8-PeCDF

[14] The COC list for this RI/FS was developed per the procedures in the RI/FS Work Plan (DOE 2011a); the compounds listed here were not included on the COC list for this RI/FS.

— 2,3,7,8-hexachlorodibenzo-p-dioxin (isomers)
— 2,3,7,8-hexachlorodibenzo-p-furan (isomers)
— 2,3,7,8-heptachlorodibenzo-p-dioxin (isomers)
— 2,3,7,8-heptachlorodibenzo-p-furan (isomers)
— octachlorodibenzo-p-dioxin
— octachlorodibenzo-p-furan

Significant organic analyte contamination within the PGDP process buildings and support facilities is not suspected; therefore, the organic analytes were excluded. Dioxins and furans are typically byproduct of high temperature operations, such as solid waste incineration or coal combustion. These operations are not substantial in PGDP process or support buildings; therefore, dioxin/furan by-products are not anticipated and also were excluded.

To evaluate COCs for waste from the Soils OU, SWOU, and GWOU remediation projects, analytes for which data exist from sediments and soils were downloaded from the Paducah DWGIS and incorporated into a comprehensive database. Each data set for a specific site, such as a SWMU, first was downloaded into a spreadsheet from Paducah DWGIS, based on the approximate geographical location at the site. These data were labeled with a field identifier associating the data with the site and then downloaded into a database along with data from other PGDP areas. The analytical profile database was reviewed and corrected as necessary to make each field entry consistent in format and to ensure analytical results were reported in consistent units.

Data not applicable to this RI/FS were screened from the database to minimize the database size and to ease management for subsequent statistical analyses. Soil data collected from depths greater than 10 ft,[15] the assumed deepest reasonable excavation, were screened out. The following are the other data not pertinent to the analytical profile and were screened from further consideration:

- Geotechnical and physical data

- Analytes not listed as COPCs in the Risk Methods Document (DOE 2011b) (e.g., calcium, sodium, magnesium, potassium, silicon, tin)

- Wet chemistry results

- Gross alpha and beta

- Toxicity Characteristic Leaching Procedure (TCLP) results

- Quality Assurance (QA) results (e.g., surrogate values, field duplicate samples)

The database was queried to determine if any analytes failed to report values greater than the analytical method detection limit (MDL) or practical quantitation limit (PQL) (i.e., all results were nondetect values) for non-radioactive analytes or the analyte minimum detectable concentration (MDC) for radioactive analytes. All analytes in the database reported more than one value above detection limits, so

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[15] It is recognized that deeper excavation may be performed in association with infrastructure (e.g., utilities, etc.); however, these deeper excavations are expected to be isolated and involve a minimal volume by comparison to other activities. As such, this deeper excavation work is not expected to affect the waste concentration profile and the deeper concentration data were not considered.

no analytes were eliminated from the PGDP sitewide COPC list. Nondetect values were retained as their respective analytical MDL or PQL or MDC for later statistical analysis.[16]

Preliminary statistics were performed on each analyte in the database using available data. This included calculation of the mean, minimum, maximum, and the 95% upper confidence limit (95% UCL) on the mean, if enough data was available (see Appendix D for statistical calculations). UCLs were computed 95% UCL of the mean using the EPA software package ProUCL version 4.00.04. These statistics were assessed for sediment and soils. If the 95% UCL of the mean exceeded the maximum concentration in a dataset for a given analyte, the maximum concentration was used in lieu of the mean for comparison to the soil screening level as described herein. The 95% UCL on the mean for each analyte for these three matrices was compared to available background concentrations and soil screening levels (SSLs) (DOE 2011b). If the 95% UCL on the mean for an analyte was greater than its background value, the analyte was retained as a COC for further analysis (even if the 95% UCL on the mean was less than the SSL). If no background value was available, an analyte with 95% UCL on the mean greater than its SSL was retained as a COC for further analysis.

Limited data were available for some sites within an OU, so calculation of a 95% UCL value was sometimes of questionable statistical value and, for most sites, fails to report data for all PGDP COPCs. When a 95% UCL could not be computed, the maximum concentration reported for an analyte at any of the sites was used to establish the waste concentration for calculation of the weighted average. It was assumed that the maximum concentration at each site estimates the maximum credible COC concentrations in excavated soil.

If an analyte was not found to be a COC in the previous screening steps, the maximum analyte value was compared to the background concentration and SSL. An analyte otherwise eliminated in the process was retained as a COC if (1) the maximum value exceeded both the background (if available) and the SSL, and (2) the 95% UCL on the mean was within 75% of either the background or the SSL. This step was performed to retain relevant analytes while dismissing those that were statistical outliers.

This final list of COCs was used to develop the PWAC for evaluation of the On-Site Alternative. The COCs for each individual remediation site were evaluated, and these site-specific COCs were used in calculation of a weighted average concentration, as discussed in Section 4.2.6.

4.2.3 D&D Analytical Profile

4.2.3.1 ETTP waste profiles as surrogate data

ETTP used the same gaseous diffusion process as that used at PGDP; therefore, it was assumed that contamination of piping, valves, compressors, converters, and the facilities themselves will have similar waste types and concentrations. Although the ETTP gaseous diffusion process was a high enrichment plant, whereas PGDP is a low enrichment plant, the best available data are surrogate data from waste profiles for disposal at EMWMF. It was therefore assumed, in general, that the waste stream analyses for disposal of ETTP D&D waste provide a similar waste profile that is an acceptable surrogate of the average concentration of COCs in PGDP. The waste profiles developed at ETTP were statistically derived through an approved work plan defining the data quality objectives to develop the number of samples required for statistical analysis, the sampling approach, representative sample locations, analytical

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[16] The database was used to generate the dataset for calculation of the 95% UCL of the mean for the waste characterizations; some older radionuclear concentrations were flagged as nondetect; however, use of these results as nondetect values is considered to be efficient for gross contamination for the waste profiles considered and is not anticipated to materially affect the assessment.

requirements, data validation requirements, and the statistical analysis methodology. Concentrations for ETTP waste profile analytes were statistically defined using the 95% UCL on the mean.

Each facility at PGDP scheduled for D&D was associated with a specific waste profile from ETTP, based on process knowledge at both PGDP and ETTP and professional judgment. The following waste profiles from ETTP were used (see Appendix D for a complete listing of PGDP facilities, waste volumes, and the associated ETTP waste profiles):

- K-25 facility (two waste profiles for facility areas exhibiting higher and lower contamination) (e.g., the abovegrade structure at C-310 and the asbestos-containing material at C-310, respectively);

- K-25 Piping (two waste profiles for piping with higher and lower contamination), which includes the process piping from the cascade in K-25 (e.g., the piping at C-310-A and the piping at C-310, respectively);

- K-25 Valves, which includes the valves that were part of the cascade (e.g., the tanks at C-315);

- K-25 Compressors, which includes the compressors used in the cascade (e.g., the compressors at C-310);

- K-25 Converters, which includes the converters used in the cascade (e.g., the converters at C-331);

- K-413, which received enriched uranium and included three product withdrawal systems and cylinder fill positions (e.g., the foundation at C-310-A);

- Poplar Creek facilities, which included facilities supporting operational activities, such as facilities for UF_6 feed vaporization, conversion of gaseous UF_6 tails to liquid, and test loops [e.g., the remainder (abovegrade structure, foundation) at C-315]; and

- Low Risk/Low Complexity, which includes non-process buildings with limited likelihood of LLW, RCRA, TSCA, and MLLW wastes such as administrative buildings, trailers, warehouses, laboratories, test facilities, utility structures and infrastructures, fuel storage facilities, the steam plant, and switch yards (e.g., batteries from C-331).

The assumption that waste profiles at ETTP are representative for facilities at PGDP was applied for the uranium isotopes (U-233/U-234, U-235, and U-238) and for inorganic and organic contaminants. Although both PGDP and ETTP enriched uranium, PGDP processed over an order of magnitude more spent uranium from the Hanford and Savannah River reactors (approximately 100,000 tons at PGDP versus 5,600 tons at ETTP) (DOE 1999). The spent uranium from the Hanford and Savannah River reactors included contaminants not otherwise associated with uranium ore [e.g., Tc-99, neptunium-237 (Np-237), americium-241 (Am-241), plutonium-239/240 (Pu)-239/240], so the components at PGDP initially were anticipated to have had higher activities for certain radionuclides than those from ETTP (DOE 1999). Only a limited amount of these radionuclides would have been available upon feeding into the cascade because the majority would have reacted on the surface of the storage cylinders after conversion to the volatile actinide fluoride. Most of these radionuclides would have been entirely extracted very early in the diffusion process and would have contaminated primarily the converter barriers and some piping and valves at the process entry stage, although they may have migrated further down the cascade over time. Much of this contamination would have been eliminated at PGDP when barriers were removed during the Cascade Improvement Program (CIP) and the Cascade Uprating Program (CUP), which were completed after all spent uranium was processed. It was estimated that less than half of the contaminants potentially fed to the cascade remain. The cascade has continued to operate however, and most of the residual contaminants associated with the reactor tails processing would be flushed from the cascade, whereas the K-25 cascade was decommissioned in 1985 with much of the contaminated material remaining in the piping and equipment. Consequently, the waste profile values from K-25 and its cascade bound the potential activity of uranium as a maximum. Uncertainties associated with the use of the ETTP waste profiles are discussed in Section 4.3 of this Report.

The PGDP cascade is shorter than that of Portsmouth (PORTS) and Oak Ridge (ETTP) with 1,820 stages versus 4,080 and 4,020 stages, respectively; therefore, the PGDP UF_6 product had significant quantities of Tc-99 during the time recycled uranium was being processed into UF_6.

Unlike PGDP, PORTS and ETTP had longer purge cascades and were able to withdraw their product below the technetium "pocket" or the location of maximum concentration for the intermediate Tc-99 gaseous compounds. This helped minimize Tc-99 in their product UF_6, but resulted in accumulation of Tc-99 in the purge cascades. Conversely, PGDP, with the shorter purge cascade, had higher Tc-99 concentrations in produced UF_6, which is expected to have reduced the levels of Tc-99 in the process equipment. In other words, much of the Tc-99 that was fed into the PORTS and ETTP Gaseous Diffusion Plants (GDPs) became trapped in their cascades and especially in their higher assay cells. Although two CIPs were performed at each of the three sites, the higher assay cells at PORTS and ETTP were not a part of the programs; only the lower assay sections of the cascades were changed out. With the exception of the stages of the purge cascade, almost all PGDP gaseous diffusion equipment was changed out during the two CIPs.

Once the processing of recycled uranium ended and the use of it as feed was discontinued for the GDPs, the amount of Tc-99 in the PGDP UF_6 product was reduced significantly. The PGDP product, however, still has Tc-99 in the UF_6. ETTP operation was terminated in 1985, and the PORTS GDP operated until 2001. During the time period following discontinuing recycled uranium feed and the shutdown of PORTS and ETTP, Tc-99 in the PGDP UF_6 product continued to be transferred to PORTS and ETTP and diminished the amount of Tc-99 at PGDP.

There is uncertainty involved with the estimate of Tc-99 that may remain in the equipment, and the actual amount of Tc-99 remaining in the cascade may be lower than otherwise would be estimated. This is supported by the current UF_6 being able to meet the UF_6 product specification of 1–10 ppb of Tc-99.

4.2.3.2 Calculation of weighted averages

The analytical waste profile for the K-25 D&D wastes, which includes structural components (e.g., masonry, steel, wood, glass, tars), concrete slabs and foundations, and underlying soils associated with the slabs and foundations, was used to develop a volume-based estimate of concentration/activity for both the high-end and low-end waste volume scenarios. The high-end waste volume scenario assumes, for the On-Site Alternative, that waste generated by D&D activities would be disposed of in an on-site waste disposal facility. It is therefore represented by the analytical waste profile from ETTP, weighted for contribution based on the volume at PGDP. Table 4.6 presents the waste profile for each ETTP facility equating to facilities at PGDP for the high-end waste volume scenario Table 4.7 presents this information for the low-end waste volume scenario. Table 4.8 presents a comparison of the weighted concentration or activity averages for the high-end and low-end waste volume estimates. The alignment of PGDP facilities with each ETTP waste profile is provided in Appendix D. Uncertainties associated with this approach are discussed in Section 4.3.

The weighted concentration or activity averages use the relative volume contributed from each PGDP facility associated with a specific waste profile from ETTP, but do not specifically account for differences in mass, such as the mass (density) difference between soil, soil/concrete, construction debris, and scrap steel. The waste volumes presented in Appendix D were calculated using the inventory of wastes described in Section 4.1. Individual waste volumes were separated and categorized into various waste types best matching the waste profiles available from ETTP so that weighted averages could be calculated.

The profiles for many of the wastes at ETTP do not include data for analytes that are not COCs for that particular ETTP waste stream. Some contribution from such analytes that are COCs for PGDP was anticipated; however, elimination of these data from the weighting calculation would skew the average to higher concentrations, while substitution with a value of zero in the weighting calculation would skew the average lower. As a result, the higher value of one half of the maximum reported detected value or one half of the detection limit or the average of the reported estimated values, if available, was used for the PGDP COCs without ETTP data as a bounding condition. If the analyte was not tested or was not reported in the ETTP waste profile, then the minimum value reported from an available building waste profile was used as the surrogate value to provide a realistic value to bound the upper contaminant concentration. For instance, TCE data for the low concentration K-25 ETTP stream do not exist; therefore, the value for the high concentration K-25 ETTP stream was used. The formula for calculating a weighted average is included as Eq. 4.1.

Table 4.6. High-Volume Building Decontamination and Demolition Estimate Waste Profile

ETTP Building	K25	K25 Low Side	K25 Converters	K25 Compressors	K25 Piping 1	K25 Piping 2	K25 Valves	Low-Risk/Low Complexity	K413	Poplar Creek Process Facilities	Non-Hazardous	Building D&D High-Volume Weighted Contaminant Activity or Concentration[1]
Radionuclides (95% UCL - pCi/g)												
Am-241	1.30E-01	1.30E-01	9.35E-01	1.30E-01	9.94E-01	9.35E-01	6.58E-01	2.10E-01	3.10E-01	5.61E-01	6.50E-02	1.19E-01
Cs-137	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.50E+00	1.60E-01	1.60E-01	8.00E-02	8.80E-02
K-40	--	--	--	--	--	--	--	--	--	--	--	0.00E+00
Np-237	7.00E-02	7.00E-02	3.91E+01	7.00E-02	3.50E+00	3.91E+01	3.05E-01	5.30E-01	7.00E-02	1.40E-01	3.50E-02	1.98E+00
Pu-238	4.00E-02	4.00E-02	7.62E-01	4.00E-02	5.78E-01	7.62E-01	3.64E-01	1.25E-01	4.00E-02	4.00E-02	2.00E-02	6.00E-02
Pu-239/240	4.00E-02	4.00E-02	5.81E-01	4.00E-02	4.54E-01	5.81E-01	4.85E-01	8.00E-02	4.00E-02	3.32E-01	2.00E-02	5.34E-02
Tc-99	5.52E-01	5.52E-01	5.52E-01	5.52E-01	7.32E-01	6.17E-01	5.52E-01	3.47E+01	7.57E+00	5.20E+00	2.76E-01	3.76E-01
Th-228	3.60E-01	3.60E-01	3.60E-01	3.60E-01	3.60E-01	3.60E-01	3.60E-01	5.30E-01	3.60E-01	3.60E-01	1.80E-01	1.96E-01
Th-230	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01	2.90E+00	5.00E-01	5.00E-01	2.50E-01	2.74E-01
Th-232	1.90E-01	1.90E-01	1.90E-01	1.90E-01	1.90E-01	1.90E-01	1.90E-01	6.40E-01	1.90E-01	1.90E-01	9.50E-02	1.04E-01
U-233/234	1.83E+02	1.22E+01	1.75E+03	5.68E+03	3.84E+03	1.73E+05	4.26E+02	4.80E+01	9.98E+00	8.29E+01	4.99E+00	1.10E+03
U-235	1.94E+01	5.92E-01	9.01E+01	1.38E+02	3.06E+02	6.43E+03	2.19E+01	3.74E+00	5.32E+00	4.52E+00	2.96E-01	4.36E+01
U-238	6.21E+01	6.29E-01	9.09E+00	2.49E+01	1.58E+02	1.02E+03	5.32E+00	4.54E+01	4.48E+00	5.32E+01	3.15E-01	2.24E+01
Metals (95% UCL - mg/kg)												
Al	812	812	1,099	812	812	812	812	157,535	7,553	27,110	19.9	17.5
Sb	8.20	82.6	0.170	71.0	0.170	0.170	0.170	50.1	2.18	17.1	0.0850	0.525
As	327	115	5.49	5.49	5.49	5.49	5.49	47.0	5.49	61.7	2.75	1.88
Ba	82.6	97.1	82.6	82.6	82.6	82.6	82.6	1,175	1,528	383	41.3	13.0
Be	0.260	0.260	0.260	0.260	0.260	0.260	0.260	2.21	0.590	3.52	0.130	0.0407
Cd	18.7	36.0	0.160	0.160	0.160	0.160	0.160	470	3.12	4.15	0.0800	0.275
Cr	462	256	124	1,506	35.2	35.2	35.2	1,306	35.2	417	17.6	7.35
Cu	1,345	1,682	129,187	42,434	49,138	446,038	54,062	228,762	101	1,574	46.4	33.7

Table 4.6. High-Volume Building Decontamination and Demolition Estimate Waste Profile (Continued)

ETTP Building	K25	K25 Low Side	K25 Converters	K25 Compressors	K25 Piping 1	K25 Piping 2	K25 Valves	Low-Risk/Low Complexity	K413	Poplar Creek Process Facilities	Non-Hazardous	Building D&D High-Volume Weighted Contaminant Activity or Concentration[1]
Pb	57.8	3,528	18.8	38.0	18.8	18.8	18.8	3,954	1,040	2,763	9.40	23.9
Mn	4,934	4,152	8,820	9,710	9,976	8,028	9,922	18,823	247	2,743	54.1	47.0
Hg	76.0	0.342	0.00700	0.00700	0.00700	0.00700	0.00700	2.28	1.31	1.13	0.00350	0.0905
Ni	347	293	164,328	15,275	108,781	533,853	100,511	3,274	36.7	642	18.3	7.72
Se	283	333	0.790	0.790	0.790	0.790	0.790	47.0	0.79	6.31	0.395	2.41
Ag	28.9	30.0	0.0800	23.0	0.460	29.7	0.0800	6.78	0.0800	0.0800	0.0400	0.223
Sr	2,060	3.48	69.0	596	--	--	51.0	47.3	119	609	1.74	2.91
Tl	19.7	--	--	--	--	--	--	282	--	--	0.369	0.143
V	85.0	83.8	11.5	11.5	11.5	11.5	11.5	282	11.5	63.8	5.73	2.31
Zn	1,436	87,867	4.00	8.00	4.00	4.00	539	208,369	1,136	19,888	2.00	529
Organics (95% UCL - mg/kg)												
Acenaphthene	160	0.420	0.420	0.420	0.420	0.420	0.420	2.50	0.900	0.420	0.210	0.249
Acetone	--	--	--	--	--	--	--	18.0	--	1.28	0.00E+00	6.56E-04
Acetophenone	--	0.332	--	--	--	--	--	0.890	--	--	0.00E+00	0.00199
Anthracene	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.900	0.365	0.0645	0.0202
BEHP	--	--	--	--	--	--	--	3.69	11.8	13.4	0.00E+00	2.37E-04
Benzo(a)anthracene	0.215	0.215	0.215	0.215	0.215	0.215	0.215	2.50	0.900	0.215	0.108	0.0337
Benzo(a)pyrene	0.165	0.165	0.165	0.165	0.165	0.165	0.165	2.50	0.900	0.165	0.0825	0.0259
Benzo(b)fluoranthene	0.200	0.200	0.200	0.200	0.200	0.200	0.200	2.50	0.900	0.200	0.100	0.0314
Benzo(ghi)perylene	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Benzo(k)fluoranthene	0.245	0.245	0.245	0.245	0.245	0.245	0.245	2.50	0.900	0.245	0.123	0.0384
Benzoic Acid	5.02	--	--	--	--	--	--	--	--	13.2	0.00E+00	0.00577
BHC (beta-)	--	--	--	--	--	--	--	0.0800	--	--	0.00E+00	2.92E-06
Butanone (1-)	--	--	--	--	--	--	--	0.0219	--	--	0.00E+00	8.00E-07
Butyl benzyl phthalate	--	--	--	--	--	--	--	1.70	--	4.62	0.00E+00	6.21E-05
Carbazole	256	0.460	0.460	0.460	0.460	0.460	0.460	2.50	0.900	0.460	0.230	0.366

Table 4.6. High-Volume Building Decontamination and Demolition Estimate Waste Profile (Continued)

ETTP Building	K25	K25 Low Side	K25 Converters	K25 Compressors	K25 Piping 1	K25 Piping 2	K25 Valves	Low-Risk/Low Complexity	K413	Poplar Creek Process Facilities	Non-Hazardous	Building D&D High-Volume Weighted Contaminant Activity or Concentration[1]
Chlordane (gamma-)	0.323	--	--	--	--	--	--	0.0500	--	0.250	0.00E+00	3.73E-04
Chloro-3-methylphenol (4-)	--	--	--	--	--	--	--	1.50	--	--	0.00E+00	5.48E-05
Chloroform	8.00E-04	8.00E-04	8.00E-04	8.00E-04	8.00E-04	8.00E-04	8.00E-04	8.00E-04	0.0750	0.0380	4.00E-04	1.26E-04
Chrysene	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.270	0.900	0.140	0.0700	0.0219
Cresol (o-)	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Cresol (p-)	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Cumene	--	--	--	--	--	--	--	0.026	--	--	0.00E+00	9.42E-07
DCE (cis-1,2-)	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.0750	0.0380	0.00125	3.91E-04
DDD (4,4'-)	0.374	--	--	--	--	--	--	--	--	--	0.00E+00	4.30E-04
DDE (4,4'-)	9.61	--	--	--	--	--	--	0.130	--	--	0.00E+00	0.0110
DDT (4,4'-)	3.08	--	--	--	--	--	--	0.270	--	--	0.00E+00	0.00355
Dibenzo(ah)anthracene	0.900	0.900	0.900	0.900	0.900	0.900	0.900	2.5	0.900	1.10	0.450	0.141
Dibenzofuran	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Dieldrin	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0300	0.00938
Diethyl phthalate	1.55	0.0630	--	--	--	--	--	13.1	--	--	0.00E+00	0.00263
Dimethylbenzene (1,2-)	--	--	--	--	--	--	--	0.0144	--	--	0.00E+00	5.26E-07
Di-n-butyl phthalate	3.55	--	--	--	--	--	--	0.620	8.38	--	0.00E+00	0.00417
Di-n-octyl phthalate	--	--	--	--	--	--	--	1.69	--	--	0.00E+00	6.17E-05
Endosulfan II	--	--	--	--	--	--	--	0.100	--	--	0.00E+00	3.65E-06
Endosulfan sulfate	--	--	--	--	--	--	--	0.0700	--	--	0.00E+00	2.56E-06
Endrin	--	--	--	--	--	--	--	0.0700	--	--	0.00E+00	2.56E-06
Endrin Aldehyde	0.0720	--	--	--	--	--	--	--	--	--	0.00E+00	8.27E-05
Ethylbenzene	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00820	0.00250	0.0355	0.00125	3.91E-04
Fluoranthene	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.600	0.370	0.370	0.185	0.0578
Fluorene	0.390	0.390	0.390	0.390	0.390	0.390	0.390	2.50	0.390	0.390	0.195	0.0610
Heptachlor epoxide	--	--	--	--	--	--	--	0.020	--	0.0300	0.00E+00	7.30E-07

Table 4.6. High-Volume Building Decontamination and Demolition Estimate Waste Profile (Continued)

ETTP Building	K25	K25 Low Side	K25 Converters	K25 Compressors	K25 Piping 1	K25 Piping 2	K25 Valves	Low-Risk/Low Complexity	K413	Poplar Creek Process Facilities	Non-Hazardous	Building D&D High-Volume Weighted Contaminant Activity or Concentration[1]
Hexanone (2-)	--	--	--	--	--	--	--	0.0148	--	--	0.00E+00	5.40E-07
Indeno(123-cd)pyrene	0.375	0.375	0.375	0.375	0.375	0.375	0.375	2.50	0.375	0.375	0.188	0.0587
Methyl naphthalene (2-)	88.4	--	--	--	--	--	--	0.15	--	--	0.00E+00	0.102
Methyl-2-pentanone (4-)	--	--	--	--	--	--	--	0.00250	--	--	0.00E+00	9.13E-08
Methylphenol (2-)	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Methylphenol (3&4-)	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Methylene chloride	--	--	--	--	--	--	--	0.00600	--	0.0700	0.00E+00	2.19E-07
Naphthalene	306	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.550	0.0850	0.378
PCB - Aroclor 1016	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.45	4.65	0.0165	0.00825	8.77E-04
PCB - Aroclor 1221	0.0335	0.0335	0.0335	0.0335	0.0335	0.0335	0.0335	0.45	4.10	0.0335	0.0168	8.79E-04
PCB - Aroclor 1232	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.45	5.50	0.0165	0.00825	8.78E-04
PCB - Aroclor 1242	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	41.3	5.00	0.0165	0.00825	0.080
PCB - Aroclor 1248	0.224	0.224	0.224	0.224	0.224	0.224	0.224	140	7.00	49.62	0.112	0.271
PCB - Aroclor 1254	1.42	1.42	1.42	1.42	1.42	1.42	1.42	63.41	108	186	0.711	0.123
PCB - Aroclor 1260	0.72	0.72	0.72	0.72	0.72	0.72	0.72	16.29	152	36.7	0.360	0.0318
PCB (Total)	11.09	11.09	11.09	16	11.09	11.09	11.09	275	178	293	5.5	0.533
Pentachlorophenol	2.38	--	--	--	--	--	--	--	--	--	0.00E+00	0.00273
Phenanthrene	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.470	0.900	0.335	0.0850	0.0266
Phenol	--	--	--	--	--	--	--	3.5	--	78.6	0.0000	1.28E-04
Pyrene	0.285	0.285	0.285	0.285	0.285	0.285	0.285	1.87	0.900	0.285	0.143	0.0446
TCE	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.0132	0.0750	0.0495	0.00100	3.14E-04
PCE	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.0750	0.0425	5.00E-04	1.57E-04
Tetrachlorophenol (2,3,4,6-)	1.6	--	--	--	--	--	--	--	--	--	0.00E+00	0.00184
Toluene	--	--	--	--	--	--	--	0.00340	--	--	0.00E+00	1.24E-07
Vinyl Chloride	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.0750	0.0305	5.00E-04	1.57E-04
Xylenes (M+P)	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.0122	0.0750	0.0750	0.00125	3.92E-04

[1] High-volume weighted averages are based on the volume of waste for each PGDP facility as assigned to a similar facility at ETTP. It includes all waste streams in the weighting process.

Table 4.6. High-Volume Building Decontamination and Demolition Estimate Waste Profile (Continued)

BEHP - bis 2-ethylhexyl phthalate
DCE - dichloroethene
DDD - dichlorodiphenyldichloroethane
DDE - dichlorodiphenyldichloroethene
DDT - dichlorodiphenyltrichloroethane
ETTP - East Tennessee Technology Park
mg/kg - milligrams per kilogram
PCB - polychlorinated biphenyl
PCE - perchloroethene
pCi/g - picocuries per gram
TCE - trichloroethene
UCL_{95} - 95 percent upper confidence limit on the mean

Table 4.7. Low-Volume Building Decontamination and Demolition Estimate Waste Profile

ETTP Building	K25	K25 Low Side	K25 Converters	K25 Compressors	K25 Piping 1	K25 Piping 2	K25 Valves	Low-Risk/ Low Complexity	K413	Poplar Creek Process Facilities	Non-Hazardous	Building D&D Low-Volume Weighted Contaminant Activity or Concentration[1]
Radionuclides (95% UCL - pCi/g)												
Am-241	1.30E-01	1.30E-01	9.35E-01	1.30E-01	9.94E-01	9.35E-01	6.58E-01	2.10E-01	3.10E-01	5.61E-01	6.50E-02	2.48E-01
Cs-137	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.60E-01	1.50E+00	1.60E-01	1.60E-01	8.00E-02	1.60E-01
Np-237	7.00E-02	7.00E-02	3.91E+01	7.00E-02	3.50E+00	3.91E+01	3.05E-01	5.30E-01	7.00E-02	1.40E-01	3.50E-02	4.90E+00
Pu-238	4.00E-02	4.00E-02	7.62E-01	4.00E-02	5.78E-01	7.62E-01	3.64E-01	1.25E-01	4.00E-02	4.00E-02	2.00E-02	1.35E-01
Pu-239/240	4.00E-02	4.00E-02	5.81E-01	4.00E-02	4.54E-01	5.81E-01	4.85E-01	8.00E-02	4.00E-02	3.32E-01	2.00E-02	1.18E-01
Tc-99	5.52E-01	5.52E-01	5.52E-01	5.52E-01	7.32E-01	6.17E-01	5.52E-01	3.47E+01	7.57E+00	5.20E+00	2.76E-01	7.36E-01
Th-228	3.60E-01	3.60E-01	3.60E-01	3.60E-01	3.60E-01	3.60E-01	3.60E-01	5.30E-01	3.60E-01	3.60E-01	1.80E-01	3.54E-01
Th-230	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01	5.00E-01	2.90E+00	5.00E-01	5.00E-01	2.50E-01	4.96E-01
Th-232	1.90E-01	1.90E-01	1.90E-01	1.90E-01	1.90E-01	1.90E-01	1.90E-01	6.40E-01	1.90E-01	1.90E-01	9.50E-02	1.88E-01
U-233/234	1.83E+02	1.22E+01	1.75E+03	5.68E+03	3.84E+03	1.73E+05	4.26E+02	4.80E+01	9.98E+00	8.29E+01	4.99E+00	2.73E+03
U-235	1.94E+01	5.92E-01	9.01E+01	1.38E+02	3.06E+02	6.43E+03	2.19E+01	3.74E+00	5.32E+00	4.52E+00	2.96E-01	1.08E+02
U-238	6.21E+01	6.29E-01	9.09E+00	2.49E+01	1.58E+02	1.02E+03	5.32E+00	4.54E+01	4.48E+00	5.32E+01	3.15E-01	5.56E+01
Metals (95% UCL - mg/kg)												
Al	812	812	1,099	812	812	812	812	157,535	7,553	27,110	19.9	28.8
Sb	8.20	82.6	0.170	71.0	0.170	0.170	0.170	50.1	2.18	17.1	0.0850	1.24
As	327	115	5.49	5.49	5.49	5.49	5.49	47.0	5.49	61.7	2.75	2.63
Ba	82.6	97.1	82.6	82.6	82.6	82.6	82.6	1,175	1,528	383	41.3	1.81
Be	0.260	0.260	0.260	0.260	0.260	0.260	0.260	2.21	0.590	3.52	0.130	0.00479
Cd	18.7	36.0	0.160	0.160	0.160	0.160	0.160	470	3.12	4.15	0.0800	0.626
Cr	462	256	124	1,506	35.2	35.2	35.2	1,306	35.2	417	17.6	5.21
Cu	1,345	1,682	129,187	42,434	49,138	446,038	54,062	228,762	101	1,574	46.4	49.4
Pb	57.8	3,528	18.8	38.0	18.8	18.8	18.8	3,954	1,040	2,763	9.40	52.5
Mn	4,934	4,152	8,820	9,710	9,976	8,028	9,922	18,823	247	2,743	54.1	77.0
Hg	76.0	0.342	0.00700	0.00700	0.00700	0.00700	0.00700	2.28	1.31	1.13	0.00350	0.223

Table 4.7. Low-Volume Building Decontamination and Demolition Estimate Waste Profile (Continued)

ETTP Building	K25	K25 Low Side	K25 Converters	K25 Compressors	K25 Piping 1	K25 Piping 2	K25 Valves	Low-Risk/ Low Complexity	K413	Poplar Creek Process Facilities	Non-Hazardous	Building D&D Low-Volume Weighted Contaminant Activity or Concentration[1]
Ni	347	293	164,328	15,275	108,781	533,853	100,511	3,274	36.7	642	18.3	5.61
Se	283	333	0.790	0.790	0.790	0.790	0.790	47.0	0.790	6.31	0.395	5.72
Ag	28.9	30.0	0.0800	23.0	0.460	29.7	0.0800	6.78	0.0800	0.0800	0.0400	0.525
Sr	2,060	3.48	69.0	596	--	--	51.0	47.3	119	609	1.74	5.96
Tl	19.7	--	--	--	--	--	--	282	--	--	0.369	0.0821
V	85.0	83.8	11.5	11.5	11.5	11.5	11.5	282	11.5	63.8	5.73	1.50
Zn	1,436	87,867	4.00	8.00	4.00	4.00	539	208,369	1,136	19,888	2.00	1,317
Organics (95% UCL - mg/kg)												
Acenaphthene	160	0.420	0.420	0.420	0.420	0.420	0.420	2.50	0.900	0.420	0.210	0.465
Acetone	--	--	--	--	--	--	--	18.0	--	1.28	0.00E+00	0.00163
Acetophenone	--	0.332	--	--	--	--	--	0.890	--	--	0.00E+00	0.00497
Anthracene	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.900	0.365	0.0645	0.00230
BEHP	--	--	--	--	--	--	--	3.69	11.8	13.4	0.00E+00	5.91E-04
Benzo(a)anthracene	0.215	0.215	0.215	0.215	0.215	0.215	0.215	2.50	0.900	0.215	0.108	0.00403
Benzo(a)pyrene	0.165	0.165	0.165	0.165	0.165	0.165	0.165	2.50	0.900	0.165	0.08	0.00315
Benzo(b)fluoranthene	0.200	0.200	0.200	0.200	0.200	0.200	0.200	2.50	0.900	0.200	0.100	0.00376
Benzo(ghi)perylene	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Benzo(k)fluoranthene	0.245	0.245	0.245	0.245	0.245	0.245	0.245	2.50	0.900	0.245	0.123	0.00456
Benzoic Acid	5.02	--	--	--	--	--	--	--	--	13.2	0.00E+00	0.0144
BHC (beta-)	--	--	--	--	--	--	--	0.0800	--	--	0.00E+00	7.28E-06
Butanone (1-)	--	--	--	--	--	--	--	0.0219	--	--	0.00E+00	1.99E-06
Butyl benzyl phthalate	--	--	--	--	--	--	--	1.70	--	4.62	0.00E+00	1.55E-04
Carbazole	256	0.460	0.460	0.460	0.460	0.460	0.460	2.50	0.900	0.460	0.230	0.740
Chlordane (gamma-)	0.323	--	--	--	--	--	--	0.0500	--	0.250	0.00E+00	9.29E-04
Chloro-3-methylphenol (4-)	--	--	--	--	--	--	--	1.50	--	--	0.00E+00	1.36E-04
Chloroform	8.00E-04	8.00E-04	8.00E-04	8.00E-04	8.00E-04	8.00E-04	8.00E-04	8.00E-04	0.0750	0.0380	4.00E-04	1.58E-05
Chrysene	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.270	0.900	0.140	0.0700	0.00251

Table 4.7. Low-Volume Building Decontamination and Demolition Estimate Waste Profile (Continued)

ETTP Building	K25	K25 Low Side	K25 Converters	K25 Compressors	K25 Piping 1	K25 Piping 2	K25 Valves	Low-Risk/ Low Complexity	K413	Poplar Creek Process Facilities	Non-Hazardous	Building D&D Low-Volume Weighted Contaminant Activity or Concentration[1]
Cresol (o-)	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Cresol (p-)	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Cumene	--	--	--	--	--	--	--	0.0258	--	--	0.00E+00	2.35E-06
DCE (*cis*-1,2-)	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.0750	0.0380	0.00125	4.58E-05
DDD (4,4'-)	0.374	--	--	--	--	--	--	--	--	--	0.00E+00	0.00107
DDE (4,4'-)	9.61	--	--	--	--	--	--	0.130	--	--	0.00E+00	0.0275
DDT (4,4'-)	3.08	--	--	--	--	--	--	0.270	--	--	0.00E+00	0.00884
Dibenzo(ah)anthracene	0.900	0.900	0.900	0.900	0.900	0.900	0.900	2.50	0.900	1.10	0.450	0.0161
Dibenzofuran	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Dieldrin	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0300	0.00106
Diethyl phthalate	1.55	0.0630	--	--	--	--	--	13.1	--	--	0.00E+00	0.00656
Dimethylbenzene (1,2-)	--	--	--	--	--	--	--	0.0144	--	--	0.00E+00	1.31E-06
Di-n-butyl phthalate	3.55	--	--	--	--	--	--	0.620	8.38	--	0.00E+00	0.0104
Di-n-octyl phthalate	--	--	--	--	--	--	--	1.69	--	--	0.00E+00	1.54E-04
Endosulfan II	--	--	--	--	--	--	--	0.100	--	--	0.00E+00	9.10E-06
Endosulfan sulfate	--	--	--	--	--	--	--	0.0700	--	--	0.00E+00	6.37E-06
Endrin	--	--	--	--	--	--	--	0.0700	--	--	0.00E+00	6.37E-06
Endrin Aldehyde	0.0720	--	--	--	--	--	--	--	--	--	0.00E+00	2.06E-04
Ethylbenzene	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00250	0.00820	0.00250	0.0355	0.00125	4.48E-05
Fluoranthene	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.600	0.370	0.370	0.185	0.00657
Fluorene	0.390	0.390	0.390	0.390	0.390	0.390	0.390	2.500	0.390	0.390	0.195	0.00710
Heptachlor epoxide	--	--	--	--	--	--	--	0.0200	--	0.0300	0.00E+00	1.82E-06
Hexanone (2-)	--	--	--	--	--	--	--	0.0148	--	--	0.00E+00	1.35E-06
Indeno(123-cd)pyrene	0.375	0.375	0.375	0.375	0.375	0.375	0.375	2.50	0.375	0.375	0.188	0.00683
Methyl naphthalene (2-)	88.4	--	--	--	--	--	--	0.150	--	--	0.00E+00	0.253
Methyl-2-pentanone (4-)	--	--	--	--	--	--	--	0.0025	--	--	0.00E+00	2.27E-07
Methylphenol (2-)	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00

Table 4.7. Low-Volume Building Decontamination and Demolition Estimate Waste Profile (Continued)

ETTP Building	K25	K25 Low Side	K25 Converters	K25 Compressors	K25 Piping 1	K25 Piping 2	K25 Valves	Low-Risk/ Low Complexity	K413	Poplar Creek Process Facilities	Non-Hazardous	Building D&D Low-Volume Weighted Contaminant Activity or Concentration[1]
Methylphenol (3&4-)	--	--	--	--	--	--	--	--	--	--	0.00E+00	0.00E+00
Methylene chloride	--	--	--	--	--	--	--	0.0060	--	0.0700	0.00E+00	5.46E-07
Naphthalene	306	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.550	0.0850	0.879
PCB - Aroclor 1016	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.450	4.65	0.0165	0.00825	0.00E+00
PCB - Aroclor 1221	0.0335	0.0335	0.0335	0.0335	0.0335	0.0335	0.0335	0.450	4.10	0.0335	0.0168	0.00E+00
PCB - Aroclor 1232	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.450	5.50	0.0165	0.00825	0.00E+00
PCB - Aroclor 1242	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	41.3	5.00	0.0165	0.00825	0.00E+00
PCB - Aroclor 1248	0.224	0.224	0.224	0.224	0.224	0.224	0.224	140	7.00	49.6	0.112	0.00E+00
PCB - Aroclor 1254	1.42	1.42	1.42	1.42	1.42	1.42	1.42	63.4	108	186	0.711	0.00E+00
PCB - Aroclor 1260	0.720	0.720	0.720	0.720	0.720	0.720	0.720	16.3	152	36.7	0.360	0.00E+00
PCB (Total)	11.1	11.1	11.1	16.0	11.1	11.1	11.1	275	178	293	5.54	0.00E+00
Pentachlorophenol	2.38	--	--	--	--	--	--	--	--	--	0.00E+00	0.00682
Phenanthrene	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.470	0.900	0.335	0.0850	0.00305
Phenol	--	--	--	--	--	--	--	3.50	--	78.6	0.00E+00	3.18E-04
Pyrene	0.285	0.285	0.285	0.285	0.285	0.285	0.285	1.87	0.900	0.285	0.143	0.0052
TCE	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.0132	0.0750	0.0495	0.00100	3.80E-05
PCE	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.0750	0.0425	5.00E-04	1.93E-05
Tetrachlorophenol (2,3,4,6-)	1.60	--	--	--	--	--	--	--	--	--	0.00E+00	0.00458
Toluene	--	--	--	--	--	--	--	0.0034	--	--	0.00E+00	3.09E-07
Vinyl Chloride	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.0750	0.0305	5.00E-04	1.93E-05
Xylenes (M+P)	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0122	0.0750	0.0750	0.00125	4.67E-05

[1] Low-volume weighted averages are based on the volume of waste for each PGDP facility as assigned to a similar facility at ETTP. It includes all waste streams in the weighting process.

DCE - dichloroethene

DDD - dichlorodiphenyldichloroethane

DDE - dichlorodiphenyldichloroethene

DDT - dichlorodiphenyltrichloroethane

ETTP - East Tennessee Technology Park

Table 4.7. Low-Volume Building Decontamination and Demolition Estimate Waste Profile (Continued)

mg/kg - milligrams per kilogram
PCB - polychlorinated biphenyl
PCE - perchloroethene
pCi/g - picocuries per gram
TCE - trichloroethene
UCL - upper confidence limit on the mean

Table 4.8. D&D Waste Profile Comparison of High-End and Low-End Waste Volume Estimates

Contaminant	High-End Waste Volume Weighted Contaminant Activity or Concentration[1]	Low-End Waste Volume Weighted Contaminant Activity or Concentration[2]
Radionuclides (95% UCL—pCi/g)		
Am-241	0.119	0.248
Cs-137	0.0880	0.160
Np-237	1.98	4.90
Pu-238	0.0600	0.135
Pu-239/240	0.0534	0.118
Tc-99	0.376	0.736
Th-228	0.196	0.354
Th-230	0.274	0.496
Th-232	0.104	0.188
U-233/234[3]	1,100	2,730
U-235	43.6	108
U-238	22.4	55.6
Metals[4] (95% UCL—mg/kg)		
Al	17.5	28.8
Sb	0.525	1.24
As	1.88	2.63
Ba	13.0	1.81
Be	0.0407	0.00479
Cd	0.275	0.626
Cr	7.35	5.21
Cu	33.7	49.4
Pb	23.9	52.5
Mn	47.0	77.0
Hg	0.0905	0.223
Ni	7.72	5.61
Se	2.41	5.72
Ag	0.223	0.525
Tl	0.143	0.0821
V	2.31	1.50
Zn	529	1,317
Organics (95% UCL—mg/kg)		
Acenaphthene	0.249	0.465
Anthracene	0.0202	0.00230
Benzo(a)anthracene	0.0337	0.00403
Benzo(a)pyrene	0.0259	0.00315
Benzo(b)fluoranthene	0.0314	0.00376
Benzo(k)fluoranthene	0.0384	0.00456
Carbazole	0.366	0.740
Chloroform	1.26E-04	1.58E-05
Chrysene	0.0219	0.00251
DCE (*cis*-1,2-)	3.91E-04	4.58E-05
Dibenzo(ah)anthracene	0.141	0.0161

Table 4.8. D&D Waste Profile Comparison of High-End and Low-End Volume Estimates (Continued)

Contaminant	High-End Waste Volume Weighted Contaminant Activity or Concentration[1]	Low-End Waste Volume Weighted Contaminant Activity or Concentration[2]
Organics (95% UCL—mg/kg)		
Dieldrin	0.00938	0.00106
Ethylbenzene	3.91E-04	4.48E-05
Fluoranthene	0.0578	0.00657
Fluorene	0.0610	0.00710
Indeno(123-cd)pyrene	0.0587	0.00683
Naphthalene	0.378	0.879
PCB—Aroclor 1016	8.77E-04	0.00
PCB—Aroclor 1221	8.79E-04	0.00
PCB—Aroclor 1232	8.78E-04	0.00
PCB—Aroclor 1242	0.0799	0.00
PCB—Aroclor 1248	0.271	0.00
PCB—Aroclor 1254	0.123	0.00
PCB—Aroclor 1260	0.0318	0.00
PCB (Total)	0.533	0.00
Phenanthrene	0.0266	0.00305
Pyrene	0.0446	0.00520
TCE	3.14E-04	3.80E-05
PCE	1.57E-04	1.93E-05
Vinyl Chloride	1.57E-04	1.93E-05
Xylenes (M+P)	3.92E-04	4.67E-05

[1] High-volume weighted averages are based on the volume of waste for each PGDP facility as assigned to a similar facility at ETTP. It includes all waste streams in the weighting process.
[2] Low-volume weighted averages are based on the volume of waste for each PGDP facility as assigned to a similar facility at ETTP. It includes all waste streams in the weighting process.
[3] U-233/234 data references can be found in Appendix D, Table D.3.
[4] Metals in bold are the metals regulated as toxicity characteristic metals under RCRA (D004—D011).
DCE = dichloroethene
mg/kg = milligrams per kilogram
PCB = polychlorinated biphenyl
PCE = perchloroethene
pCi/g = picocuries per gram
TCE = trichloroethene
95% UCL = 95 percent upper confidence limit on the mean

The high-end waste volume scenario assumes that generated waste would be disposed of in an on-site disposal facility; therefore, the calculation of the weighted averages includes all waste types (LLW/RCRA/TSCA/MLLW and waste that meets the WAC of the C-746-U Landfill). Table 4.6 shows the weighted average for the high-end waste volume scenario, and Appendix D provides tables showing the waste profile and the details used to calculate the weighted averages.

The low-end waste volume scenario assumes that LLW/RCRA/TSCA/MLLW waste would be placed in an on-site disposal facility; therefore, waste that meets the WAC of the C-746-U Landfill was excluded from calculation of the weighted averages. Table 4.7 shows the weighted average for the low-end volume, and Appendix D provides tables showing the waste profile and the details used to calculate the weighted averages.

4.2.4 Soils OU, SWOU, and GWOU Projects Analytical Profile

It is estimated that the planned ER projects, including the Soils OU, SWOU, and GWOU, will generate a total of approximately 120,000 yd^3 of the 4.0 mcy under the high-end waste volume scenario (3% of the total volume) and an estimated 10,000 yds^3 of waste in the low-end volume estimate of 1.5 mcy (less than 1% of the total). The BGOU is considered separately from the ER projects and is discussed in Section 4.2.5. The Soils OU accounts for the majority of the waste generated in these ER projects, contributing 80% of the project waste volume generated under the high-end volume estimate and 65% for the low-end volume estimate, while the SWOU accounts for the majority of the remainder. The GWOU accounts for less than 7% of the ER project waste generated.

These volumes were used to provide appropriate weighting of the average for the concentration of each analyte in evaluation of the On-Site Alternative, similar to the process described in Section 4.2.3 for the D&D waste and as further detailed in Section 4.2.6. Soil and sediment analytical results for each remedial action site were downloaded from the Paducah DWGIS. Each SWMU boundary was identified and approximated within the Paducah DWGIS query to review characterization data available within the anticipated ER soil excavation footprint. Areas beyond the anticipated excavation area and depth were excluded to avoid potential low bias of the data set and to restrict data to the actual estimated waste volume.

The Soils OU, SWOU, and GWOU wastes collectively account for approximately 3% and 1% of the high-end and low-end waste volume scenarios, respectively, so the contribution of these wastes to the overall waste concentrations for evaluation is *de minimis*. Still, efforts were made to develop a reasonable waste profile.

Summary statistical analysis initially was performed for individual areas to derive appropriate data that was then used to provide a representative concentration for the ER projects’ waste profile. The arithmetic mean, median, minimum and maximum values, minimum and maximum detection limits, and the 95% UCL on the mean were calculated for each OU, in addition to number of samples and number of detections above the analytical MDL or PQL for nonradioactive analytes or MDC for radionuclides (see Appendix D for statistical calculations). Analytes that had maximum detected concentrations within each site below the screening criteria (e.g., surface and subsurface soil background values and SSLs) were eliminated from the database.

Table 4.9 shows the waste profile and associated COC concentrations for the ER projects; additional information is provided in Appendix D. Uncertainties associated with this approach are discussed in Section 4.3.

Table 4.9. PGDP Soils OU, SWOU, and GWOU Projects Waste Profile[1]

Contaminant	Maximum Activity or Concentration	Minimum Activity or Concentration
Radionuclides (pCi/g)		
Am-241	1.60	0.0700
Co-60	0.0600	0.0200
Cs-137	181	0.0200
Np-237	3.00	0.0120
Pu-238	0.383	0.166
Pu-239	7.90	0.00460
Ra-226	Nondetect	Nondetect

Table 4.9. PGDP Soils OU, SWOU, and GWOU Projects Waste Profile (Continued)

Contaminant	Maximum Activity or Concentration	Minimum Activity or Concentration
Tc-99	640	0.400
Th-228	0.867	0.398
Th-230	78.2	0.150
Th-232	1.09	0.367
U-234	71.0	0.0700
U-235	3.60	0.0130
U-238	190	0.0900
Metals[2] (mg/kg)		
Ag	73.9	0.00185
Al	17,100	2,270
As	45.2	1.63
Ba	1,620	1.27
Be	10.5	0.00594
Cd	6.53	0.00433
Co	16.1	0.0576
Cr	258	0.129
Cu	231	0.209
Fe	52,100	3,790
Hg	7.70	2.71E-04
Mn	2,720	3.04
Ni	85.4	0.298
Pb	323	3.13
Se	1.28	0.0960
Tl	1.56	0.117
U	6,500	11.2
V	43.2	0.231
Zn	390	14.1
Organics (mg/kg)		
Anthracene	84.3	3.77
Benz(a)anthracene	39.2	1.81
Benzo(a)pyrene	37.7	1.65
Benzo(b)fluoranthene	62.4	2.63
Benzo(k)fluoranthene	94.1	3.96
Chrysene	43.7	2.01
PAH Toxicity Equivalent	86.3	0.00820
Trichloroethene	79.0	0.00900
Vinyl chloride	4.80	0.700
PCB-1016	0.700	0.700
PCB-1242	0.610	0.270
PCB-1248	35.0	0.0200
PCB-1254	2.77	0.0310
PCB-1260	370	0.00500

Table 4.9. PGDP Soils OU, SWOU, and GWOU Projects Waste Profile (Continued)

Contaminant	Maximum Activity or Concentration	Minimum Activity or Concentration
Organics (mg/kg)		
PCB	73.0	0.0770
Dioxin/Furan Toxicity Equivalent	0.00106	4.00E-07
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	5.71E-04	7.00E-06
1,2,3,4,6,7,8-Heptachlorodibenzofuran	4.19E-04	7.00E-06
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	8.00E-05	1.00E-05
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.00E-05	1.00E-05
1,2,3,4,7,8-Hexachlorodibenzofuran	6.00E-05	3.00E-06
1,2,3,6,7,8-Hexachlorodibenzofuran	8.00E-05	1.00E-05
Octachlorodibenzo-p-dioxin	0.0126	4.00E-05
Octachlorodibenzofuran	0.00160	1.00E-05
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	0.00160	4.40E-06
Pentachlorodibenzofuran	0.00179	0.00179
1,2,3,7,8-Pentachlorodibenzofuran	9.00E-05	5.80E-06
2,3,4,7,8-Pentachlorodibenzofuran	5.00E-05	1.00E-05
2,3,7,8-Tetrachlorodibenzo-p-dioxin	6.00E-05	1.00E-05
2,3,7,8-Tetrachlorodibenzofuran	1.10E-04	1.00E-05

[1] Analytical data comes from data available in the PGDP data warehouse at the time the evaluation was initiated (i.e., 2009).
[2] Metals in bold are the metals regulated as toxicity characteristic metals under RCRA (D004—D011).
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
pCi/g = picocuries per gram

4.2.5 BGOU Analytical Profile

The waste within the BGOU has not been sampled or characterized other than some limited characterization data for the burial ground at SWMU 7 of the C-747-A Burial Ground area. The only other samples collected were around the perimeter of the burial grounds and are not representative of the BGOU waste that will be disposed of in an on-site waste disposal facility upon excavation. The waste placed in the burial ground at SWMUs 2, 3, and 4 is being evaluated for potential removal among other alternatives. Due to the limited data available for the PGDP BGOU wastes, waste characterization data from the ETTP BGOU were used as surrogate data for the PGDP BGOU.

Table 4.10 shows the BGOU waste profile and associated COC concentrations. Using the volume estimates in the 2007 approved LCB, it is estimated that the BGOU will generate a total of approximately 376,000 yd^3 of the 4 mcy (approximately 9% of the total volume) under the high-end waste volume scenario and 220,000 yd^3 in the low-end waste volume estimate of 1.5 mcy (approximately 15% of the total volume). These volumes are used to provide appropriate weighting of the average for the concentration of each analyte in evaluation of the On-Site Alternative. Uncertainties associated with this approach are discussed in Section 4.3.

The BGOU RI contains quantity estimates for wastes in various SWMUs (DOE 2009). These quantity estimates include pyrophoric uranium in SWMU 2 and uranium contaminated waste in SWMU 3. Although concentration data for these wastes are not available, the BGOU RI estimates that there are approximately 270 tons of uranium in SWMU 2 and approximately 3,300 tons of uranium in SWMU 3. The uranium consists of pieces of uranium metal and is not considered mobile due to insolubility in water (DOE 2009). As discussed previously, for the purposes of this RI/FS, the contaminant inventory limits defined by the PWAC apply only to mobile forms of a contaminant (e.g., nickel as a component of soil that is capable of dissolving into percolating water, etc.). Waste placed in a nonmobile form, such as nickel ingots or the solid uranium in SWMUs 2 and 3, etc., will not be subject to the contaminant inventory limits defined by the PWAC.

4.2.6 Comprehensive CERCLA Waste Forecast Weighted Average

A weighted average for the entire forecasted CERCLA waste volume was calculated by applying the specific waste profile analyte concentrations and the corresponding waste profile volume. Weighted averages were calculated for both the high-end and low-end volume estimates (see Table 4.11).

COCs for the total estimated waste volume were based on the COC list developed for the D&D waste profile. Different ER project waste profiles may have shorter COC lists; the ER waste profile COCs are included in the D&D waste profile COC list. This means that it is possible that a given ER project may not have data for each analyte in the D&D COC list. In general, this is not anticipated to change the overall results of this RI/FS because the analytes from a given ER project waste profile that also are not COCs are expected to have inconsequential contribution to risk in that particular waste.

Values for omitted analytes were selected using the higher value of one half of the maximum reported detected value for the dataset, one half of the MDL or PQL, the average of the reported estimated values as a bounding condition, or the minimum value reported in the other waste profiles.

The D&D waste volume accounts for approximately 85% of the waste volume for the weighted average calculation under the high-end waste volume scenario and 88% under the low-end waste volume scenario.

Table 4.10. BGOU Waste Profile

Contaminant	Activity or Concentration
Radionuclides (95% UCL—pCi/g)	
Am-241	2.75
Cs-137	0.244
K-40	26.3
Np-237	0.555
Pb-210	10.3
Ra-226	3.72
Ra-228	23.0
Tc-99	34.6
Th-228	21.4
Th-230	107
Th-232	19.3
U-233/234	1,430
U-235	177
U-238	922
Metals[1] (95% UCL—mg/kg)	
Sb	0.170
As	10.0
Ba	572
Be	3.14
Cd	0.931
Cr	66.1
Cu	323
Pb	44.1

Table 4.10. BGOU Waste Profile (Continued)

Contaminant	Activity or Concentration
Mn	2,394
Hg	0.689
Ni	5,471
Se	4.64
Ag	2.40
Tl	0.738
Zn	128
Organics (95% UCL—mg/kg)	
Acenaphthene	0.600
Acenaphthylene	0.200
Anthracene	2.40
BEHP	9.89
Benzo(a)anthracene	1.10
Benzo(a)pyrene	10.8
Benzo(b)fluoranthene	24.2
Benzo(k)fluoranthene	0.760
Carbazole	6.69
Chrysene	16.3
Dichloroethene (*cis*-1,2)	76.6
Dibenzo(ah)anthracene	1.60
Ethylbenzene	0.00734
Fluoranthene	45.8
Fluorene	5.64
Indeno(123-cd)pyrene	11.7
Naphthalene	4.47
PCB (total or sum of Aroclors)	11.1
Phenanthrene	41.0
Pyrene	34.1
Trichloroethene	0.100
Vinyl Chloride	0.0187
Xylene (total)	0.00742

[1] Metals in bold are the metals regulated as toxicity characteristic metals under RCRA (D004—D011).
BEHP = bis 2-ethylhexyl phthalate
mg/kg = milligrams per kilogram
PCB = polychlorinated biphenyl
pCi/g = picocuries per gram
95% UCL = 95% upper confidence limit on the mean

Table 4.11. Waste Contaminant Concentration for the On-Site CERCLA Disposal Facility Alternative

Contaminant	High-Volume Building D&D Profile[1]	Low-Volume Building D&D Profile[2]	BGOU Profile[3,4]	SOU, SWOU, and GWOU Waste Profile[5,6]	High-Volume Disposal Cell Contaminant Concentration	Low-Volume Disposal Cell Contaminant Concentration
Radionuclides (95% UCL - pCi/g)						
Am-241	1.19E-01	2.48E-01	2.75E+00	1.60E+00	3.84E-01	6.15E-01
Cs-137	8.80E-02	1.60E-01	2.44E-01	1.81E+02	8.02E-01	1.32E+00
K-40	--	--	2.63E+01	--	6.75E-06	1.70E-05
Np-237	1.98E+00	4.90E+00	5.55E-01	3.00E+00	2.55E+00	4.33E+00
Pu-238	6.00E-02	1.35E-01	--	3.83E-01	8.02E-02	1.24E-01
Pu-239/240	5.34E-02	1.18E-01	--	7.90E+00	9.98E-02	1.58E-01
Tc-99	3.76E-01	7.36E-01	3.46E+01	6.40E+02	5.72E+00	9.61E+00
Th-228	1.96E-01	3.54E-01	2.14E+01	8.67E-01	2.03E+00	3.35E+00
Th-230	2.74E-01	4.96E-01	1.07E+02	7.82E+01	9.54E+00	1.61E+01
Th-232	1.04E-01	1.88E-01	1.93E+01	1.09E+00	1.74E+00	2.91E+00
U-233/234	1.10E+03	2.73E+03	1.43E+03	7.10E+01	1.50E+03	2.56E+03
U-235	4.36E+01	1.08E+02	1.77E+02	3.60E+00	6.96E+01	1.19E+02
U-238	2.24E+01	5.56E+01	9.22E+02	1.90E+02	1.06E+02	1.80E+02
Metals (95% UCL - mg/kg)						
Al	17.5	28.8	--	17,100	52.3	76.7
Sb	0.525	1.24	0.170	--	0.662	1.08
As	1.88	2.63	10.0	45.2	2.51	2.53
Ba	13.0	1.81	572	1,620	23.6	13.9
Be	0.0407	0.00479	3.14	10.5	0.0930	0.0756
Cd	0.275	0.626	0.931	6.53	0.363	0.570
Cr	7.35	5.21	66.1	258	10.2	6.09
Cu	33.7	49.4	323	231	45.5	48.1
Pb	23.9	52.5	44.1	323	30.9	46.7
Mn	47.0	77.0	2,394	2,720	83.8	109
Hg	0.0905	0.223	0.689	7.70	0.130	0.221
Ni	7.72	5.61	5,471	85.4	57.8	87.0
Se	2.41	5.72	4.64	1.28	3.08	5.01
Ag	0.223	0.525	2.40	73.9	0.402	0.661
Sr	2.91	5.96	--	--	3.66	5.14
Tl	0.143	0.0821	0.738	1.56	0.189	0.086
V	2.31	1.50	--	43.2	3.07	1.57
Zn	529	1,317	128	390	667	1,140
Organics (95% UCL - mg/kg)						
Acenaphthene	0.249	0.465	0.600	--	0.319	0.410
Acetone	6.56E-04	0.00163	--	--	0.00240	0.00411
Acetophenone	0.00199	0.00497	--	--	0.00251	0.00429
Anthracene	0.0202	0.00230	2.40	84.3	0.161	0.234
BEHP	2.37E-04	5.91E-04	9.89	--	0.0869	0.149

Table 4.11. Waste Contaminant Concentration for the On-Site CERCLA Disposal Facility Alternative (Continued)

Contaminant	High-Volume Building D&D Profile[1]	Low-Volume Building D&D Profile[2]	BGOU Profile[3,4]	SOU, SWOU, and GWOU Waste Profile[5,6]	High-Volume Disposal Cell Contaminant Concentration	Low-Volume Disposal Cell Contaminant Concentration
Benzo(a)anthracene	0.0337	0.00403	1.10	39.2	0.105	0.111
Benzo(a)pyrene	0.0259	0.00315	10.8	37.7	0.178	0.252
Benzo(b)fluoranthene	0.0314	0.00376	24.2	62.4	0.336	0.511
Benzo(ghi)perylene	0.00E+00	0.00E+00	--	--	0.00E+00	0.00E+00
Benzo(k)fluoranthene	0.0384	0.00456	0.760	94.1	0.183	0.234
Benzoic Acid	0.00577	0.0144	--	--	0.00726	0.0124
BHC (beta-)	2.92E-06	7.28E-06	--	--	3.67E-06	6.28E-06
Butanone (1-)	8.00E-07	1.99E-06	--	--	1.01E-06	1.72E-06
Butyl benzyl phthalate	6.21E-05	1.55E-04	--	--	7.81E-05	1.34E-04
Carbazole	0.366	0.740	6.69	--	0.519	0.739
Chlordane (gamma-)	3.73E-04	9.29E-04	--	--	4.69E-04	8.02E-04
Chloro-3-methylphenol (4-)	5.48E-05	1.36E-04	--	--	6.89E-05	1.18E-04
Chloroform	1.26E-04	1.58E-05	--	--	2.94E-04	2.46E-04
Chrysene	0.0219	0.00251	16.3	43.7	0.230	0.348
Cresol (o-)	0.00E+00	0.00E+00	--	--	0.00E+00	0.00E+00
Cresol (p-)	0.00E+00	0.00E+00	--	--	0.00E+00	0.00E+00
Cumene	9.42E-07	2.35E-06	--	--	1.19E-06	2.03E-06
DCE (*cis*-1,2-)	3.91E-04	4.58E-05	76.6	--	0.672	1.15
DDD (4,4'-)	4.30E-04	0.00107	--	--	5.41E-04	9.25E-04
DDE (4,4'-)	0.0110	0.0275	--	--	0.0139	0.0238
DDT (4,4'-)	0.00355	0.00884	--	--	0.00447	0.00764
Dibenzo(ah)anthracene	0.141	0.0161	1.60	--	0.191	0.0378
Dibenzofuran	0.00E+00	0.00E+00	--	--	0.00E+00	0.00E+00
Dieldrin	0.00938	0.00106	--	--	0.0123	0.00182
Diethyl phthalate	0.00263	0.00656	--	--	0.00331	0.00566
Dimethylbenzene (1,2-)	5.26E-07	1.31E-06	--	--	6.61E-07	1.13E-06
Di-n-butyl phthalate	0.00417	0.0104	--	--	0.00525	0.00898
Di-n-octyl phthalate	6.17E-05	1.54E-04	--	--	7.76E-05	1.33E-04
Endosulfan II	3.65E-06	9.10E-06	--	--	4.59E-06	7.86E-06
Endosulfan sulfate	2.56E-06	6.37E-06	--	--	3.22E-06	5.50E-06
Endrin	2.56E-06	6.37E-06	--	--	3.22E-06	5.50E-06
Endrin Aldehyde	8.27E-05	2.06E-04	--	--	1.04E-04	1.78E-04
Ethylbenzene	3.91E-04	4.48E-05	0.00734	--	5.56E-04	1.49E-04
Fluoranthene	0.0578	0.00657	45.8	--	0.474	0.692
Fluorene	0.0610	0.00710	5.64	--	0.126	0.0906
Heptachlor epoxide	7.30E-07	1.82E-06	--	--	9.19E-07	1.57E-06
Hexanone (2-)	5.40E-07	1.35E-06	--	--	6.80E-07	1.16E-06
Indeno(123-cd)pyrene	0.059	0.00683	11.7	--	0.176	0.181
Methyl naphthalene (2-)	0.102	0.253	--	--	0.128	0.219
Methyl-2-pentanone (4-)	9.13E-08	2.27E-07	--	--	1.15E-07	1.96E-07
Methylphenol (2-)	0.00E+00	0.00E+00	--	--	0.00E+00	0.00E+00
Methylphenol (3&4-)	0.00E+00	0.00E+00	--	--	0.00E+00	0.00E+00
Methylene chloride	2.19E-07	5.46E-07	--	--	2.76E-07	4.71E-07

Table 4.11. Waste Contaminant Concentration for the On-Site CERCLA Disposal Facility Alternative (Continued)

Contaminant	High-Volume Building D&D Profile[1]	Low-Volume Building D&D Profile[2]	BGOU Profile[3,4]	SOU, SWOU, and GWOU Waste Profile[5,6]	High-Volume Disposal Cell Contaminant Concentration	Low-Volume Disposal Cell Contaminant Concentration
Naphthalene	0.378	0.879	4.47	--	0.515	0.826
PCB - Aroclor 1016	8.77E-04	0.00E+00	--	--	0.00110	0.00E+00
PCB - Aroclor 1221	8.79E-04	0.00E+00	--	--	0.00111	0.00E+00
PCB - Aroclor 1232	8.78E-04	0.00E+00	--	--	0.00110	0.00E+00
PCB - Aroclor 1242	0.0799	0.00E+00	--	--	0.101	0.00E+00
PCB - Aroclor 1248	0.271	0.00E+00	--	--	0.341	0.00E+00
PCB - Aroclor 1254	0.123	0.00E+00	--	--	0.155	0.00E+00
PCB - Aroclor 1260	0.0318	0.00E+00	--	--	0.040	0.00E+00
PCB (Total)	0.533	0.00E+00	11.1	73.0	0.671	0.00E+00
Pentachlorophenol	0.00273	0.00682	--	--	0.00344	0.00588
Phenanthrene	0.0266	0.00305	41.0	--	0.393	0.617
Phenol	1.28E-04	3.18E-04	--	--	1.61E-04	2.75E-04
Pyrene	0.0446	0.00520	34.1	--	0.355	0.515
TCE	3.14E-04	3.80E-05	0.100	79.0	0.109	0.185
PCE	1.57E-04	1.93E-05	--	--	3.33E-04	2.49E-04
Tetrachlorophenol (2,3,4,6-)	0.00184	0.00458	--	--	0.00231	0.0040
Toluene	1.24E-07	3.09E-07	--	--	1.56E-07	2.67E-07
Vinyl Chloride	0.00016	1.93E-05	0.0187	4.80	0.00688	0.0114
Xylenes (M+P)	0.00039	4.67E-05	0.00742	--	5.58E-04	1.51E-04
Dioxin/Furan Toxicity Equivalent	0.00E+00	0.00E+00	--	0.00106	0.00E+00	0.00E+00

1 - Total Building D&D High-Volume Estimate (CY): 3,404,710
2 - Total Building D&D Low-Volume Estimate (CY): 1,318,040
3 - Total BGOU Waste High-Volume Estimate (CY): 375,710
4 - Total BGOU Waste Low-Volume Estimate (CY): 220,140
5 - SOU, SWOU, & GWOU Waste High-Vol Est (CY): 118,250
6 - SOU, SWOU, & GWOU Waste Low-Vol Est (CY): 9,960
BHC - 1,2,3,4,5,6-hexachlorocyclohexane
BEHP - bis 2-ethylhexyl phthalate
DCE - dichloroethene
DDD - dichlorodiphenyldichloroethane
DDE - dichlorodiphenyldichloroethene
DDT - dichlorodiphenyltrichloroethane
mg/kg - milligrams per kilogram
PCB - polychlorinated biphenyl
PCE - perchloroethene
pCi/g - picocuries per gram
TCE - trichloroethene
UCL - upper confidence limit on the mean

The lack of concentration data for the analytes omitted from the COC list for this RI/FS may bias the weighted concentration or activity average in the following ways:

- If the omitted data are ignored and the volume weighted concentration (or activity) average is based only on available COC data, the calculated weighted average would be biased high. This is because the concentration portion of the calculation considers only COC concentrations without regard to lower concentrations of COC analytes that may be present in other ER waste, but are not COCs for other waste.

- If the weighted average is based on the available COC data and it is assumed that COC analytes not included as COCs in a given waste are equivalent to no contamination (i.e., the data point is set to some value related to the analytical MDL or PQL for nonradioactive analytes or the MDC for radiological analytes), the calculated volume weighted concentration (or activity) average may be biased low. This is because some concentrations of these analytes may exist between the MDL or PQL and the concentration that would have triggered inclusion of the analyte in a COC list.

4.3 UNCERTAINTIES

The base case waste volumes presented in Table 4.3 was developed based on information in the 2007 approved LCB available at the time of initiating PWAC development (2009). As new information becomes available (e.g., from RIs conducted at the OUs), the waste forecast may change. As such, the waste volume data contain some inherent uncertainty, including the following.

- Remedial strategy or cleanup goals. The waste inventory associated with future CERCLA actions was developed from information contained in the PGDP LCB, which is based on current remediation strategies. Depending on the actual remedial strategies and cleanup criteria, the waste volumes and analytical profiles may change.

- Decision uncertainty. A burial ground may be capped in place rather than completely excavated. Similarly, a building may be reindustrialized in the future and not demolished within the forecast period (2014 to 2039). The relative impact due to decision uncertainty associated with the non-D&D projects is anticipated to be small compared to the overall volume generated by the D&D actions.

- Volume variability. The waste volume estimates are based on preliminary analysis of depth and lateral extent of contamination; however, when ER and D&D actions commence, the actual area of contamination may be less than or greater than estimated. The high- and low-end volume estimates are used to account for volume variability.

- Treatment. Some waste types may require treatment to meet the WAC of the disposal facility. Treatment technologies can increase or decrease waste volume. It has been assumed, for this evaluation, that there will be no net change in the total volume of waste following treatment. Although there is uncertainty with this assumption, this uncertainty is bounded by the overall waste variability.

- Recycling/Reuse. Some of the waste materials may be recycled or reused. This could reduce the overall waste disposal volume. This uncertainty is addressed through the low-end waste volume estimate.

- Schedule uncertainty. Project sequencing, budgetary constraints, or changes in remedial strategy may result in changes to the annual waste generation rates compared to the project forecasts available at the time of this RI/FS evaluation. This uncertainty is addressed through using an average volume of waste per year for cost elements.

- Other uncertainties. There are uncertainties related to assumptions used to develop the waste forecast itself. Some of the projected waste generation or waste management activities may not actually occur. For instance, waste volumes may increase for a given activity based on new analytical data, indicating larger extents than originally calculated.

Surrogate waste profile data from ETTP were used in this evaluation to characterize PGDP D&D and BGOU waste. The following provides a list of uncertainties associated with the waste profiles.

- The K-25 facilities at ETTP used the same gaseous diffusion process as PGDP and presumably had similar operations, but several potential differences could affect the actual waste profiles:

  — PGDP processed much more reactor waste (spent uranium) from DOE-Hanford and DOE-Savannah River than ETTP, so different levels of Np-237, Am-241, Pu-239/240, and Tc-99 likely are in the piping and converters of the PGDP cascade system.

  — PGDP continues operations that would purge reactor tail contaminants from the cascade, whereas operations at K-25 ceased in 1985 with more contaminants trapped in the cascade.

  — Maintenance activities, such as the CIP/CUP, may have been different at the two facilities, causing a difference in residual contamination.

  — PGDP is anticipated to undergo a systematic shutdown upon closure that may reduce residual contaminants in the cascade and the facilities.

  — The K-25 waste profiles from ETTP used as surrogates for some PGDP D&D wastes do not include all of the K-25 structure, and equipment may have variable contaminant concentrations. Additional waste characterization data are being generated for K-25 that may change the waste profile data used as surrogates for PGDP. In particular, increases in Tc-99 waste profile values at K-25 could increase the volume estimate for waste potentially excluded from disposal in an on-site waste disposal facility at PGDP.

  — The final closure of the two sites may be different, such that more residual contamination is removed prior to D&D activities at PGDP.

- The burial grounds at ETTP may have received different waste than the BGOU at PGDP. Also, some burial grounds at PGDP may be capped in place without removal of all wastes, which may differ from the remediation strategy at ETTP.

- The correlation of waste profiles at PGDP and ETTP assumes similar historical operations; however, operations at each site for any given facility may have been different at various times.

- The ETTP waste profiles were developed based on an aggressive sampling and analysis plan that typically sampled the most likely areas to be contaminated (i.e., biased hot-spot sampling) with use of the 95% UCL on the mean. This would result in a high bias of the 95% UCL of the mean, may not be representative of conditions at PGDP, and may result in concentrations used as surrogates for PGDP-derived wastes that are biased high.

- The evaluation considered PGDP soil and sediment analytical data within the planned area of excavation for each SWMU or AOC. Lower activities/concentrations in the surrounding soils were excluded in order to bound the values on the high side. Since the excavation of some surrounding less-contaminated soils is likely, the actual volume weighted activities/concentrations may be less than calculated.

- COCs were based on historical information as well as surrogate waste profiles from ETTP. Future waste characterization sampling may add or eliminate COCs.

- Several COCs were retained in waste profiles for PGDP facilities and SWMUs or AOCs, but no data were available from the surrogate ETTP waste profiles used. Concentrations for omitted analytes were incorporated using the methodology described in Section 4.2.6, potentially resulting in low or high bias to the volume-weighted concentration or activity averages.

- The waste profiles and volumes associated with the D&D activities were segregated into various waste types (LLW/RCRA/TSCA/MLLW, nonhazardous) based on previous waste estimates and using engineering judgment for each facility. Analytical waste characterization has not been performed to verify these classifications.

5. DETAILED DESCRIPTION OF ALTERNATIVES

This chapter describes the remedial action objectives (RAOs) for this RI/FS and provides a detailed description of the three CERCLA waste disposal alternatives:[*] No Action, Off-Site Disposal, and On-Site Disposal. The No Action Alternative is described in Section 5.2. For the Off-Site Alternative, Section 5.3 provides a description of the off-site waste disposal facilities, their WAC requirements, waste packaging considerations, and waste transportation capabilities. For the On-Site Alternative, Section 5.4 provides details of the candidate site screening, conceptual design, construction sequencing, operations, PWAC, closure, and postclosure.

5.1 REMEDIAL ACTION OBJECTIVES

The purpose of this remedial action is to develop a sitewide strategy for disposing of CERCLA wastes generated during future ER of PGDP and to facilitate cleanup of individual SWMUs, AOCs, buildings, and D&D of PGDP and associated facilities. The CERCLA disposal waste includes LLW/RCRA/TSCA/MLLW in combination with nonhazardous solid wastes. The waste includes soil, sediment, concrete, scrap metal, building demolition debris, and other dry waste.

While it is recognized that some wastes may require chemical or physical treatment prior to disposal, it is the responsibility of the waste-generating project to meet the WAC of the disposal facility (whether on-site or off-site). Waste treatment would be evaluated and documented on a project-specific basis and would be the responsibility of the generating project; therefore, costs associated with waste treatment, if needed, are not included in this RI/FS.

CERCLA guidance defines RAOs as "medium-specific or OU-specific goals for protecting human health and the environment" (EPA 1988). According to the NCP [40 *CFR* § 300.430(e)(2)(i)], RAOs should specify the media and COCs, potential exposure pathways, and remediation goals. Because the action associated with this RI/FS is to evaluate disposal alternatives for waste types derived from a wide range of sources and activities, it is not appropriate to establish specific cleanup goals within OU source areas or impacted media. Instead, these goals will be developed at the project level during remediation planning.

The following RAOs have been established for the On-Site Alternative:

- Prevent releases of CERCLA waste from a disposal cell that result in a contaminant concentration in groundwater that exceeds the higher of the background concentration or the maximum contaminant level (MCL)[17] or, if neither an MCL nor background concentration is available, the residential risk-based no action level (NAL) (DOE 2011b), at the edge of waste (EOW);

- Prevent exposure by a human receptor to contaminants migrating from CERCLA waste that results in a cumulative human health risk after management in excess of risk-based and hazard-based target levels [i.e., when contaminant levels are greater than background, a cumulative risk in excess of the

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[*]The C-746-U Landfill can accept certain nonhazardous solid waste generated by CERCLA activities at PGDP. Nonhazardous solid waste generated under CERCLA would be eligible for disposal at either a potential on-site WDF or the C-746-U Landfill. Waste disposal decisions will be made on a project-by-project basis. It is anticipated that PGDP CERCLA projects typically will dispose of nonhazardous solid waste at the C-746-U Landfill; however, in some cases, projects may dispose of solid waste at a potential on-site WDF based on project efficiency and operational considerations such as managing project waste characterization and segregation resources; maximizing operational efficiencies at the C-746-U Landfill and a potential on-site WDF; and efficiently utilizing air space at the C-746-U Landfill and a potential WDF. For purposes of this RI/FS, each of the remedial action alternatives is assumed to utilize this approach.

[17] Secondary MCLs are not considered.

EPA risk range of 1E-04 to 1E-06 or hazard index (HI) = 1 to 3]. When groundwater modeling predicts that a single contaminant will be present in groundwater at a point of exposure at the waste facility boundary or DOE property boundary, the MCL for the chemical will be used as a protective value consistent with EPA guidance (EPA 1991). In making this determination, a "single contaminant" will be considered to be predicted and present when concentrations of all other contaminants within the same time interval are predicted to be below their residential NAL (derived using a target HI of 0.1 and/or a target ELCR of 1E-06) or background concentration in groundwater.

- Prevent exposure to or direct contact with buried waste or its progeny for as long as the waste presents unacceptable risk (i.e., cumulative risk after management in excess of the EPA risk range of 1E-04 to 1E-06 or HI = 1).

The DOE remediation strategy for PGDP is to complete the cleanup in two phases: (1) pre-gaseous diffusion plant (GDP) shutdown; and (2) post-GDP shutdown. Currently, remediation activities in the pre-GDP shutdown OUs are on-going and preliminary planning for post-PGDP shutdown has been initiated. Additional detail can be found in the Site Management Plan (DOE 2013). These RAOs support this strategy by evaluating disposal options for both phases of the remediation, holistically.

The On-Site Disposal Alternative involves the construction of a new on-site CERCLA WDF at PGDP. For this alternative, these RAOs have been applied in establishing PWAC for an on-site WDF. The PWAC specify the waste types and COCs for which specific concentration or activity limits are needed. Development of the PWAC is presented in Section 5.4.6 and detailed in Appendix C, which also describes the potential exposure pathways, receptors, fate and transport modeling, and risk and dose assessment procedures that were used.

5.2 NO ACTION ALTERNATIVE

The NCP requires that the No Action Alternative be considered and carried through the FS analysis in order to provide a baseline for comparison with other alternatives. The No Action Alternative meets this condition. Under the No Action Alternative, no change would take place in the current waste disposal practices. Each OU-specific remedial action project would evaluate and select a method of CERCLA waste disposal. Waste that meets the WAC of the on-site C-746-U Landfill would be disposed of there; otherwise, waste would be shipped to appropriate off-site disposal facilities. It is assumed that there would be no waste reduction efforts. The No Action Alternative is evaluated for the off-site base case (most likely) waste volume scenario, as described in Section 4.1.

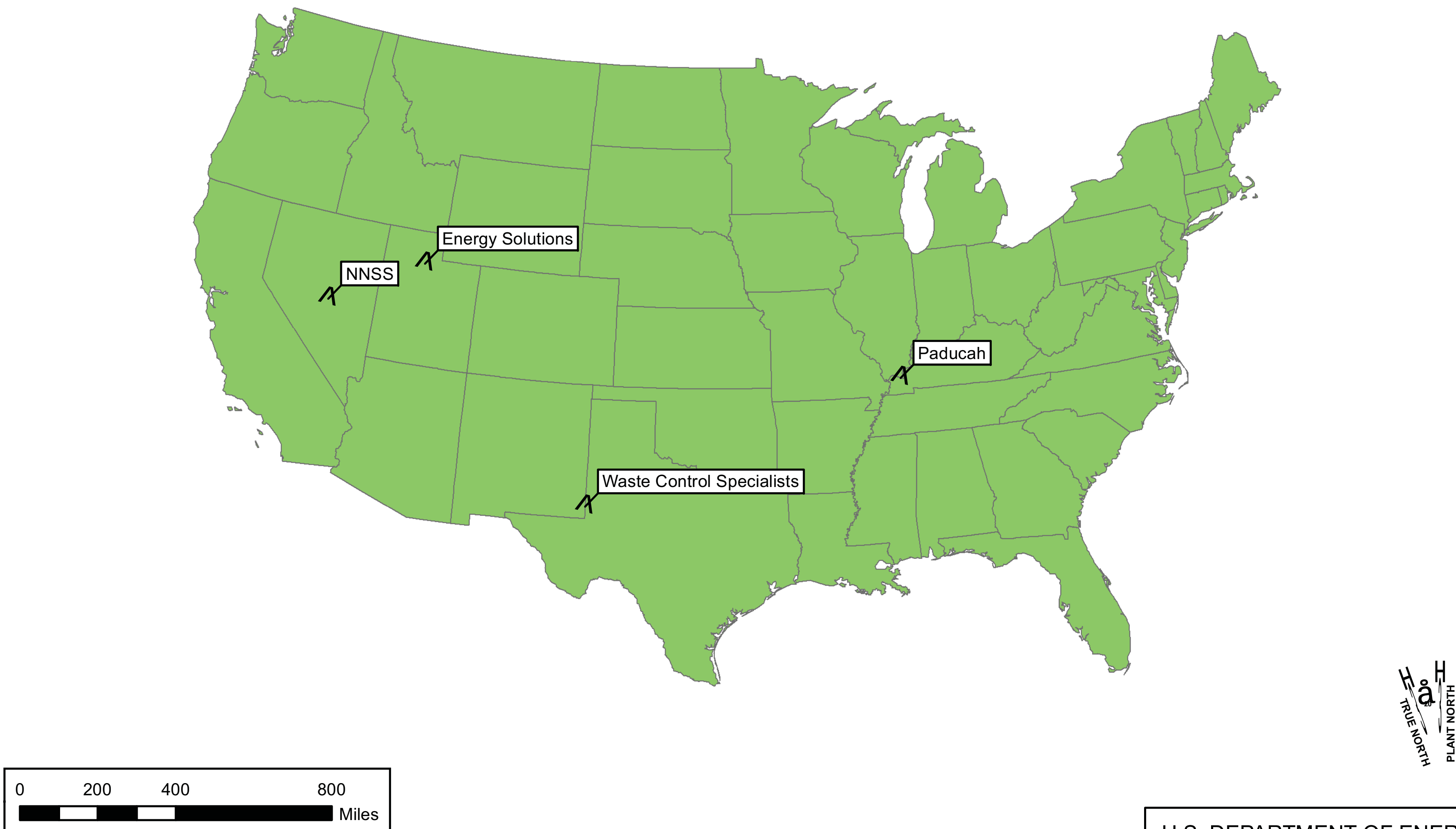
It is assumed for this RI/FS that the primary off-site disposal facility for PGDP nonclassified LLW/RCRA/TSCA/MLLW would be the Energy*Solutions* facility in Clive, Utah. This is because it is possible to ship waste in bulk containers to that facility by rail, which results in lower overall disposal costs than shipping waste by truck to Energy*Solutions* or Nevada National Security Site (NNSS) in Mercury, Nevada. NNSS is the only facility used for disposing of PGDP classified wastes. The license for the federal waste portion of the Waste Control Specialists (WCS) facility in Andrews County, Texas, was issued on September 18, 2012. As of December 20, 2012, the DOE approval process had not been completed. This facility may be considered and evaluated for future waste shipments after the facility is approved by DOE for waste disposal, as long as the transportation and disposal costs in the RI/FS are representative of WCS cost. Other assumptions and details of off-site waste disposal for the No Action Alternative are the same as for the Off-Site Alternative, and are presented in Section 5.3.

5.3 OFF-SITE ALTERNATIVE

The Off-Site Alternative includes two waste volume scenarios for comparison purposes: (1) a high-end waste volume scenario for which CERCLA waste (including waste that would meet the WAC for the C-746-U Landfill) is assumed to be shipped off-site; and (2) a low-end waste volume (3.2 mcy) scenario, which assumes various waste volume reduction actions, continued use of the on-site C-746-U Landfill for waste that meets that facility's WAC, and off-site disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill. The base case (most likely) waste volume scenario is based on waste forecasts developed directly from DOE's LCB (DOE 2006), which includes volume estimates for currently planned remediation efforts and estimated volumes for D&D of the GDP and associated environmental remediation actions. It should be noted that the LCB is periodically adjusted as additional information becomes available, including volume estimates. Changes in volume are an uncertainty. The base case has the same volume assumptions and amounts as the No Action Alternative. This volume is composed of 2.5 mcy of LLW/RCRA/TSCA/MLLW that would require off-site disposal and 1.1 mcy of waste that would meet the C-746-U Landfill WAC and be disposed of at the C-746-U Landfill. The base case volume scenario does not assume any recycling, reuse, or other waste reduction initiatives.

Waste packaging would be dependent on the waste form, waste category, and mode of transportation. The transportation method would be dependent on the disposal facility. The disposal facilities that may be used include Energy*Solutions* in Clive, Utah and NNSS in Mercury, Nevada. Energy*Solutions* can be reached either by rail or truck; NNSS can be reached primarily by truck. Although waste can be shipped a portion of the distance by rail, it must be transferred to trucks for the remaining distance and is used in limited applications. Prior attempts by PGDP to ship waste by rail and truck to NNSS proved less cost effective compared to shipment by truck due to the additional administrative requirements (e.g., meeting compliance requirements and paperwork for both transportation modes); additional staffing requirements for the transload facility and oversight; and time and costs associated with transferring the loads. One of the largest cost impacts related to transload efforts is the long turn-around time on railcars and leased cargo containers. Typically, these types of conveyances (railcars with intermodals) are not government-owned equipment and are leased rather than purchased because the railcars and intermodals are expensive to purchase. The shipments may take over two weeks to be transported to the transload facility; several days to be transferred to truck and shipped to NNSS; and, depending on NNSS turnaround of empty containers, it may take many more days or weeks to arrive back at the transload facility. Once back at the transload facility, it may take another two or more weeks to return the containers to the site for reuse. Demurrage costs are incurred daily when containers and railcars are not actively being transported. Additionally, if there is a large project where containers are being filled at a steady pace, a substantial fleet of containers and railcars would need to be secured to ensure steady operations. Therefore, only truck shipments to NNSS are evaluated within this RI/FS. A map showing the locations of the off-site disposal facilities is presented in Figure 5.1. Transportation risks are included in Appendix E, Attachment E1.

The development of the Off-Site Alternative was based on current PGDP off-site waste disposal practices. This strategy provides a sound basis for establishing implementability considerations, current information on shipping container types, transportation methods and routes, familiarity with disposal facility waste acceptance requirements, and cost experience. If this alternative is selected as the preferred remedy, off-site disposal facilities that may become available in the future also would be considered over the course of disposal operations as a method to validate and maintain cost efficiency. One such facility is Waste Control Specialists in Andrews County, Texas. The license for the federal waste portion of the WCS facility in Andrews County, Texas, was issued on September 18, 2012. As of December 20, 2012, the DOE approval process had not been completed. This facility may be considered and evaluated for future waste shipments after the facility is approved by DOE for waste disposal, as long as the transportation and disposal costs in the RI/FS are representative of WCS cost. As a result, this facility could be considered for future PGDP wastes, although the WAC and costs would need to be reviewed.



U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

Figure 5.1. Off-site Disposal Facility Locations

LATA Environmental Services of Kentucky, LLC

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Energy*Solutions* is assumed to be the primary off-site disposal facility for nonclassified LLW/RCRA/TSCA/MLLW. This is based on a review of site shipping records from 2006 to 2011 that compared various combinations of container types and transportation methods for disposal of PGDP waste at Energy*Solutions* and NNSS. Primarily because of the ability to ship waste more cost effectively in bulk containers by rail, Energy*Solutions* resulted in the lower overall nonclassified LLW/RCRA/TSCA/MLLW disposal cost (combination of container, transportation, and disposal). In the RI/FS, it is assumed that this facility will provide the lower off-site disposal cost. Another consideration for this facility is its capacity to accept the PGDP waste volume and waste generation schedule.

It is assumed that the relatively small volume of classified waste (~196,100 yd^3 from the LCB) will be disposed of at NNSS. Wastes shipped to NNSS would be shipped via truck in DOE-compliant containers or packages. NNSS facility staff indicated that they could accept the classified waste volume in the forecast; however, the current closure date of cells that are currently operational is 2027, which does not accommodate the completion date of for post-GDP shutdown D&D and remediation in 2039. It is assumed that for the purposes of this RI/FS, DOE either would extend operations at NNSS or another disposal facility capable of accepting classified wastes for the DOE complex that would be identified prior to 2028 and be available through 2040. It is recognized that there is uncertainty associated with these assumptions, and it is possible that an off-site facility would not be available.

5.3.1 Disposal Facility Descriptions and Waste Acceptance

Off-site disposal facilities that can accept LLW/RCRA/TSCA/MLLW waste types are required for the Off-Site Alternative. The off-site disposal costs (for both the high-end and low-end waste volume scenarios) are based on transportation to and disposal at these facilities. This subsection describes the Energy*Solutions* and NNSS facilities. Table 5.1 summarizes off-site disposal facilities, waste container types, and transportation methods used in the cost estimate for the Off-Site Alternative.

DOE is responsible for waste characterization and certification; waste segregation, compaction, or shredding; and treatment necessary to meet a disposal facility's WAC. These costs are not included in this RI/FS, as these will be the responsibility of the individual OU-specific projects.

5.3.1.1 Energy*Solutions* of Clive, Utah

Description. Energy*Solutions*, located approximately 75 miles west of Salt Lake City in Clive, Utah, is licensed and permitted to receive LLW, MLLW (i.e., LLW/RCRA, LLW/TSCA), uranium/thorium mill tailings, naturally occurring radioactive material, and accelerator-produced radioactive material for disposal. The facility is located in a remote Utah desert with low precipitation and nonpotable groundwater, within a 100 square mile hazardous waste zone established by the state of Utah. The nearest population center is approximately 40 miles away.

The Energy*Solutions* disposal facility is an abovegrade, engineered disposal facility with four lined disposal cells to segregate waste types. The facility design for the LLW and MLLW cells was patterned after DOE and EPA specifications for the disposal embankments (cells) built for cleanup of the Vitro Mill Site in Salt Lake City, Utah, under the DOE Uranium Mill Tailings Remedial Action Program. The liner of the facility contains a natural clay foundation and a clay layer, and the cap contains a 7-ft clay radon barrier, drainage/frost protection layer, and a coarse rock erosion barrier. The waste is deposited in 12-inch layers and then compacted.

Table 5.1. Off-Site Disposal Facilities

Transportation, Storage, and Disposal Facility (TSDF) (Vendor)[6]	Waste Type, Container, and Transportation Method			Rail Access
	Waste Type	Potential Container	Potential Transportation Method	
Energy*Solutions* Clive, Utah	High density LLW[1] Low density LLW[1] High density TSCA[2] waste Low density TSCA[2] waste MLLW[3] MLLW[3]	Low-sided gondola High-sided gondola Low-sided gondola High-sided gondola Low-sided gondola Sealand	Rail Rail Rail Rail Rail Truck	Yes
Nevada National Security Site (NNSS)[4] Mercury, Nevada	Classified Waste LLW	Sealand (B-25/ST-90)	Truck	No[5]

[1] Includes waste that meets the WAC of the C-746-U Landfill in the high-end waste volume scenario.
[2] TSCA also includes LLW/TSCA.
[3] MLLW also includes LLW/RCRA, LLW/RCRA/TSCA, and RCRA.
[4] Although NNSS can receive a wider range of waste types, this analysis assumes primary shipment to Energy*Solutions* and the only wastes assumed for shipment to NNSS are classified wastes.
[5] As noted in the text, there is not direct rail access to NNSS. Transloading rail shipments to truck to complete shipment to NNSS is feasible; however, classified shipment may require security controls or measures that are not conducive to rail shipments. Historical use of transloading was found to be cost effective only in limited instances.
[6] As of December 20, 2012, the DOE approval process had not been completed. The license for the WCS facility in Andrews County, Texas, for the federal waste portion was not issued until after the preliminary off-site alternative evaluation was conducted; however, WCS may be considered and evaluated for future off-site disposal.

Waste received at this facility must be packaged to meet U.S. Department of Transportation (DOT) regulations. Packaging options acceptable at Energy*Solutions* include bags, boxes, drums, gondola railcars, dump trucks, Sealand containers, intermodal containers, and roll-off containers. Other containers are acceptable on a case-by-case basis. Bulk shipment of wastes can be accepted in lined trucks or railcars.

The Energy*Solutions* facility is capable of receiving both rail and truck shipments and can receive up to 150 railcars or 80 trucks a day, respectively. The rail route to Energy*Solutions* from Paducah in travel distance is approximately 2,092 rail miles, with three rail companies (Paducah and Louisville Railroad, Canadian National Railroad, and Union Pacific Railroad) that provide service. Truck transportation to Energy*Solutions* is approximately 1,670 road miles.

Waste Acceptance. The waste acceptance process at Energy*Solutions* includes the following:

- Conduct initial discussions with Energy*Solutions*;
- Sample and characterize waste;
- Complete and submit waste profile record;
- Complete treatability and solidification study (if required);
- Review waste profile and gain approval; and
- Receive notice to transport.

Specific items that cannot be disposed of at Energy*Solutions* include sealed sources, shock-sensitive waste and materials, batteries, water- or air-reactive waste and materials (e.g., unstabilized trap material), and classified waste.

MLLW must meet applicable requirements of RCRA standards 40 *CFR* § 264 and 268 for treatment and disposal. Nonradioactive hazardous waste, waste containing free liquids, fine particulate waste (unless immobilized), compressed gases, explosive waste, pyrophoric waste, waste containing etiologic agents, and waste containing greater than 1% chelating agents cannot be accepted for disposal.

Representative samples of the waste are analyzed by Energy*Solutions* for TCLP, radionuclides, and other analytes as required to verify that the waste meets acceptance parameters per the facility WAC, and to establish incoming shipment tolerances. Energy*Solutions* or an independent third party may conduct chemical screening analyses, but the radiological analyses must be conducted by a third party.

5.3.1.2 Nevada National Security Site, Mercury, Nevada

Description. NNSS is a DOE site designated for the disposal of LLW and MLLW generated as the result of cleanup activities across the DOE complex. NNSS encompasses approximately 1,375 square miles and is one of the largest restricted access areas in the United States. The remote site is surrounded by thousands of acres of land withdrawn from the public domain for use as a protected wildlife range and for a military gunnery range, creating an unpopulated land area comprising some 5,470 square miles. NNSS is located 65 miles north of Las Vegas. There are 400 miles of paved roads and 300 miles of unpaved roads, two airstrips, and 10 heliports at NNSS, as well as several active water wells and an electric power transmission system.

National Security Technologies, LLC, operates the NNSS Subtitle D and RCRA Subtitle C landfills. NNSS accepts solid LLW and treated MLLW for disposal. NNSS has been the only facility utilized for disposal of classified wastes from PGDP to date.

NNSS is capable of receiving waste shipments only by truck. Truck transportation from Paducah to NNSS is approximately 1,828 road miles. Transportation of waste to NNSS must be coordinated with the facility and the transportation route must avoid Hoover Dam and Las Vegas.

Waste packaging must meet applicable DOE orders and Title 10 *CFR*, Title 40 *CFR*, and Title 49 *CFR* requirements. Waste packaging containers accepted include cargo containers (Sealand type), B-25/ST-90 containers, and 55-gal or 85-gal drums. Alternate packaging may be accepted (e.g., super sacks or burrito bags); however, NNSS must be consulted in advance to verify acceptability. Bulk waste generally is not accepted, but large items (such as machinery) may be considered.

Waste Acceptance. The waste acceptance process at NNSS includes the following:

- Contact NNSS and verify waste can be accepted;
- Develop, implement, and maintain waste certification program documents;
- Submit waste profile and characterization data;
- Review waste profile and gain approval; and
- Make schedule and shipping arrangements.

Hazardous wastes regulated under 40 *CFR* §§ 261-268 are not permitted for disposal at NNSS; however, MLLW waste can be accepted as long as it meets LDRs and the NNSS WAC requirements. Additionally, MLLW must be packaged separately from LLW. Liquid waste or waste containing free liquids must be converted to a form containing minimal liquids.

5.3.2 Waste Packaging

Packaging requirements for wastes would be determined based on the form [e.g., treated or untreated soil, debris, miscellaneous solids, personal protective equipment (PPE)/trash, or sediment/sludge], waste type (e.g., LLW, RCRA, TSCA, MLLW, nonhazardous solid waste), transportation mode (truck or rail), disposal facility location, and other considerations. The primary options for packaging the forecasted waste types include small containers, large containers, and bulk containers.

Packaging technologies are used to provide safe containment of waste during transport, storage, and disposal. Transport vehicles can be used in conjunction with packaging for relocation of waste to approved off-site facilities. Some transport vehicles can be equipped to provide containment within additional packaging.

Small Containers. A number of small containers such as lab packs, B-12/B-25/ST-90 boxes, drums, and overpacks are designed to contain various waste media (e.g., debris, solid, sludge, granular) and types. Small containers would be applicable to certain wastes, and are typically disposed of with the waste rather than emptied and reused.

Large Containers. Large containers include Sealand containers, intermodal containers, and other container types with various weight and volume capacities, loading capabilities (top-, side-, or end-loaded), and handling characteristics. A variety of waste media and waste types can be loaded into the containers. Large containers usually can be decontaminated and reused. Dedicated containers can be reused for similar waste with only external decontamination.

Bulk Containers. Bulk containers are single-use containers and can be disposed of with the waste. A Super Sack®, a large reinforced bag, is an example of a bulk waste package that can contain soil-like waste. Some Super Sacks® also are designed to contain debris. Other bulk containers include gondola rail cars, which are reusable and typically used for soil and/or debris.

5.3.3 Waste Transport

The off-site facilities considered are accessible by truck. Energy*Solutions* also can be accessed by rail. Various transportation and packaging options are considered for the cost analysis, and the most efficient and cost-effective are utilized in the cost analysis.

Truck. Trucks can transport bulk wastes either in containers or in closed beds that provide adequate containment. Trucking companies must be approved by DOE via the DOE Consolidated Audit Program and meet DOT requirements. Truck drivers must have a current Commercial Driver's License with a DOT Hazardous Materials endorsement. Both off-site disposal facilities are configured to receive waste directly via truck.

Rail. Railcars could be loaded directly at PGDP with containerized waste or bulk waste. Currently, Energy*Solutions* in Clive, Utah, is the only treatment, storage, and disposal facility under consideration configured to receive bulk rail shipments. Shipment to other existing off-site disposal facilities would require either transfer of the waste from railcars to trucks for the last leg of the trip or construction of a rail spur from the nearest rail line to the disposal facility.

5.4 ON-SITE ALTERNATIVE

The On-Site Alternative involves the disposal of CERCLA waste into a newly constructed, abovegrade, on-site, waste disposal facility located on property currently owned by DOE. The On-Site Alternative includes the same two waste volume scenarios as off-site disposal: (1) a high-end waste volume scenario for which CERCLA waste would be disposed of in a newly constructed on-site facility; and (2) a low-end waste volume scenario, which assumes various waste volume reduction actions, continued use of the on-site C-746-U Landfill for disposal of waste meeting the WAC of the C-746-U Landfill, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in a newly constructed on-site disposal facility. The base case (most likely) volume scenario of 3.6 mcy is composed of 2.5 mcy of LLW/RCRA/TSCA/MLLW that would be disposed of, for this alternative, in a new on-site waste disposal facility and 1.1 mcy of waste meeting the WAC of the C-746-U Landfill would be disposed of at the C-746-U Landfill.

For this alternative, waste not meeting the WAC for an on-site disposal facility would be disposed of at an approved, permitted, and operating off-site treatment, storage, and disposal facility. For this RI/FS, it is assumed that 5% of the waste volume would not meet the WAC of a new On-Site WDF.

If the On-Site Alternative is selected, the final design may differ from the conceptual design to accommodate the configuration of the selected site and site features, to incorporate standard practice or new technologies, or to improve the design performance of the facility. The findings of the PWAC modeling may be used to inform the design of an on-site WDF. For example, an amendment could be added to the bottom layer of the waste placed in the WDF or the natural subgrade soils underlying the WDF could be removed and replaced with a higher K_d or lower hydraulic conductivity soil; both of these would have the effect of retarding contaminant transport. Raising the K_d of a contaminant in bulk soil through addition of one or more additives within the landfill system would result in retardation of transport of chemicals out of the landfill or through the soils underlying the landfill. The capacity of the soils to attenuate contaminant migration out of the landfill can be increased through the mixing or application of soil additives. Most additives for sorptive attenuation of contaminants are based upon activated carbon, metal oxides (typically of iron and/or aluminum), and/or clay minerals. These soil additives do not break down or readily decompose in the subsurface environment, thus their longevity as reactive sorbent materials is a function of contaminant loading and overall sorptive capacity.

New information relevant to the development of the PWAC (e.g., hydrogeological properties, groundwater flow properties, K_d values, waste characterization, etc.) should be considered for incorporation as it becomes available.

5.4.1 Screening of Candidate On-Site Disposal Locations

DOE began evaluation of waste disposal options for PGDP CERCLA waste in 2000. Although that effort was discontinued before an RI/FS process was completed, a siting study for potential on-site disposal locations was conducted. The preliminary evaluation for on-site disposal, *Initial Assessment of Consideration of On-Site Disposal of CERCLA Waste Facility as a Potential Disposal Option at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000), was prepared to assess (1) if the evaluation of an on-site disposal strategy for the forecasted CERCLA wastes was warranted; and (2) if an evaluation was warranted, to propose a method of evaluation. The initial assessment was modeled after a similar evaluation of disposal alternatives by DOE in Oak Ridge, Tennessee (DOE 1996).

The initial PGDP assessment concluded that the evaluation of an on-site disposal strategy was warranted, and proposed the CERCLA process for decision making and documentation. A subsequent document was prepared to evaluate if viable locations exist at PGDP to construct an on-site waste disposal facility. The report, *Identification and Screening of Candidate Sites for a Potential Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001), documented the process used to identify candidate sites at PGDP and to screen those candidate sites for further evaluation in a RI/FS. The remainder of Section 5.4.1 and related subsections discuss the site screening process.

Based on the 2001 waste forecast of 3.1 mcy, a conceptual design found that a minimum area of 110 acres would be needed for the waste disposal footprint, surrounding dike, and operations support facilities. The 2001 siting study considered land space constraints and identified 10 sites on DOE-owned property that could meet the 110-acre footprint requirement. One of the 10 sites, Site 3, later was eliminated because a portion of that site was designated for the construction of the depleted uranium hexafluoride facility. Site 3 was reconfigured and renamed Site 3A. Additionally, it was recognized that the area immediately north of the C-746-U Landfill generally met the land space requirements identified in the 2001 Siting Study. This location was included in the list of potentially viable locations and identified as Site 11. Sites 5 and 6 were eliminated due to high percentages of their acreage being occupied by overhead TVA power lines; Site 5A was created from overlapping portions of Sites 5 and 6.

For this RI/FS, preliminary conceptual design efforts for an on-site waste disposal facility indicate that a waste disposal footprint of approximately 43 acres would be needed for the high-end waste volume estimate, compared to a projected 30 acres in the 2001 study (DOE 2001), but that the overall facility area still could be accommodated on 110 acres. Accordingly, the current site screening process evaluated the 12 candidate sites defined in the RI/FS Work Plan (DOE 2011a), consisting of 9 sites defined in the 2001 Siting Study, a reconfigured Site 3 (Site 3A), Site 5A (comprising portions of Sites 5 and 6), and the Site 11 described above. The locations of the 12 sites are shown in Figure 5.2.

The site screening process was conducted using the following steps:

- Develop Threshold, Secondary, and Final Criteria;
- Develop a weighting and scoring system for Secondary Criteria;
- Present the screening process to the regulatory agencies and incorporate comments;
- Screen the 12 sites identified in the RI/FS Work Plan against Threshold Criteria;
- Evaluate the sites that pass the Threshold screening against Secondary Criteria;

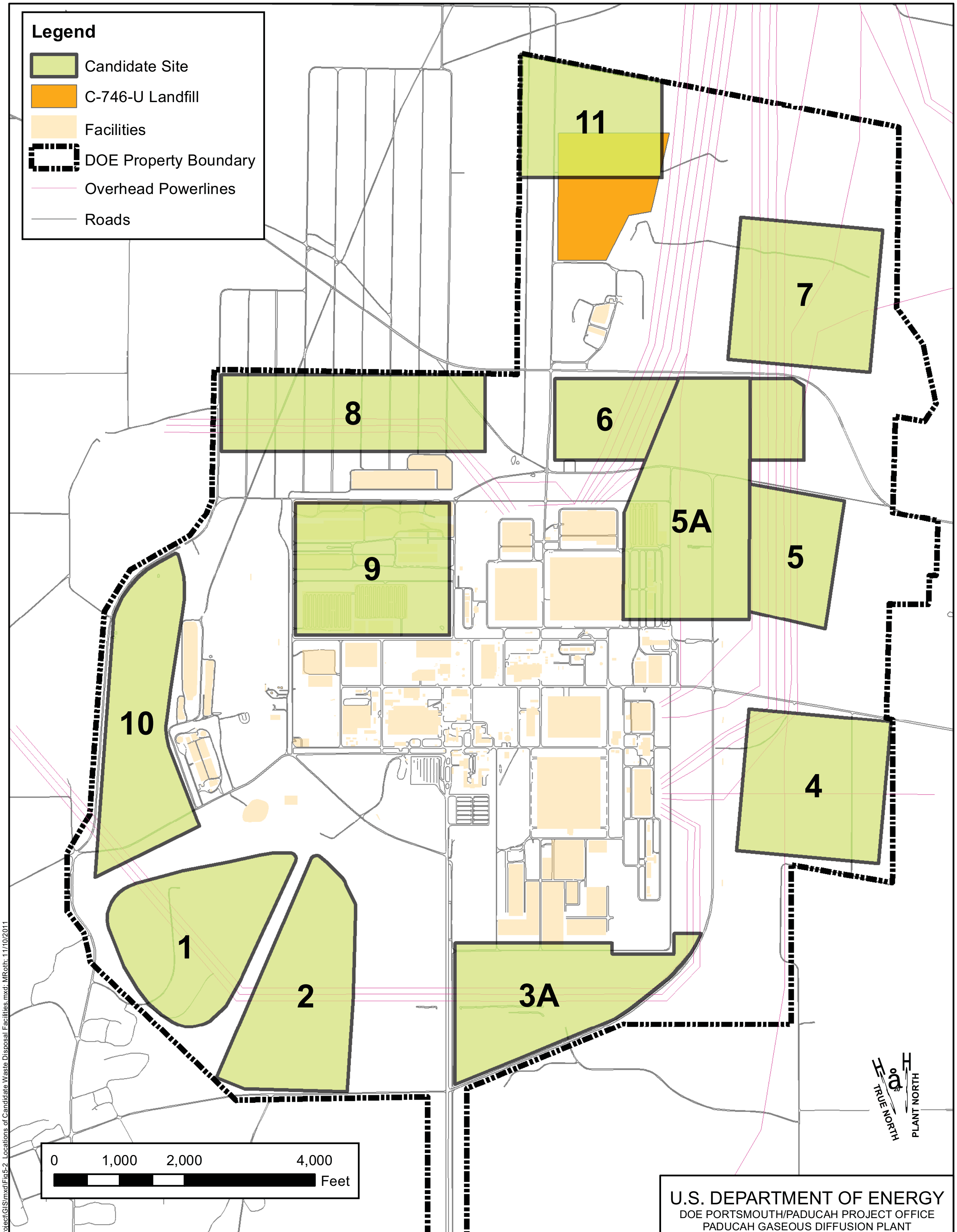

Figure 5.2. Locations of Candidate Waste Disposal Facility Sites

- Present the screening results to the regulatory agencies and incorporate comments;
- Present the screening results at a public meeting to solicit input; and
- Consider public input to the screening process/results.

The following subsections summarize the methodology used to screen candidate sites to identify for stakeholders the most viable location(s) to represent the On-Site Alternative for the FS evaluation (DOE 2001). The screening process is described detail in Appendix E.

5.4.1.1 Screening criteria and development

Criteria to evaluate candidate on-site disposal locations were developed based on technical requirements and ability to comply with potential ARARs. Criteria were defined in sufficient detail to allow understanding of the meaning and significance of each criterion and what parameters represent a low or high score (Appendix E, Table E.1). A requirement applied in developing the criteria was that they must discriminate among sites. Factors that failed to discriminate among sites, regardless of their importance, were not included as screening criteria. Factors common to the 12 sites were eliminated from the screening process in order to reduce the potential for masking the distinguishing site features in the overall scoring process. The rationale for excluding specific common factors from the screening process is provided in Appendix E.

Threshold Criteria. Threshold Criteria were based on minimum technical requirements, floodplain and wetland considerations, and a minimum area of 110 acres, based on the facility conceptual design.

Available Area, with subcriteria *Adequate area* and *DOE-owned property*. A site was considered to have sufficient available area only if it is a 110-acre site completely within DOE-owned property with no more than 20% of its total acreage within the 100- or 500-year floodplains or otherwise unavailable for use (i.e., presence of power lines that cannot be relocated or wetlands). The presence of overhead power lines also was a consideration. Overhead power lines owned by Electric Energy, Inc., (EEI) can be relocated, whereas TVA-owned overhead power lines cannot. The cost and logistics associated with relocation of the EEI lines was documented in an April 2009 study conducted by Commonwealth Associates, Inc.. If more than 20% of a site was unavailable for use due to the presence of TVA-owned power lines that cannot be relocated or wetlands, the site was considered to fail the Threshold Criterion for available area.

- **Floodplains.** Use of the site cannot restrict flow of water in the 100-year or 500-year flood or reduce temporary water storage capacity of a 100-year or 500-year flood event.

- **Seismic Conditions.** The waste footprint must have a separation of at least 200 ft from a fault with displacement in Holocene time.

These criteria were designed to be applied on a strictly pass-fail basis, with the intent that a site undergo secondary screening only if it met all of the Threshold Criteria.

Secondary Criteria. Secondary Criteria consist of the following:

- Hydrologic considerations
- Terrain stability
- Information availability
- Site contamination
- Land use
- Transportation access

- Utilities
- Buffers
- NEPA considerations

Each of these criteria is comprised of subcriteria. Each of the subcriterions was assigned a weight according to its relative importance. Unlike the Threshold Criteria, which were designed to be applied on a pass-fail basis, the Secondary Criteria were scored on a relative scale. Additional descriptions and definitions of these criteria are provided in Appendix E.

5.4.1.2 Site screening and scoring

The site screening, weighting, and scoring were conducted. To support informed decision making, site descriptions; data including calculations of the areas covered by potential wetlands, floodplains, and overhead power lines; and a GIS with various layers relevant to the Secondary Criteria were considered. The site screening focused on deriving results that were tangible, defensible, and as objective as possible. The results of the screening process are summarized here. Additional detail, including the site scoring process, is provided in Appendix E.

Threshold Screening. The threshold screening was conducted for the 12 candidate sites using the Threshold Criteria described in Section 5.4.1.1. Threshold screening was performed independently to encourage evaluation from various perspectives and to limit the potential for preconceived conclusions.

The results of the threshold screening are presented in Table 5.2. Two previous site-specific seismic studies conducted at PGDP concluded that no faults with Holocene age displacement are present; therefore, the 12 sites passed the seismic criterion of being greater than 200 ft from a Holocene fault. Seven of the 12 sites, Sites 2, 4, 5, 6, 7, 8, and 10, failed the threshold screening based on the presence of floodplains or more than 20% of the site's otherwise being unavailable for use. The presence of potential wetlands and permanent TVA overhead power lines comprising more than 20% of a candidate site also resulted in the elimination of sites.

Secondary Screening. Sites 1, 3A, 5A, 9, and 11 were carried forward for screening against the Secondary Criteria. Each of these sites is considered technically adequate for construction of an on-site waste disposal facility. The secondary screening was conducted to identify the most viable location(s) to represent the on-site disposal alternative for the FS evaluation.

Weighting factors were developed for the secondary screening to ensure criteria with more relative importance were appropriately considered or factored into the scoring. The use of a relatively low range for scores (0 to 3) and weighting factors (1 to 3), limited the potential for subjectivity in the scoring process. Subsequent to the independent scoring, the scores were compiled and reviewed. It determined that the process had achieved its purpose of clearly defining one or more sites to represent the on-site disposal alternative for the FS.

In addition to deriving the total site scores, subtotals were summed individually for what was designated as "inherent" vs. "logistical" criteria. This approach was agreed to by Kentucky and EPA regulators in an August 13, 2009, teleconference to help ensure that the best site was selected based on intrinsic site characteristics rather than primarily on factors of relative short-term "constructability" convenience. Inherent criteria are intrinsic site characteristics such as geology, hydrogeology, and natural site hydrology. Logistical criteria are factors such as information availability, location of power lines, existing infrastructure, and site access that represent more short-term, constructability considerations compared to

Table 5.2. Threshold Screening Results

Site	Adequate Area	DOE-Owned Property	Predominantly Outside Floodplains	Greater than 200 ft from Holocene Faults or Lineaments	Comments
1	✓	✓	✓	✓	**This site passes the Threshold Criteria screening.**
2	**X**	✓	**X**	✓	Approximately 30 percent of the site is unavailable due to presence of floodplains.
3A	✓	✓	✓	✓	**This site passes the Threshold Criteria screening.**
4	**X**	✓	**X**	✓	Approximately 24% of the site is unavailable due to presence of floodplains.
5	**X**	✓	✓	✓	A minimum of 36% of the site is unavailable due to permanent TVA power lines.
5A	✓	✓	✓	✓	**This site passes the Threshold Criteria screening.**
6	**X**	✓	✓	✓	Approximately 35% of the site is unavailable due to permanent TVA power lines.
7	**X**	✓	**X**	✓	Approximately 47% of the site is unavailable for use--approximately 25% due to the presence of floodplains and 22% due to permanent TVA overhead power lines that cannot be relocated.
8	**X**	✓	✓	✓	The site is inundated with potential wetlands, which cover a minimum of 25% of the total area not including buffer zones.
9	✓	✓	✓	✓	**This site passes the Threshold Criteria screening.**
10	X	✓	**X**	✓	Approximately 29% of the area is unavailable due to presence of floodplains.
11	✓	✓	✓	✓	**This site passes the Threshold Criteria screening.**

✓ = Passes threshold screening
X = Fails threshold screening

the long-term inherent factors. These factors are temporary when compared to the long-term considerations for a permanent disposal facility. This approach used to help ensure that the best site was selected to represent on-site disposal, based on intrinsic site characteristics rather than factors of relative short-term constructability convenience.

The summary results of the secondary screening are provided in Table 5.3, including the list of secondary criteria, weighting factors, scoring, and designation of criteria as inherent or external. Table 5.4 provides a summary of site scores along with site rankings. The Total Weighted Scores in Tables 5.4 and E.4 are the total weighted scores for each site as included in Table 5.3 (and Table E.3). As noted in the table footnote, higher scores indicate the site is more favorable based on the secondary criteria ranking.

Based on the results of the screening process, Site 3A would appear to be the most desirable location for the on-site disposal facility. However, all evaluated sites (Sites 1, 5A, 9, and 11) are adequate for construction of a potential waste disposal facility.

5.4.1.3 Regulatory interface

DOE solicited input from EPA and Kentucky regulatory agencies on development of the screening methodology, the siting criteria and weighting factors, and results of the screening process. A teleconference was held August 5, 2009, to discuss the proposed siting methodology, and on August 13, 2009, to discuss development of the siting criteria and weighting for the Secondary Criteria. Regulator comments from the two teleconferences were incorporated into the process before the site screening and scoring were finalized.

As part of the CERCLA process, and as defined in the FFA for PGDP, EPA and Kentucky regulatory agencies will continue to provide input to DOE on the CERCLA waste disposal alternatives, including a recommended site to represent the On-Site Alternative. This input will include comments on the RI/FS Report, Proposed Plan, ROD, and any post-ROD documentation if the On-Site Alternative is selected.

5.4.1.4 Public participation

Public participation is integral to the CERCLA process. DOE has solicited public feedback throughout the CERCLA process, including hosting several public meetings and coordinating with the CAB. Site 3A and Site 11 were added subsequent to the 2001 siting study based in part on public participation. The general siting study approach and siting considerations for the current effort were discussed at the March 24, 2009, Public Meeting. Additionally, the D1 RI/FS Work Plan was made available to CAB members upon its release in 2009.

The Proposed Plan will present the alternatives evaluated, including the recommended location for a disposal facility if the On-Site Alternative is selected. The public will have the opportunity to formally comment on the Proposed Plan.

5.4.2 Conceptual Design

The On-Site Alternative consists of an on-site WDF designed to accept the waste categories and waste types that are forecasted to be generated. The facility is referred to herein as the CERCLA WDF. The conceptual designs presented are based on low-end, base case, and high-end waste volume capacities and the evaluation of two “prototype” disposal sites.

Table 5.3. Secondary Site Screening Results

Secondary Criteria	Weight Factor[1]	Weighted Site Scores					Inherent[2]
		1	3A	5A	9	11	
Hydrologic Considerations							
Proximity to the 100-year and 500-year floodplains	2	22	40	42	30	32	Y
Distance to streams	2	24	34	34	24	20	Y
Distance to water wells	2	38	40	28	24	16	Y
Hydrogeologic setting	3	57	57	33	12	15	Y
Terrain Stability							
Surface geologic processes and topography	1	12	16	19	19	13	Y
Information Availability							
Seismic Data	3	24	60	24	27	57	N
Geotechnical Data	2	14	34	20	22	34	N
Hydrologic Data	2	22	20	30	34	32	N
Site Contamination							
Soil contamination	2	24	36	20	6	30	Y
Groundwater contamination	3	60	63	18	6	24	Y
Land Use							
Industrial vs. recreational land use	3	12	54	42	63	36	N
Existing facilities requiring demolition	2	40	28	16	6	34	N
Expandability	2	30	22	26	24	12	Y
Transportation Access							
Site access	1	10	18	20	18	17	N
Impacts to roads	2	26	24	32	30	16	N
Utilities							
Relocation of existing utilities	2	16	16	20	30	42	N
Existing support infrastructure	1	5	9	13	16	19	N
Buffers							
Physical buffer space	1	7	7	15	20	5	Y
NEPA Considerations							
Wetlands	2	32	14	30	32	30	Y
Threatened & endangered species and sensitive habitats	3	18	60	36	12	9	Y
Aesthetics	2	26	22	34	42	26	Y
WEIGHTED SCORES PER SITE:	Inherent	350	411	335	251	232	
	External	169	263	217	246	287	
	TOTAL	519	674	552	497	519	

[1] Weighting Range: 1-3. Items with a higher weighting were determined to be more important than items with a lower weighting.
[2] Inherent criteria are those that are intrinsic site characteristics instead of logistical criteria, which are relatively short-term factors.

Table 5.4. Summary Screening Results

Secondary Criteria Weighted Scores	Total Weighted Site Scores					Site Score Rankings				
	1	3A	5A	9	11	1	3A	5A	9	11
Score 1	75	93	81	73	76	4	1	2	5	3
Score 2	75	95	77	68	67	3	1	2	4	5
Score 3	70	94	70	73	81	4	1	4	3	2
Score 4	88	104	83	82	83	2	1	3	4	3
Score 5	62	97	78	64	66	5	1	2	4	3
Score 6	71	94	82	75	72	5	1	2	3	4
Score 7	78	97	81	62	74	3	1	2	5	4
TOTAL Weighted Scores and Rankings Per Site:	519	674	552	497	519	26	7	17	28	24

Total Weighted Site Scores—Higher scores indicate the site is more favorable based on the secondary criteria ranking.

Site Score Rankings—Each site total weighted score was ranked with the highest score = 1 and the lowest = 5. The lowest total ranking indicates the site is more favorable based on the secondary criteria scoring.

Each of the prototype sites (addressed in Section 5.4.5) can be designed to reasonably accommodate the WDF footprint (including an earthfill dike); stormwater ditches and ponds; leachate and contact water storage tanks; a security road and fence; services roads and parking; and other supporting structures/facilities. The land surface area impacted by operations for all waste volume scenarios is approximately 110 acres. The following subsections describe the conceptual design elements common to these sites, unless otherwise specified. Figures presented in Appendix F show a layout, cross sections, operational phases, and other details of the conceptual designs for both of the prototype sites.

The terms used to describe the WDF layout, construction, and development areas are defined as follows.

- **CERCLA WDF.** The entire (approximately 110 acre) WDF site, including the disposal cell, earthfill dike, and support facilities, purpose of which is the safe and environmentally responsible disposal of waste generated from CERCLA activities at PGDP.

- **Contact water.** Precipitation that has come in contact with the surface of the active workface.

- **Landfill operations area.** The portion of the site that encompasses an active landfill area (i.e., workface area), temporary roads, tipping pads, dump stations, dump ramps, the future disposal cell, and the earthfill dike.

- **Support area.** The portion of the site outside the landfill operations area, including roads, buildings, ponds, tanks, and other features.

- **Active landfill area.** The portion of the landfill operations area that is active at a specific point in time, either currently receiving waste or containing disposed waste without interim or intermediate cover. The active landfill area has controlled worker access and is considered the contamination area (CA) or "exclusion zone." The active landfill area is underlain by the liner and leachate collection systems and includes temporary staging areas at each workface.

- **Tipping pad.** An area designated for unloading waste and decontaminating vehicles after unloading. A tipping pad and its surrounding area are outside the CA and are maintained clean and contamination free.

- **Phase.** A portion of the landfill operations area that is fully constructed to receive waste. This typically includes a segment (or segments) of the earthfill dike, liner, and leachate collection systems. Landfills are normally constructed in phases for economic and management/operational reasons. Phases are sequentially designated by Roman numerals (i.e., Phase I, Phase II, and Phase III).

- **Subphase.** A division of a phase that is defined by engineered components such as diversion berms, changes in liner grade, or other features designed to segregate sources of leachate, contact water, and/or surface water. Subphases are identified by a letter designation (e.g., Phase I-A).

- **Disposal cell (or landfill cell).** A designated area within a phase that is designed to receive a specific and contiguous volume of waste (i.e., waste not separated by operational or interim cover). Disposal cells are sequentially numbered (i.e., Cell 1, Cell 2, Cell 3).

- **Leachate.** Fluids which have collected on or within the containment systems of a landfill area. Leachate includes fluid that seeps out the bottom of waste, from infiltration water that percolates through the waste. Leachate may contain contaminants and must be managed accordingly.

- **Lift.** A vertical layer of waste in a cell, not to exceed some predetermined design height. The top of each lift may be covered with temporary, clean, intermediate cover, depending on waste and timing of placement of next lift.

- **Surface water.** Accumulated precipitation or supplied water that has not collected on or within the containment systems of the landfill operations area.

- **Workface.** A small part of an active landfill area that is open and currently receiving waste. As part of normal operations, soil waste material may be intermittently placed in a temporary staging stockpile in this area. The workface and temporary staging area are uncovered, but are covered in accordance with ARARs. Multiple workfaces may be operated at the same time to accommodate waste receipts.

5.4.2.1 Conceptual site layout

This section describes the conceptual CERCLA WDF site layout, including the landfill, support facilities, and other site improvements common to each of the two prototype site locations.

The conceptual landfill would consist of an double lined, earthen cell with a composite cap, designed to meet the performance objectives of 40 *CFR* § 264.301(c) and 401 *KAR* 34:230 Section 2(3). Conceptual support facilities would include stormwater management, leachate treatment, security, maintenance, administration, and waste weighing facilities. Table 5.5 shows the estimated areas for each CERCLA WDF component (based on the conceptual designs developed for each of the waste volume scenarios).

Table 5.5. Conceptual CERCLA WDF Component Areas

CERCLA WDF Component	Waste Volume Scenario		
	Low-end	Base Case	High-end
Area of Waste Disposal Cell Only (Waste Footprint)	19 acres	29 acres	43 acres
Area of Earthfill Dike, Perimeter Roads, and Ditches	37 acres	44 acres	52 acres
Area of Support Facilities	13 acres	14 acres	15 acres
TOTAL AREA	69 acres	87 acres	110 acres

For conceptual design, a 110-acre footprint was used in determining minimum area requirements. If on-site disposal is the selected alternative, the area requirement would be finalized during final design based on the site selected and final waste disposal volume estimates.

If a final design would require flatter side slopes than the conceptual design in order to address seismic issues, a 110-acre site is expected to accommodate the increase in side slope area size for the low-end and base case volume scenarios. For the high-end volume scenario, another 10 to 15 acres may be needed for such contingencies. A larger footprint allows more options for waste disposal cell placement and layout to avoid areas such as transmission lines and wetlands. For the low-end volume scenario, the surface area required would be less, but because support facilities would require nearly the same amount of space as the high-end volume design, the reduction of the facility footprint is limited to the active waste disposal facility, associated ditches, and the sedimentation pond(s) areas.

To address the uncertainty in waste volume projections as related to footprint requirements, the potential for expandability of the candidate sites was considered during the site screening process (see Appendix E individual candidate site discussions as well as Table E.3). Additionally, space constraints could be addressed through optimization of the facility design or ancillary facility location.

5.4.2.2 Landfill capacity

Landfill capacity, often referred to as "airspace," is the total volume available between the bottom liner and top cover systems. Upon completion of a landfill, a majority of the airspace will be filled with waste (including debris and soil), but a portion of this volume may be occupied by clean fill soil or other suitable materials to be used as needed as void fill placed between bulky waste items (debris), as fill for access ramps, and as temporary cover soil placed during operations. The fill material also may be selected to prevent chemical leaching or to bind chemicals as they leach from the waste.

The conceptual design for an on-site waste disposal facility assumes that the airspace needed for waste and clean fill is equal to the loose volume (i.e., as-generated) of the waste. This assumption balances various factors as described below. The actual volume associated with an alternative may differ for a variety of reasons such as updated waste forecasts or the need for additional fill to facilitate disposal of non-soil wastes.

Factors That Increase Airspace

- Clean fill soil may be needed as part of normal landfill operations, for constructing access ramps, as temporary cover, and for debris void fill (when sufficient waste soil is not available).

- The timing of waste forms delivered to the landfill can affect soil needs. For example, if several shipments of debris are delivered without waste soil, then additional clean fill soil may be needed to fill void spaces when the debris is placed in the landfill.

Factors That Reduce Airspace

- Sizing of debris waste prior to delivery to the landfill may reduce as-placed void volume.

- The waste forecast projects an approximate 50/50 mix of debris and soil. Voids in the disposed debris can be filled with the waste soil (only using clean fill when absolutely necessary).

- Soil, both clean fill and waste, will decrease in volume (shrink) after placement into the landfill and compaction with heavy equipment.

- Compressible debris will decrease in volume after placement into the landfill and compaction with heavy equipment.

- Clean fill soil used as temporary cover will be stripped, stockpiled, and reused during landfill operations as practicable.

The conceptual design takes these stated factors into consideration when evaluating site area and landfill operational needs. This is important for the high-end waste volume scenario, because site area is directly related to airspace requirements.

5.4.2.3 Fencing and site security

Access to the landfill would be controlled to prevent illegal waste dumping, minimize potential exposure to hazards at the site, and prevent unauthorized vehicular traffic. The site would be fully encompassed by a chain-link fence. Gates at the fence would be locked, and PGDP security personnel would patrol the site as part of their daily routine during active operations until the final cap is complete. Additional protective measures such as high security fencing or lighting may be required if a cell within the WDF were to accept classified waste.

Signs would be placed on the fence and points of entry to identify access restrictions and potential hazards. Temporary signs and fencing would be used at operating areas to warn of hazards and isolate zones from unauthorized intrusion.

5.4.2.4 Ingress and egress

During normal landfill operating hours, ingress and egress would be through a controlled gate in the fence, along the main access road. Only authorized personnel would have keyed access for site ingress and egress. Waste hauling vehicles entering the landfill must pass over the scale en route to the landfill operations area.

5.4.2.5 Roads and parking

Conceptually, a main access road would provide access to the site. The road would be paved and designed to support expected traffic loads regardless of weather and sloped for proper drainage. Road cuts and fills would be sloped, drained, and seeded to minimize erosion and soil loss.

Internal waste haul roads would be located inside the landfill operations area and used by waste vehicles for access to the dump ramps. These roads would be semipermanent, constructed on a compacted earthfill subgrade, and completed with suitable road mix gravel to maintain a smooth, stable driving surface. Suitable aggregate for repairing haul roads and dump ramps would be stockpiled on-site. Road maintenance would be performed on an as-needed basis by landfill operations personnel using on-site equipment.

To facilitate hauling waste to the dump ramp, temporary roads would be constructed across the landfill cell above the landfill liner. Temporary roads would be realigned, lengthened, or shortened, as needed, to reach planned disposal areas and minimize the distance waste needs to be pushed to the workface.

Vehicle parking for site visitors, landfill operators, and administrative staff would be provided near the main entrance gate. The parking area would be positioned such that on-site workers and visitors would not pass through the waste haul traffic.

5.4.2.6 Traffic

During normal operations under the conceptual design, the majority of traffic would be waste hauling trucks. Workers and administrative personnel would arrive and depart for each daily shift, outside of times scheduled for accepting waste loads. Visitors will be required to check in at the administration building for sign-in, training, and escort before proceeding further into the WDF. Speed limits and other cautionary information would be posted by signs. Unauthorized traffic will not be permitted at the WDF.

Waste haulers delivering waste to the CERCLA WDF would be directed to the workface by posted signs and flagging clearly marking the proper path. At the entrance to the dump ramp, a waste operations person would take the driver's manifest and weigh scale ticket, and advise the driver regarding daily protocol for which dump ramp to use and when to enter the workface queue for waste dumping. Radio communications would be used among landfill operators, managers, and the administration office as needed to direct waste haulers and coordinate traffic with other heavy equipment operations.

5.4.2.7 Landfill operations area

The conceptual landfill operations area includes the earthfill berm, future operating phases, temporary roads, tipping pads, and the active fill area. The conceptual CERCLA WDF would be operated as an "area method" landfill. Waste would be placed on one contiguous liner system with a final cover encapsulating the entire cell. The area method, as opposed to the trench method, takes full advantage of the potential landfill volume capacity and provides redundant systems for leachate collection.

5.4.2.8 Support facilities

The support facilities for the conceptual design are described below.

- **Waste Vehicles Weight Scale.** Each haul truck entering the site would stop on the site scale, be identified by the scale operator, and have its weight recorded in the waste receipt database. The scale would have a radio communication device allowing the driver to speak to management for support, if necessary. From the scale, the driver would proceed to the dump ramp. Dedicated trucks will be used to haul waste so a tare weight can be established for each truck. The use of the tare weight allows for the trucks to be weighed only on the way into the landfill.

- **Maintenance Building.** The maintenance building will house parts lockers, equipment storage, tool cribs, lubricants, and maintenance equipment. Flooring would be partial concrete and partial loose rock to accommodate both rubber-tired and tracked equipment. Space in the building would be lighted and heated to allow for adequate winter storage of weather-sensitive equipment and supplies and equipped with appropriate ventilation to allow for evacuation of engine vapors and heated air. The maintenance building also would contain a bathroom facility, safety shower, and emergency eyewash shower.

- **Leachate Treatment Facility.** A leachate treatment facility, including leachate collection storage with secondary containment, would house process equipment needed to treat leachate and discharge water to the surface water detention basin. The leachate treatment facility would include necessary pumps, piping, filters, active systems, valves, instruments, controls, emergency equipment, and ancillary equipment. The facility would be equipped with fire pull alarm actuators, methane monitors and alarms, an autodialer, fire extinguishers, heating and lighting, and radio and telephone communications.

- **Storage and Stockpile Areas.** Storage areas for soil and aggregate stockpiles and other routinely used materials would be designated. Portable and/or permanent sheds would be erected and used, as needed, to support landfill operations.

- **Contact Water Storage Facility.** Contact water would be stored in large tanks or other containers with secondary containment. This facility would include necessary pumps, piping, valves, instruments, controls, and ancillary equipment. The contact water in the tanks would be sampled and discharged to either the leachate treatment facility or the surface water detention pond, as appropriate, based on sample results.

- **Surface Water Detention Pond.** The surface water detention pond(s) would collect and store surface water, and provide adequate detention time for settling of suspended solids before waters are discharged. The pond(s) would be capable of handling the 25-year/24-hour precipitation event (per 40 *CFR* § 264.301 and 401 *KAR* 34:230), with additional volume for freeboard and an appropriate safety factor to be defined during the design process.

5.4.2.9 Utilities

The scale, administrative support buildings, water treatment, equipment maintenance, surface water detention pond(s), and storage facilities included in the conceptual design would be provided with electrical power and communications service as needed. Potable water would be supplied from the PGDP water treatment plant (or West McCracken Water District, depending on site location) via connection to main service lines. Sanitary wastewater will be treated in a new on-site sewage plant under this action, the existing PGDP sewage treatment plant, an existing septic system, or a new on-site septic system established under this action.

Classified waste disposal would require additional utilities and site infrastructure. Such requirements include nighttime lighting to 0.2 ft-candles, special conduit for electrical wiring systems, and other security-related infrastructure.

5.4.2.10 Landscaping and windbreaks

The CERCLA WDF site landscaping would be developed to meet the following goals:

- Reduce short-term (during operations) and long-term (postclosure) visual impacts;

- Grade surfaces for run-on control to minimize surface water flow and promote proper drainage within the site;

- Create stable, low maintenance land surfaces to minimize soil erosion; and

- Plant permanent vegetation to improve aesthetics and serve as windbreaks.

5.4.2.11 Landfill components

Components of a CERCLA WDF must provide long-term protection of human health and the environment and remain stable throughout the postclosure period. Current technology applied to achieve these goals includes multiple containment systems constructed of earthen and geosynthetic materials, piping, and vegetation. This subsection describes landfill components applicable to the RI/FS conceptual design. Conceptual details are shown in Appendix F.

Lines and Grades. Construction at a CERCLA WDF site would be completed to the lines, grades, and elevations shown on the final design plans. A qualified surveyor would perform the necessary survey, layout, and measurement work required to construct and operate a landfill according to approved plans. Particular attention would be given to those items that are sensitive to grade and slope (e.g., landfill liner, leachate collection system, drainage).

Maximum Landfill Height. The maximum design landfill height is dictated by many factors, including stability, settlement, drainage, visual impacts, and seismic impacts.

Earthfill Dike. An earthfill dike, constructed of clean, suitable soils, would be constructed around the perimeter of the cell. Suitable soils are defined as soils meeting the specific performance requirements of the design including compaction, density, slope stability, and bearing capacity; free of organic materials, debris, or large rock; and not susceptible to excessive shrinkage, expansion, or erosion.

The earthfill dike would provide stable lateral containment and protect against erosion, biointrusion, and inadvertent intrusion by humans or animals. The top of the dike would anchor the liner geosynthetic components, tie into the cover system, and provide for drainage ditches and a perimeter access road. The outer slope would be vegetated to minimize erosion.

Liner, Leachate, and Leachate Collection System. The constructed liner (below the waste) would consist of a multilayer system comprised of earth and geosynthetic materials as shown on the cross section detail in Figure F.1, Appendix F. The purpose of this system is to allow for collection and removal of liquids that accumulate on top of the liner and to minimize the amount of leachate migrating out of the disposal unit. A double-liner system is proposed, with two low-permeability geosynthetic liners and leachate collection and leak detection systems. In accordance with 40 *CFR* § 264.301(c) (RCRA hazardous waste disposal regulations), the top (primary) liner would be constructed of materials (e.g., an FML) to prevent the migration of hazardous constituents into the secondary liner during the active life and postclosure period. The lower (secondary) component of the composite bottom liner would be designed and constructed of materials to minimize the migration of hazardous constituents if a breach in the primary component were to occur. The base liner system proposed for the conceptual design includes the following layers, from the cell base (bottom of waste) down to the geologic buffer:

- **Protective Soil Layer.** A protective soil layer would be placed over the upper leachate collection stone and geotextile to prevent physical damage to the liner system during operations.

- **Primary Leachate Collection Layer.** The primary leachate collection layer consists of a gravel layer at the base of the cell and highly permeable geonet (i.e., geocomposite drainage net) along the sloping walls. The gravel leachate collection layer sandwiched between two layers of geotextile at the base of the cell would be capable of collecting leachate volumes generated during operations and the smaller volumes of leachate anticipated after the final cap is installed. The geotextile layers would cushion and protect the primary liner and retard migration of fines from the overlying soil and waste into the gravel to prolong the functional life of the leachate recovery system. Perforated leachate collection pipes would be placed in the gravel drainage layer to transfer leachate by gravity to one or more header pipes. Header pipes would connect to a series of sumps, from which leachate could be pumped to a leachate treatment facility. On the sloping walls of the facility, geocomposite drainage net would transmit leachate to the gravel leachate collection layer on the cell base.

- **Primary Liner.** The primary liner would consist of a durable dual textured FML designed to prevent the migration of leachate into the underlying leak detection layer. A geosynthetic clay liner (GCL) may be included if the design indicates it is necessary.

- **Leak Detection Layer.** A gravel leachate leak detection layer sandwiched between two geotextile layers would collect leachate that may seep through the primary liner. This layer would be graded to drain toward detection piping. The detection piping would be connected to a separate detection sump in the leachate collection to facilitate transfer to a facility outside of the disposal cell. This is considered a backup system; unless there is a breach in the primary liner, little or no leachate is expected to enter this system during the operational or postclosure periods.

- **Secondary Liner.** An FML and low permeability soil material would retard migration of leachate and contaminants in the leachate released from the overlying layers. This layer would be placed over the geologic buffer. The FML would be a manufactured geosynthetic barrier composed of materials compatible with the waste and resistant to degradation by the chemical constituents expected to be present in the leachate. A GCL may be included to enhance the performance of the liner.

Geologic Buffer. TSCA regulations require the added protection of a geologic buffer if the depth from the bottom of the waste to the top of the groundwater is less than 50 ft.

Systems for Removal, Storage, and Treatment of Leachate. The conceptual landfill design includes, above the primary liner, a leachate collection system that transmits leachate to a sump(s). The sump(s) would be accessible via pipes leading to the top of the earthfill dike. Automated pumps and piping within the sump access pipes would remove leachate that accumulates in the sumps and transmit the leachate to holding tanks. The holding tanks would be equipped with sampling ports, valves, controls, monitoring equipment, pumps, and piping. All tanks would be aboveground, with secondary containment systems.

From the holding tanks, leachate would be pumped to a leachate treatment facility. The leachate treatment facility would house all process equipment needed to treat leachate to acceptable regulatory limits and discharge treated water to a surface water detention basin. The leachate treatment facility would pump treated effluent to posttreatment holding tanks or other containment units. These would include sampling ports, valves, instruments, monitoring equipment, secondary containment, and pumps for discharging clean water to the detention pond(s) or, if necessary, returning the fluid back to the leachate treatment facility for reprocessing. The process throughput capacity of the leachate treatment system would be determined by final design.

Systems for Removal, Storage, and Treatment of Contact Water. Contact water is defined as surface water that has potentially made contact with the waste. Contact water may be clean or contaminated, and must be collected, stored, and characterized to determine treatment requirements, if any, for discharge.

The contact water control system would consist of collection sumps, pumps, piping, valves, storage tanks, and ancillary equipment. Portable pumps and hoses may be used to remove contact water from the active landfill area and transmit the water to a collection sump(s). Systems would convey contact water from the collection sump(s) to several large holding tanks or other containment. Tanks would be aboveground, with secondary containment systems, and would be equipped with ports for sampling and analysis of contact water, measurement devices, pumps, valves, piping and ancillary equipment. The system would be capable of pumping water from the holding tanks to the leachate treatment facility. The throughput sizing of the contact water systems will be determined as part of the final design. Solids carried by the contact water may be clean or contaminated and may be disposed of in the WDF or may be collected, stored, and characterized to determine if they may be reused as intermediate cover.

Surface Water Run-On/Run-Off Controls. Sitewide surface water run-on and run-off will be managed in compliance with ARARs. Surface water management structures, including berms, ditches, ponds, spillways, pumps, pipelines, and other improvements, will be designed to address site-specific conditions.

Surface water run-on control may be provided by means of a drainage ditch and elevated roadway constructed along the perimeter of the entire site. Surface water accumulated in drainage basins outside the CERCLA WDF would not enter the landfill site.

Within the WDF, surface water run-off (except leachate or contact water) would be diverted through a network of drainage ditches to a surface water detention pond or series of detention ponds. Drainage ditches would be sized, sloped, and lined and/or protected with riprap to convey the design storm flows without excessive damage, erosion, or sedimentation to WDF features.

The surface water detention pond(s) would store surface water and provide adequate detention time for settling of suspended solids before waters are discharged. The pond(s) would be capable of handling the 25-year/24-hour precipitation event with additional volume for freeboard and an appropriate factor of safety. Site-specific conditions and final engineering analysis would dictate whether the pond(s) would discharge via a gravity or pump system. An emergency spillway, designed to manage storm events exceeding the maximum design event, would be provided.

Intermediate Cover. Intermediate cover is defined as temporary soil cover that is placed above the waste during operations. Intermediate cover differs from interim cover in that intermediate cover is used between disposal cells (i.e., on top of lifts), while interim cover is placed at final grades (i.e., on top of completed disposal cells).

Once a cell is filled to the design lift height, intermediate cover would be placed above the waste. Intermediate cover would consist of clean earth fill material, placed, and compacted in layers. The thickness of the intermediate cover determined based on best management practices and typically ranges from 6-36 inches. The intermediate cover would provide a clean, stable surface for traffic. Another important purpose of intermediate cover is to shed direct surface water runoff from the top of the waste lift, thereby reducing the amount of liquid managed by the leachate and contact water systems.

When a new lift waste is to be constructed above an existing lift, a portion of the intermediate cover may be removed prior to waste placement. Once removed, the intermediate cover soil can either be stockpiled for reuse as intermediate cover or classified as void fill and incorporated into the waste.

Interim and Final Cover. In accordance with 40 *CFR* § 264.310 (RCRA hazardous waste land disposal regulations), the final cover would be designed and constructed to do the following:

- Minimize migration of liquids through the closed disposal cell over the long term;
- Promote drainage and minimize erosion or abrasion of the cover;
- Accommodate settling and subsidence of the WDF cover to maintain the cover's integrity;
- Provide a permeability less than or equal to the permeability of the bottom-liner system or natural subsoils present; and
- Function with minimal maintenance.

The overall effectiveness of the final cover in reducing infiltration is the key to cell performance and could be increased through a variety of technical measures. The effectiveness of individual drainage layers could be increased, the number of drainage layers could be increased, the effective flow distance could be reduced, and the effectiveness of underlying low-permeability layers could be increased. Technical means for accomplishing these improvements would include material substitution, addition of clay modifiers to reduce permeability, and the use of geosynthetic clay liners. Cover technology is evolving and additional methods for reducing infiltration may be available at the time of final design. The overall goal would be to minimize leachate generation through the reduction of infiltration.

The cover would be sloped to facilitate runoff and be placed over the waste, overlapping the top of the earthfill dike. Figure F.1, Appendix F, shows a cross section of the conceptual landfill cover components. The conceptual design for the cover consists of the following elements, from bottom to top.

- **Interim Cover.** Following placement of waste to final grade in any area, an interim cover would be placed over the waste to minimize infiltration and contain the waste before closure. The interim cover would include a soil layer to provide a uniform layer between the waste and the final cover. This soil layer would bring the disposal cell to final grade in preparation for final cover placement. An interim vegetative soil layer would be placed and seeded above the contour soil layer to reduce erosion before placement of the final cover. The vegetative layer, including soil and plant matter, would be removed and replaced with compacted fill prior to construction of the final cover.

- **Secondary Hydraulic Barrier.** During final closure, a, low permeability soil layer would be placed above the interim cover. This layer would be considered the secondary hydraulic barrier and would be similar in design to the low permeability soil layer of the secondary lower liner. A GCL may be included to enhance the performance of the secondary hydraulic barrier in the final cover if the design indicates it is needed.

- **Primary Hydraulic Barrier.** An FML will be placed above the low permeability soil layer. This would serve as the primary low permeability layer and prevent infiltration into the cell.

- **Drainage Layer.** Above the FML would be a gravel drainage layer sandwiched between two layers of geotextile. The upper geotextile would minimize clogging of the drainage layer and the lower geotextile as well as protect the FML from puncture.

- **Biointrusion Layer.** A biointrusion layer would prevent burrowing animals and plant root systems from penetrating through the cover system and would discourage digging or drilling by an inadvertent intruder. This layer would be constructed of cobbles or cobble-size riprap (large, angular stones) and would minimize erosion and facilitate infiltration of water into the drainage layer. A graded natural filter would overlie the biointrusion layer to prevent clogging of the porous layer with the overlying soil.

- **Erosion Resistant Layer.** A vegetated soil-rock matrix over the disposal cell would protect the disposal cell layers from the effects of wind and water erosion. This layer would accommodate the typical root systems of planted and native vegetation. This layer, the drainage layer, and the biointrusion layer together would be much thicker than the local frost depth, preventing frost damage to the FML and the low-permeability soil layer. Side slopes of the cover system would be covered with a soil-rock matrix and a riprap layer to minimize erosion.

Gas Venting System. Landfill gas is produced when solid organic waste decomposes. The quantity and composition of landfill gas depends on the types of solid waste decomposing. The rate of gas production is governed by the level of microbial decomposition occurring in the waste.

Permeability of soils in the liner, cover, and surrounding area influence the movement of landfill gas. Dry soil does not significantly impair gas movement, but saturated and frozen soils act as a gas flow barrier. If the landfill liner and cover materials act as barriers to gas migration, landfill gas pressure can increase and lateral movement of landfill gas through the sides (near anchor trenches) could occur.

Although the forecasted waste is not expected to contain significant amounts of decomposable material, minimal amounts of landfill gas would be expected. A methane gas generation analysis will be performed as part of the design to establish limits on the amount of waste that typically would decompose in aboveground conditions, such as wood, paper, or vegetation, that could be placed in the landfill.

Containment Stability. All landfill components would be designed for stability under anticipated conditions throughout the site's operating life and during the postclosure period (the postclosure period is assumed for estimating and modeling purposes). After that time, gradual degradation may occur unless periodic maintenance is performed; however, the engineered earth components are expected to remain stable, as soil properties affecting stability are understood and design methods are well established.

Landfill components would be designed to resist damage from earthquake forces. Preliminary seismic investigations at PGDP indicate that the maximum earthquake-induced design force would be based on a peak ground acceleration in the range of 0.30 g to 0.50 g (with the final design peak ground acceleration to be determined). All landfill components (i.e., liner, cover, and leachate systems) that contain waste and prevent the release of hazardous substances would be designed to maintain structural integrity when subjected to the maximum seismic design force. Additional stability analysis would be conducted for final design.

The following engineering design considerations that affect containment stability have been evaluated in developing the conceptual design and would be further evaluated as final design criteria.

- **Slope Angles.** Slopes would be evaluated to balance the opposing needs of airspace and stability. Slope stability analyses would use appropriate factors of safety for both static and dynamic loading.

- **Earth Material Properties.** Materials with shear strength properties (cohesion and internal friction angle) would be specified as appropriate. The specification of earth materials would consider the range of moisture conditions, shear strength under static and dynamic loading, and acceptable deformations.

- **Geosynthetic Materials Selection.** Liner material would be specified to an appropriate thickness for tensile strength. Textured FML may be specified to provide a higher interface friction angle.

- **Geogrid Reinforcement.** The inclusion of geogrid reinforcement within the earthfill dike, below the liner system, and/or within the final cover system would be evaluated as another means to strengthen landfill components and prolong stability.

- **Subsurface Drainage.** Landfill systems and operating components would be designed for rapid subsurface drainage, to prevent the buildup of excess pore water pressures that can cause unstable conditions or potential for liquefaction.

- **Minimal Liner Penetrations.** Penetrations through liners, for leachate collection pipes or other systems, may be particularly vulnerable to damage from earthquake-induced stresses. Alternatives to liner penetrations, such as sump access through pipes above the liner, would be considered.

- **Dual Containment.** Engineering design would evaluate dual containment for leachate transmission pipes. Installation of pipes within secondary containment pipes would likely have greater resilience to lateral movement (e.g., earthquake-induced ground motions) and reduce the potential for pipe rupture.

- **Independent Final Cover Components.** All final cover components, including landfill gas vents, must accommodate potential movement, such as differential settlement. The components would be designed to work independently, so that localized movement does not reduce the overall containment effectiveness.

The earthwork construction materials considered for conceptual design and cost analyses possess sufficient shear strength for seismic stability (i.e., slope stability and low potential for liquefaction). Additionally, the earthfill dike shown in the conceptual design is a large containment feature that encompasses and buttresses the entire disposal cell. The conceptual cell geometry and the assumptions regarding material strength used to reasonably represent an expected final design configuration of a facility engineered to maintain structural integrity under the anticipated range of seismic loads. If the On-Site Alternative is selected, further in-depth evaluation of construction materials and seismic stability analysis would be performed in final design to fully address seismic conditions at PGDP. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

5.4.2.12 Quality Assurance/Quality Control

A QA/quality control program would be developed and employed, as appropriate, in accordance with the FFA.

5.4.3 Construction Sequencing

Landfills are designed and constructed in phases for cost-effectiveness, effective leachate and surface water management, and control of active waste disposal areas. The size, shape, and volume of each phase are based on site-specific factors and the expected rate at which waste is received.

The CERCLA WDF would be constructed and filled to the following general guidelines:

- **First Phase.** The first phase (Phase I) would be sized to accept waste volumes projected for the period through year 2019. For the high-end volume scenario, this volume is approximately 1,200,000 yd^3 and would consist of a variety of waste categories and waste types as described in Chapter 4.

- **Additional Phases.** Each additional phase (Phases II and up) would be constructed in advance of filling the preceding phase, so that interruption to ongoing landfill operations is minimized.

- **Vertical lifts.** The landfill would be constructed in vertical lifts. Generally, a new lift would not begin within a disposal cell until the first lift has been completed in the next cell (e.g., Lift 2 in Cell 1 would not begin until Lift 1 in Cell 2 has been filled), so that lifts are built in a step-wise manner. This assures stability during operations.

- **Clean vs. Contaminated Equipment.** Once landfill operations begin, equipment working within the active landfill area is considered contaminated. Contaminated equipment remains within the active landfill area (the "exclusion zone" or CA) for the life of the facility. Equipment that handles clean materials and is used in clean areas is not permitted to come in contact with waste, leachate, or contact water.

- **Final Cover Construction Sequence.** Final cover would be installed in at least four separate segments. The objective is to install the final cover as soon as practicable after filling the WDF to the design height to minimize leachate production and reduce the cost of leachate treatment.

5.4.4 Operations and Closure

5.4.4.1 Operational period

The design operating/closure period for a CERCLA WDF is 30 years. If on-site disposal is the selected remedy, then Phase I construction would be scheduled to begin in 2014, Phase II in 2019, Phase III in 2025, and Phase IV in 2031. Operations would cease in 2039, with final closure in 2044. As phases of the landfill are completed, closure activities would occur on each completed phase concurrently with operation of the subsequent phase. For example, Phase I closure would begin in 2020 concurrent with operations in Phase II.

5.4.4.2 Closure

Closure activities (2039 to 2044) would include removal of support facilities that no longer are needed and placement of the demolition materials within the waste disposal cell. Following completion of waste disposal operations, the final cover would be installed. Site restoration includes grading and seeding of disturbed site areas.

5.4.4.3 Postclosure period

Following closure of the facility in 2044, DOE would closely monitor and maintain the site in accordance with DOE Orders. During the postclosure period, it is assumed that DOE would retain control of the site, and, as a result, no inappropriate use of the site (e.g., occupation or intrusion) could occur. For cost estimating purposes, a 1,000-year postclosure period is assumed; however, DOE will provide engineering controls, SM&M and institutional controls for as long as the waste disposed of in the facility could pose an unacceptable risk to human health or the environment, as assessed during the CERCLA five-year reviews. For the purposes of developing the PWAC, a postclosure period of 170 years is assumed (as discussed in Section 5.4.6).

An indefinite period of institutional control, consisting of administrative controls (e.g., land use restrictions) and engineering controls (e.g., cap and fence maintenance), follows the postclosure period. Costs beyond the assumed 1,000-year period are not included since such cost estimates would be unreliable and the present value for any such cost estimates would be minimal. Also, the facility would be subject to the CERCLA "five-year review" process, as described in the FFA.

5.4.5 Prototype Sites

Screening of candidate sites is detailed in Section 5.4.1. The screening process indicated that any of the final five sites would be adequate for construction of a waste disposal facility.

There are two distinct groundwater settings at PGDP: the southern setting over the Porters Creek Clay and the northern setting over the RGA. These two hydrogeological settings have distinct groundwater flow characteristics with associated variables regarding the ability to monitor contaminant releases to groundwater and to control contaminant migration in case of a release. One site from each setting was selected to serve as a prototype site. These are Site 3A, located at the southern end of the DOE property boundary in the southern hydrogeologic setting, and Site 11, located north of the current C-746-U Landfill facility in the northern hydrogeologic setting. Site 3A, which overlies the Porters Creek Clay to the south, is representative of the hydrogeologic settings of Site 1. Site 11, which overlies the RGA to the north, is representative of the hydrogeologic settings of Sites 5A and 9. These sites also were selected as prototype sites because comprehensive seismic investigations have been performed at or near Sites 3A and 11.

Based on previous studies conducted across the site, the layers and aggregations for Site 3A are anticipated to be similar for Site 1, and the layers and aggregations for Site 11 are anticipated to be similar for Sites 5A and 9. A PGDP sitewide groundwater flow model (DOE 1997) developed using MODFLOW, as well as more recently completed modeling (PRS 2010), was combined with MODPATH to estimate hydraulic gradients, flow distances, and hydraulic conductivities along site-to-receptor flow paths for the candidate sites that pass the threshold screening (i.e., Sites 1, 3A, 5A, 9, and 11). As shown in Table 5.6, the geologic layers, layer thicknesses, hydraulic conductivities, and particle gradients are similar for Sites 1 and 3A and for Sites 5A, 9, and 11, respectively, further supporting the use of Sites 3A and 11 as prototype sites.

Table 5.6. Summary of Southern and Northern Setting Candidate Site Properties

Summary of Southern Setting Candidate Site Properties				
	Site 3A		**Site 1**	
Layer	**Thickness (ft)**	**Bulk Density**	**Thickness (ft)**	**Bulk Density**
Geologic Buffer—Unsaturated	10	1.34	10	1.34
Geologic Buffer—Saturated	0	1.34	0	1.34
Terrace Gravel (Lower Continental Deposit)—Unsaturated	20	1.41	4	1.41
Terrace Gravel (Lower Continental Deposit)—Saturated	15	1.56	10	1.56

Site Property	**Site 3A**	**Site 1**
Hydraulic Conductivity (ft/d)	93	93
Average Depth to Saturated Horizontal Flow Groundwater (ft)	35	14
Particle Gradient (ft/ft)	0.00322	0.00894

Summary of Northern Setting Candidate Site Properties						
	Site 11		**Site 5A**		**Site 9**	
Layer	**Thickness (ft)**	**Bulk Density**	**Thickness (ft)**	**Bulk Density**	**Thickness (ft)**	**Bulk Density**
Geologic Buffer—Unsaturated	10	1.34	10	1.45	10	1.45
Geologic Buffer—Saturated	0	1.34	8	1.45	10	1.45
Unsaturated Upper Continental Deposits	22	1.43	44	2.05	0	NA
Saturated Upper Continental Deposits	14	1.43	54	1.45	35	1.45
RGA	35.5	1.67	20	1.67	30	1.67

Site Property	**Site 11**	**Site 5A**	**Site 9**
Hydraulic Conductivity (ft/d)	2,800	2,200	2,500
Average Depth to Saturated Horizontal Flow Groundwater (ft)	43	60	57
Particle Gradient (ft/ft)	0.00066	0.0013	0.00087

There are site-specific considerations for each prototype site that affect decisions on where to place the landfill operations area, support facilities, detention pond, roads, and other features. Figures F.4 to F.9 (Appendix F) show prototype site-specific conceptual design layouts for the two prototype sites. This subsection summarizes the practical advantages and limitations of each site.

5.4.5.1 Site 3A

Site 3A is bisected by a large overhead east-west power line crossing near the center of the site (Figure 5.2). It is assumed that Phase I and Phase II construction and their initial cells would be filled to the south of the power line right-of-way. It is further assumed, for purposes of conceptual design, that the power lines would be relocated at the beginning of Phase II construction.

Phase I would be constructed within the southwest part of Site 3A. The liner would generally slope to the north. Phase II would be constructed east of Phase I, and then subsequent phases would progress from west to east. The final phase would be constructed at the east end of the landfill operations area.

Site 3A—Development Advantages. Relative to groundwater flow, Site 3A is located well upgradient from the northern DOE property boundary and the nearest downgradient well is approximately 4,500 ft away. This would provide for a significant downgradient buffer zone in the case of a contaminant release from a potential disposal facility located at Site 3A. Site 3A is located over the low permeability Porters Creek Clay, which may limit the potential for downward migration of a release and allow more effective monitoring, containment, and control as compared to a site overlying the RGA. Site 3A does not overlie, and is not immediately upgradient of, existing plumes at PGDP (see Appendix E for more information). Because of its location relative to the existing plumes at PGDP and the downward flow confinement provided by the Porters Creek Clay, groundwater monitoring of potential contaminant releases could be accomplished more easily compared to a site with existing groundwater contamination and/or located over the RGA.

Site 3A is located just south of the industrialized portion of PGDP, proximal to plant utilities and roadways. There is potential for future expansion to the north; however, the cylinder yards would need to be cleared before expansion could be accomplished. Waste haul distances would be relatively short and confined within a restricted access area. There is no known buried waste at Site 3A. A seismic study and geotechnical investigation have been conducted at Site 3A. No faults of Holocene age were found.

Site 3A—Development Limitations. Of the two prototype sites, Site 3A would require the most clearing, grubbing, and earthwork for site preparation. Such site development would impact approximately 110 acres of relatively undisturbed lands. Site 3A also contains more potential wetlands than Site 11. There would be limited room for material stockpiles, storage sheds, and additional support facilities. Three large overhead east-west power transmission lines bisect the site. The power lines would need to be rerouted to accommodate a fully built-out landfill. The geometry of the site requires more liner and final cover area relative to the amount of airspace, as compared to Site 11. The geometry of the site also creates a need for several surface water detention ponds for stormwater management during construction and operations; there is insufficient area at the lower end of the site for constructing a single pond. Some of these developmental limitations could be offset if expansion to the north were to become feasible.

5.4.5.2 Site 11

Site 11 (located north of the C-746-U Landfill) would utilize existing infrastructure and the property north and west of the currently operating C-746-U Landfill (Figure 5.2). The landfill operations area would be bounded to the west and north by the DOE property boundary, to the east by the overhead power lines right-of-way, and to the south by the existing C-746-U Landfill facility.

Phase I would be constructed and landfill operations would begin at the southwest corner of the site adjacent to the C-746-U Landfill. Subsequent phases would proceed east and north. The final phase would be constructed at the northeast corner of the landfill.

Site 11—Development Advantages. The primary advantage to Site 11 is that existing resources (i.e., infrastructure, roads, equipment, stockpile, lay-down, utilities, groundwater monitoring systems, and labor) can be shared between the C-746-U Landfill and a CERCLA WDF. The site is enclosed by an existing fence that restricts public access. Part of the necessary surface water and sediment management controls are already in place and would supplement future needs. Utilities, such as electrical, plant phone, communications, lighting, potable water, and a septic system, currently serve the C-746-U Landfill and could be expanded to accommodate additional facilities necessary for a CERCLA WDF. A seismic investigation has been conducted at Site 11; no Holocene faults were found.

Site 11—Development Limitations. A tributary of Little Bayou Creek crosses the site from southwest to northeast, and would need to be rerouted to accommodate the landfill. A moderate amount of clearing, grubbing, and earthwork would be needed for site preparation. There would be limited room for material stockpiles, storage sheds, and additional support facilities. The boundaries of Site 11 offer little potential for expansion. This could be a disadvantage if the waste volumes requiring disposal in an on-site WDF exceed current forecasts. The location of this site at the northern DOE property boundary prevents establishment of a buffer zone to the north or west. There is also a potential acreage need conflict between the C-746-U Landfill and a new on-site disposal facility under the base case waste volume scenario.

Of the two prototype sites, Site 11 is farther from the waste source, equating to a longer haul distance. Waste hauls to this site would require installation of an overpass above the public road (Ogden Landing Road) to avoid impact to local traffic. The geometry of the site creates a need for new surface water detention ponds; there is likely insufficient area at the lower end of the site for constructing a single pond. Developing this site would result in some impact to relatively undisturbed lands.

The existing PGDP plumes (Appendix E) are located upgradient, underlying, and downgradient of Site 11. The location of this site relative to the groundwater plumes would need to be accounted for in the monitoring program at Site 11 due to potential commingling. Site 11 is underlain by the relatively permeable RGA. Downward migration of contaminants leaching from the cell would be difficult to contain or control because of the relatively high permeability and lack of confining layers.

5.4.6 PWAC Development/Performance Assessment

This section discusses the models and assigned parameters used to complete the necessary fate and transport modeling to support the development of PWAC for a potential on-site WDF. Appendix C provides additional supporting information for the PWAC modeling and calculations presented in this section.

- Operational/Closure Period source depletion (Attachment C1)
- Study of hydrogeologic data for Site 3A (GEO Consultants 2009) (Attachment C2)
- Terrace Gravel groundwater flow model description (Attachment C3)
- Disposal Unit Source Term-Multiple Species (DUSTMS) and Analytical, Transient 1-2-3-Dimensional (AT123D) Parameters (Attachment C4)
- Predicted groundwater concentration graphs at WDF boundary (Attachment C5)
- Potential receptors and exposure pathways (Attachment C6)
- Inadvertent intruder analysis (Attachment C7)

- Facilitated transport evaluation (Attachment C8)

- Uncertainty analysis (Attachment C9)

- Long-term uranium modeling uncertainty analysis (Attachment C10)

- Factors affecting calculated PWAC values (Attachment C11)

The PWAC allows for the evaluation of the viability of disposing of CERCLA waste in an on-site disposal facility. The model simulations provide information to develop requirements (i.e., the PWAC) for decision making that ensure adequate performance of the facility as described in DOE Order 458.1 (i.e., "Remain effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years") and for a period up to 1,600 years evaluating reasonable achievement of protectiveness. Additionally, simulations are carried out to 10,000 years to provide information on long-term protectiveness of human health.

The PWAC provides an estimate of the average contaminant concentrations allowed in the total waste volume. Individual loads could be higher or lower, but the total mass of any one constituent present in the landfill will not exceed the PWAC inventory mass. As such, the PWAC establishes the total contaminant amount allowed in the landfill, such as maximum curies permitted in the cell or the single contaminant limit per COPC. As the PWAC considers migration of chemicals in groundwater, the contaminant inventory limits defined by the PWAC apply only to mobile forms of a contaminant (e.g., nickel as a component of soil that is capable of dissolving into percolating water, etc.). Wastes placed in a non-mobile form, such as nickel ingots, etc., will not be subject to the contaminant inventory limits defined by the PWAC.

The PWAC is useful only in evaluating the viability of an on-site disposal facility. If selected as the preferred alternative, the PWAC values for an on-site disposal facility would require modification after the disposal facility design is finalized. As used for the purposes of this RI/FS, the PWAC for a contaminant is defined as the maximum allowable mass of a contaminant in disposed material that will not result in (1) releases to receiving media that exceed MCLs/background concentrations or risk-based criteria or (2) direct exposure risks or doses that exceed acceptable cancer risk-based and non-cancer hazard-based levels. This definition is consistent with, but goes beyond that presented in DOE Order 435.1 Attachment 2 (*Radioactive Waste Management Manual*). PWAC are defined as technical and administrative requirements that a waste must meet in order for it to be accepted at a storage, treatment, or disposal facility. Generally, PWAC as defined here are dependent on five primary characteristics including the following:

- Facility design, including liner and cover, integrity, and institutional controls;

- Mobility of contaminants from or retention of contaminants within a waste (e.g., soil, stabilized soils, concrete, metals, etc.);

- Exposure point characteristics, including type of receptor, location, and exposure media;

- Exposure point risk/dose targets (i.e., target cancer risk, target hazard level, MCLs, dose-based risks, etc.) and period of compliance; and

- Potential engineered barrier failure.

It is important to recognize that the PWAC, in addition to assessing the viability of the On-Site Alternative, is intended to inform the design of an on-site WDF as it progresses from the conceptual level to final design. The PWAC and the findings of the sensitivity or uncertainty modeling for the PWAC,[18] may be used to inform design elements or design element modifications such that increased waste concentrations or contaminant masses may be achieved while still meeting the RAOs. One example of where the understanding of the PWAC as it relates to design elements could be implemented if desired would be the modification of the WDF subgrade to achieve a higher K_d value for this soil layer, which would result in the WAC differing from the PWAC.

As described in the Work Plan (DOE 2011a), the PWAC are based on groundwater transport of contaminants and the exposure scenario of a residential groundwater user drawing water from a well located at the edge of waste, the waste disposal facility boundary, the property boundary, or surface water outcrop. This receptor was selected because this individual reasonably would be expected to receive the highest cancer risk, hazard, and/or radionuclide dose from most contaminants migrating from the landfill.

Other constraints including, but not limited to, landfill worker protection and operational requirements (i.e., waste form and placement, etc.) are not considered in the development of the PWAC, but are anticipated to be incorporated into the WAC if the On-Site Alternative is selected. Some WAC concentrations also may increase compared to PWAC concentrations as a result of final site selection, final WDF design, etc. Such revisions to the PWAC are expected to occur as part of developing the final WDF design and O&M plan.

5.4.6.1 Selected models and their application

The fate and transport modeling utilized the following model codes to represent conditions at the two prototype sites (i.e., Site 3A and Site 11) and at areas to which contaminants may migrate. These models are industry standard simulation codes that have received regulatory and stakeholder acceptance for use at the PGDP and in other similar projects.

- Hydrologic Evaluation of Landfill Performance (HELP)
- DUSTMS
- MODFLOW
- MODPATH
- AT123D

Use of these models is consistent with Tier 3 of the groundwater-modeling matrix presented in *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE 2011b). As explained therein, Tier 3 is used when enhanced modeling is needed to support PGDP decision documents. Following is a description of the modeling performed to support PWAC development.

HELP Model. The HELP model was used to evaluate the rate of vertical water percolation into and through the WDF (Schroeder et al. 1994). HELP is a quasi-two-dimensional, deterministic, water-routing model for developing water balances. The model accepts weather, soil, and design data. The model accounts for the effects of surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture storage, lateral subsurface drainage, leachate recirculation, unsaturated vertical drainage, and leakage through soil, geomembrane, or composite liners. This program is the most widely

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[18] Section 5.4.6.8 discusses the findings of the uncertainty modeling.

used model to conduct water balance analyses of landfills, cover systems, and solid waste disposal and containment facilities. The model facilitates rapid estimation of the amounts of runoff, evapotranspiration, drainage, leachate collection, and liner leakage that may be expected to result from the operation of a wide variety of landfill designs.

HELP model simulations were performed under three failure scenarios to estimate the vertical water flux percolating through the waste to the water table. The three failure scenarios for the disposal cell components are (DOE 2011a):

- **Instantaneous Failure.** Liner system components fail at Year 200 (200 years subsequent to the commencement of the Operational/Closure Period). The HELP-computed percolation rate at Year 200 is equivalent to that predicted for the failed system.

- **Gradual Failure.** Liner system components begin to gradually degrade starting at Year 200 (200 years subsequent to the commencement of the Operational/Closure Period) according to a decay function discussed later in this section. Complete liner system component failure occurs at Year 600. The gradual failure scenario is used to calculate PWAC values.

- **No Failure.** Liner system components maintain integrity throughout the period of interest (through Year 10,000).

The HELP model was applied to determine the water balance for three time periods:

- **Operational/Closure Period (Year 0 to 30).** Landfill components that would be in place include the leachate collection system with a barrier liner beneath the waste and a temporary cover would also be in place. It was assumed that the leachate collection system would operate effectively throughout this period and, therefore, negligible quantities of water would leak through the liner. The average water flux through the waste and collected by the leachate collection system was predicted using the HELP model to be approximately 8.1×10^{-6} cm/year (see Figure 5.3 and Attachment C1). Results for the Operational Period do not vary by scenario or site.

- **Postclosure Period (Year 30 to 200).** The landfill components of the waste disposal cell would be in place (i.e., both cover and liner components including FMLs, drainage layers, low-permeability clay layers, and geologic buffer layer). The leachate collection system would continue to operate through year 130; however, since minimal leakage occurs during the postclosure period and to simplify the modeling, the leachate collection system was simulated as being in operation during the postclosure period (Year 30 to 200). The average flux to the water table estimated by HELP for this landfill configuration is 7.8 x 10-7 cm/year (see Figure 5.3 for the gradual failure scenario).

  Note that the assumed duration of the postclosure period for modeling purposes is 170 years to evaluate effectiveness. This is only an assumption for modeling and does not reflect the anticipated on-going SM&M requirements for an on-site disposal facility that DOE would maintain for as long as the material disposed in the facility presents an unacceptable risk to human health and the environment.

- **Long-term Modeling Period (Year 200 to 10,000).** The modeling simulations assume that failure of the manmade flexible membrane liner (FML) layers in both the bottom liner and cap and failure of the two drainage layers below the waste (DOE 2011a) begin 170 years after closure (i.e., construction of the final cover) of the on-site disposal facility (i.e., Year 200, or 170 years following the Operational/Closure Period) and do not consider any maintenance or engineering or institutional control period beyond this time (as discussed in the conceptual design Section 5.4.2).

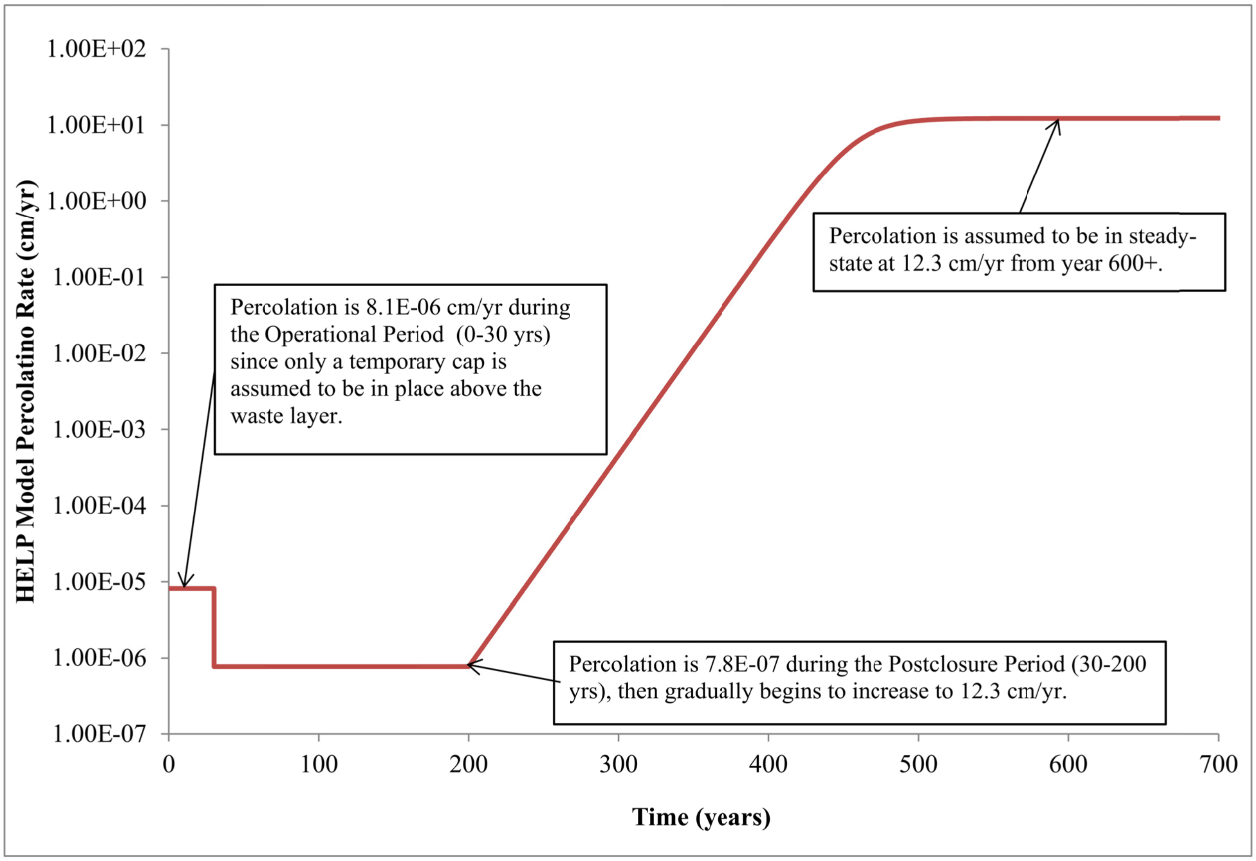

Figure 5.3. Percolation of Landfill Leachate to Groundwater Table as a Function of Time Under the Gradual Failure Scenario

Additionally, the hydraulic conductivity of the clay layers in both the bottom liner and cover system is increased one order of magnitude at Year 600. For the gradual failure, no failure, and instantaneous failure scenarios, the sand drainage layer in the cover system also was assumed to fail and is modeled as a vertical flow layer. Information presented during the February 22, 2012, "Symposium on Performance Modeling of Low-Level Radioactive Waste Disposal Facilities," as well as literature reviews (e.g., DOE 1998) on performance of cover systems and a subsequent review of the conceptual design with respect to this information, indicate that the sand drainage layer in the cover system potentially can be modeled as a drainage layer as opposed to a vertical percolation layer during the Long-Term Modeling Period; the sand drainage layer is modeled as a drainage layer during the Operation/Closure and the Postclosure Periods. As such, sensitivity modeling of the sand drainage layer and biointrusion layer of the conceptual cover system has been performed. Discussion on this approach is included in Section 5.4.6.9. Modeling past 10,000 years was performed as part of the uncertainty analyses and as described in the Work Plan (DOE 2011a), because some radionuclide contaminants (and decay products from ingrowth) will not reach their peak concentration prior to 10,000 years. An uncertainty analysis examining ingrowth and risk beyond 10,000 years will be completed for U-238 (parent compound) and Th-230 (progeny). The results of the modeling in excess of 10,000 years are presented in Section 5.4.6.8 and Appendix C, Attachment 10.

Under the no failure scenario, the components of the waste disposal cell were assumed to be in place, and the water flux was assumed to be equal to the postclosure period value of 7.8 x 10-7 cm/year. Under the gradual and instantaneous failure scenarios, the lateral gravel drainage layer beneath the waste was assumed to degrade starting at Year 200. To account for degradation, the man-made FML layers no longer act as barrier layers, and the two drainage layers below the waste no longer function (i.e., they effectively become vertical percolation layers). The uncertainty associated with degradation of the clay barriers is evaluated and discussed in Section 5.4.6.7; however, the engineering/institutional controls and necessary SM&M activities will continue for as long as the waste disposed in the facility poses an unacceptable risk to human health and environment.

Due to the aforementioned degradation, the average water flux through the landfill under both the gradual and instantaneous failure scenario was estimated to increase to 12.3 cm/year after failure was complete (Figure 5.3). Under the gradual failure scenario, the degradation and concurrent increase in average water flux due to component degradation, estimated using Eq. 1, were assumed to increase gradually during the postclosure period and peak 570 years after initiation of the postclosure period (Year 600). Similarly, under the instantaneous failure scenario, the increase to the higher water flux of 12.3 cm/yr was assumed to be instantaneous at the end of the postclosure period (Year 200).

The model used for gradual failure due to degradation of the FML, cover, and liner from Year 200 to 600 is represented by the following equation (Lee et al. 1995).

$$F(t) = \frac{f_2 \times f_3}{f_2 + (f_3 - f_2) \times e^{-\alpha(t-t_1)}} \qquad \text{(Eq. 1)}$$

where

$F(t)$ = groundwater recharge rate at time of interest (t), cm/yr
f_2 = average groundwater recharge in the postclosure period based on HELP run, cm/year
f_3 = the final groundwater recharge based on HELP run for the long-term modeling period after cover and liner failure, cm/year
t = the time (years) at which F(t) is measured
t_1 = the time (years) at the end of the postclosure period (i.e., Year 200)

α = the decay constant (0.064 $year^{-1}$), specifically developed for this time frame and differential magnitude in recharge rates

The value of the decay constant, α, was assumed to be 0.064 $year^{-1}$, which resulted in the water flux reaching the fully degraded recharge rate of 12.3 cm/yr approximately 400 years after initiation of gradual failure (Year 600). The value of the decay constant determined the time at which the peak water flux was attained (i.e., failure of the liner components was complete).

Key parameters used in the HELP model simulations were as follows:

- Climatic parameters—growing season, average quarterly relative humidity, normal mean monthly temperature and precipitation, and evaporative zone depth (Table 5.7);

- Disposal cell design parameters—maximum drainage distance for lateral drainage layers, layer thickness, layer description, leachate recirculation procedure, and geomembrane (i.e., FML) characteristics (Tables 5.8 and 5.9); and

- Soil characteristics—porosity, field capacity, wilting point, saturated hydraulic conductivity, initial moisture storage, and Soil Conservation Service runoff curve number (Tables 5.8 and 5.9).

DUSTMS Model. The DUSTMS model (Sullivan 2001) was used to estimate the mass rate at which a contaminant will vertically migrate out of the disposal facility to the underlying groundwater table. The DUSTMS model was used to determine contaminant release rates from the disposal unit to surrounding soil using water infiltration rates predicted by the HELP model. DUSTMS is a one-dimensional model that simulates contaminant transport through, and leaching from up to 10 different materials per simulation.

DUSTMS allows for consideration of the characteristics affecting migration rate including contaminant inventory, the waste and the containers used to dispose of the inventory (if applicable), and the physical processes that lead to release from the facility (i.e., fluid flow, container degradation, waste leaching, and contaminant transport). The DUSTMS model is designed to achieve a balance between the use of simple but conservative assumptions that may lead to predicted releases greater than that which may be reasonably expected; and the use of complicated models that include all known physical and chemical processes that may influence a release, but require long lists of input variables which are generally unknown.

DUSTMS modeling was performed for the instantaneous failure, gradual failure, and no failure scenarios. For the gradual failure scenario, DUSTMS modeling was performed for 10 organic indicator chemicals, 17 metals, and 21 radionuclides (includes radionuclides formed through decay chains). The waste was assumed to be homogeneous soil-like material for the modeling used to develop the PWAC. This assumption provides an overestimation of the contamination potentially leaching from the waste for preliminary evaluation in the FS because of the greater surface area for soil compared to other wastes, such as concrete, from which contaminants could leach. Modification of this assumption to more closely simulate actual waste categories would be necessary to refine the final WAC, if an on-site disposal alternative is selected.

Table 5.7. Climatic Parameters Used by the HELP Model (DOE 2011a)

Parameter	Values
Fraction of area allowing runoff[a]	100%
Evaporative zone depth[b]	21 inches for Operational/Closure Period, and 26 inches for Postclosure and Long-Term Modeling Periods
Start of growing season[b]	105^{th} Julian day
End of growing season[b]	300^{th} Julian day
Average annual wind speed[b]	8.2 mph
Average 1st quarter relative humidity[b]	70%
Average 2nd quarter relative humidity[b]	67%
Average 3rd quarter relative humidity[b]	72%
Average 4th quarter relative humidity[b]	54%
Normal mean monthly precipitation (Jan)[c]	3.27 inches
Normal mean monthly precipitation (Feb)	3.90 inches
Normal mean monthly precipitation (Mar)	4.92 inches
Normal mean monthly precipitation (April)	5.01 inches
Normal mean monthly precipitation (May)	4.94 inches
Normal mean monthly precipitation (Jun)	4.05 inches
Normal mean monthly precipitation (Jul)	4.19 inches
Normal mean monthly precipitation (Aug)	3.34 inches
Normal mean monthly precipitation (Sept)	3.69 inches
Normal mean monthly precipitation (Oct)	3.00 inches
Normal mean monthly precipitation (Nov)	4.32 inches
Normal mean monthly precipitation (Dec)	4.65 inches
Normal mean monthly temperature (Jan)[c]	32.6°F
Normal mean monthly temperature (Feb)	36.9°F
Normal mean monthly temperature (Mar)	47.5°F
Normal mean monthly temperature (Apr)	57.9°F
Normal mean monthly temperature (May)	66.7°F
Normal mean monthly temperature (Jun)	75.2°F
Normal mean monthly temperature (Jul)	78.8°F
Normal mean monthly temperature (Aug)	76.8°F
Normal mean monthly temperature (Sept)	70.2°F
Normal mean monthly temperature (Oct)	58.7°F
Normal mean monthly temperature (Nov)	47.9°F
Normal mean monthly temperature (Dec)	37.3°F

[a] The actual amount of runoff is calculated by the model depending on the slope of topsoil.
[b] Evapotranspiration data are default values for Evansville, Indiana (approximately same latitude as Paducah, Kentucky), depending on the growth and type of the vegetation on the topsoil.
[c] Obtained from 30 years of historical National Oceanic and Atmospheric Administration precipitation and temperature data for Paducah, Kentucky (Owenby and Ezell 1992).

Table 5.8. HELP Landfill Design Profile and Soil Characteristics—Postclosure Period (DOE 2011a)

Layer #	Material Type	Layer Type	Layer Thickness (inches)	Soil Texture Type	Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/sec)	Initial Moisture Content		Drainage Length (ft)	Drain Slope (%)	FML Pinhole Density	FML Installation Defects	FML Placement Quality
1	Native Soil (vegetative)	1	18	12	0.45*	0.342	0.21	2.32E-06*	0.2347	***	--	--	--	--	--
2	Native Soil	1	42	12	0.45*	0.342	0.21	5.00E-07*	0.3420	***	--	--	--	--	--
3	Filter sand	1	12	3	0.457	0.083	0.033	3.10E-03	0.0843	***	--	--	--	--	--
4	Geotextile	1	0.0625	20	0.85	0.01	0.005	1.00E+01	0.0501	***	--	--	--	--	--
5	Cobble/gravel/sand	1	36	21	0.397	0.032	0.013	3.00E-01	0.0321	***	--	--	--	--	--
6	Drainage sand	2	12	1	0.417	0.045	0.018	1.00E-02	0.0452	***	380	2	--	--	--
7	Geotextile	2	0.125	20	0.85	0.01	0.005	1.00E+01	0.0100	***	380	2	--	--	--
8	FML (HDPE)	4	0.04	35				2.00E-13	0.0000	***	--	--	0	0.5	2 (Excellent)
9	Clay barrier/ contour layer	3	36	16	0.427	0.418	0.367	1.00E-07*	0.4270	***	--	--	--	--	--
10	Waste	1	1,020	22	0.419	0.307	0.18	1.90E-05	0.3588		--	--	--	--	--
11	Contour layer	1	12	26	0.445	0.393	0.277	1.90E-06	0.4112		--	--	--	--	--
12	Geotextile	1	0.125	20	0.85	0.01	0.005	1.00E+01	0.1103		--	--	--	--	--
13	Drainage sand	2	12	1	0.417	0.045	0.018	1.00E-02	0.1158		364	5	--	--	--
14	Geotextile	2	0.125	20	0.85	0.01	0.005	1.00E+01	0.0766		364	5	--	--	--
15	FML (HDPE)	4	0.06	35				2.00E-13	0.0000		--	--	0	0.5	2 (Excellent)
16	Bonded Geotextile	2	0.236	34	0.85	0.01	0.005	3.30E+01	0.0100		364	5	--	--	--
17	FML (HDPE)	4	0.06	35				2.00E-13	0.0000		--	--	0	0.5	2 (Excellent)
18	Clay barrier**	3	36	16	0.427	0.418	0.367	1.00E-07*	0.4270		--	--	--	--	--

Table 5.8. Landfill Design Profile and Soil Characteristics—Postclosure Period (Continued)

Layer #	Material Type	Layer Type	Layer Thickness (inches)	Soil Texture Type	Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/sec)	Initial Moisture Content		Drainage Length (ft)	Drain Slope (%)	FML Pinhole Density	FML Installation Defects	FML Placement Quality
19	Geo-buffer layer	1	120	12	0.45*	0.342	0.21	5.00E-07*	0.3420		--	--	--	--	--
20	Existing Silty Clay	1	264 (Site 11) 240 (Site 3A)	26	0.445 (Site 11) 0.400* (Site 3A)	0.393	0.277	3.80E-07* (Site 11) 3.67E-06* (Site 3A)	0.3930		--	--	--	--	--

Notes:
- HDPE = high density polyethylene.
- FML = flexible membrane lining.
- No recirculation of leachate is assumed.
- Moisture content values are in units of pore water volume per total volume soil and void space.
- FML installation defects are in units of defects per acre. A defect is estimated using an area of 1 cm^2.
*Signifies value is not the default value associated with the specified HELP Soil Texture Type.
**Signifies location where HELP Percolation/Leakage rate is used as DUST-MS water velocity.
***Initial soil moisture content was calculated by HELP (Schroeder et al. 1994). Remaining moisture contents were assigned using the final moisture content of the Operational Period HELP scenario.
- "Native Soil," "Geo-buffer layer," and "Existing Silty Clay" soil porosities and hydraulic conductivities are from Site 3A Seismic Investigation Report, Assessment of the Adequacy of Data Report, and GB-02D lithologic log.
- Soil layering and properties are based upon the June 2010 PGDP Public Fact Sheet, Waste Disposal Options.
- FML Pinhole Density in units of number of holes per acre. Diameter of defect is equal to geomembrane thickness.
- The cover system design curve number is 87.6 (slope 2%, slope length 380 ft, fair stand of grass (3), with soil texture type 12).

Table 5.9. HELP Landfill Design Profile and Soil Characteristics—Long-Term Modeling Period (DOE 2011a)

Layer #	Material Type	HELP Layer Type	Layer Thickness (inches)	HELP Soil Texture Type	Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/sec)	Initial Moisture Content (vol. water/ total vol.)
1	Native Soil (vegetative)	1	18	12	0.45*	0.342	0.21	2.32E-06*	0.3071
2	Native Soil	1	42	12	0.45*	0.342	0.21	5.00E-07*	0.3491
3	Filter sand	1	12	3	0.457	0.083	0.033	3.10E-03	0.1118
4	Cobble/gravel/sand	1	36	21	0.397	0.032	0.013	3.00E-01	0.0570
5	Drainage sand	1	12	1	0.417	0.045	0.018	1.00E-02	0.0370
6	Clay barrier	1	36	16	0.427	0.418	0.367	1.00E-06*	0.4270
7	Waste	1	1,020	22	0.419	0.307	0.18	1.90E-05	0.3070
8	Silty clay	1	12	26	0.445	0.393	0.277	1.90E-06	0.3930
9	Drainage sand	1	12	1	0.417	0.045	0.018	1.00E-02	0.0450
10	Clay barrier	1	36	16	0.427	0.418	0.367	1.00E-06*	0.4270
11	Geo-buffer layer**	1	120	12	0.45*	0.342	0.21	5.00E-07*	0.3930
12	Existing Silty Clay	1	264 (Site 11) 240 (Site 3A)	26	0.445 (Site 11) 0.400* (Site 3A)	0.393	0.277	3.80E-07* (Site 11) 3.67E-06* (Site 3A)	0.3930

Notes:

* - Signifies value is not the default value associated with the specified HELP Soil Texture Type.

** - Signifies location where HELP Percolation/Leakage rate is used as DUST-MS water velocity.

- Moisture content values are in units of pore water volume per total volume soil and void space.

- The cover system design curve number is 87.6 (slope 2%, slope length 380 ft, fair stand of grass (3), with soil texture type 12).

- "Native Soil," "Geo-buffer layer," and "Existing Silty Clay" soil porosities and hydraulic conductivities are from Site 3A Seismic Investigation Report, Assessment of the Adequacy of Data Report, and GB-02D lithologic log.

- Initial moisture content values were assigned as calculated in the final time step of the HELP Post Closure model. The Long Term initial moisture content values correspond to the same layers specified in the Post Closure model.

The DUSTMS transport model is a finite difference model. Initial concentrations were input as a total concentration (Sullivan 2001) since it was assumed that the waste was soil-like and homogenous. Waste containers were not modeled in DUSTMS because it was assumed that the contaminants were readily available for transport and not packaged or treated to decrease leachability. Also, according to Sullivan (2001), use of the waste containers provides an opportunity to overpredict chemical retardation if both waste-to-water and soil-to-water partitioning coefficients are assigned.

Key parameters used for DUSTMS modeling included the following:

- Disposal cell design parameters—height, horizontal surface area, thickness of layers, and placement sequence of waste types;
- Percolation rate as determined by the HELP model;
- Waste inventory—initial contaminant mass, contaminant half-life, and approximate size and thickness of the waste;
- Waste characteristics—waste volumes, site-specific and generic soil/water distribution coefficient (K_d) factors, diffusion coefficients, and release mechanism for the waste form; and
- Backfill soil characteristics—site-specific and generic K_d factors, diffusion coefficient, dispersivity, porosity, density, and moisture content.

DUSTMS parameter values are derived from environmental conditions. It is likely that environmental conditions will vary both spatially and temporally. The assumed general environmental conditions for Site 3A and Site 11 are included below. Attachment C9 includes an assessment of the potential effect of environmental conditions different than those assumed.

- **Waste form**—Low redox potential with little to no measurable dissolved oxygen (DO) due to full enclosure by a gas-impermeable cover and the presence of ferrous metals (scrap metal) in the waste. Alkaline pH (8–10) is assumed due to hydrated lime in waste concrete. Reduced form of metals and anions [e.g., Am(III), As(III), As(-II), Se(-2), Cr(III), U(4), Hg(I), Ni(II), Sn(II), etc.] would be expected to predominate over oxidized forms.
- **Unsaturated zone**—High DO (4–6 ppm) is anticipated. Oxidizing conditions due to rainwater recharge. Neutral to slightly acidic pH (4.5–7) assumed. Oxidized species expected to predominate over reduced forms.
- **Saturated zone**—Low to moderate DO (1–4 ppm) and circumneutral pH (6.5–7.5) is anticipated. Little or no change in redox potential is expected in going from the unsaturated zone into the saturated zone. However, the chemical composition of groundwater in the RGA may be quite different than pore water from the leachate, so additional chemically mediated precipitation may take place in the RGA.

Values for the above parameters are listed in Table 5.10 and with complete references in Attachment C4 in Appendix C. Schematic diagrams showing the different layers and material aggregations modeled in DUSTMS are shown in Figures 5.4 (Site 3A) and 5.5 (Site 11).[19]

MODFLOW and MODPATH. MODFLOW (McDonald and Harbaugh 1988) is a three-dimensional, finite difference model capable of simulating both steady-state and transient head distribution for a saturated groundwater flow field. MODPATH (Pollack 1994) is a three-dimensional, particle-tracking model capable of using the hydraulic head distribution generated by MODFLOW to track flow paths of particles released in the groundwater flow field modeled in MODFLOW.

A PGDP sitewide groundwater flow model (DOE 1997) was developed for the PGDP using MODFLOW. The PGDP sitewide groundwater flow model and MODPATH were used to estimate hydraulic gradients, flow distances, and hydraulic conductivities along site-to-receptor flow paths. This information subsequently was used to develop input parameters for the AT123D saturated zone chemical fate and transport model.

MODFLOW and MODPATH modeling were performed at Site 11 to predict the groundwater migration rate and path from the location where leachate enters the RGA to downgradient exposure point locations. The calibrated, site-specific sitewide MODFLOW groundwater model covers most of PGDP except that portion to the south and above the Porters Creek Clay terrace. The MODFLOW model was approved by both the PGDP Modeling Steering Committee and the Risk Assessment Working Group. The PGDP sitewide groundwater flow model has been recently updated in consultation with the Commonwealth of Kentucky and EPA using more recent groundwater monitoring data (PRS 2010). The revised PGDP sitewide groundwater flow model was used in this modeling effort. Predictive simulations assumed long term conditions with natural recharge (i.e., precipitation) and no anthropogenic recharge from site activities (i.e., discharge of cooling water).

Site 3A is located outside of the PGDP groundwater flow model domain. To predict the groundwater migration rate and flowpath from Site 3A, a Terrace Gravel groundwater flow model was appended to the PGDP sitewide groundwater flow model. Conceptual model development was guided by the GEO Consultants (2009) study of hydrogeologic data for Site 3A as well as site knowledge. The GEO report is included as Attachment C2 to Appendix C and a description of the Terrace Gravel groundwater flow model is included as Attachment C3. The Terrace Gravel groundwater flow model was calibrated to site data and provided suitable predictions for this RI/FS.

MODPATH was used to predict flowpaths of virtual particles released from the disposal unit based on the steady-state flow field calculated by MODFLOW at Site 11 and 3A. The flowpath originated at the approximate centroid of the WDF footprint and ended at the assessment points of interest. The hydraulic heads along the flowpath of interest were evaluated, and the hydraulic gradient was estimated as the hydraulic head difference between the release point and points of assessment (POAs), divided by the distance along the flowpath from the release point to the exposure point. The average hydraulic conductivity along the flowpath of interest was selected for use in the AT123D model. Figure 5.6 provides the particle tracks with the point of origination located at the centroid of the candidate site calculated using MODPATH for Site 11 and Site 3A. Note that use of a single origination point for the particle tracks may result in a potential overestimation of contaminant concentrations at the points of exposure considered.

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[19] Note that these figures may differ from prior documents for the PGDP; the figures were developed specifically for this RI/FS and are included as Figures C.2 and C.3 of the Work Plan (DOE 2011a).

Table 5.10. DUSTMS Model Input Parameters (DOE 2011a)

Chemical-Specific[a]

Chemical	Half Life (years)	Atomic Weight (g/mol)	Solubility Limit (g/cc)	Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd) (cm^3/g)	Diffusion Coefficient (cm^2/sec)[b]	DUSTMS Landfill Waste Layer Nodal Initial Concentration (g/cm^3)[c]
Vinyl chloride	7.9	62.5	2.76E-03	0.0149	1.23E-06	1.00
TCE	4.5	131.4	1.10E-03	0.0755	9.10E-06	1.00
2-Butanone	0.038	72.1	7.40E-02	0.00554	9.30E-06	1.00
Chlorobenzene	1.64	112.6	4.72E-04	0.179	8.70E-06	1.00
Benzene	2	78.1	1.75E-03	0.0494	9.80E-06	1.00
2-Methylphenol	0.077	108	2.60E-02	0.0731	8.30E-06	1.00
Pentachlorophenol	4.2	266.3	1.95E-03	0.474	6.10E-06	1.00
Benzo(a)pyrene	5.8	252.3	1.62E-09	776	9.00E-06	1.00
PCB-1254	100	375.7	7.00E-07	248	1.00E-06	1.00
gamma-Chlordane	7.6	409.8	5.60E-08	41.1	4.37E-06	1.00
Antimony	--	121.7	1.70E-01	45 (non-clay materials) 250 (clay)	1.00E-06	1.00
Arsenic	--	74.9	1.20E-01	29	1.00E-06	1.00
Barium	--	137.3	2.80E-03	41	1.00E-06	1.00
Beryllium	--	9.01	8.40E-02	250 (non-clay materials) 1,300 (clay)	1.00E-06	1.00
Cadmium	--	112.4	1.70E-03	80 (non-clay materials) 560 (clay)	1.00E-06	1.00
Chromium	--	51.9	6.00E-01	32.1	1.00E-06	1.00
Copper	--	63.6	5.70E-04	3.1	1.00E-06	1.00
Lead	--	207.2	8.70E-04	270 (non-clay materials) 550 (clay)	1.00E-06	1.00
Manganese	--	54.9	1.10E-03	50 (non-clay materials) 180 (clay)	1.00E-06	1.00
Mercury	--	200.6	4.50E-04	52	1.00E-06	1.00
Nickel	--	58.7	1.50E-03	108	1.00E-06	1.00
Selenium	--	78.9	2.60E+00	150 (non-clay materials) 740 (clay)	1.00E-06	1.00

Table 5.10. DUSTMS Model Input Parameters (DOE 2011a) (Continued)

Chemical-Specific[a]

Chemical	Half Life (years)	Atomic Weight (g/mol)	Solubility Limit (g/cc)	Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd) (cm^3/gm)	Diffusion Coefficient (cm^2/sec)[b]	DUSTMS Landfill Waste Layer Nodal Initial Concentration (g/cm^3)[c]
Silver	--	107.9	2.50E-04	90 (non-clay materials) 180 (clay)	1.00E-06	1.00
Thallium	--	204.4	8.60E-03	71	1.00E-06	1.00
Vanadium	--	50.9	7.00E-04	1000	1.00E-06	1.00
Zinc	--	65.4	1.40E-03	200 (non-clay materials) 2,400 (clay)	1.00E-06	1.00
Cs-137	3.02E+01	137	3.40E-01	280 (non-clay materials) 1,900 (clay)	1.00E-06	1.00
Tc-99	2.13E+05	99	7.18E-03	0.282 (non-clay materials) 1 (clay)	1.00E-06	1.00
Ac-227	22	227	1.00E+01	450 (non-clay materials) 2,400 (clay)	1.00E-06	0.00
Am-241	4.32E+02	241	8.00E-03	1900 (non-clay materials) 8400 (clay)	1.00E-06	1.00
Np-237	2.14E+06	237	1.00E+01	5 (non-clay materials) 55 (clay)	1.00E-06	1.00
Pa-231	3.28E+04	231	1.00E+01	550 (non-clay materials) 2,700 (clay)	1.00E-06	0.00
Pb-210	2.20E+01	210	8.70E-04	270 (non-clay materials) 550 (clay)	1.00E-06	0.00
Pu-238	8.78E+01	238	1.00E+01	550 (non-clay materials) 5100 (clay)	1.00E-06	1.00
Pu-239	2.41E+04	239	1.00E+01	550 (non-clay materials) 5100 (clay)	1.00E-06	1.00
Pu-240	6.54E+03	240	1.00E+01	550 (non-clay materials) 5100 (clay)	1.00E-06	1.00
Ra-226	1.60E+03	226	3.10E-01	500 (non-clay materials) 9100 (clay)	1.00E-06	0.00
Ra-228	5.80E+00	228	3.10E-01	500 (non-clay materials) 9100 (clay)	1.00E-06	0.00

Table 5.10. DUSTMS Model Input Parameters (DOE 2011a) (Continued)

Chemical-Specific[a]

Chemical	Half Life (years)	Atomic Weight (g/mol)	Solubility Limit (g/cc)	Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd) (cm^3/gm)	Diffusion Coefficient (cm^2/sec)[b]	DUSTMS Landfill Waste Layer Nodal Initial Concentration (g/cm^3)[c]
Th-228	1.90E+00	228	2.80E-01	3200 (non-clay materials) 5800 (clay)	1.00E-06	0.00
Th-229	7.34E+03	229	2.80E-01	3200 (non-clay materials) 5800 (clay)	1.00E-06	0.00
Th-230	7.70E+04	230	2.80E-01	3200 (non-clay materials) 5800 (clay)	1.00E-06	1.00
Th-232	1.40E+10	232	2.80E-01	3200 (non-clay materials) 5800 (clay)	1.00E-06	0.00
U-233	1.59E+05	233	1.00E-04	35 (non-clay materials) 1600 (clay)	1.00E-06	0.00
U-234	2.40E+05	234	1.00E-04	35 (non-clay materials) 1600 (clay)	1.00E-06	1.00
U-235	7.00E+08	235	1.00E-04	35 (non-clay materials) 1600 (clay)	1.00E-06	1.00
U-236	2.34E+07	236	1.00E-04	35 (non-clay materials) 1600 (clay)	1.00E-06	0.00
U-238	4.50E+09	238	1.00E-04	35 (non-clay materials) 1600 (clay)	1.00E-06	1.00

[a] References for the parameters in this table are included in Attachment C4 in Appendix C.
[b] Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0.
[c] Waste form initial concentration specified as unit source concentration for all nodes (1 g/cm^3).

Table 5.10. DUSTMS Model Input Parameters (DOE 2011a) (Continued)

Waste Parameters

Parameter	Unit	Value
Contaminant release mechanism		None (initial concentrations assigned)
Height of waste form	cm	2.59E+03
Width of waste[d]	cm	2.77E+04
Total volume capacity in waste layer	cm^3	1.99E+12
Bulk density[e]	gm/cm^3	3.1
Moisture Content		0.3588
Darcy velocity (Operational/Closure Period)[e]	cm/s	1.624E-06 (Fill Time) 1.605E-06 (Idle Time)
Darcy velocity (Postclosure Period)[e]	cm/s	2.458E-14
Darcy velocity (Long-Term Modeling Period)[e]	cm/s	3.901E-7
Dispersivity[f]	cm	415 (Site 11) 366 (Site 3A)

Soil Parameters

		Layer Types			
Parameter	**Units**	**Native soil**	**Clay Barrier**	**Alluvium Soil**	**Sand layer**
Bulk density	g/cm^3	1.34	1.8	1.43	1.4
Dispersivity[f]	cm	415 (Site 11) 366 (Site 3A)			

Note that values for the postclosure period were used for both the postclosure and long-term modeling periods under the no failure scenario.
[d] Calculated as follows: Width = (surface area of the landfill)$^{1/2}$.
[e] Values for all periods were obtained using the Hydrologic Evaluation of Landfill Performance model for the gradual failure scenario; therefore, it represents constant value for all the layers that are equivalent to the recharge.
[f] Values estimated as 0.1 times the contaminant travel distance.

Site 3A - Postclosure Conceptual Model

HELP, DUST-MS, AT123D

DUST-MS Material	HELP Soil Layers	DUST-MS Number of Computational Nodes	Thickness (ft)	DUST-MS Bulk Density	DUST-MS Initial (t = 30 yrs) Volumetric Moisture Content	HELP Initial (t = 30 yrs) Volumetric Moisture Content
1	Soil Matirx	10	5	1.34	0.3098	0.3098
2	Filter Sand	2	1	1.4	0.0452	0.0843
	Cobble/ Gravel Sand	6	3			0.0451
	Drainage Sand	2	1			0.032
FML (HDPE) Liner						
3	Clay	6	3	1.8	0.4251	0.4251
4	Waste Form	170	85	3.1	0.3588	0.3588
3	Clay (compacted)	2	1	1.5	0.4112	0.4112
2	Drainage Sand	2	1	1.4	0.1123	0.1123
FML (HDPE) Liner	Geocomposite		0.02			
FML (HDPE) Liner 3	Clay Barrier	6	3	1.8	0.427	0.427
1	Geologic Buffer	20	10	1.34	0.342	0.393
5	Terrace Gravel (Lower Continental Deposit)	40	20	1.41	0.302	0.302
	Bottom of HELP and DUST-MS Model					
AT123D Lateral Flow Layer	Terrace Gravel (Lower Continental Deposit)		15	1.56	Saturated Horizontal Flow	
	Porter's Creek Clay		70			
McNairy Formation						

Unsaturated Vertical Flow

Figure 5.4. DUSTMS Model Layers and Select Parameters, Site 3A (DOE 2011a)

Site 11 - Postclosure Conceptual Model

HELP, DUST-MS, AT123D

DUST-MS Material	HELP Soil Layers	DUST-MS Number of Computational Nodes	Thickness (ft)	DUST-MS Bulk Density	DUST-MS Initial (t = 30 yrs) Volumetric Moisture Content	HELP Initial (t = 30 yrs) Volumetric Moisture Content
1	Soil Matirx	10	5	1.34	0.3098	0.3098
2	Filter Sand	2	1	1.4	0.0452	0.0843
	Cobble/ Gravel Sand	6	3			0.0451
	Drainage Sand	2	1			0.032
3 FML (HDPE) Liner	Clay	6	3	1.8	0.4251	0.4251
4	Waste Form	170	85	3.1	0.3588	0.3588
3	Clay (compacted)	2	1	1.8	0.4112	0.4112
2	Drainage Sand	2	1	1.4	0.1123	0.1123
FML (HDPE) Liner	Geocomposite		0.02			
3	Clay Barrier FML (HDPE) Liner	6	3	1.8	0.427	0.427
1	Geologic Buffer (clay)	20	10	1.34	0.342	0.342
5	Loess Deposit (Unsaturated UCRS) Bottom of HELP Model	44	22	1.43	0.393	0.393
6	Silt to Clay (Saturated Upper Continental Deposits) Bottom of DUST-MS Model	28	14	1.43	0.445	
AT123D Lateral Flow Layer	RGA		35.5	1.67	Saturated Horizontal Flow	
McNairy Formation						

Unsaturated Vertical Flow

Saturated Vertical Flow

Figure 5.5. DUSTMS Model Layers and Select Parameters, Site 11 (DOE 2011a)

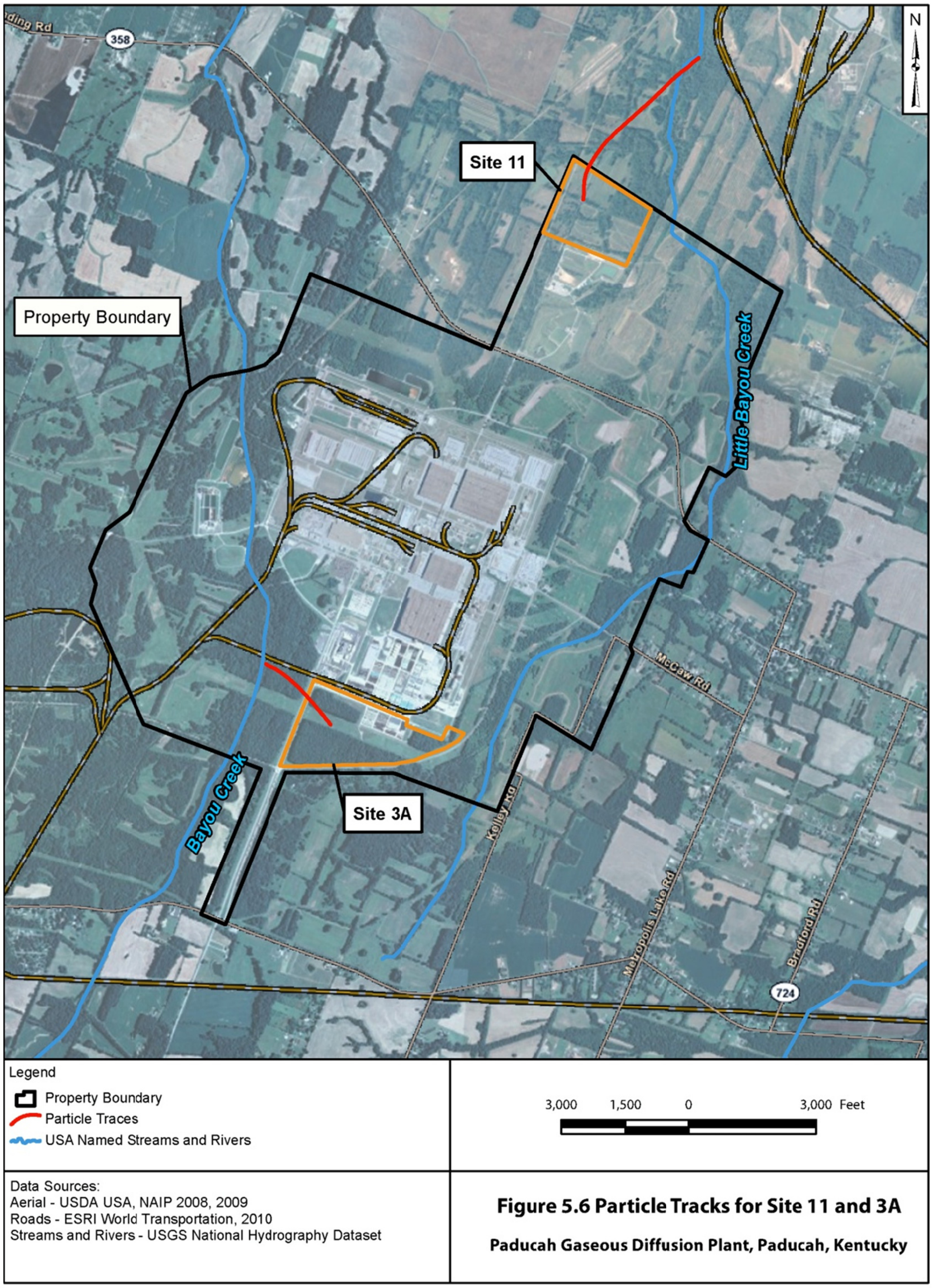

Figure 5.6. Predicted Particle Flowpaths (Sites 3A and 11)

AT123D Model. Saturated zone contaminant fate and transport modeling was performed to predict contaminant concentration at each exposure point over time due to horizontal transport within site aquifers. AT123D is a well-known and commonly used analytical groundwater pollutant fate and transport model that computes the spatial-temporal concentration distribution of chemicals in the aquifer system and predicts the transient spread of a chemical plume through an aquifer. The fate and transport processes accounted for in AT123D are advection, dispersion, adsorption/retardation, and decay. This model estimates the dissolved concentration of a chemical in three dimensions in the groundwater resulting from a continuous mass release over a source area. The contaminant mass flux predicted using the DUSTMS model was used as input to the AT123D model. Contaminant concentrations in groundwater predicted using AT123D were subsequently used as inputs for estimating risks and doses to receptors exposed to the contaminated groundwater at each of the assessment points. AT123D modeling was performed from the Operational/Closure Period and continued up to Year 10,000.

The key parameters required for AT123D modeling, which are listed in Table 5.11 and Attachment C4 to Appendix C, include the following:

- Predicted contaminant load to the water table from the disposal cell (from DUSTMS);
- Hydraulic conductivity, hydraulic gradient, porosity, aquifer depth, and dispersivities; and
- Medium-specific K_d values, soil bulk density, diffusion coefficients, and first order decay.

Downgradient migration distance was specified at three distances for Site 3A and Site 11. Migration distances included:

- Edge of waste (EOW) which for modeling purposes is considered the edge of the waste mass (the actual location of the EOW assessment point would be outside the waste management area or final cover system);

- WDF boundary (118 m and 113 m from EOW for Site 3A and 11, respectively); and

- DOE property line (113 m for Site 11) or surface water outcrop (501 m for Site 3A).

Table 5.11. Parameters Used by the AT123D Model for Saturated Zone Modeling (DOE 2011a)

Analyte	t1/2 (yr)	K_d (m^3/kg)[a]	Water Diffusion (m^2/hr)	First Order Decay (1/hr)[b]
Vinyl chloride	7.900E+00	6.51E-06	4.43E-07	1.00E-05
TCE	4.500E+00	3.30E-05	3.28E-06	1.76E-05
2-Butanone	3.800E-02	2.42E-06	3.35E-06	2.08E-03
Chlorobenzene	1.640E+00	7.84E-05	3.13E-06	4.83E-05
Benzene	2.000E+00	2.16E-05	3.53E-06	3.96E-05
2-Methylphenol	7.700E-02	3.19E-05	2.99E-06	1.03E-03
Pentachlorophenol	4.200E+00	2.07E-01	2.20E-06	1.88E-05
Benzo(a)pyrene	5.800E+00	3.39E-01	3.24E-06	1.36E-05
PCB-1254	1.000E+02	1.08E-01	3.60E-07	7.91E-07
gamma-Chlordane	7.600E+00	1.80E-02	1.57E-06	1.04E-05
Antimony	--	4.50E-02	3.60E-07	0.00E+00
Arsenic	--	2.90E-02	3.60E-07	0.00E+00
Barium	--	4.10E-02	3.60E-07	0.00E+00
Beryllium	--	2.50E-01	3.60E-07	0.00E+00
Cadmium	--	8.00E-02	3.60E-07	0.00E+00
Chromium	--	3.21E-02	3.60E-07	0.00E+00
Copper	--	3.10E-03	3.60E-07	0.00E+00

Table 5.11. Parameters Used by the AT123D Model for Saturated Zone Modeling (DOE 2011a) (Continued)

Analyte	t1/2 (yr)	K_d (m^3/kg)[a]	Water Diffusion (m^2/hr)	First Order Decay (1/hr)[b]
Lead	--	2.70E-01	3.60E-07	0.00E+00
Manganese	--	5.00E-02	3.60E-07	0.00E+00
Mercury	--	5.20E-02	3.60E-07	0.00E+00
Nickel	--	1.08E-01	3.60E-07	0.00E+00
Selenium	--	1.50E-01	3.60E-07	0.00E+00
Silver	--	9.00E-02	3.60E-07	0.00E+00
Thallium	--	7.10E-02	3.60E-07	0.00E+00
Vanadium	--	1.00E+00	3.60E-07	0.00E+00
Zinc	--	2.00E-01	3.60E-07	0.00E+00
Ac-227	2.177E+01	4.50E-01	3.60E-07	3.60E-06
Am-241	4.322E+02	1.90E+00	3.60E-07	1.83E-07
Cs-137	3.017E+01	2.80E-01	3.60E-07	2.62E-06
Np-237	2.140E+06	5.00E-03	3.60E-07	3.70E-11
Pa-231	3.276E+04	5.50E-01	3.60E-07	2.41E-09
Pb-210	2.226E+01	2.70E-01	3.60E-07	3.60E-06
Pu-238	8.775E+01	5.50E-01	3.60E-07	9.01E-07
Pu-239	2.413E+04	5.50E-01	3.60E-07	3.28E-09
Pu-240	6.569E+03	5.50E-01	3.60E-07	1.21E-08
Pu-241	1.440E+01	5.50E-01	3.60E-07	5.38E-06
Ra-226	1.600E+03	5.00E-01	3.60E-07	4.95E-08
Ra-228	5.750E+00	5.00E-01	3.60E-07	1.36E-05
Tc-99	2.130E+05	2.82E-04	3.60E-07	3.72E-10
Th-228	1.913E+00	3.20E+00	3.60E-07	4.17E-05
Th-229	7.340E+03	3.20E+00	3.60E-07	1.08E-08
Th-230	7.700E+04	3.20E+00	3.60E-07	1.03E-09
Th-232	1.405E+10	3.20E+00	3.60E-07	5.65E-15
U-233	1.592E+05	3.50E-02	3.60E-07	4.98E-10
U-234	2.445E+05	3.50E-02	3.60E-07	3.30E-10
U-235	7.038E+08	3.50E-02	3.60E-07	1.13E-13
U-236	2.342E+07	3.50E-02	3.60E-07	3.38E-12
U-238	4.468E+09	3.50E-02	3.60E-07	1.76E-14

Saturated Zone Parameters

Parameter	Units	Site 11[a]	Site 3A[a]
Effective porosity	Unitless	0.30	0.30
Aquifer depth	M	10.8	4.572
Hydraulic conductivity	m/hr	35.6	1.18
Hydraulic gradient	m/m	0.00066	0.0032
Soil bulk density	g/cm^3	1.67	1.56
Longitudinal dispersivity	M	15.00	15.00
Vertical dispersivity	M	1.50	1.50
Transverse dispersivity	M	0.15	0.15

Table 5.11. Parameters Used by the AT123D Model for Saturated Zone Modeling (Continued)

Saturated Zone Parameters

Site 3A Receptor #	Site 3A Location	Downgradient Migration Distance (m)
1	Edge of Waste (EOW)	0
2	Waste Disposal Facility (WDF) Boundary	118
3	Surface Water Boundary	501

Site 11 Receptor #	Site 11 Location	Downgradient Migration Distance (m)
1	Edge of Waste (EOW)	0
2	Waste Disposal Facility (WDF)/DOE Boundary[c]	113

[a] References for the parameters in this table are included in Attachment C4 in Appendix C.
[b] Decay constants were calculated as (ln 2/$t_{1/2}$) × (1 year/8,760 hours).
[c] The WDF and DOE boundaries are in the same location at Site 11.
AT123D = Analytical Transient 1-, 2-, 3-Dimensional Model.

5.4.6.2 Surrogate groups and indicator chemicals

PWAC are necessary for numerous chemicals, so surrogate groups were developed for various classes of organic compounds. Chemical surrogate groups were developed with a representative (i.e., indicator) chemical to be modeled for each group to reduce the number of model runs. Each surrogate group represents chemicals with similar chemical properties, including solubility, volatility, and mobility; therefore, each surrogate group contains chemicals that behave similarly in the environment. The C-746-U Landfill report (DOE 2003) states that "it was determined that transport of neither the inorganic chemicals nor the radionuclides was adequately estimated through the use of indicator chemicals." The analysis found that surrogate groups were only adequately representative for organic compounds. Based on this conclusion, surrogates will be used to develop a PWAC for organics; however, radionuclides and metals will be assessed individually and not as surrogate groups. The indicator chemicals and surrogate chemical groups that they represent are provided in Table 5.12.

Table 5.12. Represented Chemical Groups and Indicator Chemicals (DOE 2011a)

Chemical Group	Indicator Chemical
Nonaromatic, Straight-Chain Halogenated Hydrocarbons	Vinyl Chloride and TCE
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons	2-Butanone
Aromatic, Ring-Structured Halogenated Hydrocarbons	Chlorobenzene
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons	Benzene
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)	o-Cresol
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group	Pentachlorophenol
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group	Benzo(a)pyrene
PCBs	Total PCBs
Pesticides	gamma-Chlordane

5.4.6.3 Derivation of dilution attenuation factor

To evaluate the transport times and concentrations of chemicals within each of the surrogate groups, the dilution attenuation factor (DAF) for the indicator chemical(s) assigned to each surrogate group was calculated, and the DAFs were applied to each surrogate chemical's concentration in disposed material (DOE 2011a). The DAF is a numerical value that quantifies the natural physical, chemical, and biological processes (e.g., advection-dispersion, sorption-retardation, and biodegradation) that result in the decrease of a chemical concentration in an environment. In simple terms, the DAF is the ratio of chemical concentration at the source (or the point of origin) to the concentration at an exposure point. The concept used to apply the DAF is shown in Figure 5.7. As shown, use of a DAF allowed for the calculation of a concentration of a contaminant in groundwater from a concentration of a contaminant in soil or waste. This is based upon the following mechanisms:

- A contaminant released to an unsaturated zone of native soil at a location above the groundwater table is expected to remain in place until water from rainfall or other sources reaches the contaminant through percolation;
- Percolating rainwater contacts and transports the dissolved chemicals through the unsaturated zone to the water table (the factors that affect leaching rate include solubility, K_d, and the amount of percolation);
- The dissolved chemicals will enter the water table and migrate with the groundwater to an exposure point.

These mechanisms allow the transport of a contaminant through a source-to-exposure point path to be assumed to follow two distinct subpaths discretized with three distinct concentrations. The two subpaths are source-to-water table and water table-to-exposure point. The concentrations are the volume-weighted average concentration of contaminant in the waste (C_S), the predicted maximum concentration of the contaminant in the leachate just above the water table (C_L), and the predicted maximum concentration of contaminant in groundwater at the exposure point (C_W). The DAF for the source-to-water table path (i.e., DAF_1) is calculated as follows:

$$DAF_1 = \frac{(C_S / K_d)}{C_L} \qquad \text{(Eq. 2)}$$

where

C_s	=	concentration of contaminant in waste (mg/kg or pCi/g)
K_d	=	soil/water distribution coefficient (L/kg),
C_L	=	concentration of contaminant leachate above the water table (mg/L or pCi/L)

The DAF for the water table-to-exposure point path (i.e., DAF_2) is calculated as follows:

$$DAF_2 = \frac{C_L}{C_W} \qquad \text{(Eq. 3)}$$

where

C_w	=	concentration of contaminant in groundwater (mg/L or pCi/L)

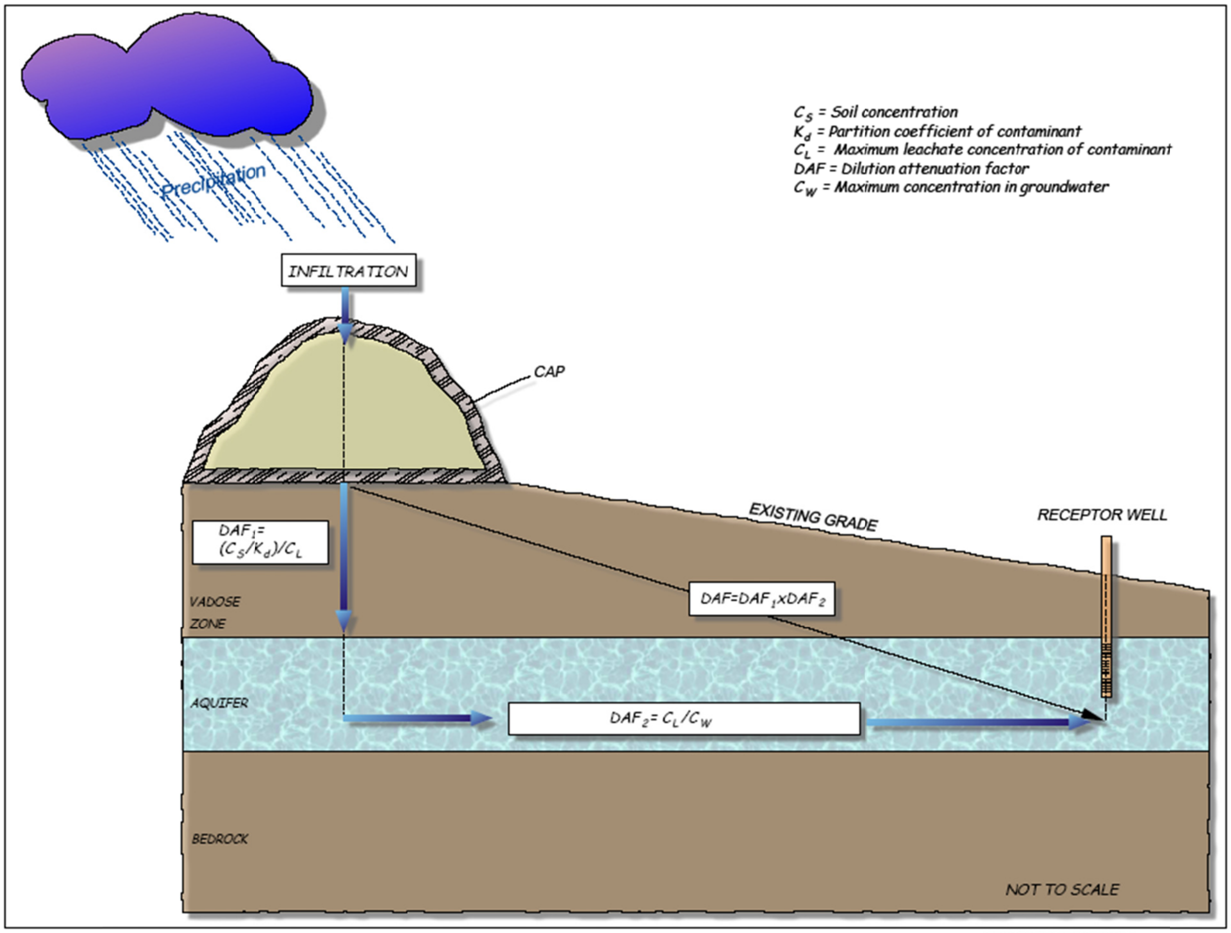

Figure 5.7. Definitions of a Dilution Attenuation Factors (DAF)

The total DAF for the source-to-exposure point path is calculated as follows:

$$DAF = DAF_1 \times DAF_2 \qquad \text{(Eq. 4)}$$

therefore

$$DAF = \frac{(C_s / K_d)}{C_w} \qquad \text{(Eq. 5)}$$

DAFs were developed for the nine primary chemical groups. An indicator chemical was selected for each group to be used in the quantitative modeling. DAFs developed for the indicator compound apply to each chemical in the group (see Table 5.12). The DAF for each indicator chemical was then calculated using Eq. 5 and are presented in Tables 5.13 and 5.14.

The groundwater concentrations for the chemicals in each surrogate group were estimated from the indicator chemical according to the following relationship (see Tables 5.13 and 5.14):

$$C_{w,\,constituent} = C_{w,surrogate} \times \frac{C_{s,constituent} \div K_{d,constituent}}{C_{s,surrogate} \div K_{d,surrogate}} \qquad \text{(Eq. 6)}$$

or

$$C_{w,consituent} = \frac{(C_{s,consituent} / K_{d,consituent})}{DAF_{indicator}} \qquad \text{(Eq. 7)}$$

where

$C_{w,\,constituent}$	=	concentration of contaminant in groundwater (mg/L or pCi/L)
$C_{w,\,surrogate}$	=	modeled concentration of surrogate contaminant in groundwater (mg/L or pCi/L)
$C_{s,\,constituent}$	=	concentration of contaminant in waste (mg/kg or pCi/g)
$C_{s,\,surrogate}$	=	concentration of surrogate contaminant in waste (mg/kg or pCi/g)
$K_{d,\,constituent}$	=	soil/water distribution coefficient for contaminant (L/kg)
$K_{d,\,surrogate}$	=	soil/water distribution coefficient for surrogate contaminant (L/kg)
DAF	=	dilution attenuation factor (unitless)

5.4.6.4 Preliminary model results and DAF values

This section presents the modeling results for the gradual failure scenario at the WDF boundary. The instantaneous and no failure scenarios are discussed in the uncertainty section provided in Section 5.4.6.8.

Table 5.13 provides the Site 11 maximum groundwater concentrations and DAFs (only for indicator chemicals) for the exposure point located at the WDF boundary for the gradual failure scenario. Table 5.14 provides maximum groundwater concentrations and DAFs (only for indicator chemical) for Site 3A at the WDF boundary for the gradual failure scenario. The maximum predicted groundwater concentrations were adjusted as appropriate to account for solubility limitations.

Table 5.13. Site 11 Groundwater Concentrations and DAFs for the Gradual Failure (T+400) Scenario, Unit Source Concentrations Used in Model

Chemical Groups[a,b]	K_d (L/kg)	Waste Concentration Used in Model (mg/kg or pCi/g)	Maximum Concentration in mg/L or pCi/L		DAF[d,e]
			WDF Boundary[c]	Time (yrs)	WDF Boundary
Nonaromatic, Straight-Chain Halogenated Hydrocarbons					
Chloroform	4.21E-02	4.43E+05	5.81E-14		
cis-1,2-DCE	2.84E-02	1.81E+05	3.51E-14		
Methylene chloride	8.01E-03	5.87E+05	4.05E-13		
Vinyl Chloride[g]	**1.49E-02**	**1.31E+05**	**4.84E-14**	**465.3**	**1.81E+20**
TCE[h]	**7.55E-02**	**1.91E+05**	**1.19E-15**	**155.4**	**2.13E+21**
PCE	2.12E-01	5.73E+04	1.27E-16		
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons					
Acetone	4.61E-04	1.58E+06	0.00E+00		
2-Butanone	**5.54E-03**	**1.21E+05**	**0.00E+00**	**N/A**	**N/A**
1-Butanone	5.54E-01	5.62E+04	0.00E+00		
Hexanone (2-)	1.20E-02	2.95E+04	0.00E+00		
Methyl-2-pentanone (4-)	1.01E-02	3.21E+04	0.00E+00		
Aromatic, Ring-Structured Halogenated Hydrocarbons					
Chlorobenzene	**1.79E-01**	**2.95E+05**	**2.61E-31**	**115.7**	**6.30E+36**
Dimethylbenzene (1,2-)	3.07E-01	1.56E+05	8.09E-32		
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons					
Benzene	**4.94E-02**	**1.65E+05**	**2.93E-22**	**107.8**	**1.14E+28**
Cumene	5.59E-01	2.18E+04	3.41E-24		
Ethylbenzene	1.63E-01	2.58E+04	1.38E-23		
Toluene	1.12E-01	6.65E+04	5.20E-23		
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)					
Acenaphthene	3.92E+00	4.02E+02	0.00E+00		
Acetophenone	4.15E-02	2.53E+04	0.00E+00		
Benzoic Acid	4.81E-04	1.11E+04	0.00E+00		
Carbazole	2.72E+00	4.98E+02	0.00E+00		
Chloro-3-methylphenol(4-)	3.19E-01	2.44E+04	0.00E+00		
o-Cresol	**7.31E-02**	**1.27E+05**	**0.00E+00**	**N/A**	**N/A**
p-Cresol	2.41E-01	1.89E+05	0.00E+00		
Dibenzofuran(s)	7.34E+00	5.41E+02	0.00E+00		
Methyl naphthalene (2-)	1.98E+00	1.22E+03	0.00E+00		
Methylphenol (3&4-)	8.70E+00	5.04E+06	0.00E+00		
Phenol	2.31E-02	3.06E+05	0.00E+00		
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group					
Anthracene	1.88E+01	4.09E+02	2.11E-41		
Benzo(a)anthracene	2.87E+02	1.34E+03	4.54E-42		
Butyl benzyl phthalate	1.10E+01	1.48E+04	1.31E-39		
Chrysene	3.19E+02	2.53E+02	7.73E-43		
Diethyl phthalate	6.58E-02	1.08E+05	1.59E-36		
Di-n-butyl phthalate	1.26E+00	7.74E+03	5.99E-39		
Di-n-octyl phthalate	6.66E+04	6.62E+05	9.66E-42		

Table 5.13. Site 11 Groundwater Concentrations and DAFs for the Gradual Failure (T+400) Scenario, Unit Source Concentrations Used in Model (Continued)

Chemical Groups[a,b]	K_d (L/kg)	Waste Concentration Used in Model (mg/kg or pCi/g)	Maximum Concentration in mg/L or pCi/L		DAF[d,e]
			WDF Boundary[c]	Time (yrs)	WDF Boundary
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group (Continued)					
Fluoranthene	3.93E+01	4.04E+03	9.98E-41		
Fluorene	6.18E+00	6.20E+03	9.77E-40		
Naphthalene	9.53E-01	1.68E+04	1.71E-38		
Pentachlorophenol	**4.74E-01**	**5.90E+05**	**1.21E-36**	**510.6**	**1.03E+42**
Phenanthrene	1.12E+01	6.75E+03	5.86E-40		
Pyrene	5.45E+01	3.66E+03	6.54E-41		
Tetrachlorophenol (2,3,4,6-)	2.24E-01	4.10E+03	1.78E-38		
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group					
BEHP	8.89E+01	1.87E+10	0.00E+00		
Benzo(a)pyrene	**7.76E+02**	**7.76E+08**	**0.00E+00**	**N/A**	**N/A**
Benzo(b)Fluoranthene	9.85E+02	9.12E+08	0.00E+00		
Benzo(k)Fluoranthene	9.85E+02	4.87E+08	0.00E+00		
Benzo(g,h,i)perylene	1.28E+03	2.05E+08	0.00E+00		
Dibenzo(a,h)anthracene	1.43E+03	2.20E+09	0.00E+00		
Indeno(1,2,3-cd)pyrene	2.78E+03	3.77E+07	0.00E+00		
PCBs					
Aroclor-1016	3.82E+01	8.86E+08	2.32E-15		
Aroclor-1221	6.73E+00	5.66E+09	8.41E-14		
Aroclor-1232	6.73E+01	5.38E+09	7.98E-15		
Aroclor-1242	6.26E+01	9.55E+08	1.53E-15		
Aroclor-1248	6.12E+01	3.37E+08	5.51E-16		
Aroclor-1254	1.05E+02	2.48E+08	2.37E-16		
Aroclor-1260	2.80E+02	2.22E+08	7.92E-17		
Total PCBs	**2.48E+02**	**2.48E+08**	**9.99E-17**	**1.60E+03**	**1.00E+22**
Pesticides					
beta-BHC	2.25E+00	1.02E+07	3.94E-33		
DDD (4,4-)	3.67E+01	5.91E+07	1.40E-33		
DDE (4,4-)	6.92E+01	1.49E+08	1.86E-33		
DDT (4,4-)	5.43E+02	2.42E+08	3.88E-34		
Dieldrin	2.04E+01	7.16E+07	3.04E-33		
Endosulfan II	1.63E+00	1.61E+07	8.56E-33		
Endosulfan sulfate	2.30E+00	1.43E+07	5.42E-33		
Endrin	8.65E+00	3.92E+07	3.94E-33		
Endrin aldehyde	8.00E+03	3.43E+09	3.72E-34		
gamma-Chlordane	**4.11E+01**	**4.12E+07**	**8.71E-34**	**7.39E+02**	**1.15E+39**
Heptachlor epoxide	6.66E+01	2.38E+08	3.11E-33		
Metals					
Sb	4.50E+01	4.51E+07	4.65E-11	1600	
As	2.90E+01	2.91E+07	7.78E+02	1600	
Ba	4.10E+01	4.11E+07	1.36E+02	1600	

Table 5.13. Site 11 Groundwater Concentrations and DAFs for the Gradual Failure (T+400) Scenario, Unit Source Concentrations Used in Model (Continued)

Chemical Groups[a,b]		K_d (L/kg)	Waste Concentration Used in Model (mg/kg or pCi/g)	Maximum Concentration in mg/L or pCi/L		DAF[d,e]
				WDF Boundary[c]	Time (yrs)	WDF Boundary
Metals (Continued)						
Be		2.50E+02	2.50E+08	0.00E+00	1600	
Cd		8.00E+01	8.01E+07	1.59E-26	1600	
Cr		3.21E+01	3.22E+07	5.02E+02	1600	
Cu		3.10E+00	3.22E+06	1.31E+04	1433	
Pb		2.70E+02	2.70E+08	2.11E-28	1600	
Mn		5.00E+01	5.01E+07	3.75E-07	1600	
Hg		5.20E+01	5.21E+07	2.52E+01	1600	
Ni		1.08E+02	1.08E+08	2.56E-03	1600	
Se		1.50E+02	1.50E+08	1.46E-34	1600	
Ag		9.00E+01	9.01E+07	1.30E-07	1600	
Tl		7.10E+01	7.11E+07	1.19E+00	1600	
V		1.00E+03	1.00E+09	0.00E+00	N/A	
Zn		2.00E+02	2.00E+08	0.00E+00	N/A	
Radionuclides						
Pu-238		5.50E+02	9.42E+15	0.00E+00	N/A	
	U-234	3.50E+01	0.00E+00	0.00E+00	N/A	
	Th-230	3.20E+03	0.00E+00	0.00E+00	N/A	
	Ra-226	5.00E+02	0.00E+00	0.00E+00	N/A	
	Pb-210	2.70E+02	0.00E+00	0.00E+00	N/A	
U-238		3.50E+01	1.18E+07	0.00E+00	N/A	
	U-234	3.50E+01	0.00E+00	0.00E+00	N/A	
	Th-230	3.20E+03	0.00E+00	0.00E+00	N/A	
	Ra-226	5.00E+02	0.00E+00	0.00E+00	N/A	
	Pb-210	2.70E+02	0.00E+00	0.00E+00	N/A	
U-234		3.50E+01	2.19E+11	0.00E+00	N/A	
	Th-230	3.20E+03	0.00E+00	0.00E+00	N/A	
	Ra-226	5.00E+02	0.00E+00	0.00E+00	N/A	
	Pb-210	2.70E+02	0.00E+00	0.00E+00	N/A	
Pu-239		5.50E+02	3.41E+13	0.00E+00	N/A	
	U-235	3.50E+01	0.00E+00	0.00E+00	N/A	
	Pa-231	5.50E+02	0.00E+00	0.00E+00	N/A	
	Ac-227	4.50E+02	0.00E+00	0.00E+00	N/A	
U-235		3.50E+01	7.59E+07	0.00E+00	N/A	
	Pa-231	5.50E+02	0.00E+00	0.00E+00	N/A	
	Ac-227	4.50E+02	0.00E+00	0.00E+00	N/A	
Pu-240		5.50E+02	1.25E+14	0.00E+00	N/A	
	U-236	3.50E+01	0.00E+00	0.00E+00	N/A	
	Th-232	3.20E+03	0.00E+00	0.00E+00	N/A	
	Ra-228	5.00E+02	0.00E+00	0.00E+00	N/A	
	Th-228	3.20E+03	0.00E+00	0.00E+00	N/A	

Table 5.13. Site 11 Groundwater Concentrations and DAFs for the Gradual Failure (T+400) Scenario, Unit Source Concentrations Used in Model (Continued)

Chemical Groups[a,b]		K_d (L/kg)	Waste Concentration Used in Model (mg/kg or pCi/g)	Maximum Concentration in mg/L or pCi/L		DAF[d,e]
				WDF Boundary[c]	Time (yrs)	WDF Boundary
Radionuclides (Continued)		3.50E+01	0.00E+00	1.78E+02	1600	
Np-237		5.00E+00	3.61E+09	1.47E+07	1600	
	Th-229	3.20E+03	0.00E+00	2.11E-09	1600	
Cs-137		2.80E+02	2.42E+16	0.00E+00	N/A	
Tc-99		2.82E-01	6.74E+09	1.64E+11	677	
Am-241		1.90E+03	6.52E+15	0.00E+00	N/A	
	Np-237	5.00E+00	0.00E+00	3.12E+09	1600	
	U-233	3.50E+01	0.00E+00	3.65E+04	1600	
	Th-229	3.20E+03	0.00E+00	3.93E-07	1600	
Th-230		3.20E+03	6.46E+13	0.00E+00	N/A	
	Ra-226	5.00E+02	0.00E+00	0.00E+00	N/A	
	Pb-210	2.70E+02	0.00E+00	0.00E+00	N/A	

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.
[b] Radionuclides in italics are decay products from the parent radionuclide.
[c] The maximum groundwater concentrations are obtained directly from AT123D. Concentrations for radionuclides were converted from mg/L to pCi/L.
[d] N/A signifies DAF calculation is not applicable because model fails to calculate chemical concentration at POAs.
[e] The DAF is calculated according to Eqn. 2 in Section 5.4.7.3.
[f] Vinyl Chloride was the indicator for chloroform, *cis*-1,2-DCE, and methylene chloride.
[g] TCE was the indicator for perchloroethene.
Unit source concentration is specified as 1 g/cm^3.
For some chemicals, the model does not predict groundwater concentrations at a given POA because of degradation and/or sorption enhancing attenuation and limiting migration.

Table 5.14. Site 3A Groundwater Concentrations and DAFs for the Gradual Failure (T+400) Scenario, Unit Source Concentrations Used in Model

Chemical Groups[a,b]	K_d (L/kg)	Waste Concentration Used in Model (mg/kg or pCi/g)	Maximum Concentration in mg/L or pCi/L		DAF[e,f]
			WDF Boundary[c]	Time (yrs)	WDF Boundary
Nonaromatic, Straight-Chain Halogenated Hydrocarbons					
Chloroform	4.21E-02	4.43E+05	2.74E-12		
cis-1,2-DCE	2.84E-02	1.81E+05	1.65E-12		
Methylene chloride	8.01E-03	5.87E+05	1.91E-11		
Vinyl Chloride[g]	**1.49E-02**	**1.31E+05**	**2.28E-12**	**450.7**	**3.85E+18**
TCE[h]	**7.55E-02**	**1.91E+05**	**2.02E-09**	**120.3**	**1.25E+15**
PCE	2.12E-01	5.73E+04	2.16E-10		
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons					
Acetone	4.61E-04	1.58E+06	0.00E+00		
2-Butanone	**5.54E-03**	**1.21E+05**	**0.00E+00**	**N/A**	**N/A**
1-Butanone	5.54E-01	5.62E+04	0.00E+00		
Hexanone (2-)	1.20E-02	2.95E+04	0.00E+00		
Methyl-2-pentanone (4-)	1.01E-02	3.21E+04	0.00E+00		
Aromatic, Ring-Structured Halogenated Hydrocarbons					
Chlorobenzene	**1.79E-01**	**2.95E+05**	**4.61E-21**	**93.0**	**3.57E+26**
Dimethylbenzene (1,2-)	3.07E-01	1.56E+05	1.43E-21		
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons					
Benzene	**4.94E-02**	**1.65E+05**	**4.36E-14**	**85.5**	**7.66E+19**
Cumene	5.59E-01	2.18E+04	5.08E-16		
Ethylbenzene	1.63E-01	2.58E+04	2.06E-15		
Toluene	1.12E-01	6.65E+04	7.74E-15		
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)					
Acenaphthene	3.92E+00	6.00E+02	0.00E+00		
Acetophenone	4.15E-02	3.78E+04	0.00E+00		
Benzoic Acid	4.81E-04	1.66E+04	0.00E+00		
Carbazole	2.72E+00	7.44E+02	0.00E+00		
Chloro-3-methylphenol(4-)	3.19E-01	3.64E+04	0.00E+00		
o-Cresol	**7.31E-02**	**1.89E+05**	**0.00E+00**	**N/A**	**N/A**
p-Cresol	2.41E-01	2.82E+05	0.00E+00		
Dibenzofuran(s)	7.34E+00	8.08E+02	0.00E+00		
Methyl naphthalene (2-)	1.98E+00	1.82E+03	0.00E+00		
Methylphenol (3&4-)	8.70E+00	7.52E+06	0.00E+00		
Phenol	2.31E-02	4.57E+05	0.00E+00		
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group					
Anthracene	1.88E+01	4.09E+02	5.60E-43		
Benzo(a)anthracene	2.87E+02	1.34E+03	1.20E-43		
Butyl benzyl phthalate	1.10E+01	1.48E+04	3.49E-41		
Chrysene	3.19E+02	2.53E+02	2.05E-44		
Diethyl phthalate	6.58E-02	1.08E+05	4.22E-38		
Di-n-butyl phthalate	1.26E+00	7.74E+03	1.59E-40		

Table 5.14. Site 3A Groundwater Concentrations and DAFs for the Gradual Failure (T+400) Scenario, Unit Source Concentrations Used in Model (Continued)

Chemical Groups[a,b]	K_d (L/kg)	Waste Concentration Used in Model (mg/kg or pCi/g)	Maximum Concentration in mg/L or pCi/L		DAF[e,f]
			WDF Boundary[c]	Time (yrs)	WDF Boundary
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group (Continued)					
Di-n-octyl phthalate	6.66E+04	6.62E+05	2.56E-43		
Fluoranthene	3.93E+01	4.04E+03	2.65E-42		
Fluorene	6.18E+00	6.21E+03	2.59E-41		
Naphthalene	9.53E-01	1.67E+04	4.53E-40		
Pentachlorophenol	**4.74E-01**	**5.90E+05**	**3.21E-38**	**310.9**	**3.88E+43**
Phenanthrene	1.12E+01	6.75E+03	1.56E-41		
Pyrene	5.45E+01	3.66E+03	1.73E-42		
Tetrachlorophenol (2,3,4,6-)	2.24E-01	4.10E+03	4.72E-40		
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group					
BEHP	8.89E+01	1.87E+10	0.00E+00		
Benzo(a)pyrene	**7.76E+02**	**7.76E+08**	**0.00E+00**	**N/A**	**N/A**
Benzo(b)Fluoranthene	9.85E+02	9.12E+08	0.00E+00		
Benzo(k)Fluoranthene	9.85E+02	4.87E+08	0.00E+00		
Benzo(g,h,i)perylene	1.28E+03	2.05E+08	0.00E+00		
Dibenzo(a,h)anthracene	1.43E+03	2.20E+09	0.00E+00		
Indeno(1,2,3-cd)pyrene	2.78E+03	3.77E+07	0.00E+00		
PCBs					
Aroclor-1016	3.82E+01	2.30E+07	8.91E-12		
Aroclor-1221	6.73E+00	1.47E+08	3.23E-10		
Aroclor-1232	6.73E+01	1.40E+08	3.07E-11		
Aroclor-1242	6.26E+01	2.48E+07	5.87E-12		
Aroclor-1248	6.12E+01	8.76E+06	2.12E-12		
Aroclor-1254	1.05E+02	6.43E+06	9.10E-13		
Aroclor-1260	2.80E+02	5.76E+06	3.04E-13		
Total PCBs	**2.48E+02**	**2.48E+08**	**1.48E-11**	**1600**	**6.76E+16**
Pesticides					
beta-BHC	2.25E+00	1.02E+07	5.43E-29		
DDD (4,4-)	3.67E+01	5.91E+07	1.93E-29		
DDE (4,4-)	6.92E+01	1.49E+08	2.57E-29		
DDT (4,4-)	5.43E+02	2.42E+08	5.34E-30		
Dieldrin	2.04E+01	7.16E+07	4.19E-29		
Endosulfan II	1.63E+00	1.61E+07	1.18E-28		
Endosulfan sulfate	2.30E+00	1.43E+07	7.46E-29		
Endrin	8.65E+00	3.92E+07	5.42E-29		
Endrin aldehyde	8.00E+03	3.43E+09	5.13E-30		
gamma-Chlordane	**4.11E+01**	**4.12E+07**	**1.20E-29**	**697.2**	**8.36E+34**
Heptachlor epoxide	6.66E+01	2.38E+08	4.28E-29		
Metals					
Sb	4.50E+01	4.51E+07	6.14E-05	1600	
As7	2.90E+01	2.91E+07	2.70E+04	1600	

Table 5.14. Site 3A Groundwater Concentrations and DAFs for the Gradual Failure (T+400) Scenario, Unit Source Concentrations Used in Model (Continued)

Chemical Groups[a,b]		K_d (L/kg)	Waste Concentration Used in Model (mg/kg or pCi/g)	Maximum Concentration in mg/L or pCi/L		DAF[e,f]
				WDF Boundary[c]	Time (yrs)	WDF Boundary
Metals (Continued)						
Ba		4.10E+01	4.11E+07	5.31E+03	1600	
Be		2.50E+02	2.50E+08	2.16E-35	1600	
Cd		8.00E+01	8.01E+07	2.24E-15	1600	
Cr		3.21E+01	3.22E+07	1.81E+04	1600	
Cu		3.10E+00	3.22E+06	1.87E+05	1208	
Pb		2.70E+02	2.70E+08	9.04E-20	1600	
Mn		5.00E+01	5.01E+07	1.17E-02	1600	
Hg		5.20E+01	5.21E+07	1.07E+03	1600	
Ni		1.08E+02	1.08E+08	3.17E-01	1600	
Se		1.50E+02	1.50E+08	6.40E-22	1600	
Ag		9.00E+01	9.01E+07	1.01E-03	1600	
Tl		7.10E+01	7.11E+07	6.57E+01	1600	
V		1.00E+03	1.00E+09	8.83E-44	1600	
Zn		2.00E+02	2.00E+08	0.00E+00	N/A	
U		3.50E+01	3.51E+07	6.96E-33	1600	
Radionuclides						
Pu-238		5.50E+02	9.42E+15	0.00E+00	N/A	
	U-234	3.50E+01	0.00E+00	6.44E-25	1600	
	Th-230	3.20E+03	0.00E+00	0.00E+00	N/A	
	Ra-226	5.00E+02	0.00E+00	0.00E+00	N/A	
	Pb-210	2.70E+02	0.00E+00	4.15E-31	1600	
U-238		3.50E+01	1.18E+07	2.34E-30	1600	
	U-234	3.50E+01	0.00E+00	1.01E-32	1600	
	Th-230	3.20E+03	0.00E+00	0.00E+00	N/A	
	Ra-226	5.00E+02	0.00E+00	0.00E+00	N/A	
	Pb-210	2.70E+02	0.00E+00	0.00E+00	N/A	
U-234		3.50E+01	2.19E+11	4.33E-26	1600	
	Th-230	3.20E+03	0.00E+00	0.00E+00	N/A	
	Ra-226	5.00E+02	0.00E+00	0.00E+00	N/A	
	Pb-210	2.70E+02	0.00E+00	3.29E-32	1600	
Pu-239		5.50E+02	3.41E+13	0.00E+00	N/A	
	U-235	3.50E+01	0.00E+00	2.81E-30	1600	
	Pa-231	5.50E+02	0.00E+00	0.00E+00	N/A	
	Ac-227	4.50E+02	0.00E+00	0.00E+00	N/A	
U-235		3.50E+01	7.59E+07	1.50E-29	1600	
	Pa-231	5.50E+02	0.00E+00	0.00E+00	N/A	
	Ac-227	4.50E+02	0.00E+00	0.00E+00	N/A	
Pu-240		5.50E+02	1.25E+14	0.00E+00	N/A	
	U-236	3.50E+01	0.00E+00	3.05E-28	1600	

Table 5.14. Site 3A Groundwater Concentrations and DAFs for the Gradual Failure (T+400) Scenario, Unit Source Concentrations Used in Model (Continued)

Chemical Groups[a,b]		K_d (L/kg)	Waste Concentration Used in Model (mg/kg or pCi/g)	Maximum Concentration in mg/L or pCi/L		DAF[e,f]
				WDF Boundary[c]	Time (yrs)	WDF Boundary
Radionuclides (Continued)						
	Th-232	3.20E+03	0.00E+00	0.00E+00	N/A	
	Ra-228	5.00E+02	0.00E+00	0.00E+00	N/A	
	Th-228	3.20E+03	0.00E+00	0.00E+00	N/A	
Np-237		5.00E+00	3.61E+09	4.74E+09	1600	
	U-233	3.50E+01	0.00E+00	1.95E+04	1600	
	Th-229	3.20E+03	0.00E+00	0.00E+00	N/A	
Cs-137		2.80E+02	2.42E+16	0.00E+00	N/A	
Tc-99		2.82E-01	6.74E+09	2.68E+12	628	
Am-241		1.90E+03	6.52E+15	0.00E+00	N/A	
	Np-237	5.00E+00	0.00E+00	1.07E+12	1600	
	U-233	3.50E+01	0.00E+00	4.03E+06	1600	
	Th-229	3.20E+03	0.00E+00	0.00E+00	N/A	
Th-230		3.20E+03	6.46E+13	0.00E+00	N/A	
	Ra-226	5.00E+02	0.00E+00	0.00E+00	N/A	
	Pb-210	2.70E+02	0.00E+00	1.72E-27	1600	

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.
[b] Radionuclides in italics are decay products from the parent radionuclide.
[c] The maximum groundwater concentrations are obtained directly from AT123D. Concentrations for radionuclides were converted from mg/L to pCi/L.
[d] N/A signifies DAF calculation is not applicable because model fails to calculate chemical concentration at POAs.
[e] The DAF is calculated according to Eqn. 2 in Section 5.4.7.3.
[f] Vinyl Chloride was the indicator for chloroform, *cis*-1,2-DCE, and methylene chloride.
[g] TCE was the indicator for perchloroethene.
Unit source concentration is specified as 1 g/cm^3.
For some chemicals, the model does not predict groundwater concentrations at a given POA because of degradation and/or sorption enhancing attenuation and limiting migration.

Groundwater concentration curves for selected indicator chemicals, metals, and radionuclides are provided in Attachment C5 to Appendix C. Groundwater concentration curves were used to evaluate the groundwater concentrations at two time periods with different acceptable receptor risks: (1) the first 1,570 years postclosure (to Year 1,600); and (2) after Year 1,600. Predicted concentrations of COCs in groundwater for the first 1,600 years were used to calculate contaminant specific PWAC values; the analysis considering times greater than 1,600 years was to provide information on variation of COC concentrations over a longer time period.

5.4.6.5 PWAC derivation

This section describes the methods and models used for the human health risk evaluations. This section also presents the PWAC and contaminant inventory limits and the methods used to derive them.

The groundwater concentrations from the gradual failure scenario were evaluated at three receptor locations (i.e., POAs). The first POA is located at the EOW. The second POA is located at the WDF boundary. For Site 3A, the WDF boundary is located approximately 118 m from the EOW. The WDF boundary is approximately 113 m from the EOW at Site 11. The third POA is at the DOE facility boundary (113 m from EOW for Site 11) or surface water outcrop at Bayou Creek (501 m from EOW for Site 3A).

Additional analyses also were conducted for groundwater concentrations at the WDF boundary and DOE property (Site 11)/surface water outcrop (Site 3A) POAs. The most sensitive receptor is the groundwater user utilizing water drawn from a well completed in PGDP aquifers. This receptor was selected since the acceptable concentrations for contaminants in water for this receptor are lower than those for the recreational user. This residential groundwater user provides the most restrictive criteria to overestimate the potential exposure in addition to overestimating the potential dose; additionally, it is improbable that a potable water well would be located this close to an on-site disposal cell. The exposure routes for the residential groundwater user are ingestion of groundwater, inhalation of vapors emitted by groundwater during household use and bathing or showering, and dermal absorption during bathing or showering (Table 5.15). Contamination through use of groundwater for irrigation and the use of groundwater for animal and dairy production is considered unlikely because surface water would be used for these purposes (ORISE 2011). This is consistent with the evaluation performed for the C-746-U Landfill presented in *Dose Modeling Evaluations and Technical Support Document for the Authorized Limits Request for the C-746-U Landfill at the Paducah Gaseous Diffusion Plant* (ORISE 2011).

Table 5.15. Target Groundwater Concentrations Used in the PWAC Calculations

Chemical Groups	Target Levels (mg/L or pCi/L)[e]			
	MCL[a]	Background[b]	Hazard Index = 1[c]	ELCR 1E-06[d]
Nonaromatic, Straight-Chain Halogenated Hydrocarbons				
Chloroform	8.00E-02	NV	4.85E-02	2.27E-04
cis-1,2-DCE	7.00E-02	NV	1.25E-02	NV
Methylene chloride	5.00E-03	NV	NV	NV
Vinyl Chloride	2.00E-03	NV	2.31E-02	7.25E-05
TCE	5.00E-03	NV	2.77E-03	4.65E-05
PCE	5.00E-03	NV	6.64E-02	7.81E-05
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons				
Acetone	NV[a]	NV	NV	NV
2-Butanone	NV	NV	NV	NV
Butanal	NV	NV	NV	NV
Hexanone (2-)	NV	NV	NV	NV
Methyl-2-pentanone (4-)	NV	NV	NV	NV
Aromatic, Ring-Structured Halogenated Hydrocarbons				
Chlorobenzene	1.00E-01	NV	NV	NV
Dimethylbenzene (1,2-)	1.00E+01	NV	4.85E-01	NV
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons				
Benzene	5.00E-03	NV	1.66E-02	4.27E-04
Cumene	NV	NV	NV	NV
Ethylbenzene	7.00E-01	NV	4.60E-01	1.51E-03
Toluene	1.00E+00	NV	NV	NV
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)				
Acenaphthene	NV	NV	1.38E-01[i]	NV
Acetophenone	NV	NV	NV	NV
Benzoic Acid	NV	NV	NV	NV
Carbazole	NV	NV	NV	2.05E-03
Chloro-3-methylphenol (4-)	NV	NV	NV	NV
o-Cresol	NV	NV	NV	NV
p-Cresol	NV	NV	NV	NV
Dibenzofuran(s)	NV	NV	NV	NV
Methyl Naphthalene (2-)	NV	NV	NV	NV
Methylphenol (3&4-)	NV	NV	NV	NV
Phenol	NV	NV	NV	NV
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group				
Anthracene	NV	NV	6.39E-01	NV
Benzo(a)Anthracene	NV	NV	NV	1.22E-05
Butyl benzyl phthalate	NV	NV	NV	NV
Chrysene	NV	NV	NV	1.15E-03
Diethyl phthalate	NV	NV	NV	NV

Table 5.15. Target Groundwater Concentrations Used in the PWAC Calculations (Continued)

Chemical Groups	Target Levels (mg/L or pCi/L)[e]			
	MCL[a]	Background[b]	Hazard Index = 1[c]	ELCR 1E-06[d]
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group (Continued)				
Di-n-butyl phthalate	NV	NV	NV	NV
Di-n-octyl phthalate	NV	NV	NV	NV
Fluoranthene	NV	NV	1.44E-01	NV
Fluorene	NV	NV	8.91E-02	NV
Naphthalene	NV	NV	2.80E-03	1.76E-04
Pentachlorophenol	1.00E-03	NV	NV	NV
Phenanthrene	NV	NV	1.44E-01 [k]	NV
Pyrene	NV	NV	5.81E-02	NV
Tetrachlorophenol (2,3,4,6-)	NV	NV	NV	NV
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group				
BEHP	NV	NV	NV	NV
Benzo(a)pyrene	2.00E-04	NV	NV	8.63E-07
Benzo(b)Fluoranthene	NV	NV	NV	1.35E-05
Benzo(k)Fluoranthene	NV	NV	NV	8.86E-05
Benzo(g,h,i)perylene	NV	NV	NV	NV
Dibenzo(a,h)Anthracene	NV	NV	NV	5.73E-07
Indeno(1,2,3-cd)pyrene	NV	NV	NV	4.52E-06
PCBs				
Aroclor-1016	NV	NV	1.99E-04 [s]	3.08E-05
Aroclor-1221	NV	NV	NV [st]	6.73E-05
Aroclor-1232	NV	NV	NV [ts]	6.73E-05
Aroclor-1242	NV	NV	NV [ts]	1.59E-05
Aroclor-1248	NV	NV	NV [ts]	1.49E-05
Aroclor-1254	NV	NV	1.87E-05 [ts]	9.80E-06
Aroclor-1260	NV	NV	NV [ts]	1.72E-06
Total PCBs	5.00E-04	NV	NV [ts]	3.18E-06
Pesticides				
beta-BHC	NV	NV	NV	NV
DDD (4,4-)	NV	NV	NV	NV
DDE (4,4-)	NV	NV	NV	NV
DDT (4,4-)	NV	NV	NV	NV
Dieldrin	NV	NV	3.18E-04	1.87E-06
Endosulfan II	NV	NV	NV	NV
Endosulfan sulfate	NV	NV	NV	NV
Endrin	2.00E-03	NV	NV	NV
Endrin Aldehyde	NV	NV	NV	NV
gamma-Chlordane[j]	2.00E-03	NV	NV	NV
Heptachlor epoxide	2.00E-04	NV	NV	NV

Table 5.15. Target Groundwater Concentrations Used in the PWAC Calculations (Continued)

Chemical Groups	Target Levels (mg/L or pCi/L)[e]			
	MCL[a]	Background[b]	Hazard Index = 1[c]	ELCR 1E-06[d]
Metals				
Sb	6.00E-03	6.00E-02	4.15E-03	NV
As	1.00E-02 [r]	5.00E-03	3.13E-03	3.80E-05
Ba	2.00E+00	2.35E-01	2.06E+00	NV
Be	4.00E-03	4.00E-03	1.86E-02	1.12E-05
Cd	5.00E-03	1.00E-02	5.13E-03	1.46E-04
Cr	1.00E-01	1.44E-01	1.47E+01 [f]	NV
Cu	1.30E+00 [g]	3.60E-02	4.17E-01	NV
Pb	1.50E-02 [g]	1.29E-01	NV	NV
Mn	NV	1.19E-01	2.45E-01	NV
Hg	2.00E-03	2.00E-04	3.09E-03	NV
Ni	NV	6.82E-01	2.08E-01	NV
Se	5.00E-02	5.00E-03	5.21E-02	NV
Ag	NV	1.10E-02	5.15E-02	NV
Tl	2.00E-03	5.60E-02	8.34E-04 [h]	NV
V	NV	1.34E-01	7.06E-04	NV
Zn	NV	5.40E-02	3.13E+00	NV
U	3.00E-02	2.00E-03	3.13E-02	NV
Radionuclides[l]				
Pu-238	NV [m]	NV	NV	7.19E-01
U-234	9.80E+00 [p]	7.00E-01	NV	1.33E+00
Th-230	NV [m]	1.10E+00	NV	1.04E+00 [o]
Ra-226	5.00E+00	6.00E-01	NV	NV [o]
Pb-210	1.06E+00	NV	NV	NV
U-238	9.80E+00 [p]	7.00E-01	NV	1.08E+00 [n]
U-234	9.80E+00 [p]	7.00E-01	NV	1.33E+00
Th-230	NV [m]	1.10E+00	NV	1.04E+00 [o]
Ra-226	5.00E+00	6.00E-01	NV	NV [o]
Pb-210	1.06E+00	NV	NV	NV
U-234	9.80E+00 [p]	7.00E-01	NV	1.33E+00
Th-230	NV [m]	1.10E+00	NV	1.04E+00 [o]
Ra-226	5.00E+00	6.00E-01	NV	NV [o]
Pb-210	1.06E+00	NV	NV	NV
Pu-239	NV [m]	1.00E-01	NV	6.98E-01
U-235	4.00E-01 [p]	3.00E-01	NV	1.31E+00
Pa-231	NV	NV	NV	NV
Ac-227	NV	NV	NV	NV
U-235	4.00E-01 [p]	3.00E-01	NV	1.31E+00 [n]
Pa-231	NV	NV	NV	NV
Ac-227	NV	NV	NV	NV

Table 5.15. Target Groundwater Concentrations Used in the PWAC Calculations (Continued)

Chemical Groups	Target Levels (mg/L or pCi/L)[e]			
	MCL[a]	Background[b]	Hazard Index = 1[c]	ELCR 1E-06[d]
Radionuclides (Continued)[l]				
Pu-240	NV [m]	3.66E-01	NV	6.98E-01
U-236	2.00E+01	NV	NV	NV
Th-232	NV [m]	NV	NV	NV [o]
Ra-228	5.00E+00	NV	NV	NV
Th-228	NV	NV	NV	NV
Np-237	NV [m]	8.00E-01	NV	1.40E+00 [n]
U-233	2.00E+01	NV	NV	NV
Th-229	NV	NV	NV	NV
Cs-137	1.14E+02	NV	NV	3.10E+00
Tc-99	9.00E+02 [q]	NV	NV	3.43E+01
Am-241	NV	NV	NV	9.06E-01
Np-237	NV	8.00E-01	NV	1.40E+00
U-233	2.00E+01	NV	NV	NV
Th-229	NV	NV	NV	NV
Th-230	NV	1.10E+00	NV	1.04E+00 [o]
Ra-226	5.00E+00	6.00E-01	NV	NV [o]
Pb-210	1.06E+00	NV	NV	NV

Note: NV indicates that a value was not available not available in the Risk Methods Document (DOE 2011b).
Contaminants noted in bold are indicator chemicals for the surrogate chemical group.

[a] Primary maximum contaminant levels (MCLs) were taken from Table A.14 in Appendix A of the Human Health Risk Methods Document (DOE 2011b).

[b] The background concentrations are provisional values for water drawn from the RGA reported in Table A.13 in Appendix A of the Human Health Risk Methods Document (DOE 2011b), when available the total concentration was used.

[c] Hazard-based concentrations were developed from the no action screening values for residential use presented in Table A.5 in Appendix A of the Human Health Risk Methods Document (DOE 2011b). The chemical-specific hazard target used in the derivation of the concentration for each individual constituent was 1. The routes of exposure included in derivation of concentrations were ingestion of groundwater, inhalation of vapors emitted by groundwater during house-hold use, inhalation of vapors emitted by groundwater while showering, and dermal contact while bathing. The hazard-based concentrations were for exposure by a child at an exposure frequency of 350 days per year. Intake of drinking water was 1 L/day.

[d] Cancer risk-based concentrations were developed from the no action screening values for residential use presented in Table A.5 in Appendix A of the Human Health Risk Methods Document (DOE 2011b). The chemical-specific cancer risk target used in the derivation of the concentration for each individual constituent was 1E-06. The route of exposure was ingestion of groundwater inhalation of vapors emitted by groundwater during house-hold use, inhalation of vapors emitted by groundwater while showering, and dermal contact while bathing. The cancer risk-based concentrations were for an exposure duration of 6 years as a child and 34 years as an adult. The exposure frequency for both child and adult was 350 days per year. Intake of drinking water was 2 L/day for an adult and 1 L/day for a child.

[e] Concentrations from which the PWAC-EOW were calculated. For all chemicals, the back-calculation concentration is the greater of MCL or background. If a chemical does not have a MCL, then the back-calculation concentration is the greater of the background or the risk/hazard-based concentration [lesser of cancer risk-based concentration (1E-06) and noncancer hazard-based concentration (HI=1)].

[f] Concentration is for total chromium.

[g] Value is a No Action value Table A.5.

[h] Concentration is for thallium chloride.

[i] Concentration for acenaphthene is listed because a value for acenaphthylene is not available.

[j] Concentrations listed are for chlordane.

[k] Concentration for fluoranthene is listed because a value for phenanthrene is not available.

[l] Five radionuclides included in the PGDP significant COPC list are not included because they would decay to either stable isotopes or would decay to isotopes more relevant to the risk and performance evaluation prior to reaching the exposure point. The three radionuclides decaying to stable isotopes and their half-lives are cobalt-60 (5.3 years), strontium-90 (28.8 years), and thorium-228 (1.9 years). (Note that thorium-228 decays though several other radionuclides with half-lives of less than 1 day prior to reaching the stable isotope. Also note that thorium-228 and its short-lived decay products are included in the derivation of the thorium-232 risk-based value as discussed in footnote t.) The isotope decaying to a more relevant isotope is americium-241. Americium-241 has a half-life of 432 years and decays to neptunium-237.

Table 5.15. Target Groundwater Concentrations Used in the PWAC Calculations (Continued)

Finally, the radionuclide radon-222, which also appears on the PGDP significant COPC list, is not included because it is a gas and would not be placed in the landfill.

[m] These radionuclides decay by alpha-emission; therefore, the 15 pCi/l total gross alpha primary MCL would be the limiting value under regulation. Because use of this MCL requires consideration of multiple radionuclides, and because consideration of multiple waste constituents at this point in the derivation of the CERCLA disposal criteria would be inconsistent with the approach used for other chemicals, compounds and radionuclides, the risk-based concentration was used for this radionuclide.

[n] The cancer risk-based value for this radionuclide was derived using a cancer slope factor that included consideration of short-lived decay products, assuming equal activity concentrations (i.e., secular equilibrium) with the principal or parent nuclide in the environment. In the Health Effects Assessment Summary Table (HEAST) for Radionuclides (see http://www.epa.gov/radiation/heast/), short-lived decay products are defined as those having a half-life less than about 3 months.

[o] The cancer risk-based value reported here was derived considering secular equilibrium of the listed radionuclides decay chain. The radionuclides considered in the analysis for the radium-226 series were radium-226 and lead-210 and their short-lived decay products. The radionuclides considered in the analysis for the thorium-232 series were thorium-232, radium-228, and thorium-228 and their short-lived decay products. Please see footnote s for a discussion of short-lived decay products.

[p] This value was derived assuming that the mass concentration MCL of 30 μg/L for total uranium is equivalent to about 20 pCi/g total uranium and that the abundance of uranium-234, uranium-235, and uranium-238 on an activity basis is 49%, 2%, and 49%, respectively.

[q] Derived from the 4 mrem/yr MCL for man-made beta-emitting radionuclides. Please see Appendix C.1 for additional information.

[r] The 0.010 mg/L MCL for arsenic is effective as of January 23, 2006, per the EPA Web site (i.e., http://www.epa.gov/OGWDW/mcl.htm). The current MCL is 0.050 mg/L.

[s] Value is for PCB 1254.

The target concentrations at the EOW were used to establish the PWAC-EOW. This PWAC-EOW was then assigned as the waste form source initial concentration and simulations were performed to calculate the contaminant concentrations in water at the WDF boundary, DOE boundary (Site 11), and surface water outcrop (Site 3A). The method used to calculate the PWAC is presented in the following equations:

$$\frac{\text{PWAC}}{C_{\text{s, chemical}}} = \frac{C_{\text{w, target}}}{C_{\text{w, chemical}}} \qquad \text{(Eq. 8)}$$

or

$$\text{PWAC} = \frac{C_{\text{w, target}} \times C_{\text{s, chemical}}}{C_{\text{w, chemical}}} \qquad \text{(Eq. 9)}$$

where

PWAC = preliminary waste acceptance criteria (mg/kg or pCi/g)
$C_{\text{w, target}}$ = target concentration for groundwater (mg/L or pCi/L)
$C_{\text{s chemical}}$ = constituent concentration in source as used in fate and transport model (mg/kg or pCi/g)
$C_{\text{w chemical}}$ = constituent concentration in groundwater from modeling results (mg/L or pCi/L)

The PWAC-EOW was calculated using Eq. 9. Results for the PWAC-EOW prior to correction for soil saturation,[20] total mass limits[21] for the disposal facility, are provided in Table 5.16 for Site 11 and in Table 5.17 for Site 3A. Results for the PWAC-EOW accounting for soil saturation and total mass limits for the disposal facility are included in Table 5.18 for Site 11 and Table 5.19 for Site 3A. Adjustments accounting for soil saturation or mass limits are made as appropriate and, if made, would result in a reduction of the chemical's initial PWAC concentration.

[20] Corrections for soil saturation are performed for those chemicals that, in their pure form, are liquids at 25°C.

[21] Recognizing that the waste will not be comprised of a single contaminant, a facility mass limit of 1E+05 mg/kg is used in lieu of 1E+06 mg/kg. This rule also is applied to radionuclides such that the specific activity (pCi/g), which would be the theoretical maximum activity for a radionuclide, is divided by 10.

Table 5.16. Site 11 PWAC-EOW Prior to Soil Saturation and Total Mass Limits Adjustments for the Gradual Failure Scenario

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)[b]	PWAC-EOW Inventory Limit (kg or Ci)[b]
Nonaromatic, Straight-Chain Halogenated Hydrocarbons		
Chloroform	4.90E+17	3.02E+21
cis-1,2-DCE	2.90E+17	1.79E+21
Methylene chloride	5.83E+15	3.60E+19
Vinyl Chloride	4.34E+15	2.67E+19
TCE	6.17E+17	3.80E+21
PCE	1.73E+18	1.07E+22
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons		
Acetone	Infinite	Infinite
2-Butanone	Infinite	Infinite
Butanal	Infinite	Infinite
Hexanone (2-)	Infinite	Infinite
Methyl-2-pentanone (4-)	Infinite	Infinite
Aromatic, Ring-Structured Halogenated Hydrocarbons		
Chlorobenzene	7.85E+34	4.84E+38
Dimethylbenzene (1,2-)	1.34E+37	8.27E+40
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons		
Benzene	2.12E+24	1.31E+28
Cumene	Infinite	Infinite
Ethylbenzene	9.83E+26	6.06E+30
Toluene	9.63E+26	5.94E+30

Table 5.16. Site 11 PWAC-EOW Prior to Soil Saturation and Total Mass Limits Adjustments for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)[b]	PWAC-EOW Inventory Limit (kg or Ci)[b]
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)		
Acenaphthene	Infinite	Infinite
Acetophenone	Infinite	Infinite
Benzoic Acid	Infinite	Infinite
Carbazole	Infinite	Infinite
Chloro-3-methylphenol (4-)	Infinite	Infinite
o-Cresol	Infinite	Infinite
p-Cresol	Infinite	Infinite
Dibenzofuran(s)	Infinite	Infinite
Methyl Naphthalene (2-)	Infinite	Infinite
Methylphenol (3&4-)	Infinite	Infinite
Phenol	Infinite	Infinite
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group		
Anthracene	1.34E+37	8.23E+40
Benzo(a)Anthracene	3.89E+33	2.39E+37
Butyl benzyl phthalate	Infinite	Infinite
Chrysene	4.07E+35	2.51E+39
Diethyl phthalate	Infinite	Infinite
Di-n-butyl phthalate	Infinite	Infinite
Di-n-octyl phthalate	Infinite	Infinite
Fluoranthene	6.29E+36	3.88E+40
Fluorene	6.11E+35	3.77E+39
Naphthalene	1.86E+32	1.15E+36
Pentachlorophenol	5.27E+32	3.25E+36
Phenanthrene	1.79E+36	1.10E+40
Pyrene	3.52E+36	2.17E+40
Tetrachlorophenol (2,3,4,6-)	Infinite	Infinite
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group		
BEHP	Infinite	Infinite
Benzo(a)pyrene	Infinite	Infinite
Benzo(b)Fluoranthene	Infinite	Infinite
Benzo(k)Fluoranthene	Infinite	Infinite
Benzo(g,h,i)perylene	Infinite	Infinite
Dibenzo(a,h)Anthracene	Infinite	Infinite
Indeno(1,2,3-cd)pyrene	Infinite	Infinite

Table 5.16. Site 11 PWAC-EOW Prior to Soil Saturation and Total Mass Limits Adjustments for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)[b]	PWAC-EOW Inventory Limit (kg or Ci)[b]
PCBs		
Aroclor-1016	5.77E+17	3.56E+21
Aroclor-1221	2.22E+17	1.37E+21
Aroclor-1232	2.22E+18	1.37E+22
Aroclor-1242	4.88E+17	3.01E+21
Aroclor-1248	4.47E+17	2.75E+21
Aroclor-1254	5.02E+17	3.10E+21
Aroclor-1260	2.36E+17	1.46E+21
Total PCBs	6.07E+19	3.74E+23
Pesticides		
beta-BHC	Infinite	Infinite
DDD (4,4-)	Infinite	Infinite
DDE (4,4-)	Infinite	Infinite
DDT (4,4-)	Infinite	Infinite
Dieldrin	7.03E+33	4.33E+37
Endosulfan II	Infinite	Infinite
Endosulfan sulfate	Infinite	Infinite
Endrin	3.18E+36	1.96E+40
Endrin aldehyde	Infinite	Infinite
gamma-Chlordane	1.51E+37	9.32E+40
Heptachlor epoxide	2.45E+36	1.51E+40
Metals		
Sb	1.20E+16	7.41E+19
As	2.27E+02	1.40E+06
Ba	3.21E+05	1.98E+09
Be	Infinite	Infinite
Cd	1.79E+30	1.10E+34
Cr	5.44E+03	3.36E+07
Cu	2.68E+02	1.65E+06
Pb	8.96E+31	5.52E+35
Mn	7.77E+12	4.79E+16
Hg	1.90E+03	1.17E+07
Ni	4.26E+09	2.62E+13
Se	2.00E+38	1.23E+42
Ag	3.90E+12	2.40E+16
Tl	1.10E+06	6.78E+09
V	1.28E+49	7.87E+52
Zn	Infinite	Infinite
U	Infinite	Infinite

Table 5.16. Site 11 PWAC-EOW Prior to Soil Saturation and Total Mass Limits Adjustments for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)[b]	PWAC-EOW Inventory Limit (kg or Ci)[b]
Radionuclides		
Pu-238	Infinite	Infinite
U-238	Infinite	Infinite
U-234	Infinite	Infinite
Pu-239	Infinite	Infinite
U-235	Infinite	Infinite
Pu-240	Infinite	Infinite
Np-237	2.58E+02	1.59E+03
Cs-137	Infinite	Infinite
Tc-99	2.67E+01	1.65E+02
Am-241	Infinite	Infinite
Th-230	Infinite	Infinite

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical groups.

[b] The preliminary Waste Acceptance Criteria-edge of waste (PWAC-EOW) values presented are initial values back calculated from the resulting groundwater concentration. They have not been corrected for soil saturation limits or total mass limits for the disposal facility. Note that "Infinite" indicates that the model output concentration at the EOW was zero or there was no criteria to establish a PWAC-EOW.

Table 5.17. Site 3A PWAC-EOW Prior to Soil Saturation and Total Mass Limits Adjustments for the Gradual Failure Scenario

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)[b]	PWAC-EOW Inventory Limit (kg or Ci)[b]
Nonaromatic, Straight-Chain Halogenated Hydrocarbons		
Chloroform	1.09E+16	6.73E+19
cis-1,2-DCE	6.46E+15	3.98E+19
Methylene chloride	1.30E+14	8.01E+17
Vinyl Chloride	9.68E+13	5.96E+17
TCE	3.61E+11	2.22E+15
PCE	1.01E+12	6.25E+15
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons		
Acetone	Infinite	Infinite
2-Butanone	Infinite	Infinite
Butanal	Infinite	Infinite
Hexanone (2-)	Infinite	Infinite
Methyl-2-pentanone (4-)	Infinite	Infinite
Aromatic, Ring-Structured Halogenated Hydrocarbons		
Chlorobenzene	3.11E+24	1.91E+28
Dimethylbenzene (1,2-)	5.31E+26	3.27E+30
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons		
Benzene	1.15E+16	7.11E+19
Cumene	Infinite	Infinite
Ethylbenzene	5.35E+18	3.29E+22
Toluene	5.24E+18	3.23E+22
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)		
Acenaphthene	Infinite	Infinite
Acetophenone	Infinite	Infinite
Benzoic Acid	Infinite	Infinite
Carbazole	Infinite	Infinite
Chloro-3-methylphenol (4-)	Infinite	Infinite
o-Cresol	Infinite	Infinite
p-Cresol	Infinite	Infinite
Dibenzofuran(s)	Infinite	Infinite
Methyl Naphthalene (2-)	Infinite	Infinite
Methylphenol (3&4-)	Infinite	Infinite
Phenol	Infinite	Infinite
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group		
Anthracene	2.80E+28	1.72E+32
Benzo(a)Anthracene	8.14E+24	5.01E+28
Butyl benzyl phthalate	Infinite	Infinite
Chrysene	8.53E+26	5.25E+30
Diethyl phthalate	Infinite	Infinite
Di-n-butyl phthalate	Infinite	Infinite
Di-n-octyl phthalate	Infinite	Infinite
Fluoranthene	1.32E+28	8.11E+31

Table 5.17. Site 3A PWAC-EOW Prior to Soil Saturation and Total Mass Limits Adjustments for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)[b]	PWAC-EOW Inventory Limit (kg or Ci)[b]
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group (Continued)		
Fluorene	1.28E+27	7.89E+30
Naphthalene	3.90E+23	2.40E+27
Pentachlorophenol	1.10E+24	6.79E+27
Phenanthrene	3.75E+27	2.31E+31
Pyrene	7.36E+27	4.53E+31
Tetrachlorophenol (2,3,4,6-)	Infinite	Infinite
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group		
BEHP	Infinite	Infinite
Benzo(a)pyrene	Infinite	Infinite
Benzo(b)Fluoranthene	Infinite	Infinite
Benzo(k)Fluoranthene	Infinite	Infinite
Benzo(g,h,i)perylene	Infinite	Infinite
Dibenzo(a,h)Anthracene	Infinite	Infinite
Indeno(1,2,3-cd)pyrene	Infinite	Infinite
PCBs		
Aroclor-1016	4.22E+10	2.60E+14
Aroclor-1221	1.62E+10	1.00E+14
Aroclor-1232	1.62E+11	1.00E+15
Aroclor-1242	3.57E+10	2.20E+14
Aroclor-1248	3.27E+10	2.01E+14
Aroclor-1254	3.67E+10	2.26E+14
Aroclor-1260	1.73E+10	1.06E+14
Total PCBs	4.44E+12	2.73E+16
Pesticides		
beta-BHC	Infinite	Infinite
DDD (4,4-)	Infinite	Infinite
DDE (4,4-)	Infinite	Infinite
DDT (4,4-)	Infinite	Infinite
Dieldrin	5.83E+27	3.59E+31
Endosulfan II	Infinite	Infinite
Endosulfan sulfate	Infinite	Infinite
Endrin	2.64E+30	1.63E+34
Endrin aldehyde	Infinite	Infinite
gamma-Chlordane	1.25E+31	7.73E+34
Heptachlor epoxide	2.03E+30	1.25E+34
Metals		
Sb	9.63E+08	5.93E+12
As	6.09E+00	3.75E+04
Ba	5.11E+03	3.15E+07
Be	5.56E+31	3.42E+35
Cd	9.95E+16	6.13E+20

Table 5.17. Site 3A PWAC-EOW Prior to Soil Saturation and Total Mass Limits Adjustments for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)[b]	PWAC-EOW Inventory Limit (kg or Ci)[b]
Metals (Continued)		
Cr	1.27E+02	7.85E+05
Cu	2.10E+01	1.29E+05
Pb	5.68E+18	3.50E+22
Mn	3.27E+07	2.02E+11
Hg	1.81E+01	1.11E+05
Ni	1.58E+06	9.76E+09
Se	1.65E+22	1.02E+26
Ag	1.77E+07	1.09E+11
Tl	3.79E+03	2.34E+07
V	4.16E+29	2.56E+33
Zn	9.56E+47	5.89E+51
U	3.56E+35	2.19E+39
Radionuclides		
Pu-238	Infinite	Infinite
U-238	1.16E+35	7.16E+35
U-234	1.14E+35	7.04E+35
Pu-239	Infinite	Infinite
U-235	4.75E+33	2.92E+34
Pu-240	Infinite	Infinite
Np-237	8.91E-01	5.49E+00
Cs-137	Infinite	Infinite
Tc-99	2.08E+00	1.28E+01
Am-241	Infinite	Infinite
Th-230	Infinite	Infinite

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical groups.

[b] The preliminary Waste Acceptance Criteria-edge of waste (PWAC-EOW) values presented are initial values back calculated from the resulting groundwater concentration. They have not been corrected for soil saturation limits or total mass limits for the disposal facility. Note that “Infinite” indicates that the model output concentration at the EOW was zero or there was no criteria to establish a PWAC-EOW.

Table 5.18. Site 11 PWAC for the Gradual Failure Scenario

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Nonaromatic, Straight-Chain Halogenated Hydrocarbons						
Chloroform	1.40E+03	8.65E+06	1.40E+03	8.65E+06	1.40E+03	8.65E+06
cis-1,2-DCE	5.73E+02	3.53E+06	5.73E+02	3.53E+06	5.73E+02	3.53E+06
Methylene chloride	1.86E+03	1.15E+07	1.86E+03	1.15E+07	1.86E+03	1.15E+07
Vinyl Chloride	4.14E+02	2.55E+06	4.14E+02	2.55E+06	4.14E+02	2.55E+06
TCE	2.32E+02	1.43E+06	2.32E+02	1.43E+06	2.32E+02	1.43E+06
PCE	6.95E+01	4.28E+05	6.95E+01	4.28E+05	6.95E+01	4.28E+05
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons						
Acetone	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
2-Butanone	1.04E+04	6.42E+07	1.04E+04	6.42E+07	1.04E+04	6.42E+07
Butanal	4.82E+03	2.97E+07	4.82E+03	2.97E+07	4.82E+03	2.97E+07
Hexanone (2-)	2.53E+03	1.56E+07	2.53E+03	1.56E+07	2.53E+03	1.56E+07
Methyl-2-pentanone (4-)	2.76E+03	1.70E+07	2.76E+03	1.70E+07	2.76E+03	1.70E+07
Aromatic, Ring-Structured Halogenated Hydrocarbons						
Chlorobenzene	1.48E+02	9.15E+05	1.48E+02	9.15E+05	1.48E+02	9.15E+05
Dimethylbenzene (1,2-)	7.87E+01	4.85E+05	7.87E+01	4.85E+05	7.87E+01	4.85E+05
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons						
Benzene	3.23E+02	1.99E+06	3.23E+02	1.99E+06	3.23E+02	1.99E+06
Cumene	4.25E+01	2.62E+05	4.25E+01	2.62E+05	4.25E+01	2.62E+05
Ethylbenzene	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.05E+01	3.11E+05
Toluene	1.30E+02	8.02E+05	1.30E+02	8.02E+05	1.30E+02	8.02E+05
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)						
Acenaphthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Acetophenone	1.08E+03	6.68E+06	1.08E+03	6.68E+06	1.08E+03	6.68E+06
Benzoic Acid	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Carbazole	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Chloro-3-methylphenol (4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
o-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
p-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzofuran(s)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methyl Naphthalene (2-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methylphenol (3&4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group						
Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(a)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Butyl benzyl phthalate	2.99E+01	1.84E+05	2.99E+01	1.84E+05	2.99E+01	1.84E+05
Chrysene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08

Table 5.18. Site 11 PWAC for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group (Continued)						
Diethyl phthalate	2.17E+02	1.34E+06	2.17E+02	1.34E+06	2.17E+02	1.34E+06
Di-n-butyl phthalate	1.56E+01	9.61E+04	1.56E+01	9.61E+04	1.56E+01	9.61E+04
Di-n-octyl phthalate	1.33E+03	8.21E+06	1.33E+03	8.21E+06	1.33E+03	8.21E+06
Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Fluorene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Naphthalene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pentachlorophenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenanthrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tetrachlorophenol (2,3,4,6-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group						
BEHP	3.03E+01	1.87E+05	3.03E+01	1.87E+05	3.03E+01	1.87E+05
Benzo(a)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(b)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(k)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(g,h,i)perylene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzo(a,h)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Indeno(1,2,3-cd)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
PCBs						
Aroclor-1016	1.61E+01	9.92E+04	1.61E+01	9.92E+04	1.61E+01	9.92E+04
Aroclor-1221	1.03E+02	6.34E+05	1.03E+02	6.34E+05	1.03E+02	6.34E+05
Aroclor-1232	9.77E+01	6.02E+05	9.77E+01	6.02E+05	9.77E+01	6.02E+05
Aroclor-1242	1.74E+01	1.07E+05	1.74E+01	1.07E+05	1.74E+01	1.07E+05
Aroclor-1248	6.13E+00	3.78E+04	6.13E+00	3.78E+04	6.13E+00	3.78E+04
Aroclor-1254	4.50E+00	2.77E+04	4.50E+00	2.77E+04	4.50E+00	2.77E+04
Aroclor-1260	4.04E+00	2.49E+04	4.04E+00	2.49E+04	4.04E+00	2.49E+04
Total PCBs	1.73E+02	1.07E+06	1.73E+02	1.07E+06	1.73E+02	1.07E+06
Pesticides						
beta-BHC	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDD (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDE (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDT (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dieldrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan II	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan sulfate	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin Aldehyde	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
gamma-Chlordane	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heptachlor epoxide	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08

Table 5.18. Site 11 PWAC for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Metals						
Sb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
As	2.27E+02	1.40E+06	9.83E+01	6.06E+05	1.13E+00	6.97E+03
Ba	1.00E+05	6.16E+08	3.07E+04	1.89E+08	3.07E+04	1.89E+08
Be	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cd	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cr	5.44E+03	3.36E+07	5.44E+03	3.36E+07	5.44E+03	3.36E+07
Cu	2.68E+02	1.65E+06	3.19E+02	1.97E+06	3.19E+02	1.97E+06
Pb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Mn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Hg	1.90E+03	1.17E+07	3.16E+02	1.95E+06	3.16E+02	1.95E+06
Ni	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Se	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Ag	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tl	1.00E+05	6.16E+08	2.45E+03	1.51E+07	2.45E+03	1.51E+07
V	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Zn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
U[b]	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Radionuclides						
Pu-238	1.71E+12	1.05E+13	1.71E+12	1.05E+13	1.71E+12	1.05E+13
U-238	3.36E+04	2.07E+05	3.36E+04	2.07E+05	3.36E+04	2.07E+05
U-234	6.25E+08	3.85E+09	6.25E+08	3.85E+09	6.25E+08	3.85E+09
Pu-239	6.20E+09	3.82E+10	6.20E+09	3.82E+10	6.20E+09	3.82E+10
U-235	2.16E+05	1.33E+06	2.16E+05	1.33E+06	2.16E+05	1.33E+06
Pu-240	2.27E+10	1.40E+11	2.27E+10	1.40E+11	2.27E+10	1.40E+11
Np-237	2.58E+02	1.59E+03	2.58E+02	1.59E+03	3.41E+01	2.10E+02
Cs-137	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.65E+12	5.33E+13
Tc-99	2.67E+01	1.65E+02	3.70E+01	2.28E+02	3.70E+01	2.28E+02
Am-241	3.43E+11	2.12E+12	3.13E+06	1.93E+07	2.92E+05	1.80E+06
Th-230	2.02E+09	1.24E+10	2.02E+09	1.24E+10	2.02E+09	1.24E+10

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.

[b] Applying natural abundance mass ratios to elemental uranium PWAC would result in the following uranium isotope PWAC: 3.34E+04 pCi/g of U-238, 1.56E+03 pCi/g of U-235, and 3.44E+04 pCi/g of U-234.

PWAC - Preliminary Waste Acceptance Criteria

EOW - Edge of Waste

WDF - Waste Disposal Facility boundary

DOE/SW - DOE property (Site 11)/surface water outcrop (Site 3A)

Table 5.19. Site 3A PWAC for the Gradual Failure Scenario

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Nonaromatic, Straight-Chain Halogenated Hydrocarbons						
Chloroform	1.40E+03	8.64E+06	1.40E+03	8.64E+06	1.40E+03	8.64E+06
cis-1,2-DCE	5.73E+02	3.53E+06	5.73E+02	3.53E+06	5.73E+02	3.53E+06
Methylene chloride	1.86E+03	1.15E+07	1.86E+03	1.15E+07	1.86E+03	1.15E+07
Vinyl Chloride	4.14E+02	2.55E+06	4.14E+02	2.55E+06	4.14E+02	2.55E+06
TCE	2.32E+02	1.43E+06	2.32E+02	1.43E+06	2.32E+02	1.43E+06
PCE	6.95E+01	4.28E+05	6.95E+01	4.28E+05	6.95E+01	4.28E+05
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons						
Acetone	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
2-Butanone	1.04E+04	6.41E+07	1.04E+04	6.41E+07	1.04E+04	6.41E+07
Butanal	4.82E+03	2.97E+07	4.82E+03	2.97E+07	4.82E+03	2.97E+07
Hexanone (2-)	2.53E+03	1.56E+07	2.53E+03	1.56E+07	2.53E+03	1.56E+07
Methyl-2-pentanone (4-)	2.76E+03	1.70E+07	2.76E+03	1.70E+07	2.76E+03	1.70E+07
Aromatic, Ring-Structured Halogenated Hydrocarbons						
Chlorobenzene	1.48E+02	9.14E+05	1.48E+02	9.14E+05	1.48E+02	9.14E+05
Dimethylbenzene (1,2-)	7.87E+01	4.84E+05	7.87E+01	4.84E+05	7.87E+01	4.84E+05
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons						
Benzene	3.23E+02	1.99E+06	3.23E+02	1.99E+06	3.23E+02	1.99E+06
Cumene	4.25E+01	2.62E+05	4.25E+01	2.62E+05	4.25E+01	2.62E+05
Ethylbenzene	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.05E+01	3.11E+05
Toluene	1.30E+02	8.01E+05	1.30E+02	8.01E+05	1.30E+02	8.01E+05
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)						
Acenaphthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Acetophenone	1.08E+03	6.67E+06	1.08E+03	6.67E+06	1.08E+03	6.67E+06
Benzoic Acid	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Carbazole	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Chloro-3-methylphenol (4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
o-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
p-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzofuran(s)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methyl Naphthalene (2-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methylphenol (3&4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group						
Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(a)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Butyl benzyl phthalate	2.99E+01	1.84E+05	2.99E+01	1.84E+05	2.99E+01	1.84E+05
Chrysene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Diethyl phthalate	2.17E+02	1.34E+06	2.17E+02	1.34E+06	2.17E+02	1.34E+06
Di-n-butyl phthalate	1.56E+01	9.61E+04	1.56E+01	9.61E+04	1.56E+01	9.61E+04

Table 5.19. Site 3A PWAC for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group (Continued)						
Di-n-octyl phthalate	1.33E+03	8.21E+06	1.33E+03	8.21E+06	1.33E+03	8.21E+06
Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Fluorene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Naphthalene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pentachlorophenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenanthrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tetrachlorophenol (2,3,4,6-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group						
BEHP	3.03E+01	1.86E+05	3.03E+01	1.86E+05	3.03E+01	1.86E+05
Benzo(a)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(b)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(k)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(g,h,i)perylene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzo(a,h)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Indeno(1,2,3-cd)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
PCBs						
Aroclor-1016	1.61E+01	9.92E+04	1.61E+01	9.92E+04	1.61E+01	9.92E+04
Aroclor-1221	1.03E+02	6.34E+05	1.03E+02	6.34E+05	1.03E+02	6.34E+05
Aroclor-1232	9.77E+01	6.02E+05	9.77E+01	6.02E+05	9.77E+01	6.02E+05
Aroclor-1242	1.74E+01	1.07E+05	1.74E+01	1.07E+05	1.74E+01	1.07E+05
Aroclor-1248	6.13E+00	3.77E+04	6.13E+00	3.77E+04	6.13E+00	3.77E+04
Aroclor-1254	4.50E+00	2.77E+04	4.50E+00	2.77E+04	4.50E+00	2.77E+04
Aroclor-1260	4.04E+00	2.49E+04	4.04E+00	2.49E+04	4.04E+00	2.49E+04
Total PCBs	1.73E+02	1.07E+06	1.73E+02	1.07E+06	1.73E+02	1.07E+06
Pesticides						
beta-BHC	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDD (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDE (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDT (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dieldrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan II	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan sulfate	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin Aldehyde	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
gamma-Chlordane	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heptachlor epoxide	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Metals						
Sb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
As	6.09E+00	3.75E+04	2.84E+00	1.75E+04	5.09E-01	3.13E+03

Table 5.19. Site 3A PWAC for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Metals (Continued)						
Ba	5.11E+03	3.15E+07	7.92E+02	4.88E+06	5.11E+03	3.15E+07
Be	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cd	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cr	1.27E+02	7.85E+05	1.27E+02	7.85E+05	1.27E+02	7.85E+05
Cu	2.10E+01	1.29E+05	2.24E+01	1.38E+05	2.24E+01	1.38E+05
Pb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Mn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Hg	1.81E+01	1.11E+05	7.46E+00	4.59E+04	1.81E+01	1.11E+05
Ni	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Se	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Ag	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tl	3.79E+03	2.34E+07	4.45E+01	2.74E+05	3.79E+03	2.34E+07
V	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Zn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
U[b]	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Radionuclides						
Pu-238	1.71E+12	1.05E+13	1.71E+12	1.05E+13	1.71E+12	1.05E+13
U-238	3.36E+04	2.07E+05	3.36E+04	2.07E+05	3.36E+04	2.07E+05
U-234	6.25E+08	3.85E+09	6.25E+08	3.85E+09	6.25E+08	3.85E+09
Pu-239	6.20E+09	3.82E+10	6.20E+09	3.82E+10	6.20E+09	3.82E+10
U-235	2.16E+05	1.33E+06	2.16E+05	1.33E+06	2.16E+05	1.33E+06
Pu-240	2.27E+10	1.40E+11	2.27E+10	1.40E+11	2.27E+10	1.40E+11
Np-237	8.91E-01	5.49E+00	8.91E-01	5.49E+00	1.54E-01	9.49E-01
Cs-137	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.65E+12	5.33E+13
Tc-99	2.08E+00	1.28E+01	2.27E+00	1.40E+01	2.28E+00	1.40E+01
Am-241	3.43E+11	2.11E+12	4.86E+03	3.00E+04	1.27E+03	7.82E+03
Th-230	2.02E+09	1.24E+10	2.02E+09	1.24E+10	2.02E+09	1.24E+10

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.
[b] Applying natural abundance mass ratios to elemental uranium PWAC would result in the following uranium isotope PWAC: 3.34E+04 pCi/g of U-238, 1.56E+03 pCi/g of U-235, and 3.44E+04 pCi/g of U-234.
PWAC - Preliminary Waste Acceptance Criteria
EOW - Edge of Waste
WDF - Waste Disposal Facility boundary
DOE/SW - DOE property (Site 11)/surface water outcrop (Site 3A)

5.4.6.6 PWAC-WDF and PWAC-DOE/SW derivation

PWAC were developed based upon ELCR for the residential groundwater user and HI for the residential child groundwater user (Table A.5 of DOE 2011b) for the WDF boundary, DOE boundary (Site 11), and surface water outcrop (Site 3A). A discussion of the receptor and pathway selection for the PWAC development is provided in Attachment C6 in Appendix C. The POA for this section focuses on the WDF boundary.

The analyses for exposure to constituents potentially released to groundwater utilized the following risk and hazard target values at the three points of exposure (i.e., at the EOW, at the WDF boundary, and at the DOE property line or surface water outcrop) and two time periods (i.e., 0 to 1,600 years and beyond 1,600 years). Predicted concentrations of COCs in groundwater for the first 1,600 years were used to calculate contaminant specific PWACs at the POAs; the analysis considering times greater than 1,600 years was to provide information on variation of COC concentrations over a longer time period.

The EOW is at the edge of the waste mass. The WDF boundary is the site on which the WDF and associated infrastructure is located. For the purposes of the PWAC, this boundary is considered to be approximately 113 m from the EOW for Site 11. For Site 3A, the WDF boundary is approximately 118 m from the EOW. The final WDF boundary location will depend on site geometry and site layout and will be at least 100 m from the edge of waste (DOE Order 435.1).

The concentrations of COCs in groundwater at the exposure points were used to calculate the cancer risk and noncancer hazard (i.e., HI) for the organics, metals, and radionuclides resulting from exposure to the groundwater. The Risk Methods Document PGDP, Human Health, was the basis of these calculations (DOE 2011b).

- EOW (both time periods)

  (1) The target concentrations were the chemical-specific primary MCLs, if this value was greater than the constituent’s background concentration. If the background concentration for the constituent was greater than the MCL, then the background concentration was selected.

  (2) If chemical-specific primary MCLs were not available, then chemical-specific risk and hazard-based targets based on residential use of groundwater (i.e., residential child groundwater user) were used to derive the constituent’s target concentration in groundwater. The chemical-specific risk-based target was 1E-06, the dose-based target was 25 mrem/yr, and the chemical-specific hazard-based target was 1. If both a risk- or dose-based concentration and hazard-based concentration were derived for a constituent, then the lower of the two concentrations was selected. However, if the selected value was less than the background concentration, then the background concentration was used.

- At the boundary of the WDF[22]

  (1) Years 30 to 1,600
    (a) The risk-based target was a cumulative ELCR of 1E-04.

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[22] When groundwater modeling predicts that a single contaminant will be present in groundwater at a point of exposure at the Waste facility boundary or DOE property boundary, the MCL for the chemical will be used as a protective value consistent with EPA guidance (EPA 1991). In making this determination, a “single contaminant” will be considered to be predicted and present when concentrations of all other contaminants within the same time interval are predicted to be below their residential NAL (derived using a target HI of 0.1 and/or a target ELCR of 1E-06) or background concentration in groundwater.

(b) The hazard-based target was a cumulative HI of 1.
(c) The dose-based target was a cumulative exposure (groundwater pathway) of 25 mrem/yr.

(2) Beyond Year 1,600
(a) The risk-based target was a cumulative ELCR of 1E-04.
(b) The hazard-based target was a cumulative HI of 3.
(c) The dose-based target was a cumulative exposure (groundwater pathway) of 25 mrem/yr.

(3) Consistent with COPC selection in the Risk Methods Document, the calculation of cumulative ELCR and cumulative HI at the boundary of the WDF excludes any constituents that use the constituent's background concentration as the chemical-specific target at the EOW.

- At the DOE property line or near surface water outcrop[23]

(1) Years 30 to 1,600
(a) The risk-based target was a cumulative ELCR of 1E-06.
(b) The hazard-based target was a cumulative HI of 1.
(c) The dose-based target was a cumulative exposure (groundwater pathway) of 25 mrem/yr.

(2) Beyond Year 1,600
(a) The risk-based target was a cumulative ELCR of 1E-05.
(b) The hazard-based target was a cumulative HI of 3.
(c) The dose-based target was a cumulative exposure (groundwater pathway) of 25 mrem/yr.

Consistent with COPC selection in the Risk Methods Document (DOE 2011b), the calculation of cumulative ELCR and cumulative HI at the DOE property line excludes any constituents that use the constituent's background concentration as the chemical-specific target at the edge of the waste unit. Additionally, to target the more important risk and hazard contributors, only constituents with a chemical-specific contribution to cumulative ELCR and/or HI at the boundary of the WDF greater than 1E-07 or 0.05, respectively, were included in the calculation of cumulative ELCR and HI at the DOE property line.

The greater of cumulative ELCR and/or HI targets was used beyond 1,600 years at the boundary of the WDF and DOE property line to address the uncertainties in exposure (e.g., receptor location relative to groundwater flow) and constituent release and migration. The PWAC was calculated based on Year 0 through Year 1,600.

The target concentrations at the edge of the waste unit were used to establish the PWAC (PWAC-EOW). This PWAC-EOW then was used to calculate the contaminant concentrations in water at the boundary of the WDF. If these calculated contaminant concentrations exceed the risk-based and hazard-based targets established for the boundary of the WDF, then the PWAC is adjusted until these target risks are met. This iterative approach then was repeated for the DOE boundary for Site 11 and Bayou Creek (the location where groundwater intersects surface water prior to the DOE boundary) for Site 3A.

The equations used to calculate the chemical-specific risk and noncancer hazard estimates are as follows:

[23] See note 21.

$$Chemical - Specific\ \ Risk\ Value = \frac{C_{w\,Chemical}\ \ x\ Target\ \ Risk\ Value}{C_{w\,No\ Action}}$$

where

Chemical-Specific Risk Value	= cancer risk and noncancer hazard from groundwater exposure
$C_{w\ Chemical}$	= chemical concentration in groundwater (mg/L or pCi/L)
Target Risk Value	= target cancer risk, hazard level, or dose-based risk
$C_{w\ No\ Action}$	= cancer risk/hazard level, or dose-based risk screening value (mg/L or pCi/L)

As mentioned previously, the PWAC-EOW values presented in Tables 5.16 and 5.17 were compared to the soil saturation limits for chemicals that, in their pure form, are liquids at 25°C to ensure that the allowable contaminant concentrations would not result in the disposal of free liquids. The pore-water concentration in the waste was determined using the following equation for comparison against the solubility limits:

$$C_{pw} = \frac{Cw \times \rho_b}{\theta_v + \rho_b \times K_d} \qquad \text{(Eq. 10)}$$

where

C_{pw}	= pore-water concentration in the waste (mg/L or pCi/L)
C_w	= contaminant concentration in the waste (mg/kg or pCi/g)
ρ_b	= bulk density of the waste (3.1 g/cm^3) (Attachment C4)
K_d	= soil/water distribution coefficient (L/kg provided Attachment C4)
θ_v	= volumetric water content (0.36)

The soil saturation limits were determined using the following equation:

$$Csat = \frac{S}{\rho_b}\left(K_d \times \rho_b + \theta_v\right) \qquad \text{(Eq. 11)}$$

where

C_{sat}	= soil saturation limit (mg/kg)
S	= solubility limit in water (mg/L in Attachment C4)

The PWAC-EOW was also compared to the estimated mass of the landfill assuming a waste density of 3.1 g/cm^3. The resulting mass limit of the landfill (i.e., 6.16 x 10^9 kg) was determined as follows:

$$M_L = \rho_b \times W_D \times W_A \times C_f \qquad \text{(Eq. 12)}$$

where

M_L	= mass limit of the facility (kg)
W_D	= thickness of the waste zone (2.59 x 10^3 cm)
W_A	= waste area (7.67 x 10^8 cm^2)
C_f	= conversion factor (10^{-3} kg/g)

PWAC-EOW values that exceeded the soil saturation limit were set equal to the soil saturation limit. In addition, PWAC-EOW values that exceeded the mass limit of the landfill were set equal to the mass concentration limit based on the 6.16 x 10^9 kg mass limit. The mass concentration limit was determined as follows:

$$M_C = \frac{M_L}{\rho_b \times W_D \times W_A} \quad \text{(Eq. 13)}$$

where

M_C = mass concentration limit (1 x 10^6 mg/kg)

Tables 5.18 and 5.19 provide the PWAC-EOW, PWAC-WDF, and PWAC-DOE/SW based on the soil saturation, mass concentrations, and risk criteria limits for the disposal facility.[24] Table 5.20 provides a comparison of the PWAC concentrations and analyte masses for Sites 11 and 3A to the projected waste concentrations. The values in Table 5.20 indicate that a higher PWAC for certain contaminants is calculated for Site 11 than 3A. While the intent of the PWAC is to assess the feasibility of the On-Site Alternative, the PWAC also should be used to inform the design of an On-Site WDF. This could result in enhancements or changes to the conceptual design that consequently would result in a WAC that differs from the PWAC presented in Table 5.20. For example, the presence/properties of the upper Terrace Gravel (Site 3A) result in a lower modeled PWAC than modeled for Site 11 (a lower terrace site). At Site 3A, the Porters Creek clay is present below the upper Terrace Gravel, preventing further downward movement of contaminants and results in groundwater flowing over the Porters Creek clay to the POAs. Based on the PWAC findings, combined with an understanding of the underlying geology and the relatively shallow depth of the Porters Creek clay, control of groundwater flow through the use of a barrier system could be integrated into the design at Site 3A, which is expected to increase the WAC compared to the PWAC. This is discussed further in Section 5.4.6.8.

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[24] When groundwater modeling predicts that a single contaminant will be present in groundwater at a point of exposure at the waste facility boundary or DOE property boundary, the MCL for the chemical will be used as a protective value consistent with EPA guidance (EPA 1991). In making this determination, a "single contaminant" will be considered to be predicted and present when concentrations of all other contaminants within the same time interval are predicted to be below their residential NAL (derived using a target HI of 0.1 and/or a target ELCR of 1E-06) or background concentration in groundwater.

Table 5.20. Final PWAC Comparison to CERCLA Waste Concentrations for the On-Site Alternative

	Site 11		Site 3A			
Chemical Groups[a]	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**High-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)**	**Low-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)**
Nonaromatic, Straight-Chain Halogenated Hydrocarbons						
Chloroform	1.40E+03	8.65E+06	1.40E+03	8.64E+06	2.94E-04	2.46E-04
cis-1,2-DCE	5.73E+02	3.53E+06	5.73E+02	3.53E+06	6.72E-01	1.15E+00
Methylene chloride	1.86E+03	1.15E+07	1.86E+03	1.15E+07	2.76E-07	4.71E-07
Vinyl Chloride	4.14E+02	2.55E+06	4.14E+02	2.55E+06	6.88E-03	1.14E-02
TCE	2.32E+02	1.43E+06	2.32E+02	1.43E+06	1.09E-01	1.85E-01
PCE	6.95E+01	4.28E+05	6.95E+01	4.28E+05	3.33E-04	2.49E-04
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons						
Acetone	1.00E+05	6.16E+08	1.00E+05	6.16E+08	2.40E-03	4.11E-03
2-Butanone	1.04E+04	6.42E+07	1.04E+04	6.41E+07	NV	NV
Butanal	4.82E+03	2.97E+07	4.82E+03	2.97E+07	1.01E-06	1.72E-06
Hexanone (2-)	2.53E+03	1.56E+07	2.53E+03	1.56E+07	6.80E-07	1.16E-06
Methyl-2-pentanone (4-)	2.76E+03	1.70E+07	2.76E+03	1.70E+07	1.15E-07	1.96E-07
Aromatic, Ring-Structured Halogenated Hydrocarbons						
Chlorobenzene	1.48E+02	9.15E+05	1.48E+02	9.14E+05	NV	NV
Dimethylbenzene (1,2-)	7.87E+01	4.85E+05	7.87E+01	4.84E+05	6.61E-07	1.13E-06
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons						
Benzene	3.23E+02	1.99E+06	3.23E+02	1.99E+06	NV	NV
Cumene	4.25E+01	2.62E+05	4.25E+01	2.62E+05	1.19E-06	2.03E-06
Ethylbenzene	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.56E-04	1.49E-04
Toluene	1.30E+02	8.02E+05	1.30E+02	8.01E+05	1.56E-07	2.67E-07
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)						
Acenaphthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.19E-01	4.10E-01
Acetophenone	1.08E+03	6.68E+06	1.08E+03	6.67E+06	2.51E-03	4.29E-03
Benzoic Acid	1.00E+05	6.16E+08	1.00E+05	6.16E+08	7.26E-03	1.24E-02
Carbazole	1.00E+05	6.16E+08	1.00E+05	6.16E+08	5.19E-01	7.39E-01
Chloro-3-methylphenol (4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	6.89E-05	1.18E-04

Table 5.20. Final PWAC Comparison to CERCLA Waste Concentrations for the On-Site Alternative (Continued)

	Site 11		Site 3A			
Chemical Groups[a]	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**High-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)**	**Low-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)**
o-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	0.00E+00	0.00E+00
p-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	0.00E+00	0.00E+00
Dibenzofuran(s)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	0.00E+00	0.00E+00
Methyl Naphthalene (2-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.28E-01	2.19E-01
Methylphenol (3&4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	0.00E+00	0.00E+00
Phenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.61E-04	2.75E-04
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group						
Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.61E-01	2.34E-01
Butyl benzyl phthalate	2.99E+01	1.84E+05	2.99E+01	1.84E+05	7.81E-05	1.34E-04
Diethyl phthalate	2.17E+02	1.34E+06	2.17E+02	1.34E+06	3.31E-03	5.66E-03
Di-n-butyl phthalate	1.56E+01	9.61E+04	1.56E+01	9.61E+04	5.25E-03	8.98E-03
Di-n-octyl phthalate	1.33E+03	8.21E+06	1.33E+03	8.21E+06	7.76E-05	1.33E-04
Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.74E-01	6.92E-01
Fluorene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.26E-01	9.06E-02
Naphthalene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	5.15E-01	8.26E-01
Pentachlorophenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.44E-03	5.88E-03
Phenanthrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.93E-01	6.17E-01
Pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.55E-01	5.15E-01
Tetrachlorophenol (2,3,4,6-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	2.31E-03	3.96E-03
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group						
BEHP	3.03E+01	1.87E+05	3.03E+01	1.86E+05	8.69E-02	1.49E-01
Total PAHs[b]	7.00E+05	4.31E+09	7.00E+05	4.31E+09	1.27E+00	1.46E+00
Benzo(g,h,i)perylene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	0.00E+00	0.00E+00
PCBs						
Total PCBs[c]	1.73E+02	1.07E+06	1.73E+02	1.07E+06	6.71E-01	0.00E+00

Table 5.20. Final PWAC Comparison to CERCLA Waste Concentrations for the On-Site Alternative (Continued)

	Site 11		Site 3A			
Chemical Groups[a]	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**High-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)**	**Low-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)**
Pesticides						
beta-BHC	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.67E-06	6.28E-06
DDD (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	5.41E-04	9.25E-04
DDE (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.39E-02	2.38E-02
DDT (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.47E-03	7.64E-03
Dieldrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.23E-02	1.82E-03
Endosulfan II	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.59E-06	7.86E-06
Endosulfan sulfate	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.22E-06	5.50E-06
Endrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.22E-06	5.50E-06
Endrin Aldehyde	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.04E-04	1.78E-04
gamma-Chlordane	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.69E-04	8.02E-04
Heptachlor epoxide	1.00E+05	6.16E+08	1.00E+05	6.16E+08	9.19E-07	1.57E-06
Metals						
Sb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	6.62E-01	1.08E+00
As	1.13E+00	6.97E+03	5.09E-01	3.13E+03	2.51E+00	2.53E+00
Ba	3.07E+04	1.89E+08	7.92E+02	4.88E+06	2.36E+01	1.39E+01
Be	1.00E+05	6.16E+08	1.00E+05	6.16E+08	9.30E-02	7.56E-02
Cd	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.63E-01	5.70E-01
Cr	5.44E+03	3.36E+07	1.27E+02	7.85E+05	1.02E+01	6.09E+00
Cu	2.68E+02	1.65E+06	2.10E+01	1.29E+05	4.55E+01	4.81E+01
Pb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.09E+01	4.67E+01
Mn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	8.38E+01	1.09E+02
Hg	3.16E+02	1.95E+06	7.46E+00	4.59E+04	1.30E-01	2.21E-01
Ni	1.00E+05	6.16E+08	1.00E+05	6.16E+08	5.78E+01	8.70E+01
Se	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.08E+00	5.01E+00
Ag	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.02E-01	6.61E-01
Tl	2.45E+03	1.51E+07	4.45E+01	2.74E+05	1.82E-01	7.45E-02

Table 5.20. Final PWAC Comparison to CERCLA Waste Concentrations for the On-Site Alternative (Continued)

Chemical Groups[a]	Site 11 PWAC Average Concentration (mg/kg or pCi/g)	Site 11 PWAC Inventory Limit (kg or Ci)	Site 3A PWAC Average Concentration (mg/kg or pCi/g)	Site 3A PWAC Inventory Limit (kg or Ci)	High-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)	Low-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)
V	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.07E+00	1.57E+00
Zn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	6.67E+02	1.14E+03
U[d]	1.00E+05	6.16E+08	1.00E+05	6.16E+08	NV	NV
Radionuclides						
Pu-238	1.71E+12	1.05E+13	1.71E+12	1.05E+13	8.02E-02	1.24E-01
U-238	3.36E+04	2.07E+05	3.36E+04	2.07E+05	1.06E+02	1.80E+02
U-234	6.25E+08	3.85E+09	6.25E+08	3.85E+09	1.50E+03	2.56E+03
Pu-239	6.20E+09	3.82E+10	6.20E+09	3.82E+10	9.98E-02	1.58E-01
U-235	2.16E+05	1.33E+06	2.16E+05	1.33E+06	6.96E+01	1.19E+02
Pu-240	2.27E+10	1.40E+11	2.27E+10	1.40E+11	9.98E-02	1.58E-01
Np-237	3.41E+01	2.10E+02	1.54E-01	9.49E-01	2.55E+00	4.33E+00
Cs-137	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.02E-01	1.32E+00
Tc-99	2.67E+01	1.65E+02	2.08E+00	1.28E+01	5.72E+00	9.61E+00
Am-241	2.92E+05	1.80E+06	1.27E+03	7.82E+03	3.84E-01	6.15E-01
Th-230	2.02E+09	1.24E+10	2.02E+09	1.24E+10	9.54E+00	1.61E+01

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.

[b] Consistent with the Risk Methods Document (DOE 2011b), Total PAHs includes benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

[c] Consistent with the Risk Methods Document (DOE 2011b), Total PCBs includes Aroclors-106, 1221, 1232, 1242, 1248, 1254, and 1260.

[d] For Site 3A and Site 11, the final PWAC for elemental uranium is 1.00E+05 mg/kg. Applying natural abundance mass ratios to elemental uranium PWAC would result in the following uranium isotope PWAC: 3.34E+04 pCi/g of uranium-238, 1.56E+03 pCi/g of uranium-235, and 3.44E+04 pCi/g of uranium-234.

NV - no value given in Table 4.10 for this constituent.

5.4.6.7 Inadvertent intruders

This section summarizes the intruder scenarios for a potential on-site waste disposal facility. DOE will provide long-term care of the facility such that an inadvertent intruder is not a likely scenario; however, the inadvertent intruder scenarios are summarized and screened in this report based on the assumption that long-term care is lost in the future. The intruder scenarios are screened based on the conceptual design of a potential on-site disposal facility (i.e., depth to the waste, side slope, and biointrusion layers). A variety of intruder scenarios were considered and screened to determine if they would be applicable scenarios for the long-term presence of an on-site disposal facility. The scenarios included three acute (short duration) scenarios and five chronic (long duration) exposure scenarios. A summary is provided below, and the more detailed analysis is included in Appendix C, Attachment C7.

The acute scenarios included the following:

- Construction
- Discovery
- Drilling

Based on the conceptual design of a potential on-site waste disposal facility, primarily the cap thickness, none of these scenarios were considered plausible. See Appendix C, Attachment C6 for the evaluation to support this conclusion.

The chronic intruder scenarios included the following:

- Postconstruction
- Resident
- Radon
- Biointrusion
- Post-drilling

Based on conceptual design aspects of a potential on-site disposal facility, the biointrusion layer, thickness of the cap, and overall height, none of these scenarios were considered plausible.

5.4.6.8 Uncertainties in the PWAC development

Several uncertainties in the model inputs have the potential to affect the results of the fate and transport modeling and the resulting PWAC values. These uncertainties and their potential impact (i.e., a sensitivity analysis) on the PWAC are further discussed in Attachment C9 to Appendix C and are summarized here. The uncertainty modeling was performed using the gradual failure scenario as the baseline of comparison for the uncertainty modeling results. One of the purposes of the PWAC and the findings of the uncertainty/sensitivity analysis is to inform the design of an on-site WDF as it progresses from the conceptual level to final design. One example of where the understanding of the PWAC, as it relates to design elements could be implemented, if desired, would be the modification of the WDF subgrade to achieve a higher K_d value for this soil layer.

Both qualitative and quantitative assessments were performed as part of the uncertainty analysis. Qualitative assessments were performed for the following parameters and are documented in Attachment C9 to Appendix C.

- Chemical environment
- Waste characterization uncertainty

- Homogenized waste
- Receptor location
- Source depletion during operational/closure period
- Clay barrier environment
- Centerline groundwater concentration and well dilution
- Ingrowth of organics
- Ingrowth of radiological constituents
- 1,000-year rainfall storm event uncertainty
- FML Installation quality uncertainty

These parameters were evaluated quantitatively during the uncertainty analysis. Table C.9.1 in Attachment C9 to Appendix C provides more details including assignment of model values.

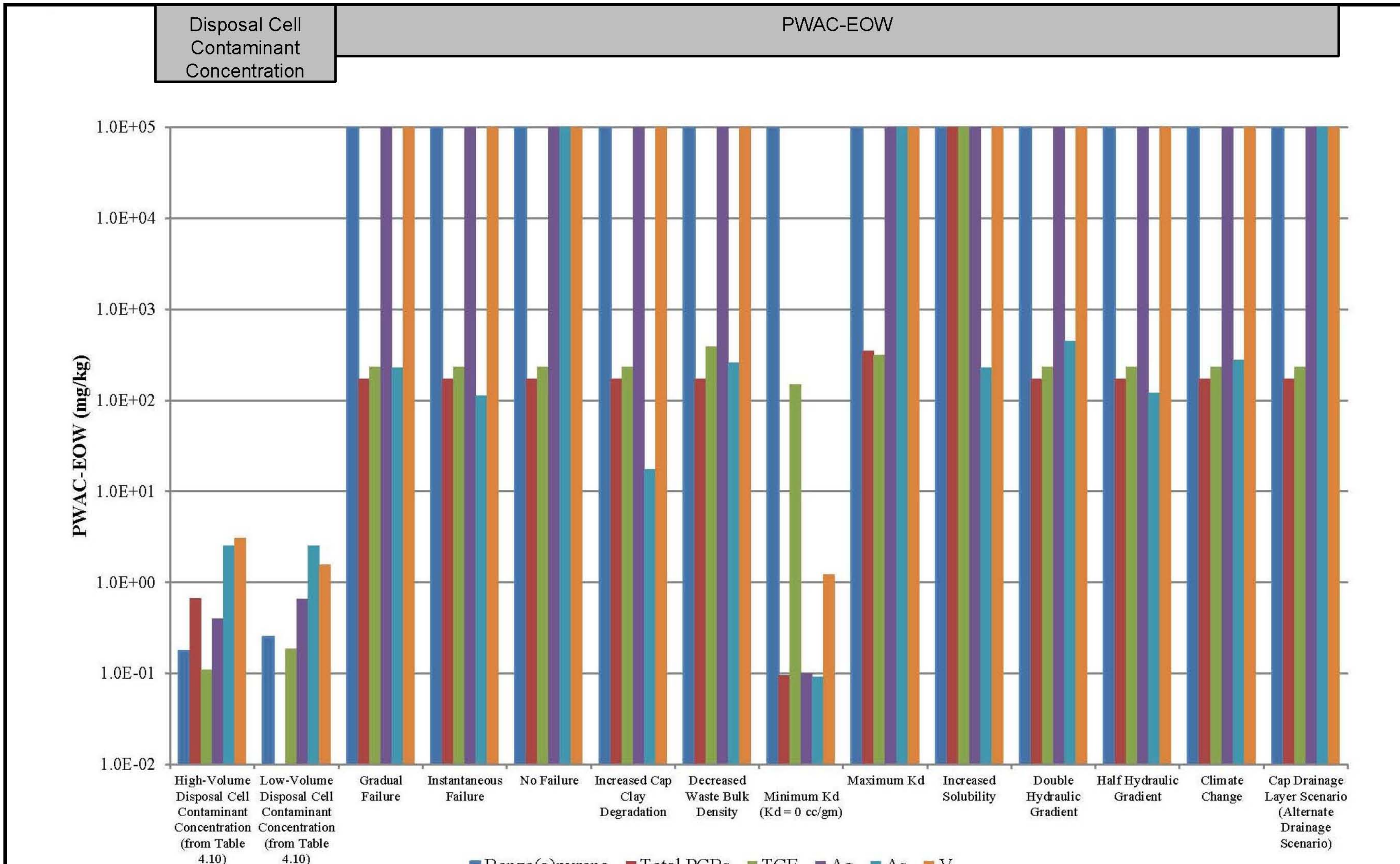
- FML instantaneous failure
- FML no failure
- Hydraulic conductivity of compacted clay liners
- Hydraulic conductivity of cap soil and clay
- Partitioning coefficient variation
- Solubility uncertainty
- Hydraulic gradient uncertainty
- Climate change (variation of precipitation and temperature)
- Waste Form bulk density

A select list of chemical constituents was selected for quantitative uncertainty analysis. These constituents represent each chemical group and are key compounds regarding evaluation of the on-site waste disposal option. The following are the evaluated chemical constituents:

- Silver (Ag)
- Arsenic (As)
- Vanadium (V)
- Technetium (Tc-99)
- Neptunium (Np-237)
- Uranium (U-238, U-235, and U-234)
- Americium (Am-241)
- Trichloroethene (TCE)
- Benzo(a)pyrene
- Polychlorinated biphenyls (PCBs)

Attachment C9 in Appendix C presents initial PWAC (PWAC-EOW) values for the gradual failure scenario compared to calculated PWAC-EOW values for the uncertainty scenarios (see Table C.9.2 to Table C.9.10). Figures 5.8 and 5.9 depict the PWAC-EOW for evaluated organic and inorganic compounds by uncertainty scenario compared to the gradual failure scenario and the anticipated disposal cell concentration for Site 11 and Site 3A, respectively. Similarly, the Site 11 and Site 3A PWAC-EOW comparisons for evaluated radionuclides are presented in Figures 5.10 and 5.11, respectively. Each PWAC-EOW presented in Attachment C9 to Appendix C has been corrected for saturation and total mass limits.

Overall, model results indicate that the PWAC-EOW is relatively sensitive to several parameters including K_d; chemical solubility (increased solubility generally increases the PWAC-EOW); and cap soil



Notes:
1.0E+05 mg/kg is maximum possible concentration
High and low volume disposal cell concentrations referenced from Table 4.10.
For low volume scenario PCBs are not placed in WDF (see Table 4.10).
PWAC-EOW corrected for solubility limits for organic compounds.

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Figure 5.8. Comparison of PWAC-EOW Uncertainty Analysis Results, Site 11 Organics and Inorganics Gradual Failure Scenario

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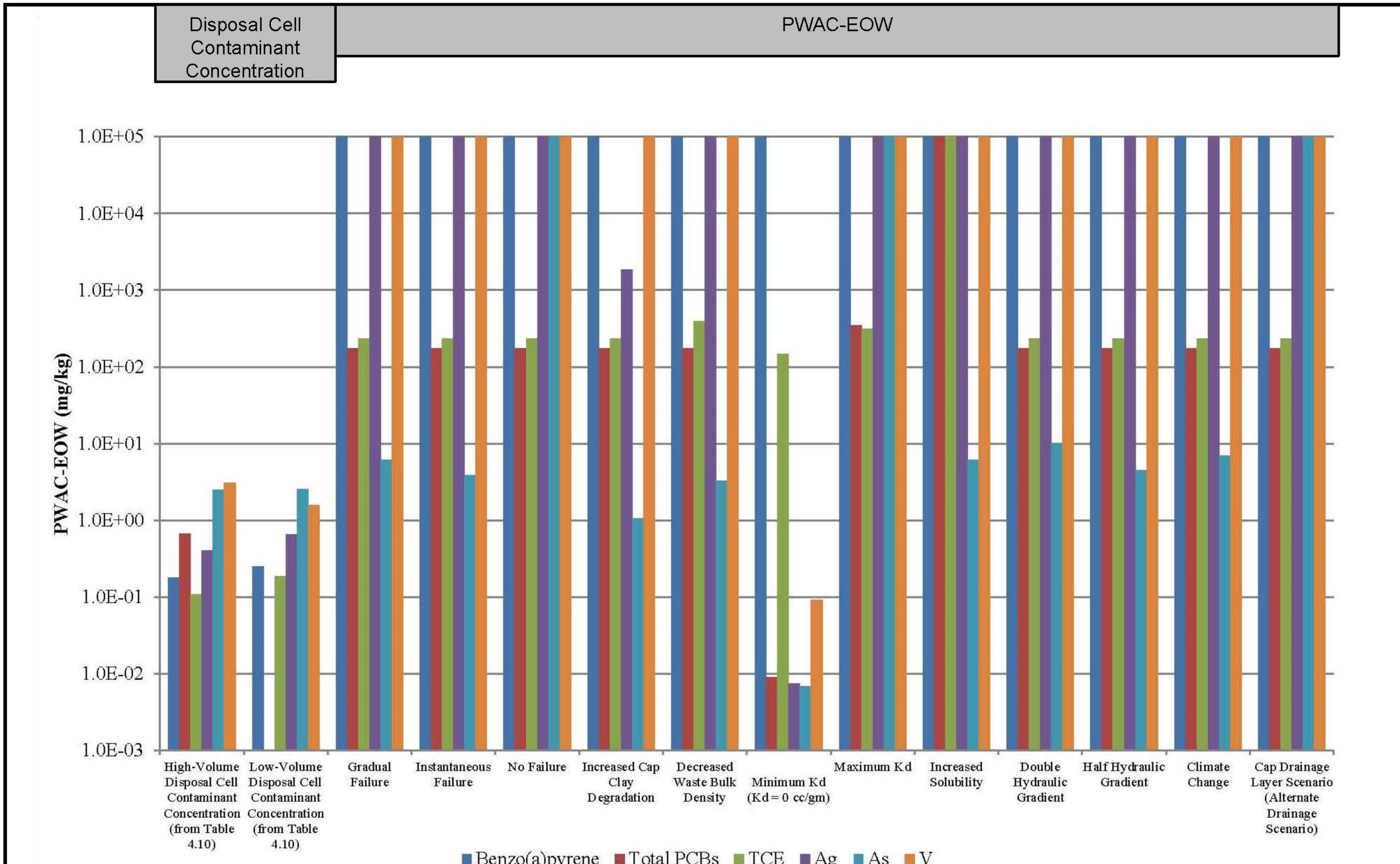

Notes:
1.0E+05 mg/kg is maximum possible concentration.
High and low volume disposal cell concentrations referenced from Table 4.10.
For low volume scenario PCBs are not placed in WDF (see Table 4.10).
PWAC-EOW corrected for solubility limits for organic compounds.

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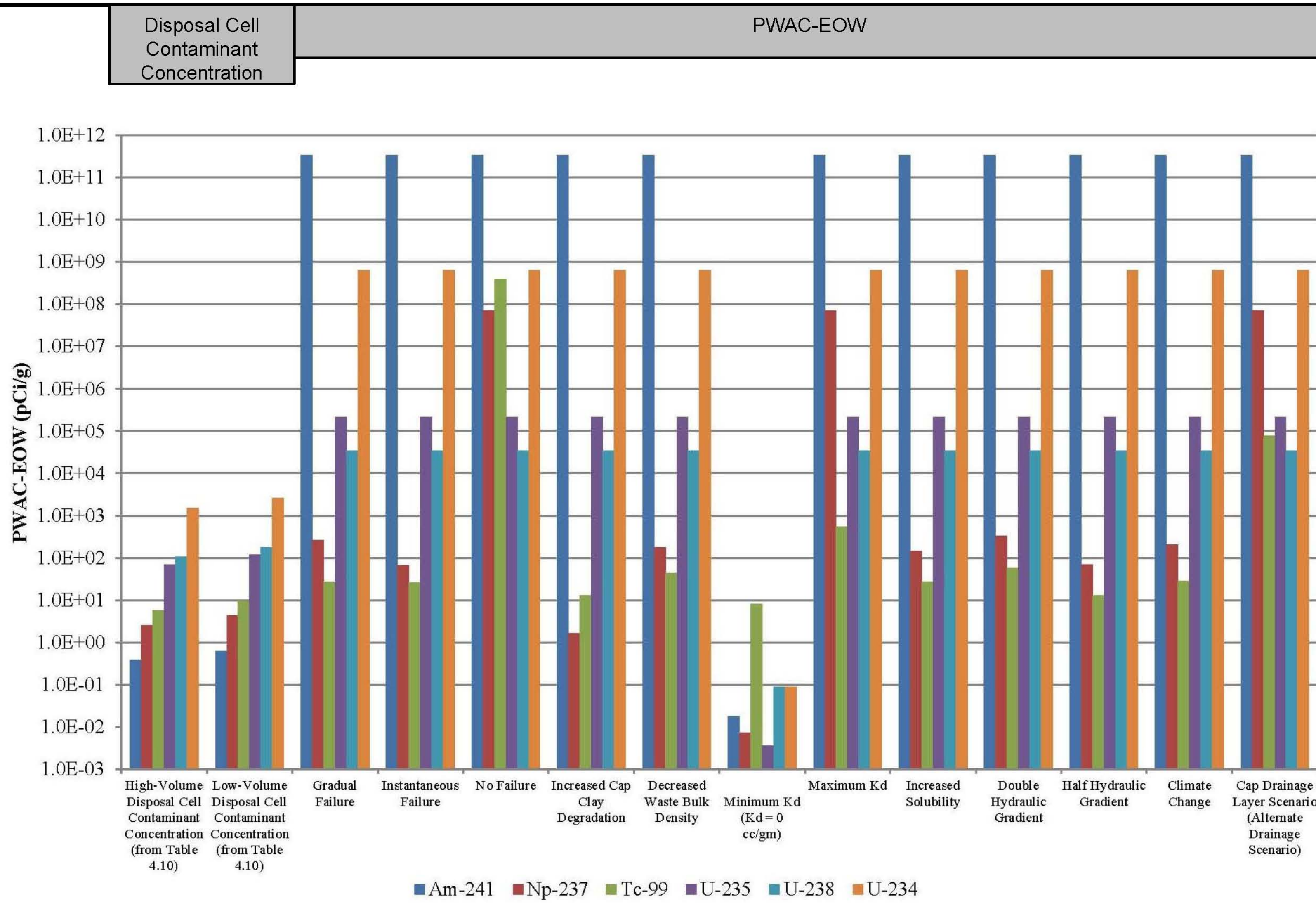
Figure 5.9. Comparison of PWAC-EOW Uncertainty Analysis Results, Site 3A Organics and Inorganics Gradual Failure Scenario



Notes:
High and low volume disposal cell concentrations referenced from Table 4.10.
For low volume scenario PCBs are not placed in WDF (see Table 4.10).

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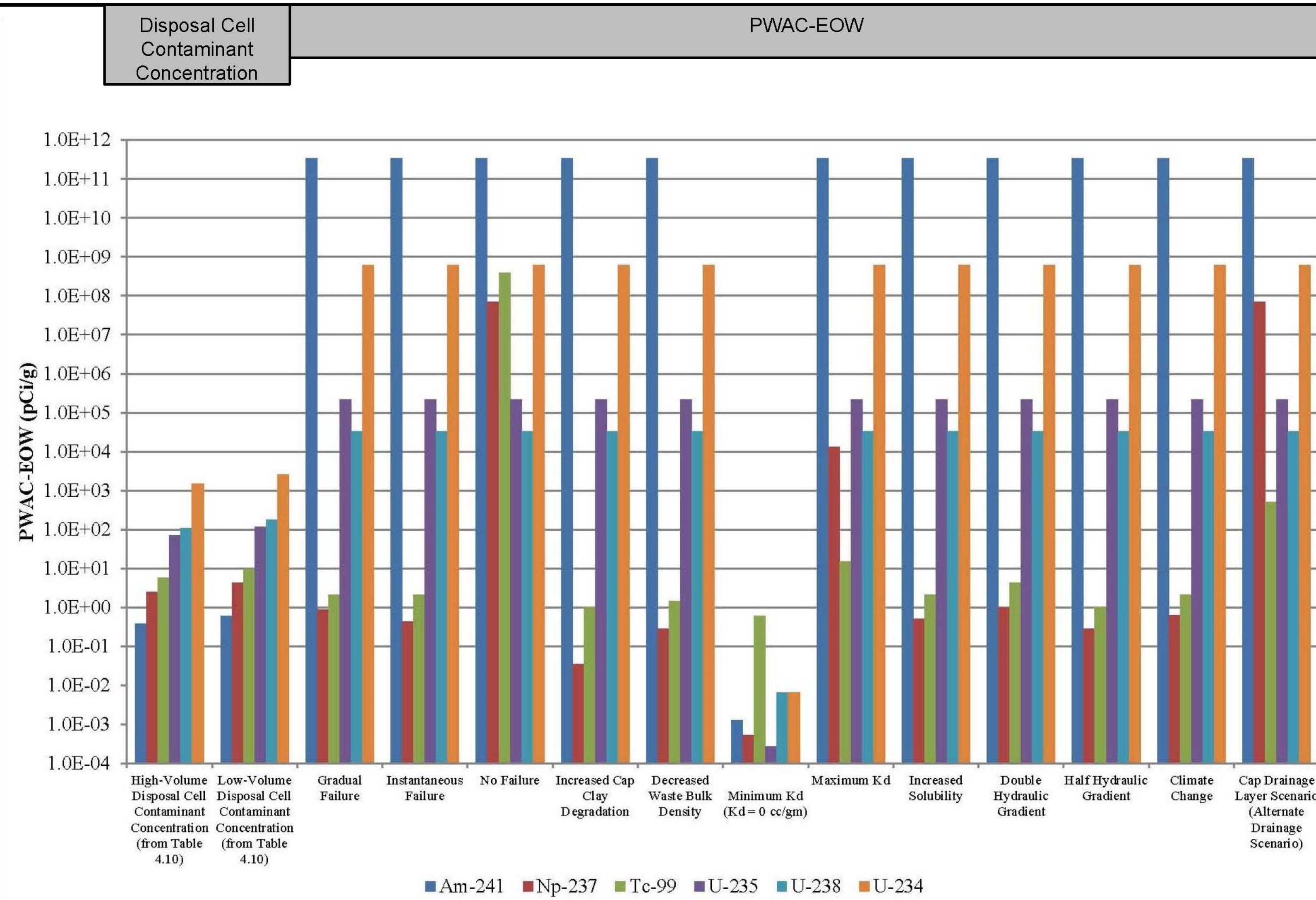
Figure 5.10. Comparison of PWAC-EOW Uncertainty Analysis Results, Site 11 Radionuclides Gradual Failure Scenario



Notes:
High and low volume disposal cell concentrations referenced from Table 4.10.
For low volume scenario PCBs are not placed in WDF (see Table 4.10).

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Figure 5.11. Comparison of PWAC-EOW Uncertainty Analysis Results, Site 3A Radionuclides Gradual Failure Scenario

and clay hydraulic conductivity (K) (increased K generally decreases PWAC-EOW). Results also indicate that the model is relatively insensitive to the specification of values for the other evaluated parameters.

Results show that the value of the PWAC-EOW is sensitive to assignment of the chemical-specific K_d. With increasing K_d, indicating more chemical affinity for the solid phase compared to the aqueous phase, the PWAC-EOW for the simulated chemical constituents increases or stays the same compared to the PWAC-EOW calculated for the gradual failure scenario. Conversely, with the K_d set to the extreme and unlikely minimal level of 0 L/kg, indicative of no contaminant adsorption to the solid phase, the PWAC-EOW for the simulated chemical constituents decreases compared to the PWAC-EOW calculated for the gradual failure scenario. Also, inspection of Figures 5.8 through 5.11 reveals that PWAC-EOW values calculated using K_d equal to zero (K_d = 0 L/kg) are near or less than the high-volume and low-volume anticipated disposal cell concentrations. It is highly unlikely that any physically possible geochemical environment exists such that a K_d for all contaminants equal to 0 L/kg over the entire simulated volume is appropriate for either short periods or, as in the case of this analysis, time periods on the order of hundreds of years. Specifying a K_d equal to 0 L/kg was done to bound the entire range of theoretical K_d values at the low end as a worst case scenario (i.e., no sorption).

The PWAC modeling results indicated that some of the radionuclide contaminants (and decay products from ingrowth) would not reach their peak concentration prior to the 10,000-year evaluation period. As a result, an uncertainty analysis to examine growth and risk beyond 10,000 years was completed per the requirements of the Work Plan for uranium-238 as a parent compound and thorium-230 as its progeny (DOE 2011a). This analysis is presented in Attachment C10.

As discussed in Section 5.4.6.6, the PWAC values for certain contaminants are lower for Site 3A than for Site 11. This is a result of the Porters Creek clay underlying the upper Terrace Gravel at Site 3A, which prevents further downward movement of contaminants and results in groundwater flowing over the Porters Creek clay to the POAs. Because of the relatively shallow depth of the Porters Creek clay, control of groundwater flow through the use of a barrier system could be integrated into the design at Site 3A. Conceptually, such a barrier system could be installed around the perimeter of the WDF and be keyed into the Porters Creek clay. This would control migration of groundwater beneath the WDF and increase the travel time of contaminants from the WDF to the POAs, which is expected to increase the WAC compared to the PWAC.

The PWAC values for Tc-99 are sensitive to the concentration in water used as the MCL equivalent. The MCL for Tc-99 is 4 mrem/yr. The PWAC values for Tc-99 were derived using the EPA published value of 900 pCi/L; however, this result differs with the derivation of a 4 mrem/yr dose-based value of 3,910 pCi/L included in Risk Methods Document (DOE 2011b). As can be shown using the dose conversion factors included in the Risk Methods Document, the dose to an adult from ingesting water containing Tc-99 at a concentration of 900 pCi/L at the rate of 2 L/day at the frequency of 350 days/yr would be approximately 0.9 mrem/yr. Use of the dose-based value of 3,910 pCi/L would result in roughly a factor of 4 increase for all Tc-99 PWAC values.

The value of the PWAC-EOW also is sensitive to the handling of the cover system drainage layer in HELP. This is discussed in the following section.

5.4.6.9 Alternate drainage scenario modeling

As discussed previously, the PWAC and associated uncertainty assessments, in addition to assessing the viability of an on-site waste disposal facility, are intended to inform the design of an on-site WDF as it progresses from the conceptual level to final design such that increased waste concentrations or contaminant masses may be achieved while still meeting the RAOs. As such, some of the final WAC concentrations for an on-site facility could increase compared to the PWAC.

As discussed in Section 5.4.6, the sand drainage layer was modeled as a vertical flow layer to derive the PWAC. The uncertainty modeling associated with treating the sand drainage layer in the cover system as a vertical flow layer versus a drainage layer for the long-term modeling period had the largest overall effect on the PWAC values of any of the other parameters examined as part of the uncertainty analysis. A review of literature and industry standard approaches was performed to better understand the appropriate method for modeling drainage.

The majority of cover systems studied in Dwyer (2003) are both thinner in overall cross-section than the conceptual cover system for the On-Site WDF presented in this RI/FS report, and many do not include a biointrusion layer. The findings included in Dwyer (2003) indicate that while HELP reasonably predicts infiltration for Subtitle C cover systems that incorporate drainage layers, similar to the conceptual design for the On-Site Alternative included in this RI/FS report, HELP consistently overpredicts infiltration (i.e., would result in an overestimation of leaching from the landfill) for cover systems without geomembranes. This would be the situation once the geomembranes begin to fail during the postclosure period and once they have completely failed during the long-term modeling period. The incorporation of a biointrusion layer comprised of rocks and boulders, overlaid by a filter sand and underlain by a drainage sand in the conceptual cover system design has the added advantage of providing a secondary layer within the cover system to facilitate drainage from the system and thereby reduce infiltration beyond the postclosure period. Based on this information, a sensitivity analysis was performed by modeling the cover system with the inclusion of a drainage layer for the entire modeling period. This approach is consistent with the modeling approach for the cover system drainage layer used for the EMWMF project at Oak Ridge (Table E.4 from DOE 1998).

Table 5.21 includes a summary of the HELP-predicted percolation rates for the gradual failure and alternate drainage scenarios. The gradual failure scenario was reassessed with the cover system drainage sand modeled as a drainage layer in HELP through the long-term modeling period. All other parameters and assumptions of the gradual failure scenario were retained. The infiltration for the long-term modeling period using this configuration is 0.321 cm/yr (3.21 mm/yr). This value is consistent with published infiltration rates for evapotransport (ET)[25] cover systems (EPA 2003; Dwyer 2003). Additionally, Table 5.22 includes a comparison of the PWAC-EOW values obtained using the gradual failure and alternate drainage scenarios for selected chemical constituents. The PWAC-EOW values are equal to or greater in magnitude than the simulated chemical constituents when the drainage layer is operational for the entire simulation duration (including the long-term modeling period).

Daniel and Gross (1996) summarized the factors that are most likely to affect the drainage layer in a cover system adversely: excessive clogging, insufficient flow rate capacity, insufficient number or flow rate capacity of outlets, freeze effects, and slope instability. Of these factors, flow rate capacities, freeze effects, and slope instability would be assessed as part of the design process. To better understand the effects of clogging on the sand drainage layer within the cover system, a sensitivity assessment was performed. The hydraulic conductivities of the drainage sand and biointrusion layers were decreased by one order of magnitude to understand the effect of deposition or precipitation of fines into these layers[26]

[25] The conceptual design for the cover system includes geosynthetics; however, these are assumed to fail gradually during the postclosure period and not to be present during the long-term modeling period; therefore, the cover system during the long-term modeling period is anticipated to behave similarly to an ET cover system.
[26] Note that as part of the long-term modeling period, the hydraulic conductivities of the clay portion of the cover system have been increased one order of magnitude from 10^{-7} cm/sec (Year 30-200) to 10^{-6} cm/sec (starting at Year 600) (DOE 2011a).

(clogging scenario). For the case where the drainage sand layer was assumed to become completely clogged and no longer function as a drainage layer (this layer was incorporated into the underlying soil layer and modeled as a barrier layer), the biointrusion layer was modeled as a drainage layer (biointrusion layer drainage). This sensitivity assessment revealed little change in infiltration for either case. Specifically, for the aforementioned clogging and biointrusion drainage scenarios, the HELP-predicted infiltration rates were 0.31 cm/yr.

One difference between modeling the long-term performance of the sand drainage layer as a vertical flow layer versus a drainage layer in HELP is that vertical flow layers in HELP do not allow for evapotranspiration, thereby increasing the infiltration rate. In other words, once water enters a vertical flow layer, it can move downward only and cannot move upward due to evapotranspiration. Ignoring evapotranspiration from the sand drainage layer maximizes the amount of water available for infiltration in the model, but is not necessarily physically realistic. Based on this limitation within the HELP model, it may be more appropriate to model the sand drainage layer as a drainage layer or use other models that account for evapotranspiration. In either case, to account for long-term performance, a sensitivity of the infiltration rate to the hydraulic conductivity of the sand drainage layer should be performed.

Uncertainty modeling performed to assess the impacts of warmer weather patterns with higher annual precipitation is discussed in Section 5.4.6.8 and Attachment C9 in Appendix C. The findings of this uncertainty analysis indicate that, although precipitation is increased, the infiltration decreases as a result of an increase in the predicted evapotranspiration, likely due to a longer growing season and enhanced evaporation due to increased soil temperature.

Based on these findings, it may be appropriate to assess the PWAC for an On-Site WDF with the sand drainage layer modeled as a drainage layer in HELP. For this sensitivity analysis, the value of the decay constant, α, was assumed to be 0.051 per year, which results in the water flux reaching the fully degraded recharge rate of 0.321 cm/yr approximately 400 years after initiation of gradual failure (i.e., Year 600). The value of the decay constant determined the time at which the peak water flux was attained (i.e., failure of the liner components was complete). Other aspects of the gradual failure scenario were maintained as modeled previously.

Table 5.21. Predicted Landfill Percolation and PWAC-EOW Variation Due to Cap Drainage Layer Uncertainty

HELP Predicted Percolation Rate			
DUSTMS Gradual Failure Scenario (T+400 years) Year	DUSTMS Gradual Failure Scenario (T+400 years) Percolation Rate (cm/s)	DUSTMS Alternate Drainage Scenario Year	DUSTMS Alternate Drainage Scenario Percolation Rate (cm/s)
30	2.46E-14	30	2.46E-14
200	2.46E-14	200	2.46E-14
225	1.22E-13	225	8.88E-14
250	6.03E-13	250	3.21E-13
350	3.63E-10	350	5.45E-11
425	3.96E-08	425	2.06E-09
500	3.64E-07	500	9.40E-09
550	3.89E-07	550	1.01E-08
600	3.90E-07	600	1.02E-08
10000	3.90E-07	10000	1.02E-08

Contaminant	PWAC-EOW Average Concentrations (mg/kg or pCi/g)			
	Site 11 Gradual Failure Scenario	Site 11 Cap Drainage Layer Scenario (Alternate Drainage Scenario)	Site 3A Gradual Failure Scenario	Site 3A Cap Drainage Layer Scenario (Alternate Drainage Scenario)
Benzo(a)pyrene	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Total PCBs	1.73E+02	1.73E+02	1.73E+02	1.73E+02
TCE	2.32E+02	2.32E+02	2.32E+02	2.32E+02
Ag	1.00E+05	1.00E+05	1.00E+05	1.00E+05
As	2.27E+02	1.00E+05	6.09E+00	1.00E+05
V	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Am-241	3.43E+11	3.43E+11	3.43E+11	3.43E+11
Np-237	2.58E+02	7.05E+07	8.91E-01	7.05E+07
Tc-99	2.67E+01	7.85E+04	2.08E+00	5.16E+02
U-235	2.16E+05	2.16E+05	2.16E+05	2.16E+05
U-238	3.36E+04	3.36E+04	3.36E+04	3.36E+04
U-234	6.25E+08	6.25E+08	6.25E+08	6.25E+08

Note: PWAC-EOW values shown are corrected for soil saturation and total mass limits.

Table 5.22 provides a comparison of the limiting PWAC values for Site 11 and Site 3A using the alternate drainage scenario to the projected waste analyte masses.

5.4.6.10 Management of other waste

It is assumed that some of the CERCLA wastes will exceed the WAC for an on-site waste disposal facility and will be shipped off-site for disposal. For this RI/FS, it was assumed that 5% of contaminated waste would exceed an on-site disposal facility WAC because of excessive specific radioactivity or concentrations that exceed the WAC. It was assumed that this waste would meet the Energy*Solutions* WAC; therefore, cost estimates assume shipment of these wastes to Energy*Solutions*. The details for shipping and disposal are as described for the Off-Site Alternative in Section 5.3.

The assumption that 5% of the total waste volume would not meet the WAC for an on-site waste disposal facility is reasonable based on the PWAC values (Section 5.4.6.9) developed for both prototype sites (Site 3A and Site 11) and the waste profile characterization (see Section 4.2). Table 5.20 presents the PWAC for Site 3A and Site 11 compared to the waste profile concentration or activity for each COC under the high-end and low-end volume scenarios.

For Site 11, based on the final calculated PWAC and waste profile developed in this RI/FS, a negligible amount (approximately 1%) of the total waste volume would require off-site disposal under either the low-end or high-end volume scenario; therefore, the assumption that 5% of the waste volume under the On-Site Alternative would require off-site disposal appears reasonable for Site 11. Arsenic is the analyte driving the waste volume requiring off-site disposal under either the low-end or high-end volume scenario.

For Site 3A, based on the PWAC and waste profile developed in this RI/FS, approximately 24% of the total waste volume would require off-site disposal under the low-end volume scenario, and approximately 30% of the total volume would require off-site disposal under the high-end volume scenario. Np-237, Tc-99, arsenic, and copper are the analytes driving the waste volume requiring off-site disposal under either the low-end or high-end volume scenario.

Some of the WAC concentrations for the facility may increase compared to the PWAC concentrations based on differences between the conceptual design and the final design for the landfill. Although the volume of waste projected to require off-site disposal (approximately 28% for high-volume scenario and approximately 17% for low-volume scenario) under the Site 3A PWAC is greater than the assumed 5%, the difference is subject to change with finalization of the WAC (DOE 2011a). Cost differences with a change of this magnitude are within the typical costing accuracy of an RI/FS (+50% to -30%).

Table 5.22. PWAC Comparison for the Gradual Failure and Alternate Drainage Scenario

	Gradual Failure Scenario (Table 5.20)				Alternate Drainage Scenario					
	Site 11		Site 3A		Site 11		Site 3A			
Chemical Groups[a]	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**High-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)**	**Low-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)**
Nonaromatic, Straight-Chain Halogenated Hydrocarbons										
Chloroform	1.40E+03	8.65E+06	1.40E+03	8.64E+06	1.40E+03	8.65E+06	1.40E+03	8.64E+06	2.94E-04	2.46E-04
cis-1,2-DCE	5.73E+02	3.53E+06	5.73E+02	3.53E+06	5.73E+02	3.53E+06	5.73E+02	3.53E+06	6.72E-01	1.15E+00
Methylene chloride	1.86E+03	1.15E+07	1.86E+03	1.15E+07	1.86E+03	1.15E+07	1.86E+03	1.15E+07	2.76E-07	4.71E-07
Vinyl Chloride	4.14E+02	2.55E+06	4.14E+02	2.55E+06	4.14E+02	2.55E+06	4.14E+02	2.55E+06	6.88E-03	1.14E-02
TCE	2.32E+02	1.43E+06	2.32E+02	1.43E+06	2.32E+02	1.43E+06	2.32E+02	1.43E+06	1.09E-01	1.85E-01
PCE	6.95E+01	4.28E+05	6.95E+01	4.28E+05	6.95E+01	4.28E+05	6.95E+01	4.28E+05	3.33E-04	2.49E-04
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons										
Acetone	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	2.40E-03	4.11E-03
2-Butanone	1.04E+04	6.42E+07	1.04E+04	6.41E+07	1.04E+04	6.42E+07	1.04E+04	6.41E+07	NV	NV
Butanal	4.82E+03	2.97E+07	4.82E+03	2.97E+07	4.82E+03	2.97E+07	4.82E+03	2.97E+07	1.01E-06	1.72E-06
Hexanone (2-)	2.53E+03	1.56E+07	2.53E+03	1.56E+07	2.53E+03	1.56E+07	2.53E+03	1.56E+07	6.80E-07	1.16E-06
Methyl-2-pentanone (4-)	2.76E+03	1.70E+07	2.76E+03	1.70E+07	2.76E+03	1.70E+07	2.76E+03	1.70E+07	1.15E-07	1.96E-07
Aromatic, Ring-Structured Halogenated Hydrocarbons										
Chlorobenzene	1.48E+02	9.15E+05	1.48E+02	9.14E+05	1.48E+02	9.15E+05	1.48E+02	9.14E+05	NV	NV
Dimethylbenzene (1,2-)	7.87E+01	4.85E+05	7.87E+01	4.84E+05	7.87E+01	4.85E+05	7.87E+01	4.84E+05	6.61E-07	1.13E-06
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons										
Benzene	3.23E+02	1.99E+06	3.23E+02	1.99E+06	3.23E+02	1.99E+06	3.23E+02	1.99E+06	NV	NV
Cumene	4.25E+01	2.62E+05	4.25E+01	2.62E+05	4.25E+01	2.62E+05	4.25E+01	2.62E+05	1.19E-06	2.03E-06
Ethylbenzene	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.56E-04	1.49E-04
Toluene	1.30E+02	8.02E+05	1.30E+02	8.01E+05	1.30E+02	8.02E+05	1.30E+02	8.01E+05	1.56E-07	2.67E-07
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)										
Acenaphthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.19E-01	4.10E-01
Acetophenone	1.08E+03	6.68E+06	1.08E+03	6.67E+06	1.08E+03	6.68E+06	1.08E+03	6.67E+06	2.51E-03	4.29E-03
Benzoic Acid	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	7.26E-03	1.24E-02

Table 5.22. PWAC Comparison for the Gradual Failure and Alternate Drainage Scenario (Continued)

	Gradual Failure Scenario (Table 5.20)				Alternate Drainage Scenario					
	Site 11		Site 3A		Site 11		Site 3A			
Chemical Groups[a]	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**PWAC Average Concentration (mg/kg or pCi/g)**	**PWAC Inventory Limit (kg or Ci)**	**High-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)**	**Low-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)**
Carbazole	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	5.19E-01	7.39E-01
Chloro-3-methylphenol (4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	6.89E-05	1.18E-04
o-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	0.00E+00	0.00E+00
p-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	0.00E+00	0.00E+00
Dibenzofuran(s)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	0.00E+00	0.00E+00
Methyl Naphthalene (2-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.28E-01	2.19E-01
Methylphenol (3&4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	0.00E+00	0.00E+00
Phenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.61E-04	2.75E-04
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group										
Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.61E-01	2.34E-01
Butyl benzyl phthalate	2.99E+01	1.84E+05	2.99E+01	1.84E+05	2.99E+01	1.84E+05	2.99E+01	1.84E+05	7.81E-05	1.34E-04
Diethyl phthalate	2.17E+02	1.34E+06	2.17E+02	1.34E+06	2.17E+02	1.34E+06	2.17E+02	1.34E+06	3.31E-03	5.66E-03
Di-n-butyl phthalate	1.56E+01	9.61E+04	1.56E+01	9.61E+04	1.56E+01	9.61E+04	1.56E+01	9.61E+04	5.25E-03	8.98E-03
Di-n-octyl phthalate	1.33E+03	8.21E+06	1.33E+03	8.21E+06	1.33E+03	8.21E+06	1.33E+03	8.21E+06	7.76E-05	1.33E-04
Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.74E-01	6.92E-01
Fluorene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.26E-01	9.06E-02
Naphthalene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	5.15E-01	8.26E-01
Pentachlorophenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.44E-03	5.88E-03
Phenanthrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.93E-01	6.17E-01
Pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.55E-01	5.15E-01
Tetrachlorophenol (2,3,4,6-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	2.31E-03	3.96E-03
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group										
BEHP	3.03E+01	1.87E+05	3.03E+01	1.86E+05	3.03E+01	1.87E+05	3.03E+01	1.86E+05	8.69E-02	1.49E-01
Total PAHs[b]	7.00E+05	4.31E+09	7.00E+05	4.31E+09	7.00E+05	4.31E+09	7.00E+05	4.31E+09	1.27E+00	1.46E+00
Benzo(g,h,i)perylene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	0.00E+00	0.00E+00
PCBs										
Total PCBs[c]	1.73E+02	1.07E+06	1.73E+02	1.07E+06	1.73E+02	1.07E+06	1.73E+02	1.07E+06	6.71E-01	0.00E+00

Table 5.22. PWAC Comparison for the Gradual Failure and Alternate Drainage Scenario (Continued)

	Gradual Failure Scenario (Table 5.20)				Alternate Drainage Scenario					
	Site 11		Site 3A		Site 11		Site 3A			
Chemical Groups[a]	PWAC Average Concentration (mg/kg or pCi/g)	PWAC Inventory Limit (kg or Ci)	PWAC Average Concentration (mg/kg or pCi/g)	PWAC Inventory Limit (kg or Ci)	PWAC Average Concentration (mg/kg or pCi/g)	PWAC Inventory Limit (kg or Ci)	PWAC Average Concentration (mg/kg or pCi/g)	PWAC Inventory Limit (kg or Ci)	High-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)	Low-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)
Pesticides										
beta-BHC	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.67E-06	6.28E-06
DDD (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	5.41E-04	9.25E-04
DDE (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.39E-02	2.38E-02
DDT (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.47E-03	7.64E-03
Dieldrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.23E-02	1.82E-03
Endosulfan II	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.59E-06	7.86E-06
Endosulfan sulfate	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.22E-06	5.50E-06
Endrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.22E-06	5.50E-06
Endrin Aldehyde	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.04E-04	1.78E-04
gamma-Chlordane	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.69E-04	8.02E-04
Heptachlor epoxide	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	9.19E-07	1.57E-06
Metals										
Sb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	6.62E-01	1.08E+00
As	1.13E+00	6.97E+03	5.09E-01	3.13E+03	1.00E+05	6.16E+08	1.00E+05	6.16E+08	2.51E+00	2.53E+00
Ba	3.07E+04	1.89E+08	7.92E+02	4.88E+06	1.00E+05	6.16E+08	1.00E+05	6.16E+08	2.36E+01	1.39E+01
Be	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	9.30E-02	7.56E-02
Cd	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.63E-01	5.70E-01
Cr	5.44E+03	3.36E+07	1.27E+02	7.85E+05	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.02E+01	6.09E+00
Cu	2.68E+02	1.65E+06	2.10E+01	1.29E+05	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.55E+01	4.81E+01
Pb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.09E+01	4.67E+01
Mn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	8.38E+01	1.09E+02
Hg	3.16E+02	1.95E+06	7.46E+00	4.59E+04	2.35E+04	1.45E+08	2.35E+04	1.44E+08	1.30E-01	2.21E-01
Ni	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	5.78E+01	8.70E+01
Se	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.08E+00	5.01E+00
Ag	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	4.02E-01	6.61E-01
Tl	2.45E+03	1.51E+07	4.45E+01	2.74E+05	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.82E-01	7.45E-02

Table 5.22. PWAC Comparison for the Gradual Failure and Alternate Drainage Scenario (Continued)

	Gradual Failure Scenario (Table 5.20)				Alternate Drainage Scenario					
	Site 11		Site 3A		Site 11		Site 3A			
Chemical Groups[a]	PWAC Average Concentration (mg/kg or pCi/g)	PWAC Inventory Limit (kg or Ci)	PWAC Average Concentration (mg/kg or pCi/g)	PWAC Inventory Limit (kg or Ci)	PWAC Average Concentration (mg/kg or pCi/g)	PWAC Inventory Limit (kg or Ci)	PWAC Average Concentration (mg/kg or pCi/g)	PWAC Inventory Limit (kg or Ci)	High-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)	Low-Volume Disposal Cell Contaminant Concentration (mg/kg or pCi/g)
V	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	3.07E+00	1.57E+00
Zn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	6.67E+02	1.14E+03
U[b]	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08	NV	NV
Radionuclides										
Pu-238	1.71E+12	1.05E+13	1.71E+12	1.05E+13	1.71E+12	1.05E+13	1.71E+12	1.05E+13	8.02E-02	1.24E-01
U-238	3.36E+04	2.07E+05	3.36E+04	2.07E+05	3.36E+04	2.07E+05	3.36E+04	2.07E+05	1.06E+02	1.80E+02
U-234	6.25E+08	3.85E+09	6.25E+08	3.85E+09	6.25E+08	3.85E+09	6.25E+08	3.85E+09	1.50E+03	2.56E+03
Pu-239	6.20E+09	3.82E+10	6.20E+09	3.82E+10	6.20E+09	3.82E+10	6.20E+09	3.82E+10	9.98E-02	1.58E-01
U-235	2.16E+05	1.33E+06	2.16E+05	1.33E+06	2.16E+05	1.33E+06	2.16E+05	1.33E+06	6.96E+01	1.19E+02
Pu-240	2.27E+10	1.40E+11	2.27E+10	1.40E+11	2.27E+10	1.40E+11	2.27E+10	1.40E+11	9.98E-02	1.58E-01
Np-237	3.41E+01	2.10E+02	1.54E-01	9.49E-01	7.05E+07	4.34E+08	7.05E+07	4.34E+08	2.55E+00	4.33E+00
Cs-137	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.02E-01	1.32E+00
Tc-99	2.67E+01	1.65E+02	2.08E+00	1.28E+01	7.85E+04	4.84E+05	5.16E+02	3.18E+03	5.72E+00	9.61E+00
Am-241	2.92E+05	1.80E+06	1.27E+03	7.82E+03	3.43E+11	2.12E+12	3.43E+11	2.11E+12	3.84E-01	6.15E-01
Th-230	2.02E+09	1.24E+10	2.02E+09	1.24E+10	2.02E+09	1.24E+10	2.02E+09	1.24E+10	9.54E+00	1.61E+01

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.

[b] Consistent with the Risk Methods Document (DOE 2011b), Total PAHs includes benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

[c] Consistent with the Risk Methods Document (DOE 2011b), Total PCBs includes Aroclors-106, 1221, 1232, 1242, 1248, 1254, and 1260.

[d] For Site 3A and Site 11, the final PWAC for elemental uranium is 1.00E+05 mg/kg. Applying natural abundance mass ratios to elemental uranium PWAC would result in the following uranium isotope PWAC: 3.34E+04 pCi/g of uranium-238, 1.56E+03 pCi/g of uranium-235, and 3.44E+04 pCi/g of uranium-234.

NV - no value given in Table 4.10 for this constituent.

The PWAC were developed using the methodology presented in the Work Plan (DOE 2011a). Because this methodology considers only groundwater transport and exposure, it is recognized that some of the final calculated PWAC values may have other criteria that will be applied to the WAC, such as worker safety or restrictions on waste types (e.g., TRU waste would not eligible to be placed in an on-site WDF), etc. Additionally, the PWAC also should be used to inform the design of an on-site WDF. As a result of any design changes, if the On-Site Alternative is chosen, some WAC concentrations may increase compared to the final PWAC concentrations (Table 5.20). See Appendix C, Attachment 11 for further discussion.

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6. DETAILED EVALUATION OF ALTERNATIVES

Under CERCLA, preferred remedial alternatives are selected by evaluating the feasibility of a range of alternatives. The process for conducting a CERCLA FS is described in 40 *CFR* § 300.430(e). This FS was conducted to evaluate a preferred disposal alternative for CERCLA waste generated at PGDP. The three disposal alternatives evaluated in this RI/FS are No Action, Off-Site Disposal, and On-Site Disposal.

The base case volume of waste predicted to be generated is the most likely scenario based on currently available information. The base case waste volume is 3.6 mcy, composed of 2.5 mcy of LLW/RCRA/TSCA/MLLW and 1.1 mcy of nonhazardous solid waste. This waste volume was used to compare the alternatives on an equal volume basis. The actual volume associated with an alternative may differ for a variety of reasons such as updated waste forecasts or the need for additional fill to facilitate disposal of non-soil wastes.

No Action Alternative. The NCP requires that the No Action Alternative be carried through the FS analysis to provide a baseline for comparison with other alternatives. The No Action Alternative meets this condition. For the No Action Alternative, the CERCLA-generated waste volume to be disposed of is approximately 3.6 mcy (i.e., the base case). Of that volume, forecasted waste that meets the WAC of the C-746-U Landfill (~1.1 mcy) would be disposed of in the existing C-746-U Landfill. The remaining waste volume (~2.5 mcy) would be shipped off-site for disposal. There would be no change to current waste disposal practices nor any new actions to reduce exposure, as described in the approved RI/FS WP (DOE 2011a). The No Action Alternative is described in detail in Section 5.2.

Off-Site Disposal Alternative. The Off-Site Alternative high-end waste volume scenario assumes that CERCLA-generated waste would be shipped to off-site disposal facilities and that there would be no utilization of the C-746-U Landfill. The Off-Site Alternative low-end waste volume scenario assumes various waste volume reduction actions, continued use of the C-746-U Landfill for disposal of waste meeting the WAC of the C-746-U Landfill, and off-site disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill. The base case waste volume scenario for the Off-Site Alternative is the No Action Alternative. A detailed description of the Off-Site Alternative is provided in Section 5.3.

On-Site Disposal Alternative. The On-Site Alternative high-end waste volume scenario assumes that all CERCLA-generated waste would be disposed of in a newly-constructed on-site waste disposal facility. The On-Site Alternative low-end waste volume scenario assumes various waste reduction actions, continued use of the C-746-U Landfill for disposal of waste meeting the WAC of the C-746-U Landfill, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in the new on-site disposal facility. A detailed description of the On-Site Alternative is provided in Section 5.4.

The three alternatives were evaluated using information assembled for the RI and individually assessed with respect to the CERCLA threshold and balancing criteria described in Section 6.1. A comparative evaluation then is conducted, as described in Chapter 7, to determine the relative merits and weaknesses of the alternatives. Evaluation of CERCLA-prescribed modifying criteria occurs after the RI/FS, during Proposed Plan and ROD development.

6.1 OVERVIEW OF EVALUATION CRITERIA

Statutory requirements that guide the FS evaluation under CERCLA 40 *CFR* § 300.430(e)(9)(iii) state that a remedial action must achieve the following:

- Be protective of human health and the environment,
- Attain ARARs or define criteria for invoking a waiver,
- Be cost-effective, and
- Use permanent solutions to the maximum extent practicable.

CERCLA requires that nine criteria, as defined in the NCP, be used to evaluate the expected performance of remedial actions. The criteria are categorized as threshold (2 criteria), balancing (5 criteria), and modifying criteria (2 criteria). The criteria are described in the following subsections.

6.1.1 Threshold Criteria

According to 40 *CFR* § 300.430(f)(1)(i)(A), two threshold criteria must be met. An alternative must satisfy each of the following to be considered.

(1) **Overall Protection of Human Health and the Environment.** This criterion requires that the alternative adequately protect human health and the environment [40 *CFR* § 300.430(e)(9)(iii)(A)].

Each alternative was evaluated against this criterion to assess whether adequate protection of human health and the environment is provided. The overall analysis of protection considers the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

(2) **Compliance with ARARs (Unless a Specific ARAR is Waived).** CERCLA §121 (d) specifies that remedial actions for cleanup of hazardous substances must comply with the substantive requirements, criteria, standards, or limitations under federal or more stringent state environmental laws that are applicable or relevant and appropriate to the hazardous substances or circumstances at a site [40 *CFR* § 300.430(e)(9)(iii)(B)] unless a waiver is granted.

Each alternative was assessed against this evaluation criterion to determine whether it met federal and state ARARs. A detailed discussion of ARARs is provided in Appendix G. The detailed analysis of the three alternatives (Sections 6.2 to 6.4) summarizes which requirements are applicable or relevant and appropriate and how these requirements would be met. When an ARAR is not met, a basis may be presented for justifying one of the six waiver categories allowed under CERCLA 40 *CFR* § 300.430(f)(1)(ii)(C). Alternately, a basis may be presented for using other waivers or variances under identified ARARs, such as 40 *CFR* § 761.75(c)(4). As a result, this FS relies upon a waiver under 40 *CFR* § 761.75(c)(4); see Section 6.4.2 for discussion on the use of this waiver for the requirements of 40 *CFR* § 761.75(b)(3):

> (3) Hydrologic conditions. The bottom of the landfill shall be above the historical high groundwater table as provided below. Floodplains, shorelands, and groundwater recharge areas shall be avoided. There shall be no hydraulic connection between the site and standing or flowing surface water. The site shall have monitoring wells and leachate collection. The bottom of the landfill liner system or natural in-place soil barrier shall be at least 50 ft from the historical high water table.

For example, 40 *CFR* § 761.75(b)(3) requires that the bottom of a landfill liner system or natural in-place soil barrier be at least 50 ft from the historical high water table. An “equivalent standard of performance” waiver of the 50-ft buffer requirement would be invoked, as described in Section 6.4.2, to support the on-site disposal alternative, if selected. This is considered feasible since a waiver of this ARAR was granted for the EMWMF in Oak Ridge. Protection of groundwater would be provided by the existence of a geologic buffer under the disposal cell as described in Section 5.4.2.11.

6.1.2 Balancing Criteria

Alternatives were evaluated using the following five balancing criteria [40 *CFR* § 300.430(f)(1)(i)(B)].

(3) **Long-term Effectiveness and Permanence.** This criterion normally focuses on the nature and magnitude of the risks associated with untreated waste/treatment residuals. This criterion includes consideration of the adequacy and reliability of any associated engineering controls, as well as monitoring and maintenance requirements [40 *CFR* § 300.430(e)(9) (iii)(C)].

The evaluation of alternatives against this criterion for this RI/FS focuses on the risk remaining at disposal sites after waste is disposed of and the disposal facilities are closed. For the On-Site Alternative evaluation, this criterion includes the time period following disposal cell closure. "Long-term" for the Off-Site and No Action Alternatives begins when the waste has been disposed of at Energy*Solutions*, NNSS, or the C-746-U Landfill. Off-site disposal facilities were qualitatively evaluated under the assumptions that they operate in accordance with permits and licenses, are closed in accordance with plans, and perform consistently with their modeled performance after closure.

For this FS, long-term effectiveness and permanence is evaluated under the following categories and includes the integration of NEPA values:

- Magnitude of residual risk and uncertainties
- Adequacy and reliability of controls
- Long-term environmental effects
- Long-term socioeconomic and land use impacts
- Irreversible and irretrievable commitment of natural resources
- Cumulative environmental impacts
- Environmental justice

The risk posed by contamination potentially left in-place following CERCLA response actions (residual risk) would be assessed on a project-specific basis by the OU that implemented the removal action.

(4) **Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment.** This criterion evaluates the degree to which the alternative employs treatment to reduce the toxicity, mobility, or volume of contamination [40 *CFR* § 300.430(e)(9)(iii)(D)].

Because this RI/FS was initiated solely for the purpose of evaluating disposal alternatives and treatment options were not considered, this criterion is not used to evaluate the preferred alternatives. Decisions regarding the treatment of waste generated by the various OUs would be made on a project-specific basis. The low-end volume scenario does include waste reduction through recycling and reuse initiatives.

(5) **Short-term Effectiveness.** This criterion evaluates the effect of implementing the alternative relative to potential risks to the general public, potential threat to workers, and time required until protection is achieved [40 *CFR* § 300.430(e)(9)(iii)(E)].

Potential impacts are examined, as well as appropriate mitigating measures to maintain protection for the community, workers, environmental receptors, and potentially sensitive resources. Short-term effectiveness is evaluated under the following categories, which include the integration of NEPA values:

- Protection of the community during remedial action;
- Protection of workers during remedial action;
- Short-term environmental effects (ecological resources, threatened and endangered species, wetlands and floodplains, or cultural resources);
- Short-term socioeconomic and land use impacts; and
- Duration of remedial activities.

For the On-Site Alternative, short-term is defined as the period of construction, operation, and closure of an on-site disposal facility, but does not include the postclosure period. For the Off-Site and No Action Alternatives, short-term is defined as the period of waste generation and ends when all waste has been disposed of at an off-site facility.

(6) **Implementability.** This criterion reviews potential issues associated with implementing the alternative. The issues may involve technical feasibility, administrative feasibility, and availability of services and materials [40 *CFR* § 300.430(e)(9)(iii)(F)].

For the On-Site Alternative, it is assumed that 5% of the waste would not meet the WAC because of elevated contaminant concentrations. If the On-Site Alternative is the preferred remedy, the PWAC would be refined and finalized using site-specific characterization data for the selected on-site disposal facility location.

(7) **Cost.** This criterion weighs the capital cost; annual SM&M cost; and the combined net present value [40 *CFR* § 300.430(e)(9)(iii)(G)].

The cost estimate provides an accuracy of +50% to -30%, as typically used when preparing FS cost estimates. Expenditures were evaluated with a present value analysis using the federal projects discount rate of 2.3% as specified in the U.S. Office of Management and Budget Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (OMB 2011). The discount rate is the rate used in calculating the present value of future benefits and costs. The choice of a discount rate is important for comparing alternatives and making decisions because the higher the discount rate, the lower the present value of future cash flows.

For the No Action, On-Site Disposal, and Off-Site Disposal Alternatives, the following costs are addressed:

- Capital costs (direct and indirect)
- Waste disposal operational costs
- SM&M costs

Capital costs are those expenditures required to initiate and perform a remedial action, including characterization, design, and construction costs. Capital costs consist of direct and indirect costs. Direct costs include construction (e.g., material, labor, and equipment), service equipment, buildings, and utilities. Indirect costs include such elements as Title I and Title II engineering, Title III inspection, project integration, project administration, and management.

Waste disposal operational costs include (1) cost of containers, long-distance transportation costs, and fees paid to off-site disposal facilities; and (2) waste handling and placement, facility maintenance, and monitoring during on-site disposal operations.

SM&M costs are long-term costs that would occur after closure of an on-site disposal facility. SM&M costs for off-site disposal are assumed to be included in the disposal fees paid to the off-site facilities. EPA guidance indicates that "the period of performance for costing purposes should not exceed 30 years for the purpose of the detailed analysis" because the present value of funds expended after that period is negligible. Waste generation and disposal, however, could continue for as long as 25 years, and SM&M for an on-site disposal facility would continue for a minimum of 100 years (for the RI/FS, 1,000 years was assumed for cost estimating purposes) after closure. For the purpose of this FS evaluation, postclosure care is included in the On-Site Disposal Alternative cost estimate.

Estimated costs to perform activities were developed in fiscal year (FY) 2011 dollars. These costs then were compared in present value to account for the time value of money and projected inflation.

Present value (or present worth) analysis is a standard methodology that allows for cost comparisons of different alternatives on the basis of a single cost figure for each alternative. Present value analysis is used to evaluate expenditures (including capital, operations and maintenance, closure, and long-term stewardship) that occur at different times, putting them on a common basis to make a fair cost comparison of alternatives. This analysis requires a discounting of future dollars to reflect the time value of money. It is based on a dollar being worth more today than in the future because of potential returns that the dollar could earn if invested in alternate ways. In this manner, present value discounting reflects the potential productivity inherent in well-deployed capital.

6.1.3 Modifying Criteria

These criteria allow for the influences of the state and community. The CERCLA modifying criteria are not addressed in the detailed FS analysis because they rely on stakeholder participation and feedback on the Proposed Plan, which occur subsequent to the FS. The Proposed Plan, which documents the evaluation of the remedial alternatives and presents the preferred alternative, will be issued for public review and comment subsequent to regulatory agency concurrence. Public comments on the Proposed Plan and other components of the Administrative Record will be addressed in the ROD.

(8) **State Acceptance.** This criterion requires the consideration of comments by the state regarding any action to be performed [40 *CFR* § 300.430(e)(9)(iii)(H)].

(9) **Community Acceptance.** This criterion requires the consideration of comments by the community regarding any action to be performed [40 *CFR* § 300.430(e)(9)(iii)(I)].

The final evaluation of these modifying criteria will be conducted in the Proposed Plan and ROD. The public and the Commonwealth of Kentucky were involved in the development of the RI/FS process. The public will be given opportunity for formal review and comment when the Proposed Plan is released.

6.1.4 NEPA Values

Potential impacts to environmental conditions not otherwise specifically addressed as Threshold, Balancing, or Modifying Criteria were evaluated as NEPA values. Although NEPA values are incorporated throughout the RI/FS, there was particular focus on the values in the detailed evaluation. Evaluation of alternatives relative to "long-term effectiveness and permanence" and "short-term effectiveness" criteria qualitatively consider the following NEPA values:

- Impacts to cultural and ecological resources
- Impacts to visual aesthetics and ambient noise levels
- Socioeconomics and environmental justice
- Land use
- Irreversible and irretrievable commitment of natural resources

Cumulative impacts also were analyzed during the FS to assure that NEPA values were addressed. In addition to satisfying CERCLA requirements, this RI/FS Report addresses environmental concerns through incorporation of values outlined in NEPA, in keeping with DOE's Secretarial Policy on NEPA (DOE 1994) as well as continued progress toward overall site cleanup in support of implementing the NRDA process.

6.2 NO ACTION ALTERNATIVE

Under the No Action Alternative, there would be no change to current waste disposal practices. Each project would individually address the disposal of waste generated from remedial actions or D&D activities. Evaluation of NEPA values for this alternative is the same as for the Off-Site Alternative, Section 6.3.

For the No Action Alternative, the CERCLA-generated waste volume to be disposed of is approximately 3.6 mcy (i.e., the base case). Of that volume, all forecast nonhazardous solid waste (~1.1 mcy) would be disposed of in the existing C-746-U Landfill. The remaining waste volume (~2.5 mcy) would be shipped off-site for disposal. There would be no change to current waste disposal practices.

6.2.1 Overall Protection of Human Health and the Environment

Decisions would be made for each project/OU based on the circumstances pertinent to that project. In each case, decisions would be required to satisfy this CERCLA FS threshold criterion.

Worker risks from exposure during handling and containerization will be addressed through health and safety plans. Inherent transportation risks to transportation workers and the community from shipping the waste off-site would be controlled by compliance with DOT requirements. Additional controls include implementing vehicle inspection and maintenance, vehicle operator training, observing traffic laws, and defensive driving practices. The considerable transportation distances required for off-site disposal would result in an increased potential for accidents that could result in injuries, fatalities, or contaminant releases. Transportation risks are discussed in Section 6.3.5.1.

6.2.2 Compliance with ARARs

There are no ARARs associated with the No Action Alternative. ARARs would be developed and evaluated for each project-specific CERCLA action. ARARs must be met or waived for a remedial action.

6.2.3 Long-Term Effectiveness

It is assumed that forecasted nonhazardous solid waste (~1.1 mcy) would meet the WAC for and be disposed of in the C-746-U Landfill. The C-746-U Landfill has available build-out capacity to accept this waste, utilizes protective operational procedures and SM&M, and has an approved closure plan. The remainder of the waste for the No Action Alternative (~2.5 mcy) would be shipped off-site for disposal.

The long-term effectiveness, including cumulative impacts, would be the same as for the Off-Site Alternative. Off-site disposal options would be protective and permanent in the long-term because the off-site facilities operate in accordance with their respective WAC, construction and operating procedures, and closure/postclosure requirements. The off-site disposal facilities would be responsible for maintaining required long-term institutional controls and SM&M.

6.2.4 Reduction in Toxicity, Mobility, or Volume

For the No Action Alternative, decisions regarding the treatment of waste would be made on a project-specific basis and are not part of this FS evaluation. It is assumed there would be no efforts to reduce waste volume by recycling, reuse, or reindustrialization.

6.2.5 Short-Term Effectiveness

The short-term effectiveness, including cumulative impacts, would be the same as for the Off-Site Alternative. The primary risk to the community is due to the long-distance transport of waste to off-site disposal facilities. The off-site disposal facilities would be required to perform postclosure monitoring and maintenance activities.

6.2.6 Implementability

Transportation and disposal contracts are in place; therefore, this alternative is readily implementable. Shipping containers are available and would be purchased through procurement contracts. A long-term consideration is availability of disposal capacity and duration of operations at the off-site disposal facilities. Energy*Solutions* indicated it would have sufficient capacity for the PGDP waste volume, and disposal facility operations would continue through 2039. NNSS indicated that volume capacity would not be an issue, but the current closure date for cells that currently are operational is 2027, and the implementability of this requires DOE to identify another facility available to accept classified or other wastes eligible to be disposed of at NNSS from 2027 to 2039.

6.2.7 Cost

Costs were calculated using the current PGDP transportation and waste disposal contracts, and these are presented in terms of present value in Table 6.1. Additional details of the No Action Alternative cost estimate are provided in Appendix H (costs in Appendix H are rounded to the nearest $1,000 for the purposes of Table 6.1).

Table 6.1. No Action Alternative Cost Estimate (3.6 mcy)

LLW	**Cost**
Containers & Transportation	$401,400,000
Disposal	$527,714,000
MLLW	**Cost**
Containers & Transportation	$26,353,000
Disposal	$86,038,000
TSCA Waste	**Cost**
Containers & Transportation	$948,000
Disposal	$8,261,000

Table 6.1. No Action Alternative Cost Estimate (3.6 mcy) (Continued)

Classified Waste	Cost
Containers & Transportation	$101,262,000
Disposal	$84,026,000
C-746-U Landfill Costs	**Cost**
Operations 2014–039	$22,277,000
Construct Phases 12–23	$22,080,000
Closure	$24,440,000
Postclosure Care (30 years)	$6,183,000
TOTAL PRESENT VALUE COST	**$1,310,982,000**

Using cost basis assumptions similar to those for the Off-Site Alternative, the present value cost is approximately $1,310,982,000, which includes C-746-U Landfill costs of $74,980,000. The C-746-U Landfill costs include expansion of remaining phases 12-23 (three different expansion periods assumed in 2019, 2025, and 2031); landfill operations costs (annual cost per year from 2014 to 2039); final closure of the phases of the landfill (completed in 2039); and a 30-year postclosure care period (monitoring and maintenance from 2039 to 2069).

6.3 OFF-SITE DISPOSAL ALTERNATIVE

The Off-Site Alternative involves the project-by-project disposal of CERCLA waste and includes two waste volume scenarios for comparison purposes: (1) a high-end waste volume scenario for which CERCLA waste is assumed to be shipped off-site; (2) a low-end waste volume scenario, which assumes various waste volume reduction actions, continued use of the C-746-U Landfill for disposal of waste meeting the WAC of the C-746-U Landfill, and off-site disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill. These scenarios bracket the baseline (most likely) case of 3.6 mcy, composed of 2.5 mcy of LLW/RCRA/TSCA/MLLW that would require off-site disposal for this alternative and 1.1 mcy of waste that would meet the WAC of the C-746-U Landfill. Assumptions for the Off-Site Alternative are presented in Section 5.3.

The cost estimate for off-site disposal used current waste disposal and transportation contract rates and the most cost efficient disposal methods. The most efficient disposal method is based on a waste disposal cost analysis conducted in 2007 that compared various combinations of container types and transportation methods for disposal of waste at Energy*Solutions* and NNSS. Primarily because of the ability to ship waste in bulk containers by rail, Energy*Solutions* resulted in the lower overall disposal cost (combination of container, transportation, and disposal). Therefore, Energy*Solutions* was assumed to be the primary off-site disposal facility for LLW/RCRA/TSCA/MLLW.

Consideration was given to other methods of optimizing off-site disposal cost. The cost to dispose of soil waste is much less than the cost to dispose of debris waste. One possible method to lower off-site disposal cost is to optimize the ratio of soil and debris waste to receive the lower soil disposal cost. Based on PGDP disposal contracts, soil waste can contain up to 17% debris and still receive the soil disposal rate; however, it was concluded that there is no guarantee that the generating projects could reliably provide the needed blend of soil/debris to attain the lower soil disposal cost. The overall forecast waste volume has an approximate 50/50 blend of soil/debris, so a majority of the volume would not have the needed blend to attain the lower soil disposal cost. Optimization would require significant coordination of multiple waste generating projects, development and operation of a waste staging area, purchase of additional containers, and double handling of the wastes; therefore, for the FS, then, it was assumed that blending to the point of altering the disposal cost would not occur. Where different pricing for soil versus debris is available (e.g., low-level waste disposal at Energy*Solutions*), these different prices were used for the projected waste streams. Overall, there is not a sufficient soil-to-debris volume ratio in the waste forecast to warrant use of the lower soil disposal rate.

Evaluation of NEPA values for the Off-Site Alternative addresses potential impacts related to transportation of waste between PGDP and the off-site waste disposal facilities. Potential impacts from activities at the off-site disposal facilities already are accounted for in those facilities' operational permits and procedures.

6.3.1 Overall Protection of Human Health and the Environment

The Off-Site Alternative high-end volume scenario would protect human health and the environment and meet RAOs by removing the CERCLA waste generated at PGDP, packaging and transporting the waste off-site in licensed vehicles, and isolating it from the environment by disposal in permitted or licensed waste disposal facilities. Implementation of this alternative would prevent access to contaminated media and reduce the overall potential for releases from the OUs by permanently removing LLW/RCRA/TSCA/MLLW and nonhazardous solid waste sources from PGDP. This alternative would require waste transportation across the country, totaling millions of road-miles and/or rail-miles that, based on DOT data, potentially could result in several injuries and fatalities. These risks are discussed in Section 6.3.5.1.

For the Off-Site low-end volume scenario, a portion of the waste would be recycled or shipped off-site as described above, and the remaining waste volume would be loaded and transported to the C-746-U Landfill. This scenario would have the same protection of human health and environment as described in the high-end volume scenario, although approximately 1.1 mcy of waste meeting the WAC of the C-746-U Landfill would be disposed of on-site in the C-746-U Landfill.

Human health and the environment would be protected in the vicinity of the receiving off-site facilities and the C-746-U Landfill by disposing of the contaminated material at facilities designed, equipped, and operated to handle these wastes. Operation of these facilities is not likely to result in exposure to waste or releases to the environment because the facilities are designed, licensed, monitored, and maintained to ensure reliable waste containment. Recycling, if performed, would decrease the volumes to the receiving off-site facilities and the C-746-U Landfill and return these metals to service, thereby increasing the overall protection of human health and the environment.

Worker risks from exposure during handling and containerization will be addressed through health and safety plans. Inherent transportation risks to transportation workers and the community from shipping the waste off-site would be controlled by compliance with DOT requirements. Additional controls include implementing vehicle inspection and maintenance, vehicle operator training, observing traffic laws, and defensive driving practices. The considerable transportation distances required for off-site disposal would result in an increased potential for accidents that could result in injuries, fatalities, or contaminant releases. Transportation risks are discussed in Section 6.3.5.1.

6.3.2 Compliance with ARARs

The Off-Site Alternative consists of shipment of CERCLA waste to and disposal of in licensed or permitted off-site disposal facilities. It is assumed that individual waste generators would be responsible for treatment before disposal; therefore, ARARs for waste treatment are not addressed as part of this project (DOE 2011a). Because waste would be disposed of off-site at appropriately licensed facilities under this alternative, ARARs for waste disposal are not addressed for this alternative (DOE 2011a).

6.3.3 Long-Term Effectiveness

For the Off-Site Alternative, the long-term period of performance is considered to begin when all CERCLA wastes have been disposed of off-site at Energy*Solutions* or NNSS, and all CERCLA waste meeting the WAC of the C-746-U Landfill has been disposed of at the C-746-U Landfill. This FS does not address remedial activities nor any CERCLA waste or residuals that would be left in place at individual SWMUs, AOCs, or buildings at PGDP. Recycling is considered to meet the long-term effectiveness of the Off-Site Alternative by decreasing the volume of waste being disposed of off-site or in the C-746-U Landfill and returning the materials to a state where they may be reused.

6.3.3.1 Magnitude of residual risk

Under the high-end waste volume scenario, wastes would be permanently removed from PGDP and disposed in off-site disposal facilities. For the low-end waste volume scenario, wastes meeting the WAC of the C-746-U Landfill would be disposed of at PGDP, and the remainder would be disposed of in off-site facilities. Residual risks from materials shipped off-site would be *de minimis* for PGDP because exposure to such wastes no longer would be possible. Specific risks posed by these wastes at the off-site disposal facility are outside the scope of this analysis.

Risks posed by disposal of waste meeting the WAC of the C-746-U Landfill in the C-746-U Landfill are similarly outside the scope of this analysis because residual risks were addressed during the approval process for that landfill. The off-site disposal facilities and the C-746-U Landfill are designed, constructed, licensed, monitored, inspected, and maintained to provide reliable containment and are adequate to protect human health and the environment for long-term disposal.

6.3.3.2 Adequacy and reliability of controls

Waste would be placed in licensed or permitted engineered disposal facilities that have been receiving wastes for a number of years, were designed to accept these waste types, and operate in compliance with their permits and federal, state, and local regulations. Accordingly, reliance on specialized or unproven designs or procedures is not necessary to protect human health and the environment or meet RAOs over the long term. Reliance on proven technologies minimizes uncertainty associated with this alternative.

For the high-end waste volume scenario, all waste types would be shipped to Energy*Solutions*, with the exception of classified LLW that would be sent to NNSS. The containment systems at Energy*Solutions* and NNSS are designed to minimize the infiltration of precipitation that could mobilize contaminants and to minimize the chance for intrusion. These facilities use conventional, durable designs and materials to effectively isolate the waste. The arid climate at both facilities contributes to the long-term reliability of engineered features by minimizing infiltration. The climate also reduces the required level of maintenance and frequency of repairs by minimizing weathering effects. The remote locations of both facilities in areas of low population density lessen the chance for human intrusion, thereby providing a natural enhancement to the effectiveness of institutional and engineering controls such as barriers and other security measures. The engineered and natural features at these facilities are expected to provide adequate and reliable safeguards over the long term.

For the low-end waste volume scenario, the volume of waste meeting the WAC of the C-746-U Landfill would be disposed of at the C-746-U Landfill at PGDP. The containment system at the C-746-U Landfill is designed to minimize infiltration of precipitation and also uses conventional, durable designs and materials. The landfill effectively isolates the waste from underlying groundwater systems through operation of its leachate collection system and strict adherence to its approved WAC.

6.3.3.3 Long-term environmental effects

Long-term environmental effects are defined as those impacts that occur after the waste has been removed and transported off-site for disposal. For the high-end waste volume scenario, wastes are transported off-site and removed from PGDP, and result in no long-term environmental effects at PGDP. Potential environmental effects associated with removal or transportation of the waste, including accidental releases, are considered short-term effects and would cease after waste transportation has ended. Potential long-term environmental effects at the off-site disposal facilities from PGDP waste are expected to be minimal because the receiving facilities are designed to minimize long-term environmental impacts. The off-site disposal facilities would be responsible for maintaining the long-term institutional controls and required SM&M.

For the low-end waste volume scenario, the long-term environmental effects associated with the portion of waste meeting the WAC of the C-746-U Landfill disposed of at the C-746-U Landfill would be minimal. The landfill is located in an area designated for continued industrial land use. The landfill has sufficient capacity to accept the forecasted volume of waste meeting the WAC of the C-746-U Landfill; therefore, expansion of the landfill beyond the original design plans would not be required. Disposal of waste meeting the WAC of the C-746-U Landfill at the C-746-U Landfill is compatible and consistent with its intended use and approved WAC.

6.3.3.4 Socioeconomics and land use

The Off-Site Alternative would have no long-term socioeconomic or land use impacts at the receiving facilities. The facilities already are committed to long-term operation, maintenance, and monitoring for waste disposal. Waste in these facilities from PGDP would not affect the existing long-term land use commitment and any effect on the workforce required for operation and maintenance already has been accounted for. No changes in local population or nearby industrial or commercial operations are expected.

6.3.3.5 Cumulative environmental impacts

This alternative would not result in significant cumulative impacts to the environment; although, there could be a cumulative impact if reindustrialization were to occur while removal actions are still in progress. This could result in increased traffic into and out of PGDP; however, incremental impacts to air quality, traffic, and noise levels from waste transportation would not noticeably alter existing or future conditions. Exhaust emissions from waste transportation vehicles would have a negligible impact at PGDP or along transportation corridors used for waste shipment. Waste transportation trucks operate under required emission controls. The use of railroads for transport of the largest volumes of waste would decrease vehicle emissions. Fugitive dust generated by truck travel on dirt or gravel access roads would be minimized by dust control measures at the generator sites, PGDP, and receiving facilities. The increase in noise levels along transportation routes would be inconsequential. Noise levels associated with activities at waste-generating sites and packaging and disposal facilities would be minimized by compliance with health and safety plans, which provide for appropriate noise controls at these facilities. Potential environmental effects from these factors, as well as the potential for accidental releases during shipment, would cease after shipment and off-site disposal of waste.

Residual risk would be eliminated at PGDP because the contaminated waste would be removed from PGDP and disposed of at an off-site facility. Only limited residual risk would remain from disposal of waste meeting the WAC of the C-746-U Landfill in the C-746-U Landfill, but this landfill was designed and is operated specifically for safe disposal, as discussed previously. No long-term commitment of land and associated resources would be required at PGDP if waste were shipped off-site for disposal. Consequently, this alternative results in positive long-term environmental benefits by reducing the potential for exposure to and migration of contaminants at PGDP.

Potential long-term cumulative impacts at the off-site disposal facilities or at the C-746-U Landfill are expected to be minimal. The C-746-U Landfill was designed to receive PGDP waste meeting the WAC of the C-746-U Landfill, and there would be no cumulative impact beyond what already was planned. CERCLA wastes from PGDP would represent a relatively small portion of the total waste disposal capacity at the off-site facilities. No long-term cumulative impacts to air quality would be expected at the receiving facilities from the disposal of PGDP waste because air emissions from vehicular use and construction activities for long-term waste management, monitoring, and maintenance of the off-site facilities would not be increased.

6.3.4 Reduction in Toxicity, Mobility, or Volume

Although this RI/FS does not establish waste treatment requirements, as treatment required to meet the facility WAC is assumed to be the responsibility of the generating project, wastes would be treated, as needed, to meet the respective disposal facility's WAC. Transportation and disposal would have no effect on toxicity or mobility. The low-end waste volume scenario assumes waste reduction through recycling and reuse initiatives. Implementation of recycling would reduce the volume of waste to be disposed of, thereby reducing the available metal mass for leaching from a disposal facility. A recycling program also would likely contain a means for surface cleaning of components prior to melting or crushing, which would reduce toxicity associated with the recyclable material. Recycling has the added benefit of returning the material to a useful state.

6.3.5 Short-Term Effectiveness

For purposes of this evaluation, short-term refers to the period beginning with the generation of CERCLA waste and ending with disposal of the waste at the receiving facilities. This evaluation does not address removal activities; waste or residuals that would be left in place at individual SWMUs, AOCs, or buildings at PGDP; or the risk associated with these actions.

6.3.5.1 Protection of the community during remedial action

Risks to the community from implementation of the Off-Site Alternative are associated primarily with the transport (rail or truck) of waste to off-site disposal facilities. Public access to waste generation, packaging, and handling sites would be restricted, and these tasks would be implemented by trained personnel. Risks at the receiving facilities would be controlled by compliance with permit requirements. Access restrictions during disposal operations would minimize impact to the community. The most significant risk to the public would occur during the shipment of hazardous and low-level radioactive waste off-site. Shipment of waste currently is projected to occur over a period of 25 years, although there would be risk to site workers at PGDP when implementing any of the alternatives.

There is a risk of injury or fatality with transport of waste by truck for on-site disposal of waste that meets the WAC of the C-746-U Landfill to the C-746-U Landfill. Using injury and fatality rates for large commercial trucks on highways from the Federal Motor Carrier Safety Administration (NHTSA 2006), both the projected total injuries and the projected total fatalities for on-site waste transportation would be less than 1. This would be a conservatively high value because most or all of the transport of waste to the

C-746-U Landfill would be conducted at lower speed limits than highway transport and travel shorter distances. Additionally, most of the transportation would be on DOE-controlled (out-of-commerce) roads.

Waste transported off-site would result in more projected injuries and fatalities than predicted for on-site transportation simply because of the increase in the number of miles and trips required to reach a disposal facility. It is estimated that approximately 20 injuries and fewer than 4 fatalities would result from the transportation of waste for off-site disposal (see Appendix E, Attachment 1 for more detail). These estimates may be overstated because approximately 34 million miles of the transportation over the highway would be performed using trucking companies and drivers that specialize in the transportation of radioactive and hazardous materials and most of the transportation would be by rail (125 million railcar miles). Implementation of a recycling program would reduce the volume of waste disposed of under the Off-Site Alternative and thereby reduce the risk to the community due to long-distance transport.

6.3.5.2 Impact to workers during remedial action

The primary risk to workers would result from waste handling, transportation, and disposal activities. These activities would be conducted by trained personnel in accordance with transportation requirements, DOE requirements, and approved health and safety plans. Radiation exposure would be minimized by compliance with DOT regulations and DOE requirements for waste packaging, the use of shielding and PPE, and limits on driver work schedules.

The wastes are predominantly construction debris and soils, and there is potential for generation of fugitive dust during containerization and other waste management activities. This would be controlled by dust suppression procedures. Workers would be further protected by engineering and administrative controls, such as use of remote operations (e.g., loading of bulk waste containers using heavy equipment) and PPE, including respiratory and dermal protection.

Risks from disposal activities at the receiving facilities would be minimized by compliance with their permit requirements and other facility-specific safety requirements and established standard operating procedures. The overall risk to workers for this alternative therefore is low. Risks from recycling activities performed on-site would be minimized by compliance with applicable DOE Orders. Worker risks from exposure during handling and containerization will be addressed through health and safety plans.

6.3.5.3 Short-term environmental effects

The greatest potential for short-term environmental effects under the Off-Site Alternative would result from the potential for spills during waste handling and transportation. Adverse environmental effects in the event of a spill would be minimal because wastes would not be in liquid form, contaminant concentrations would be low for most waste, and response plans would be quickly implemented if a spill were to occur during waste loading or transportation. Fugitive dust from handling construction debris and soils could be controlled through water mists, and waste containers would be covered during transport. Free liquids resulting from the water mists are not anticipated, but would be contained and controlled within the work area. Absorbent would be added to containerized soil and construction debris wastes as needed to prevent liquid release to the ground during transport.

The risk of a release from a waste container in transport, such as from a vehicle accident or failure of the waste container, is minimal. Inherent transportation (road or rail) risks would be controlled by compliance with DOT requirements, vehicle/chassis/gondola inspection and maintenance, operator training, observance of traffic laws, and the practice of defensive driving skills. Waste containers would be inspected prior to use in accordance with DOT requirements to ensure appropriateness for the waste material and adequate physical condition. Containers would be rejected for defects such as corrosion, questionable seam integrity, inadequate or stressed closing and securing mechanisms and seals, and lack of decontamination (i.e., presence of residual waste). Waste containers would be properly prepared for loading, including installation of liners and absorbents as required, and then inspected after being filled to confirm container integrity, including assurance that no free liquids have formed during loading of wastes, doors are secure and sealed, and no leaks are present. Finally, as standard practice, waste transporters would be trained in emergency spill response to mitigate spread of any spill in transport until other spill response professionals arrive for cleanup.

Exhaust emissions and fugitive dust from waste transportation would have a negligible impact on air quality at PGDP or along transportation corridors used for waste shipment. Transportation vehicles would comply with EPA emission requirements, and waste containers would be covered and sealed to minimize particulate releases during highway and rail travel. Fugitive dust generated by travel on dirt or gravel access roads would be minimized by dust control measures at PGDP and receiving facilities. The increase in noise levels along transportation routes would be inconsequential. Noise levels associated with activities at PGDP and disposal facilities would be minimized by compliance with health and safety plans that provide appropriate noise controls. The impacts of noise levels from the off-site transportation of waste also would be negligible because the truck loads or rail shipments would be sent over a long period of time (roughly two decades).

Potential exists for environmental effects on surface water, groundwater, terrestrial, wetland, aquatic, historic, archaeological, and visual resources at the receiving facilities. Because these facilities already are operating and committed to waste disposal, the incremental increase of waste from PGDP would not result in significant additional short-term environmental impacts. These facilities have been receiving wastes for many years and have successfully operated in compliance with their permits and federal, state, and local regulations. Each facility also has established operating procedures, health and safety plans, and worker training programs to minimize the risk of release during waste handling, treatment, and disposal. The waste is primarily solid waste, so a release could be contained. Fugitive dust generation during waste management at off-site disposal facilities would be minimized through engineering and administrative controls.

Recycling, if implemented, would further reduce short-term environmental effects by reducing the volume of waste being disposed of, consequently reducing risks associated with transportation.

6.3.5.4 Socioeconomics and land use

The short-term socioeconomic impacts associated with waste handling, transportation, and disposal activities for off-site disposal would be minimal. This alternative would require minimal additional manpower resources at PGDP. Most of the infrastructure required on-site is available and would not require additional land. Outside contractors, rather than local manpower, likely would transport wastes to off-site disposal facilities. Waste transportation jobs would be created, but the geographical location that could benefit is unknown. As the receiving facilities are already operating, the manpower required to support the infrastructure is already in place. The incremental increase of waste from PGDP would not increase short-term manpower needs at these facilities.

If implemented, recycling would require the addition of infrastructure and would result in the creation of jobs for construction of the facilities as well as operation of the facilities.

6.3.5.5 Duration of remedial activities

Packaging and off-site transportation of the waste to the disposal facilities would begin in 2014 and continue through 2039. There would be minimal, if any, facility construction required for the off-site disposal because most of the infrastructure needed to transfer waste to railcar or truck loadings already is in place. There would be no long-term institutional/engineering control period associated with this alternative.

If implemented, recycling would require construction of the recycling facilities, and operation would be anticipated to occur during the forecasted operational period for the Off-Site Alternative (2024–2039).

6.3.6 Implementability

Off-site disposal of waste would be readily implementable as described for the No Action Alternative in Section 6.2.6. Incorporation of a recycling program into the Off-Site Alternative is considered to implementable.

6.3.6.1 Administrative feasibility

Implementation of this alternative would require compliance with state and federal regulations; compliance with licensing, permitting, and DOE requirements; agreements by regulatory agencies in Utah and Nevada to receive waste; and possibly agreements by regulatory agencies in several states for the interstate shipment of waste.

Review of state and federal regulations (addressed in Section 6.3.2 and Appendix G) indicates that there are no provisions that would prohibit shipment of waste generated at PGDP to the proposed receiving facilities. For PGDP actions that transfer waste off-site, permits are required at the receiving facility. Both disposal facilities at NNSS and Energy*Solutions* are permitted by Nevada and Utah, respectively. In general, the following conditions must be met to use an off-site receiving facility:

- The proposed receiving facility must be operated in compliance with all applicable federal, state, and local regulations; there must be no relevant violations at or affecting the receiving facility.

- There must be no releases from the receiving unit, and contamination from prior releases at the receiving facility must be addressed (as appropriate).

The regulatory and administrative viability of off-site waste transportation and disposal has been proven by past and present operations. Previous shipments to Energy*Solutions* and NNSS demonstrate that sustained waste shipment to these facilities is feasible. Historically, PGDP waste has been transported to off-site disposal facilities; therefore, it is assumed for the purposes of the evaluation that transportation to off-site facilities will continue to be feasible in the near-term.

Over the long-term, there is uncertainty with regard to the continued availability of off-site disposal facilities for the duration of waste generation, including facilities for disposal of classified waste; however, new commercial disposal facilities may be developed. Also, because of state equity issues, it is possible that public concerns regarding shipments outside of Kentucky could affect the availability of off-site disposal facilities. While these concerns could be addressed through appropriate channels (e.g., the National Governors Association), at a minimum, they could result in a disruption of work.

Review of state and federal regulations (Appendix G) indicates that there are no provisions that would prohibit implementation of a recycling program on-site.

6.3.6.2 Technical feasibility

The Off-Site Alternative is technically feasible. The alternative relies on proven technology that is already being implemented at PGDP, albeit at a smaller scale than when D&D occurs. Rail and truck transport for waste shipment are common methods that use readily available equipment, materials, and manpower. The receiving facilities are existing, permitted facilities that have routinely received DOE waste in the past. The facilities have the capacity and technical expertise to handle and dispose of the waste.

Site conditions are well known at the receiving facilities, and potential migration pathways are monitored to detect contaminant releases and evaluate the effectiveness of waste confinement. If a hypothetical release were to go undetected at the Energy*Solutions* or NNSS facilities, the risk of exposure would be slight because there are few potential receptors in the vicinity of the site, and no potable water aquifer underlies the site. The off-site facilities would be required to implement postclosure monitoring and maintenance activities as well as necessary long-term institutional controls.

The only technical uncertainty relative to the Off-Site/No Action Alternatives is the availability of treatment and disposal options for waste exceeding the WACs of the off-site facilities. If significant volumes of waste were generated and no treatment or disposal options could be identified for that waste, a technical challenge to implementability ultimately could result. Currently, all waste volumes are estimated to meet an off-site disposal facility WAC. In the event that waste is generated that does not meet the off-site facilities' WACs, the waste would require storage in on-site facilities that could meet the requirements for storage, pending the availability of treatment technologies or disposal options. No costs for long-term storage and eventual disposal of wastes not meeting the WAC for off-site disposal facilities are included, because these would be the responsibility of the generating project. Because the expected volumes of such waste streams are small and the resulting cost differential between disposal options is not critical, management of waste exceeding WAC is not analyzed in detail in this FS.

Several technologies exist that may be applied to potential recycling operations on-site, as described in Section 4.1.4.

6.3.6.3 Availability of services and materials

Services and materials required for waste transportation and disposal are readily available. Both rail and highway transport routes are available from PGDP. The Energy*Solutions* and NNSS facilities are permitted to dispose of the waste categories, waste types, and quantities expected to be generated by CERCLA actions at PGDP. Contracts for trucking and rail services currently are in place.

Disposal capacity at each of the off-site facilities and the PGDP C-746-U Landfill is sufficient to handle the volumes of CERCLA waste generated from PGDP in both the low-end and high-end waste volume scenarios. Long-term considerations regarding availability of disposal capacity and duration of operations at the off-site disposal facilities are the same as for the No Action Alternative, addressed in Section 6.2.6.

A recycling facility may be designed to accommodate the volumes of recyclable material expected to be generated.

6.3.7 Cost

Table 6.2 summarizes costs for the Off-Site Disposal Alternative high-end and low-end volume scenarios. Details are provided in Appendix H (costs in Appendix H are rounded to the nearest $1,000 for the purposes of Table 6.2). The Off-Site Disposal Alternative base case is the No Action Alternative; costs associated with the No Action Alternative scenario are included in Table 6.1.

Table 6.2. Off-Site Alternative Cost Estimate

High-end Waste Volume (4.0 mcy)

LLW	Cost
Containers & Transportation	$580,717,000
Disposal	$1,147,118,000
MLLW	**Cost**
Containers & Transportation	$28,978,000
Disposal	$94,607,000
TSCA Waste	**Cost**
Containers & Transportation	$1,014,000
Disposal	$9,154,000
Classified Waste	**Cost**
Containers & Transportation	$111,382,000
Disposal	$92,424,000
C-746-U Landfill Costs	
Operations 2014–2039	**$ -**
Construct Phases 12–23	**$ -**
Closure	**$ -**
Postclosure Care (30 years)	**$ -**
TOTAL PRESENT VALUE COST	**$2,065,394,000**

Low-end Waste Volume (3.2 mcy)

LLW	Cost
Containers & Transportation	$275,169,000
Disposal	$338,608,000
MLLW	**Cost**
Containers & Transportation	$23,716,000
Disposal	$77,430,000
TSCA Waste	**Cost**
Containers & Transportation	$765,000
Disposal	$5,805,000
Classified Waste	**Cost**
Containers & Transportation	**$ -**
Disposal	**$ -**
C-746-U Landfill Costs	
Operations 2014–2039	$22,277,000
Construct Phases 12–23	$22,080,000
Closure	$24,440,000
Postclosure Care (30 years)	$6,183,000
TOTAL PRESENT VALUE COST	**$796,473,000**

Base Case Waste Volume (3.6 mcy)

LLW	Cost
Containers & Transportation	$401,400,000
Disposal	$527,714,000
MLLW	**Cost**
Containers & Transportation	$26,353,000
Disposal	$86,038,000
TSCA Waste	**Cost**
Containers & Transportation	$948,000
Disposal	$8,261,000
Classified Waste	**Cost**
Containers & Transportation	$101,262,000
Disposal	$84,026,000
C-746-U Landfill Costs	**Cost**
Operations 2014–039	$22,277,000
Construct Phases 12–23	$22,080,000
Closure	$24,440,000
Postclosure Care (30 years)	$6,183,000
TOTAL PRESENT VALUE COST	**$1,310,982,000**

The high-end waste volume scenario under the Off-Site alternative does not include capital or operational costs associated with the C-746-U Landfill, as the high-end volume scenario assumes the C-746-U Landfill is unavailable due to economic, technical, or regulatory issues. The low-end scenario includes C-746-U Landfill costs including expansion of remaining phases 12–23 (three different expansion periods assumed in 2019, 2025, and 2031); landfill operations costs (annual cost per year from 2014 to 2039); final closure of all 23 phases of the landfill (completed in 2039); and a 30-year postclosure care period (monitoring and maintenance from 2039 to 2069).

There would be no SM&M cost for off-site disposal (for the high-end waste volume scenario) because SM&M costs associated with the off-site disposal component are assumed to be included in the off-site disposal facilities' disposal fees. The Off-Site Alternative costs were developed by grouping the waste types into four categories: (1) LLW (includes nonhazardous solid waste for the high-end waste volume scenario); (2) MLLW (includes LLW/RCRA, LLW/RCRA/TSCA, and RCRA); (3) TSCA waste (includes LLW/TSCA); and (4) classified waste.

For the high-end waste volume scenario, nonhazardous solid waste is assumed to be disposed of as LLW. For LLW, the off-site disposal costs are based on a volume of 3.9 mcy for the high-end waste volume scenario and 1.5 mcy for the low-end volume. Cost estimates are based on packaging the LLW in gondola railcars for shipment and disposal at Energy*Solutions* in Clive, Utah.

For MLLW, the off-site costs are based on a volume of 73,840 yd^3 for the high-end waste volume scenario and 60,420 yd^3 for the low-end volume. The cost estimate is based on packaging MLLW debris into Sealand containers for shipment by truck and packaging MLLW soils for shipment in gondola railcars to Energy*Solutions* in Clive, Utah.

For TSCA wastes, the off-site costs are based on a volume 7,050 yd^3 for the high-end waste volume scenario and 4,430 yd^3 for the low-end volume. LLW/TSCA and TSCA waste categories are combined for cost estimating. The cost estimate was based on packaging the waste in gondola railcars for shipment and disposal at Energy*Solutions* in Clive, Utah.

The high-end volume of classified waste identified in the waste inventory is 215,700 yd^3 and is included in the LLW category. This type of waste can be disposed of only at NNSS and would be shipped by truck in Sealand and B-25/ST-90 containers to the facility in to Mercury, Nevada. The low-end waste volume scenario does not include costs for classified waste disposal because this scenario assumes it will be recycled.

In addition, a cost sensitivity assessment was conducted for the nonhazardous waste[27] component of the Off-Site Alternative high-end scenario to understand better the relative impacts of some portion of this waste component being disposed of at an off-site Subtitle D landfill instead of Energy*Solutions* in Clive, Utah (see Attachment H5 of Appendix H for additional discussion and assumptions). The total present value cost for transportation and disposal of waste under the Off-Site Alternative high-end volume scenario is approximately $2.07 billion (assuming disposal at Energy*Solutions* in Clive, Utah) compared to approximately $1.47 billion if this waste were disposed of at the Waste Path facility in Calvert City, Kentucky. This sensitivity cost of $1.47 billion is approximately $627 million more than the cost of the On-Site Alternative high-end scenario ($843 million). Based on this cost sensitivity assessment, the

[27] Defined as waste meeting the WAC of the C-746-U Landfill. Although some portion of the nonhazardous waste considered in the RI/FS may be eligible for placement in a Subtitle D landfill, it is unlikely that all or even the majority of the nonhazardous waste, as defined in the RI/FS Report, would meet the required criteria. It is not known what percentage of waste meeting the WAC of the C-746-U Landfill also would meet the WAC of an off-site Subtitle D facility.

assumption of the associated projected waste volume being disposed of at the Energy*Solutions* facility in Clive, Utah, versus a more local Subtitle D facility does not affect the relative cost comparison of the alternatives.

6.4 ON-SITE DISPOSAL ALTERNATIVE

The On-Site Alternative involves the disposal of CERCLA waste in a newly constructed on-site above-grade waste disposal facility located on property owned by DOE. The detailed evaluation for this alternative considered the prototype sites, Site 3A and Site 11, described in Section 5.4.5. The On-Site Alternative includes the same two waste volume scenarios as the Off-Site Alternative: (1) a high-end waste volume scenario for which CERCLA waste would be disposed of in the newly constructed on-site facility; and (2) a low-end waste volume scenario, which assumes various waste reduction actions, continued use of the C-746-U Landfill for disposal of waste meeting the WAC of the C-746-U Landfill, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in the new on-site disposal facility. Again, these scenarios bracket the baseline (most likely) case: 2.5 mcy of LLW/RCRA/TSCA/MLLW that, for this alternative, would be disposed of in the new on-site disposal facility designed to accommodate that volume and 1.1 mcy of nonhazardous solid waste that would meet the WAC and be disposed of at the C-746-U Landfill.

6.4.1 Overall Protection of Human Health and the Environment

The On-Site Alternative would protect human health and the environment by placing waste in an engineered on-site disposal facility specifically sited, designed, constructed, operated, monitored, and maintained to contain the waste and minimize long-term environmental effects. This alternative would meet RAOs by ensuring that waste disposed of in an on-site disposal cell meets the WAC established for the facility. Waste exceeding the WAC would be packaged and transported for disposal at a permitted off-site disposal facility.

Human health and the environment would be protected in the vicinity of the C-746-U Landfill by disposing of the contaminated material at facilities designed, equipped, and operated to handle these wastes. Operation of these facilities is not likely to result in exposure to waste or releases to the environment because the facilities are designed, licensed, monitored, and maintained to ensure reliable waste containment. Recycling, if performed, would decrease the volumes to the receiving off-site facilities and the C-746-U Landfill and return these metals to service, thereby increasing the overall protection of human health and the environment.

A new on-site waste disposal facility would be designed to control releases to groundwater, soils surface water, and air, and to prevent inadvertent intrusion into the waste. The facility would be designed such that components would be operational and effective throughout operations and the postclosure periods, and containment would remain effective for 1,000 years to the extent practicable. Protection following closure also would be maintained by active institutional and engineering controls (including physical restrictions, groundwater use restrictions, monitoring, and maintenance) and permanent restrictions on land use (e.g., deed restrictions). SM&M activities and institutional/engineering controls would be continued for as long as the material placed in the facility posed an unacceptable risk to human health and environment.

Uranium-bearing materials (requiring nuclear criticality safety controls) that have accumulated inadvertently in the systems and components will need to be assessed following shutdown of the facility. This uranium-bearing material is expected, based on observations at other facilities, to be in the form of an encrustation formed as a result of the process gas in the system reacting with the moisture in the ambient air. Some uranium holdup deposits may exceed the nuclear criticality safety limits or levels determined for the WAC of the receiving facility. Deposits that do not meet the WAC of the receiving facility would need to be removed by segregation or treatment or decontaminated for on-site or off-site disposal. There is a potential for excessive hold-up material (or deposits); therefore, lessons learned from the shutdown of the PORTS GDP and from Oak Ridge will be considered, and rigid procedures to reduce the potential risk of criticality will be followed. The On-Site Alternative would be protective of human health and the environment through the following methods.

Preventing exposure to waste. An on-site disposal facility would be designed to reduce risk to human and ecological receptors by preventing direct contact with or incidental ingestion of contaminants. The conceptual design includes a final cover layer including a bio-intrusion layer of large rounded cobbles to discourage inadvertent intrusion into the waste. Exposure to the wastes by direct contact or incidental ingestion pathways would be eliminated as long as the cap is properly maintained and intrusive activities are prohibited through access restrictions and administrative controls.

Preventing surface transport of contaminants. The final cover of an on-site disposal facility would be designed to prevent erosion and/or slope failure, which otherwise could lead to surface transport of contaminants to human or ecological receptors. Stormwater management provisions would be incorporated into the design, including maintenance of vegetation on the disposal cell cover to stabilize the surface soils and minimize erosion as well as stormwater controls across the site.

Preventing fugitive dust emissions. Containment of waste within a lined and capped on-site disposal facility would remove the inhalation pathway by preventing air dispersal of contaminants. The disposal cell cover and most open areas within the site would be maintained with vegetation to stabilize the surface of the cell, minimizing fugitive dust.

Preventing or reducing leachate migration. An on-site disposal facility would include a double liner and a leachate control system to prevent migration of contaminants to surface water and groundwater. Control of leachate would prevent exposure via ingestion of or direct contact with contaminated groundwater or surface water and also would prevent migration to potential environmental receptors. Monitoring of potential migration pathways would allow evaluation of the effectiveness of waste containment and would provide advance warning of potential release so that appropriate mitigation measures could be taken.

Reducing risks to industrial workers. Human health and environmental risks from on-site waste transport and disposal activities would be minimized because the activities would be conducted by trained personnel in accordance with DOE requirements, and approved health and safety plans.

6.4.2 Compliance with ARARs

The On-Site Alternative would comply with ARARs and pertinent TBC guidance, with the exception of the TSCA requirement for a 50-ft buffer between the base of the liner and the top of the water table. Waste treatment is not included as part of this action; treatment would be evaluated and performed on a project-specific basis to ensure that the waste meets disposal facility WAC. ARARs relevant to recycling, if recycling is performed, also would be complied with. For purposes of this FS, consolidation of wastes at an on-site CERCLA waste disposal facility is to be an on-site action in accordance with the CERCLA definition of on-site and authority Section 104(d)(4) (42 *USC* 9604(d)(4). ARARs for the On-Site Alternative are provided in Appendix G.

Chemical-specific ARARs generally set cleanup or discharge limits for specific hazardous substances or contaminants. Because no specific sites or media would be remediated under this action, no chemical-specific ARARs for contaminant cleanup levels apply.

Location-specific ARARs impose restrictions on activities on the basis of sensitive resources at the site. Location-specific ARARs for this alternative were identified for the final candidate sites (Appendix G). Although no significant cultural resources were identified within the facility footprint at the candidate sites, ARARs triggered by future discoveries of cultural resources are addressed as a contingency, if these resources were discovered at a later date or the footprint were to be changed.

Action-specific ARARs for on-site disposal address construction, operation, closure, and postclosure care of an on-site waste disposal facility. On-site disposal would invoke CERCLA provisions for exemption from permitting requirements, although substantive requirements would still be met. Action-specific ARARs include design components for a disposal facility based on the overriding priority to dispose of wastes in a manner protective of human health and the environment over both the long- and short-term. These ARARs include substantive requirements drawn from RCRA, TSCA, and Commonwealth of Kentucky regulations, as well as other state and federal laws. Portions of the CAMU Rule under 40 *CFR* Part 264 Subpart S have been identified as applicable requirements under the ARARs. The design and closure requirements for the On-Site Disposal Alternative will not be based on the CAMU provisions, but rather designed and closed in accordance with ARARs associated with RCRA hazardous waste TSCA chemical waste landfills, and the design/closure ARARs identified for low-level waste landfills.

The on-site disposal facility design would incorporate TSCA requirements for a chemical landfill to accommodate wastes containing PCBs at concentrations greater than 50 ppm. A CERCLA ARAR waiver would be needed for the TSCA requirement for a 50-ft buffer between the base of the liner system and the top of the water table because this buffer would not be achievable for an on-site disposal facility located at any of the final candidate sites.

An “equivalent standard of performance” waiver of the 50-ft buffer requirement would be invoked in accordance with CERCLA §121(d)(4)(D), which provides that “…the remedial action selected will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, criteria, or limitation, through the use of another method or approach.” A geologic buffer zone would be provided such that it transmits equal or less water than a 50-ft thickness of the native subsoils. ORR sought and received this type of waiver for the EMWMF. ORR performed a side-by-side comparison of the EMWMF design and a TSCA-compliant design in the ROD. This comparison demonstrated that the EMWMF design would prevent contamination from escaping from the cell for a much longer period than a TSCA-compliant design.

The base case and low-end waste volume scenarios for the On-Site Alternative include the use of the existing C-746-U Landfill for disposal of waste meeting the WAC of the C-746-U Landfill. The C-746-U Landfill has been issued a permit by the Commonwealth of Kentucky, which includes requirements for waste acceptance. The requirements contained in the landfill permit apply to all wastes received for disposal in the unit.

6.4.3 Long-Term Effectiveness

6.4.3.1 Magnitude of risk: long-term considerations

Under this alternative, wastes meeting the WAC would be placed in a new on-site waste disposal facility. Wastes not meeting the WAC would be shipped to an off-site facility for disposal. The PWAC development and results presented in Section 5.4.6 show that is it possible for the On-Site Alternative to ensure long-term effectiveness.

Potential risks from disposal of waste meeting the WAC of the C-746-U Landfill at the C-746-U Landfill under the base case and low-volume waste scenarios are outside the scope of this analysis. Recycling is considered to meet the long-term effectiveness of the On-Site Alternative by decreasing the volume of waste being disposed of in the on-site facility or in the C-746-U Landfill and returning the materials to a state where they may be reused.

6.4.3.2 Long-term adequacy and reliability of controls

The On-Site Alternative uses proven technologies to protect human health and the environment and meet RAOs. Reliance on proven technologies reduces uncertainty associated with this alternative. Three types of controls would be incorporated into the disposal facility design: engineered controls, SM&M, and institutional controls.

Engineered controls would be built into the cell to prevent exposure to contaminants and to prevent, detect, and mitigate contaminant releases. The liner system would mitigate releases of leachate to groundwater for its design life, which is anticipated to be at least 100 years (assumed to be 200 years for the purposes of this RI/FS). The leachate collection system above the primary liner and the detection system below would be effective for the postclosure period. The secondary liner and geologic buffer would provide long-term control of leachate release. These controls would be effective throughout their minimum 100-year design life. The disposal cell cap (final cover) would prevent airborne releases and direct contact with or exposure to the waste. The thickness of the cap and the presence of the biointrusion layer consisting of large, rounded cobbles would discourage inadvertent penetration by humans and would prevent or minimize damage from burrowing animals and tree roots for hundreds of years. The disposal cell and cap would be designed to remain stable under expected environmental conditions, including possible erosion, weathering, and earthquakes. Aside from intentional human disturbance or major global climate changes, no other credible scenarios for exposing human or ecological receptors to the waste have been identified.

PGDP is situated near the NMSZ, which is a seismically active region; therefore, landfill components would be designed to resist damage from strong earthquake shaking. Landfill components would be designed for stability under anticipated conditions throughout the facility's operating life and during the postclosure period and for 1,000 years after closure to the extent practicable. Seismic hazard evaluations for PGDP indicate that the maximum earthquake-induced seismic loading can be characterized with ground surface PGA ranging from 0.3 g to 0.5 g (with the final design PGA to be determined based upon the results of site-specific site response analysis). Landfill components (liner, cover, and leachate systems) that contain waste would be designed to maintain structural integrity when subjected to the maximum earthquake (i.e., design seismic loading). If the On-Site Alternative is selected, an in-depth evaluation of construction materials and a seismic stability analysis would be performed to address fully seismic loading and its impacts on the final design.

Institutional controls and engineering controls would restrict access to the on-site facility and use of local groundwater. Site access controls (fences, signs, gates, or other physical barriers) would remain in place, and land use restrictions would be permanent. SM&M of the facilities and monitoring to determine the effectiveness of the primary controls would continue throughout the postclosure period. SM&M activities and required institutional/engineering controls would be continued for as long as the material placed in the facility posed an unacceptable risk to human health and environment.

Waste shipped off-site would be sent to facilities that are licensed and permitted by EPA and other federal and state regulatory agencies that are approved to accept CERCLA wastes in accordance with the CERCLA Off-Site Rule. Section 6.3 for the Off-Site Alternative presents additional information relative to packaging, transport, and shipment of PGDP waste to off-site disposal facilities.

6.4.3.3 Long-term environmental effects

For the purpose of this evaluation, long-term environmental effects are those impacts that may occur following closure of an on-site disposal cell. The facility would accept waste through 2039, with final cap closure expected by FY 2044. Long-term protection of environmental resources would be provided through facility design, WAC compliance, engineered controls, SM&M, and institutional controls. The potential long-term environmental effects are described here.

Transportation. The traffic resulting from workers accessing an on-site waste disposal facility to maintain institutional and engineering controls and perform monitoring would be negligible. Environmental effects associated with such transportation, such as socioeconomic, air quality, commitment of resources, and wildlife impacts, also would be negligible. Similarly, the environmental effects associated with transportation for long-term monitoring and maintenance of an off-site disposal facility, which would receive the relatively small volume of PGDP waste that fail to meet the on-site WAC, also would be minimal.

Air Quality. No long-term impacts to air quality would be expected once the final permanent cover is placed and the waste cell and borrow areas are closed. It is not anticipated that ventilation will be a part of the design, as it could lead to release of fugitive emissions including radionuclide emissions. The potential for the generation of methane gas would be calculated to estimate the quantity of degradable organic material (e.g., wood, cleared vegetation, etc.) that could be placed in the landfill. If the cover were to be compromised, fugitive air emissions, including radionuclide emissions, could be generated. PGDP waste shipped to an off-site facility would have similar potential for fugitive emissions if the off-site landfill cover were compromised. The potential for radon emission from the cover system is discussed in Appendix C, Attachment C7, Section C7.1.2.3; this analysis, which quantified radon emissions for the C-746-U Landfill, indicated that no radon would escape the first layer of the C-746-U Landfill cap. The conceptual design cover system is thicker and includes more layers than the C-746-U Landfill cover system design; therefore, the radon modeling results for the C-746-U Landfill may be extended to be the conceptual design for this project.

Surface Water Quality. An on-site disposal facility would be designed, constructed, and maintained to prevent releases or cap erosion that could adversely affect surface water quality. The cell, therefore, would be designed to resist erosion with minimal maintenance. Extensive erosion so severe that it would breach the containment systems is unlikely. Contaminant releases to surface water from leachate migrating from the cell via groundwater also are unlikely, but eventually could impact surface water quality through groundwater outcropping. The PWAC for on-site waste disposal cell prototype locations presented in Section 5.4.6 and Appendix C considers groundwater impacts at the nearest surface water body along a groundwater flow line. The impacts to surface water at seeps, local creeks, and the Ohio River would be far less than groundwater impacts at the selected exposure point; therefore, surface water impacts would be negligible.

An off-site disposal facility receiving PGDP waste will have design, monitoring, and maintenance to prevent inputs to surface water.

Groundwater Quality. An on-site disposal facility would be designed, constructed, and maintained to prevent or minimize contaminant releases to groundwater. Control elements would include a multilayer cap to minimize infiltration, synthetic and clay barriers in the liner, a geologic buffer, monitoring of the disposal facility performance, and institutional controls that would include land and groundwater use restrictions. Mitigative measures would be implemented to protect human health and the environment if releases were detected during the postclosure period. Long-term impacts to groundwater quality resulting from the implementation of this alternative would be expected to be insignificant.

While the modeling performed for this RI/FS Report (Section 5 and Appendix C) focuses on the two prototype sites, 3A and 11, groundwater modeling would be performed for the a different candidate site if selected.

An off-site disposal facility receiving PGDP waste will have design, monitoring, and maintenance to prevent inputs to groundwater.

Terrestrial Biotic Resources. The land surface at a new on-site waste disposal facility would be altered to a natural grass habitat with some shrubs and small trees as part of the hydraulic control and landscaping in the area surrounding the disposal cell. Subsequent to waste disposal facility construction, construction support facilities (e.g., storage units, screeners, trailers, etc.) would be removed and portions of the area would be regraded and seeded with native vegetation to mitigate habitat loss. Wildlife species displaced by the construction and operation activities (see Section 6.4.5.3) would reoccupy these areas following closure; however, the species composition and diversity may be different than originally present. Birds and small mammals in the surrounding area may forage in the disturbed area as the vegetative cover develops. Large mammals (e.g., deer) would continue to be excluded from the area by an access control fence.

Because active institutional controls would continue for an indefinite period, trees would be prevented from growing on the surface of the disposal cell, but likely would be allowed to grow between the fence line and the surface of the disposal facility, eventually providing a small area of fragmented forest habitat. If institutional controls were to cease, the disposal cell area eventually would progress toward an upland forest habitat and animals would reoccupy this small area. The specific design of the final cover layer would prevent burrowing by animals and would discourage growth of deep-rooted trees, but would not prevent tree establishment over the long-term. Plant uptake of contaminants could become an exposure pathway if roots were to penetrate the cap, but these contaminants would be unlikely to impact biotic resources. Uprooting of trees may compromise cap integrity by allowing infiltration and erosion to occur unless repairs are made.

There may be impacts to the terrestrial biotic resources resulting from the eventual loss of integrity of the landfill cover and/or liner. This could result in leachate reaching surface water. The long-term commitment to engineering controls, SM&M, and institutional controls results in the viability of the No Failure scenario for PWAC development and, consequently, the WAC.

Site 3A is close to existing PGDP facilities where biological resources are already impacted. Construction and operations at an on-site disposal facility would have no impact on the existing transient fauna and the limited flora in the area. Relocation of power lines at Site 3A likely would result in additional impacts to terrestrial biological resources. The specific impacts would depend on the route taken to relocate the power lines and the flora and fauna present in those areas. Once the power lines are relocated, the right-of-way area would be maintained as grassland by regular mowing. Site 11 is in a more remote area of PGDP with less impacted terrestrial biota, although the nearby C-746-U Landfill already has affected this resource. Information on the two prototype sites is detailed here as examples of how this criteria would be satisfied. This process would be repeated if one of the other candidate sites were selected.

An off-site disposal facility receiving PGDP waste will have design, monitoring, and maintenance to prevent inputs to terrestrial biotic resources.

Aquatic Biotic Resources. The potential for impacts to aquatic habitats and biota in the vicinity of disturbed areas would decrease substantially following capping and closure of an on-site waste disposal facility. Maintenance of the impervious cap would increase the volume of surface water runoff to the immediate area; however, the vegetative cover would intercept some precipitation and stabilize soils minimizing erosion and sedimentation of adjacent surface waters. Erosion of the cap is unlikely even if institutional and engineering controls cease because of the relatively gentle slopes, riprap erosion protection on the side slopes, and native grass cover on the top.

An off-site disposal facility receiving PGDP waste will have design, monitoring, and maintenance to prevent inputs to aquatic biotic resources.

Wetlands and Floodplains. Potential wetlands are located within or near the proposed waste disposal facility footprints of both prototype sites. Potential wetlands within Site 3A tend to be discontinuous areas associated with man-made obstructions to natural drainages, topographic depressions, and man-made drainages for control of stormwater runoff from the industrial area of PGDP. Some of the potential wetlands have open water during parts of the year and others consist of herbaceous vegetation in low-lying areas and drainages. Potential wetlands are located within the area of the waste disposal footprint at Site 3A where impacts to wetlands would have long-term consequences. Relocation of power lines at Site 3A likely would result in additional impacts to potential wetland areas; the specific impacts would depend on the relocation route.

Potential wetlands within Site 11 tend to be small, discontinuous areas and are located primarily outside of the waste disposal footprint. Few potential wetlands are located within the area of the proposed disposal cell location at Site 11 where impacts to wetlands would have long-term consequences.

Direct long-term impacts may include the destruction of potential wetlands located within areas that would be cleared for the facility. After the short-term facilities are removed, a portion of the land occupied by the facilities would return to a natural state. This could include the natural creation of wetlands.

Measures that mitigate the adverse effects of actions in a wetland may include, but are not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically-sensitive areas; however; any necessary mitigation activities would be identified at a later date. In the event the on-site alternative is selected and the location chosen impacts wetlands; mitigation activities would be incorporated into facility design where such impact occurs. The United States Army Corp of Engineers would be consulted.

Indirect long-term impacts could include increased sedimentation from stormwater runoff and increased soil erosion, particularly once maintenance of the engineering and institutional controls, such as stormwater controls, side-slope maintenance, and vegetative cover, have ceased. If the cap were compromised, leachate could be generated and released to the surrounding area.

Neither of the prototype sites is within the 100-year floodplain, although Site 11 would have a portion of a berm within the 500-year floodplain. Conceptual design for either prototype site does not include any permanent components to be located within a floodway. Consequently, an on-site disposal facility would not restrict floodplain water flows or reduce the temporary water storage capacity of the floodplain during 100-year and 500-year storm events. The facility would not be placed in a manner likely to result in washout of waste posing a hazard to human health, wildlife, or land or water resources. Information on the two prototype sites is detailed here as examples of how this criteria would be satisfied. This process would be repeated if one of the other candidate sites were selected.

Minimal engineering controls would be required to protect an on-site disposal facility from stormwater associated with a 100- or 500-year storm event. Direct impacts from these engineering controls would include diversion of stormwater from the site. This additional volume would not measurably contribute to flooding around the perimeter of a disposal cell and would not measurably increase the footprint of the floodplain surrounding an on-site disposal facility. Indirect impacts could include negligible increase in sedimentation in the surrounding area from stormwater diversion.

Impacts to wetlands or floodplains are not anticipated for an off-site disposal facility receiving PGDP waste or for the C-746-U Landfill under the low-end scenario.

Threatened and Endangered Species. The only current T&E species that potentially would be impacted at either of the prototype sites in the long-term is the endangered Indiana bat. PGDP is within the Mississippi River Recovery and Mitigation Focus Area, and also the assemblage of Indiana bat maternity colonies are in Ballard, Carlisle, Hickman, and McCracken Counties. One of the primary owners is the West Kentucky Wildlife Management Area. When the facility site returns to a natural state, it is conceivable that critical habitat for the bat could also naturally reestablish. If relocation of power lines were required, there could be additional impacts to habitat, with the specific impacts depending on the relocation route.

Long-term impacts to T&E species are not anticipated for an off-site disposal facility receiving PGDP waste.

Cultural Resources. The COE (1994) survey of cultural resources near PGDP did not identify any archaeological or historical resources in the vicinity of candidate disposal facility sites. If archaeological or historical artifacts or sites were to be discovered during construction, necessary measures (e.g., site mapping, artifact and data collection) would be performed in the short-term to mitigate long-term impacts. Impacts to currently unidentified adjacent cultural resources could result after cessation of engineering and institutional controls in the long-term, such as from erosion and stormwater run-on.

Impacts to cultural resources are not anticipated for an off-site disposal facility receiving PGDP waste.

Aesthetic Impacts. After closure, the waste disposal facility would remain visible for the foreseeable future, although reestablishment of forests would provide some visual buffer. The closed cell would appear as a flat-topped, low mound, with riprap sides and grass across the majority of the cap. If institutional controls were to cease, eventual reforestation of the area would reduce the contrast of the facility with the surrounding woodland, but the man-made shape of the facility would remain.

PGDP is located in an area relatively remote from sizeable communities and major highways, although some residences are nearby, and a portion of the surrounding area is used for recreational purposes; however, future development of areas around PGDP, such as community centers and other residential developments, cannot be predicted. It is assumed for assessment of visual impacts that future developments in the long-term would dominate along existing major highways, such as U.S. Highway 60. Site 3A, near the entry to the DOE-owned property, is more than a mile north of Highway 60 and distant from potential future development. Site 11 is further north and more remote from Highway 60, but is near Ogden Landing Road. Both Site 3A and Site 11 are near the perimeter boundaries of the DOE-owned property, so a facility at either site could impact visual aesthetics for recreational users or future community centers, roads, or residential areas. If relocation of power lines were required near the DOE boundary at Site 3A, there could be additional aesthetic impacts to natural areas that would be converted to maintain grasslands within the right-of-way of the rerouted lines.

Noise impacts from long-term SM&M of an on-site disposal facility would be limited to operation of the pumps and leachate treatment systems during the postclosure period. The noise from these operations may be mitigated by reestablishment of forests in the buffer area between the facility and community members and recreational users in the area. No significant noise would be generated in the long-term after cessation of the postclosure period.

Long-term impacts to aesthetics are not anticipated for an off-site disposal facility receiving PGDP waste.

6.4.3.4 Socioeconomics and land use: long-term considerations

No long-term socioeconomic impacts are anticipated from the presence of an on-site waste disposal facility or from the associated long-term monitoring and maintenance. When cleanup actions are complete, the on-site CERCLA disposal facility would be capped and would receive no further waste. The only activities would be long-term SM&M, which would require a limited workforce. This workforce would represent a small portion of the current total employment at PGDP, and the long-term effects on socioeconomics from these activities would be negligible.

No long-term socioeconomic impact would occur in the vicinity of off-site disposal facilities receiving PGDP waste. The relatively small volume of waste disposal from PGDP would have no discernible effect on the workforce required for operations and maintenance at these existing facilities.

Presence of a waste disposal facility on DOE property would be consistent with existing industrial land use and would be consistent with existing and anticipated future land use, which is also projected to be industrial. Impacts to land use and resulting impacts to regional socioeconomics would be limited to a 110-acre site in the long-term, and no changes in local population or nearby industrial or commercial operations would be expected.

6.4.3.5 Irreversible and irretrievable commitment of natural resources: long-term considerations

An on-site disposal facility would result in the irreversible and irretrievable commitment of natural resources. This would affect 95 acres for the high-end waste volume scenario in the long-term: 43 acres for the waste disposal footprint and 52 acres for the surrounding earthberm. The remaining 15 acres would be used for short-term support facilities that later would be removed and eventually returned to a natural state. SM&M for the disposal facility is projected to continue for at least 100 years (for the RI/FS; 1,000 years was used for cost estimating purposes) after the final cap installation.

6.4.3.6 Long-term cumulative environmental impacts

Cumulative environmental impacts result from the incremental impact of an action when added to past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes the actions. Cumulative impacts could result from individually minor but collectively significant actions taking place over a period of time in the long-term.

Construction of an on-site waste disposal facility might encourage additional industrial development of the surrounding area, resulting in cumulative loss of wildlife habitat; cumulative degradation of air, land, and water resources; and loss of recreational opportunities. However, this could result in cumulative benefit to socio-economics in the region. It is also possible that the presence of such a facility could discourage industrial development. Additionally, the presence of a waste disposal facility likely would impact future land use decisions on adjacent property, such as discouraging residential and commercial development in the immediate area.

Construction of an on-site facility commits land to DOE control for an indefinite period, which could encourage increased DOE use of the property.

If additional cleanup activities were undertaken in the future, then capacity would be available for consideration for disposal in the on-site waste disposal facility. In addition, removal of wastes and contamination from more on-site areas could result in positive long-term environmental effects by reducing the potential for exposure to and migration of contaminants. The loss of wildlife habitat and future land use at the disposal cell may be partially offset by cleanup and release of additional sites.

After disposal of D&D waste, the PGDP will have been removed, completing the majority of DOE cleanup goals for the site. The closure of PGDP will reduce overall employment in the area.

6.4.3.7 Environmental justice: long-term considerations

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations*, requires agencies to identify and address disproportionately high and adverse human health or environmental effects their activities may have on minority and low-income populations. Although there is a disproportionately high percentage of minority and low-income populations within 50 miles of the PGDP site (DOE 2004), the census tracts closest to PGDP do not report a higher proportion of minorities or low-income populations than the national average. Consequently, there would be no disproportionately high and adverse human health or environmental effects to minority populations and low-income populations in the long-term.

6.4.4 Reduction in Toxicity, Mobility, or Volume

PGDP wastes may require treatment to meet the WAC of an on-site disposal facility. For example, the small volume of waste designated for off-site disposal would be treated as necessary prior to transport or treated at the off-site disposal facility before disposal.

Disposal of CERCLA waste in an on-site disposal facility would reduce the mobility of the contaminants by isolating the waste from the environment, but would not reduce the toxicity or volume of waste. The low-end waste volume scenario assumes waste reduction through recycling and reuse initiatives. Recycling is considered to meet the long-term effectiveness of the On-Site Alternative by decreasing the volume of waste being disposed of on-site or in the C-746-U Landfill and returning the materials to a state where they may be reused.

6.4.5 Short-Term Effectiveness

For purposes of this evaluation, short-term refers to the period of construction, operation, and closure of an on-site waste disposal facility, but does not include the postclosure period (see Section 6.4.3 for evaluation of long-term effectiveness). This FS does not address removal activities, waste or residuals potentially left in place, or the risk associated with these elements at individual SWMUs or AOCs being remediated at PGDP. Recycling is considered to meet the short-term effectiveness of the On-Site Alternative by decreasing the volume of waste being disposed of on-site or in the C-746-U Landfill and returning the materials to a state where they may be reused.

6.4.5.1 Protection of the community during remedial action

For the On-Site Disposal Alternative, potential risk to the public could result from on-site transportation and limited off-site transportation of hazardous and radioactive waste, transportation of construction materials, traffic associated with the site workforce, operation of an on-site waste disposal facility, and windborne dispersion of contaminants. Risk to the public from waste handling and disposal activities at PGDP would be low because of the protective and control systems employed during operation. Public access would be restricted at on-site and off-site disposal facilities and at waste generation, packaging, and handling sites.

Vehicles operating in support of construction, operation, and closure of an on-site waste disposal facility could impact the public, but waste hauling between the PGDP remediation sites and a new on-site waste disposal facility would be entirely on DOE-owned property. The risk from off-site vehicular traffic related to workers commuting to the site from the community is low due to the relatively low number of workers involved. The risk from vehicular traffic associated with delivery of equipment and materials used in the construction of an on-site disposal facility would be intermittent and similar to transport associated with other limited industrial operations, and is therefore considered low. Selection of appropriate transport routes, compliance with DOT requirements, and adherence to project-specific transportation safety procedures would minimize risk.

Risks associated with off-site transport of waste are dependent on the number of miles traveled. Under this alternative, it is assumed that 5% of the forecasted waste would require off-site disposal because it would exceed the WAC of an on-site disposal facility. It is assumed that this waste would be transported by rail to Energy*Solutions*. Using rates for rail transportation, the total number of injuries and fatalities for the transportation of this waste is anticipated to be less than 1, (see Appendix E, Attachment 1 for more detail) (Saricks and Tomkins 1999). The low-end volume scenario would dispose of waste meeting the WAC of the C-746-U Landfill in the C-746-U Landfill, but also would require some additional transportation of LLW and MLLW to off-site disposal facilities. Selection of appropriate transport routes, compliance with DOT packaging and other requirements, and adherence to project-specific transportation safety and spill prevention, control, and countermeasures plans would minimize the likelihood of an accident and the severity of a release if an accident were to occur.

The operation of an on-site waste disposal facility would result in the generation of fugitive dust. Air monitoring would be conducted during operation to prevent release of contaminants above ARAR thresholds. Dust suppressants or covers would be used as necessary to mitigate releases of fugitive dust from the site to protect both workers and the public.

6.4.5.2 Impact to workers during remedial action

The primary risks to workers for this alternative would result from construction, waste handling, and disposal activities. Insignificant risk would result from transport of small volumes of waste off-site. These activities would be conducted by trained personnel in accordance with transportation requirements, DOE requirements, and approved health and safety plans. Worker exposure would be minimized by compliance with DOT and DOE waste packaging, transport, and handling requirements; the use of shielding and PPE; limits on work schedules; and other operational restrictions, such as spacing and distancing, to ensure that radiation doses to workers are kept below 5,000 mrem/year. The overall risk to site workers for this alternative would be low.

6.4.5.3 Short-term environmental effects

Terrestrial Biotic Resources. Construction and operation of an on-site waste disposal facility would have direct and indirect impacts on the terrestrial habitats, plants, and animals present within the 110-acre area. Removal of existing vegetation during construction of the disposal facility would eliminate existing habitat and change it to an urban/industrial cover type consisting of mowed grass, riprap, gravel and/or paved areas, buildings, and landscaping. Site preparation activities for development of the on-site waste disposal facility could cause the direct loss of some less mobile wildlife species (e.g., small mammals or nesting birds), while other species of wildlife would be displaced from the cleared areas. Construction and operation activities and the associated noise, vibration, vehicle emissions, fugitive dust generation, and human presence also could disturb wildlife species occupying habitats adjacent to the selected site. This could result in the emigration of some sensitive species from the surrounding area, although many species would adapt to the disturbance. Large mammals would be largely excluded from controlled areas by access control fences.

Site 3A is close to existing PGDP facilities where habitat and biological resources already are impacted. Specific additional impacts therefore would be limited. Some loss would result to mowed grass and landscaped areas, old field grassland crops, and limited field scrub-shrub habitat. Wildlife located within this type of habitat is generally limited to transient wildlife occupation and more continuous occupation by species that have adapted to heavily industrialized environments (e.g., European starling, pigeon, house mouse, groundhog). A right-of-way for overhead power transmission lines within Site 3A also contains open mowed grass areas. Located south of the right-of-way are patches of oak-hickory upland forest fragmented by areas of old field grassland crops and field scrub-shrub habitat. Typical wildlife found within the area includes deer, opossums, squirrels, songbirds, owls, hawks, and other small mammals. Various amphibians, reptiles, and terrestrial invertebrates (e.g., insects and spiders) are also present. Relocation of power lines at Site 3A likely would result in additional impacts to terrestrial biological resources. The specific impacts would depend on the location of the rerouted lines and the flora and fauna present. Once the power lines were relocated, the underlying right-of-way would be maintained as grassland by regular mowing.

Specific impacts on the terrestrial biotic communities at Site 11 mostly would be to old field grassland crops and field scrub-shrub habitat. Site preparation activities would result in the loss of oak-hickory upland forest, old field grassland crops, and open mowed grass areas.

Impacts to terrestrial biotic resources are not anticipated for an off-site disposal facility receiving the relatively small volume of PGDP waste.

Aquatic Biotic Resources. Aquatic biotic resources are limited within the areas proposed for an on-site waste disposal facility, although a small portion of a tributary to Little Bayou Creek would need to be relocated at Site 11. Direct and indirect impacts from the construction and operation of a disposal facility are anticipated to be minimal.

Wetlands and Floodplains. Federal regulations (10 *CFR* § 1022) require that the effects of any actions that could impact wetlands or floodplains be considered and any destruction, loss, or degradation of wetlands be minimized to the extent practicable. Potential wetlands are located within or near the proposed waste disposal facility footprints at both Site 3A and Site 11; wetland characteristics at each site are detailed in Section 6.4.3.3. Direct impacts would include the destruction of potential wetlands located within areas that may be cleared during site preparation activities on the 110-acre site. Indirect short-term impacts could include increased sedimentation from stormwater runoff and increased soil erosion. Construction of an on-site facility also could indirectly impact the hydrology of potential wetlands that are adjacent to the disturbed areas. Relocation of power lines at Site 3A likely would result in additional impacts to potential wetland areas; the specific impacts would depend on the relocation route.

In the event the on-site alternative is selected and the location chosen impacts wetlands; mitigation activities would be incorporated into facility design where such impact occurs. The United States Army Corp of Engineers would be consulted.

Neither of the prototype sites is located within the 100-year floodplain, and Site 11 would have only a small portion of the facility berm within a 500-year floodplain. No structures or features at either site would restrict water flow in the short-term. Conceptual design for either site does not include permanent components located within a floodway or that otherwise would reduce temporary water storage capacity of the floodplain during 100-year or 500-year storm events. The facility would not be placed in a manner likely to result in washout of waste in the short-term posing a hazard to human health, wildlife, or land or water resources.

Minimal engineering controls would be required to protect an on-site disposal cell and its support facilities from storm water associated with a 100- or 500-year storm event. Direct impacts from these engineering controls would include diversion of storm water from the site. This additional volume would not measurably contribute to flooding around the perimeter of the site and would not measurably increase the footprint of the floodplain surrounding the site. Indirect impacts could include negligible increase in sedimentation in the surrounding area from stormwater diversion.

Short-term impacts to wetlands or floodplains are not anticipated for an off-site disposal facility receiving PGDP waste or for the C-746-U Landfill under the low-end volume scenario.

Threatened and Endangered Species. The only critical habitat for T&E species potentially impacted in the short-term is critical habitat designated suitable for the endangered Indiana bat at prototype Site 11. Construction of an on-site disposal facility at Site 11 would adversely affect this critical habitat. The potential impact on the bat habitat could be minimized by selecting a site with less natural habitat. Construction and operation of an on-site waste disposal facility may require that mitigation action be taken. Mitigation costs have been incorporated into the cost estimate for Site 11 (see Appendix I).

No impacts to T&E species are anticipated for an off-site disposal facility receiving PGDP waste.

Cultural Resources. The COE (1994) survey of cultural resources near PGDP did not identify any archaeological or historical resources in the vicinity of candidate disposal facility sites. If archaeological or historical artifacts or sites were to be discovered during design or construction, work in the area would cease and would not resume until the significance of the resource was determined.

No short-term impacts to cultural resources are anticipated for an off-site disposal facility receiving PGDP waste failing.

Aesthetic Impacts. The short-term support facilities and work areas at the site would be of lower height than the on-site disposal cell being constructed. These support areas and facilities would not be visible from the community or along Highway 60 and would have *de minimis* aesthetic visual impact.

During construction and operations in the short-term, a disposal facility would be visible as described in Section 6.4.3.3. It is unlikely that a facility at either Site 3A or Site 11 would be visible from Highway 60; the highway is approximately one mile from Site 3A, and even farther from Site 11 and from most areas in the community. It would be visible from certain areas of the roads leading to each site and possibly from certain residences. If relocation of power lines required conversion of undisturbed wooded areas to maintained grasslands within the right-of-way, there could be additional aesthetic impacts.

Noise impacts from construction operations would be mitigated by vegetation in the buffer area between the site and the communities and recreational users in the area. Operations would occur only during the daytime to mitigate noise disturbance to local residents.

6.4.5.4 Socioeconomics and land use: short-term considerations

Design, construction, and operation of an on-site waste disposal facility would not be expected to have adverse impacts on local socioeconomic resources such as population, employment, housing, schools, public services, or local government expenditures (i.e., utilities, hospitals, and police and fire protection). Jobs created by the project would add to the economic and tax base for the region.

Design, permitting, and other preparatory activities would require a substantial and educated workforce. During construction, the number of workers on-site would vary depending on the work being performed and the volume of waste being handled at the time. For operation, the number of full-time staff would be limited and part-time workers would likely be used for intermittent tasks such as sampling. The number of workers that would be required for off-site waste handling and transportation under this alternative also would be limited, required only intermittently, and for a relatively short period of time. The workforce required to implement this alternative likely would be drawn from the local labor market, resulting in minimal influx of workers to the area. Consequently, no significant change in population or associated housing and services is anticipated.

For the off-site disposal component of this alternative, off-site disposal of PGDP waste would have no short-term socioeconomic impact in the vicinity of the receiving facilities. The relatively small volume of waste to be disposed of from PGDP is expected to have no discernible effect on the workforce required for operations at these facilities.

Presence of a waste disposal facility on DOE property would be consistent with existing industrial land use and would have only minimal impact on short-term land use, such as recreational use or further industrial development. Short-term impacts to land use and resulting impacts to regional socioeconomics, such as changes in local population or nearby industrial or commercial operations, are anticipated.

6.4.5.5 Irreversible and irretrievable commitment of resources: short-term considerations

As indicated in Section 6.4.3.5, the long-term effects of an on-site disposal facility would be permanent and would result in an irreversible and irretrievable commitment of natural resources for approximately 95 acres of land. The remaining 15 acres would be used in the short-term for support facilities that later would be removed and eventually returned to a natural state. Consequently, these 15 acres would be used only temporarily.

6.4.5.6 Short-term cumulative environmental impacts

Construction activities for an on-site waste disposal facility might encourage additional concurrent construction activities in the surrounding area, resulting in cumulative loss of wildlife habitat; degradation of air, land, and water resources; loss of recreational opportunities; and increase in commitment of energy and resources; however, this could result in cumulative short-term benefit to socioeconomics as more workers are brought to the area for construction. It is also possible that the presence of such a facility could discourage industrial development. Additionally, the presence of a waste disposal facility likely would impact future land use decisions on adjacent property, such as discouraging residential and commercial development in the immediate area.

Construction of an on-site facility and support facilities assumes indefinite DOE control and, therefore, minimizes short-term environmental effects. This could encourage other concurrent short-term DOE activities to maintain beneficial use of the property. Such activity at the site could include other construction activities, with consequential cumulative impacts, as described above.

If additional cleanup were encouraged by the presence of an on-site waste disposal facility, removal of wastes and contamination from more sites could result in positive environmental effects by reducing the potential for exposure to and migration of contaminants; however, there also would be additional disturbance at these sites in the short-term. The loss of wildlife habitat and future land use at the disposal cell may be partially offset by cleanup and release of additional sites. In the short-term, there would be increased risk to worker safety from additional remedial activities. There also would be increased on-site transportation, waste management, and waste disposal activities, resulting in additional commitment of natural resources.

After disposal of D&D waste, PGDP will have been removed, completing the majority of DOE cleanup goals for the site. The closure of PGDP and completion of the operational phase of the waste disposal facility will reduce overall employment in the area. Reindustrialization activities could occur simultaneously with removal actions and would result in incremental impacts to air quality, traffic, and noise levels.

6.4.5.7 Environmental justice: short-term considerations

As detailed in Section 6.4.3.7, the census tracts closest to PGDP do not report a higher proportion of minorities or low-income populations than the national average. Consequently, there would be no disproportionately high and adverse human health or environmental effects on minority populations and low-income populations in the short-term.

6.4.5.8 Duration of remedial activities

Construction and operation of an on-site disposal facility for the waste volumes managed under this alternative would be planned for completion by FY 2039, when the facility would be ready for closure by final capping. Final closure, including placement of the final permanent cover, would be planned for completion by FY 2044. SM&M activities and required institutional/engineering controls are projected to continue for at least 100 years (for the RI/FS, 1,000 years was used for cost estimating purposes) after the final cap installation.

6.4.6 Implementability

The On-Site Disposal Alternative can be implemented. This section describes both the administrative and technical feasibility of the alternative. Incorporation of a recycling program into the On-Site Alternative is considered to be implementable as described below.

6.4.6.1 Administrative feasibility

The administrative feasibility of this alternative would depend on the following:

- Agreement among FFA parties regarding selection of the alternative; and
- Availability of services, materials equipment, specialists, and prospective technologies.

The On-Site Alternative is a near-term alternative that is relatively sensitive to schedule, approval, and funding issues because of the short operational schedule (FY 2014 through FY 2039). The time required to initiate and complete construction of an on-site disposal facility would be tight in order to dovetail with remediation schedules and waste generation, although the majority of the waste forecasted is associated with D&D activities projected to start in 2019. Field characterization for final site selection, seismic design, and final facility design would need to be implemented on a fast-track basis.

Schedule Integration. The remediation schedule for OUs and other contaminated areas would have to be integrated into the disposal facility construction schedule. If the actions are not integrated, the operational schedule for the facility could be impacted.

Stakeholder Approval. Review by stakeholders, including regulatory agencies, DOE, and the public, would be required and accomplished through the CERCLA process. An expedited and integrated decision and approval process among the regulatory agencies and DOE would be required for the actions affecting an on-site waste disposal facility.

Availability of Funding. Funding for OU remediation and waste disposal facility construction would need to be available and reliable. Lack of funding could jeopardize the construction and operational schedule for an on-site waste disposal facility.

Although these issues are complex and involve multiple agencies, implementation of this alternative could result in the following benefits.

Construction efficiencies. Duplication of activities would be minimized by linking the remedial activities within the site with disposal facility construction. Equipment and crews could be used for multiple tasks. For example, removal and backfilling of contaminated soil could be linked to foundation preparation activities for a disposal facility. Stormwater management facilities could be designed and constructed to serve both runoff from remediation activities and disposal facility construction/operation.

Schedule efficiencies. These could include document submittal/approvals, equipment mobilization, and contract procurement cycles. Innovative approaches involving design-build techniques could be employed to optimize the project schedule.

Review of state and federal regulations (Appendix G) indicates that there are no provisions that would prohibit implementation of a recycling program on-site.

6.4.6.2 Technical feasibility

The On-Site Alternative is technically feasible and has been implemented at similar DOE facilities, such as the EMWMF at Oak Ridge. The technologies and materials used for this alternative are available and have been implemented at numerous hazardous and/or LLW sites of similar nature across the country (i.e., Hanford, Oak Ridge, Idaho National Engineering and Environmental Lab, Fernald). The technology is proven and reliable for the wastes projected to be generated, resulting in a low degree of uncertainty for implementation. This alternative could reasonably be implemented with minimal schedule delays resulting from technical complications.

Many engineered disposal cells have been constructed for hazardous and radioactive wastes and are operating today, demonstrating their viability. Construction and operation of an on-site disposal facility would involve no unusual or unprecedented conditions or technologies. The off-site shipment and disposal component of this alternative also represents a reliable and proven method of waste disposal.

Technical feasibility also considers the ease of undertaking additional remedial action in the future. It would be possible to accommodate additional disposal volumes in the future by expanding the cell onto adjacent areas if needed. At Site 3A, expansion to the north would require removing existing cylinder yards and investigating for potential contamination; and at Site 11, expansion to the south would result in reduced volume capacity for the C-746-U Landfill. Once the permanent cover is placed and the facility is closed, the on-site disposal facility could not be expanded easily due to sidewall construction.

Seismic design requirements are a technical consideration relative to implementing this alternative. If on-site disposal is the preferred remedy, final facility design and WAC development would require site-specific seismic parameters for soil and rock formations, appropriate peak ground acceleration or other design criteria, and additional hydrogeologic and geotechnical data.

Several technologies exist that may be applied to potential recycling operations on-site, as described in Section 4.1.4.

6.4.6.3 Process modification

Process modifications would be evaluated to determine potential enhancement of the disposal facility performance. One such modification could be the addition of a geochemical barrier at the base of the cell in conjunction with the leachate collection system. The barrier would reduce the mobility of certain contaminants. The WAC would be revised based on expected performance of a geochemical barrier or other process modifications.

Various studies have been performed to address soluble and mobile contaminants such as technetium and uranium. A study was performed for the EMWMF at ORR. The geochemical behavior of uranium and Tc-99 within the disposal facility was the focus of the analysis. Phase I was a "proof of concept" bench-scale study followed by Phase II, which compared the uranium and technetium removal characteristics of zero-valent iron (ZVI) with those of the materials identified as the most promising during Phase I. Although a third phase of the investigation was cut short due to funding reallocations, the results "strongly suggested that ZVI would be an effective geochemical barrier to mobility of uranium and perhaps technetium."

Two examples of field implementation of a geochemical barrier are found at DOE sites in Missouri and Colorado. A geochemical barrier using peat mixed with soil was placed in a layer directly above the double leachate collection system at the Weldon Spring Site Remedial Action Project in Missouri. At the UMTRA project Durango site in Colorado, the Bodo Canyon disposal cell utilized a French drain coming from the cell and the leachate ran through an *in situ* bed of ZVI.

6.4.6.4 Availability of services and materials

The availability of services and materials is not a limiting constraint. Services and materials required for construction of an on-site disposal facility, off-site disposal, transportation, and supporting operations are readily available, as are qualified personnel, specialists, and vendors. Construction would involve the use of standard construction equipment, trades, and materials. Multiple bids would be expected for construction and procurement necessary to develop an on-site disposal facility.

Permitted off-site disposal facilities are available, as described in Section 6.3, with sufficient capacity to dispose of the minor waste volume from PGDP.

6.4.7 Cost

Table 6.3 summarizes the present value costs associated with each prototype site and waste volume scenario for the On-Site Disposal Alternative. Each estimate considers site-specific conditions that affect cost (for example, location of existing infrastructure). Unit costs that form the basis of each estimate and other cost details are shown in Appendix I (costs in Appendix I are rounded to the nearest $1,000 for the purposes of Table 6.3).

The base case and low-end waste volume scenarios include C-746-U Landfill costs because, in these scenarios, nonhazardous solid waste would be disposed of at the C-746-U Landfill. These costs include expansion of remaining phases 12–23 (three different expansion periods assumed in 2019, 2025, and 2031); landfill operations costs (annual cost per year from 2014 to 2039); closure of all 23 phases of the landfill (completed in 2039); and a 30-year postclosure care period (monitoring and maintenance from 2039 to 2069).

Placement of nonhazardous solid waste in a facility designed for hazardous waste and LLW would result in a relatively high disposal cost for nonhazardous materials. The new on-site facility would be compliant with ARARs. If the C-746-U Landfill were closed and waste that meets this facility WAC were placed in the new on-site facility, a potential tradeoff could be the operation of a single waste disposal facility, instead of two or more facilities, resulting in more efficient operations and related cost savings. In the long-term, nonhazardous solid waste could be diverted from the C-746-U Landfill to the new on-site waste disposal facility, which would allow closure of the C-746-U Landfill during D&D of the plant buildings.

6.4.8 CERCLA Site Cost Comparison

As a frame of reference, the high- and low-end cost estimates per cubic yard of waste for the On-Site Alternative are compared to other DOE CERCLA disposal sites, including the facilities at Hanford, Oak Ridge, Idaho National Engineering and Environmental Lab (INEEL), and Fernald (Table 6.4). The costs per cubic yard of waste for the PGDP On-Site Alternative are of comparable magnitude to Oak Ridge, INEEL, and Fernald.

Table 6.3. On-Site Alternative Cost Estimate

High-End Waste Volume (4.0 mcy)	Cost
Site 3A: Site Development	$18,606,000
Site 3A: Construction	$361,744,000
Site 3A: Operations and Monitoring	$261,358,000
Site 3A: 5% Waste Off-site Disposal	$103,270,000
Site 3A: Closure	$74,189,000
Site 3A: Postclosure	$24,095,000
C-746-U Landfill Costs	
Operations 2014–2039	$ -
Construction Phases 12–23	$ -
Closure	$ -
Postclosure Care	$ -
TOTAL PRESENT VALUE COST $843,262,000	

High-End Waste Volume (4.0 mcy)	Cost
Site 11: Site Development	$18,606,000
Site 11: Construction	$363,286,000
Site 11: Operations and Monitoring	$261,358,000
Site 11: 5% Waste Off-site Disposal	$103,270,000
Site 11: Closure	$72,277,000
Site 11: Postclosure	$24,095,000
C-746-U Landfill Costs	
Operations 2014–2039	$ -
Construction Phases 12–23	$ -
Closure	$ -
Postclosure Care	$ -
TOTAL PRESENT VALUE COST $842,892,000	

Base Case Waste Volume (3.6 mcy)	Cost
Site 3A: Site Development	$18,606,000
Site 3A: Construction	$290,515,000
Site 3A: Operations and Monitoring	$248,128,000
Site 3A: 5% Waste Off-site Disposal	$61,800,000
Site 3A: Closure	$53,416,000
Site 3A: Postclosure	$17,933,000
C-746-U Landfill Costs	
Operations 2014–2039	$22,277,000
Construction Phases 12–23	$22,080,000
Closure	$24,440,000
Postclosure Care	$6,183,000
TOTAL PRESENT VALUE COST $765,378,000	

Base Case Waste Volume (3.6 mcy)	Cost
Site 11: Site Development	$18,606,000
Site 11: Construction	$297,810,000
Site 11: Operations and Monitoring	$248,128,000
Site 11: 5% Waste Off-site Disposal	$61,800,000
Site 11: Closure	$52,446,000
Site 11: Postclosure	$17,933,000
C-746-U Landfill Costs	
Operations 2014–2039	$22,277,000
Construction Phases 12–23	$22,080,000
Closure	$24,440,000
Postclosure Care	$6,183,000
TOTAL PRESENT VALUE COST $771,703,000	

Low-End Waste Volume (3.2 mcy)	Cost
Site 3A: Site Development	$18,606,000
Site 3A: Construction	$228,254,000
Site 3A: Operations and Monitoring	$230,349,000
Site 3A: 5% Waste Off-site Disposal	$36,075,000
Site 3A: Closure	$37,024,000
Site 3A: Postclosure	$11,771,000
C-746-U Landfill Costs	
Operations 2014–2039	$22,277,000
Construction Phases 12–23	$22,080,000
Closure	$24,440,000
Postclosure Care	$6,183,000
TOTAL PRESENT VALUE COST $637,059,000	

Low-End Waste Volume (3.2 mcy)	Cost
Site 11: Site Development	$18,606,000
Site 11: Construction	$231,129,000
Site 11: Operations and Monitoring	$230,349,000
Site 11: 5% Waste Off-site Disposal	$36,075,000
Site 11: Closure	$35,014,000
Site 11: Postclosure	$11,771,000
C-746-U Landfill Costs	
Operations 2014–2039	$22,277,000
Construction Phases 12–23	$22,080,000
Closure	$24,440,000
Postclosure Care	$6,183,000
TOTAL PRESENT VALUE COST $637,924,000	

Note: Site Development = Planning, Environmental and Engineering Services

Table 6.4. Cost Comparison to Other DOE CERCLA Sites [$ per yd^3 of waste]

Facility	Estimated Total Waste Quantity[a] (yd^3)	Present Value Based on Total Waste Quantity[b] ($/$yd^3$)
Existing DOE CERCLA Disposal Sites		
Hanford ERDF	11,800,000	$28[c]
Oak Ridge EMWMF	1,700,000	$136
INEEL ICDF	420,000	$152
Fernald OSDF	2,500,000	$181
On-Site Disposal		
PGDP (Site 3A High End Estimate)	4,000,000	$211
PGDP (Site 3A Low End Estimate)	3,210,000	$199
PGDP (Site 11 High End Estimate)	4,000,000	$211
PGDP (Site 11 Low End Estimate)	3,210,000	$199

[a] Waste volumes and present values for existing DOE CERCLA disposal sites were obtained from DOE's July 2002 Report to Congress on *The Cost of Waste Disposal: Life Cycle Cost Analysis of Disposal of Department of Energy Low-Level Radioactive Waste at Federal and Commercial Facilities*.
[b] Present Value: Existing DOE CERCLA disposal costs adjusted for present value.
[c] Hanford ERDF Present Value is lower than those of the other facilities due to economies of scale related to the large volume of waste being disposed of.

7. COMPARATIVE ANALYSIS OF ALTERNATIVES

This chapter presents a comparative analysis of the three waste disposal alternatives that were described in Chapter 5 and evaluated in Chapter 6. The three waste disposal alternatives are summarized below and in Table 7.1.

- The *No Action Alternative* involves the continuation of coordinated project-by-project disposal for CERCLA waste. This includes off-site disposal of waste that does not meet the WAC of the on-site C-746-U Landfill and continued use of the C-746-U Landfill for disposal of waste meeting the WAC of the C-746-U Landfill. The No Action Alternative uses the base case waste volume (3.6 mcy), since that represents data available in the 2007 approved LCB with respect to the anticipated waste inventory.

- The *Off-Site Alternative* involves the project-by-project disposal of CERCLA waste and includes two waste volume scenarios for comparison purposes: (1) a high-end waste volume scenario for which CERCLA waste is assumed to be shipped off-site; and (2) a low-end waste volume scenario, which assumes various waste volume reduction actions (up to 75% recycling of scrap metal and recycling/reuse of up to 75% of concrete debris), use of the C-746-U Landfill for disposal of waste that meets the facility's WAC, and off-site disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill.

- The *On-Site Alternative* involves the disposal of CERCLA waste into a newly constructed on-site waste disposal facility located on property owned by DOE. Evaluation for the On-Site Alternative includes high- and low-end waste volume scenarios: (1) a high-end waste volume scenario for which CERCLA waste would be disposed of in a newly constructed on-site facility; and (2) a low-end waste volume scenario, which assumes various waste reduction actions, continued use of the C-746-U Landfill for disposal of waste meeting the WAC of the C-746-U Landfill and disposal in a newly constructed on-site facility of CERCLA waste that does not meet the WAC of the C-746-U Landfill. The On-Site Alternative also includes, for comparative purposes, a cost estimate and conceptual design corresponding to the base case waste volume. As in the No Action Alternative, the base case scenario assumes use of the C-746-U Landfill for waste meeting that facility WAC.

Table 7.2 summarizes the primary differences and tradeoffs among the alternatives. Assuming full availability of funding, each of the alternatives supports timely remediation of PGDP and its CERCLA waste sites. The On-Site Alternative would be significantly less costly than the No Action and Off-Site Alternatives, particularly for larger waste volumes, but a portion of the DOE property would have to be permanently dedicated to waste disposal, resulting in potential impacts to future land use and the environment. The No Action, Off-Site, and On-Site Alternatives would be more effective in preventing potential future releases from CERCLA-generated waste from the PGDP because waste would be disposed of in a facility designed for site-specific conditions protective of human health and the environment. The On-Site Alternative would require long-term monitoring and maintenance of the landfill, while the Off-Site Alternative would be less effective in the short-term because of risks inherent in long distance waste transportation.

7.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Each of the alternatives is considered to be protective of human health and the environment. The On-Site Alternative would meet RAOs primarily through design and construction to required specifications and

Table 7.1. CERCLA Waste Disposal Alternatives Summary

Waste Disposal Facility	No Action Alternative	Off-Site Alternative			On-Site Alternative***		
		High-End Waste Volume	Base Case Waste Volume (No Action Alternative)	Low-End Waste Volume	High-End Waste Volume	Base Case Waste Volume	Low-End Waste Volume
Volumes (mcy)							
Recycling	0	0	0	1.1	0	0	1.1
C-746-U Landfill	1.1	0	1.1	0.6	0	1.1	0.6
Off-Site Facility	2.5	4.0	2.5	1.5	*	*	*
New On-Site Facility	0	0	0	0	4.0	2.5	1.5
Total Managed Volume	3.6	4.0	3.6	3.2	4.0	3.6	3.2
Cost Summary							
Total Present Value Cost	$1,310,982,000	$2,065,394,000	$1,310,982,000	$796,473,000	$843,262,0000	$765,378,000	$637,059,000
Cost ($)/cy**	$364	$516	$364	$248	$211	$213	$199

*Assumes 5% of the waste will not meet the WAC and will be disposed of off-site. Conceptual design assumes Total Volume.
**Cost ($)/cy based on Total Present Value Cost/Total Managed Volume.
***Site 3a Costs used for On-Site Alternative.

Table 7.2. Summary of Comparative Analysis of Alternatives

Evaluation Criteria	No Action	Off-Site Alternative	On-Site Alternative
Overall Protection of Human Health & Environment	Meets. Protective because of waste being disposed of in a landfill designed for site-specific conditions to be protective of human health and the environment. Less protective than the on-site alternative because of significantly greater transportation risks.	Meets. Protective because of waste being disposed of in a landfill designed for site-specific conditions to be protective of human health and the environment. Less protective than the on-site alternative because of significantly greater transportation risks.	Meets. Protective because of waste being disposed of in a landfill designed for site-specific conditions to be protective of human health and the environment. Less effective than the No Action or Off-Site Alternatives in preventing future releases at the PGDP.
Compliance with ARARs	Meets ARARs on a project-by-project basis.	Meets ARARs on a project-by-project basis.	Meets ARARs. Waiver would be needed for TSCA requirement (50-ft buffer between base of cell and water table).
Long-term Effectiveness and Permanence	Protectiveness effective for long-term. Waste disposed must meet receiving facility WAC.	Protectiveness effective for long-term. Waste disposed must meet receiving facility WAC.	Protectiveness effective for long-term. Waste disposed must meet risk-based WAC.
Reduction of Toxicity, Mobility, or Volume Through Treatment	Any reduction of toxicity, mobility, or volume through treatment would be determined by individual projects. Waste required to meet disposal facility WAC.	Any reduction of toxicity, mobility, or volume through treatment would be determined by individual projects. Waste required to meet disposal facility WAC.	Any reduction of toxicity, mobility, or volume through treatment would be determined by individual projects. Waste required to meet disposal facility WAC.
Short-Term Effectiveness	Protectiveness effective in the short-term; receiving facilities are appropriately licensed and have considerable operating experience. Only minor incremental environmental effects would occur at the existing off-site or on-site facilities.	Protectiveness effective in the short-term; receiving facilities are appropriately licensed and have considerable operating experience. Only minor incremental environmental effects would occur at the existing off-site or on-site facilities.	Protectiveness effective in the short-term; facility design, construction, and operation would be based on experience derived from similar facilities at DOE and other sites. Minor adverse environmental effects at a disposal facility could result from construction and operation, but would be controlled or mitigated per regulatory requirements and appropriate engineering and construction practices.

Table 7.2. Summary of Comparative Analysis of Alternatives (Continued)

Evaluation Criteria	No Action	Off-Site Disposal	On-Site Disposal
Implementability	Administrative and technical requirements are implementable. Disposal relies on commercial facilities; continued availability is not guaranteed. State equity issues may interfere with future availability. Wastes that exceed off-site disposal facility WACs would require storage, pending the availability of treatment technologies or disposal options.	Administrative and technical requirements are implementable. Disposal relies on commercial facilities; continued availability is not guaranteed. State equity issues may interfere with future availability. Wastes that exceed off-site disposal facility WACs would require storage, pending the availability of treatment technologies or disposal options.	Requirements are considered achievable. Construction and operations are implementable using available materials and technology. Services and materials are readily available. Wastes that exceed off-site disposal facility WACs would require storage, pending the availability of treatment technologies or disposal options.
Cost	Overall costs of off-site disposal are higher than on-site disposal for the waste volumes evaluated.	Overall costs of off-site disposal are higher than on-site disposal for the waste volumes evaluated. The No Action Alternative serves as the base case for the Off-Site Disposal Alternative.	Costs per yd^3 disposed are less than for off-site disposal, particularly at greater volumes.

SM&M = surveillance, maintenance, and monitoring
ARARs = applicable or relevant and appropriate requirements
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
TSCA = Toxic Substances Control Act
WAC = waste acceptance criteria

compliance with the WAC established for a new on-site CERCLA waste disposal facility. The No Action and Off-Site Alternatives would meet RAOs primarily through compliance with the WAC for each of the off-site existing permitted facilities. Each of the alternatives includes consideration of continued use of the C-746-U Landfill. For that circumstance, RAOs would be met through compliance with the WAC for the C-746-U Landfill. Recycling, if performed, would decrease the volumes to the receiving on- or off-site facilities and the C-746-U Landfill and return these metals to service, thereby increasing the overall protection of human health and the environment.

Selection of the On-Site Alternative would result in large volumes of CERCLA waste being disposed of on-site at PGDP, in an engineered facility designed for safe disposal of such wastes.

The No Action and Off-Site Alternatives would be more effective in preventing potential future releases at PGDP because most of the CERCLA waste would be disposed of in off-site permitted facilities. Both the No Action and Off-Site Alternatives would be less protective than the On-Site Alternative with respect to transportation risks.

The No Action Alternative, the low-end waste volume scenario for the Off-Site Alternative, and the low-end and base case waste volume scenarios for the On-Site Alternative all include continued use of the C-746-U Landfill for waste meeting its WAC. The C-746-U Landfill is designed, operated, and maintained in accordance with its permit to be protective of human health and the environment.

7.2 COMPLIANCE WITH ARARS

Under the No Action Alternative, ARARs would be developed and evaluated for each project-specific CERCLA action, whether on-site or off-site disposal. Accordingly, there are no ARARs associated with the No Action Alternative (DOE 2011a).

The Off-Site Alternative consists of shipment of CERCLA waste to and disposal of in licensed or permitted off-site disposal facilities. It is assumed that individual waste generators would be responsible for treatment before disposal; therefore, ARARs are not required under this RI/FS to meet any applicable LDRs or other treatment requirements under state or federal regulations (DOE 2011a). Because wastes would be disposed of off-site at appropriately licensed facilities under this alternative, ARARs for waste disposal are not addressed for this alternative (DOE 2011a).

Under the On-Site Alternative, a new on-site waste disposal facility would be designed to meet ARARs, with the exception of the TSCA requirement for a 50-ft buffer between the base of the cell and the top of the water table. This buffer would not be achievable at any of the five final candidate sites. As detailed in Section 6.4.2, an “equivalent standard of performance” CERCLA waiver of this 50-ft requirement would be invoked for the On-Site Alternative in accordance with CERCLA § 121 (4)(D). All other aspects of the On-Site Alternative design, construction, support facilities, operations, and closure are expected to comply with ARARs.

Treatment of waste is not included as part of the alternatives. Treatment would be evaluated and implemented on a project-specific basis, if required, to meet the disposal facility WAC, whether on-site or off-site.

Chemical-specific ARARs generally set cleanup or discharge limits for specific hazardous substances or contaminants.

Location-specific ARARs specify concentrations or impose restrictions on activities on the basis of sensitive resources at the site. Location-specific ARARs for the On-Site Alternative were identified for the five final candidate sites. While no significant cultural resources were identified within the facility footprint at the final candidate sites, ARARs triggered by cultural resources are addressed as a contingency, in the event that such resources are discovered at a later date or the footprint of the on-site WDF is changed.

Action-specific ARARs for on-site disposal address construction, operation, closure, and postclosure care of the on-site disposal facility. The On-Site Alternative would invoke CERCLA provisions for exemption from permitting requirements. The variety of wastes disposed of on-site under this alternative would trigger requirements for RCRA-hazardous waste, LLW, and TSCA wastes. Action-specific ARARs include design components for a disposal facility, based on the overriding priority to dispose of wastes in a manner protective of human health and the environment over both the long- and short-term.

Other action-specific ARARs address management of stormwater runoff, fugitive dust emissions, treatment of leachate and decontamination wastewater, staging of the wastes during operations, waste storage pending disposal, disposal facility closure, and postclosure care. Appendix G contains a more detailed discussion of ARARs for all alternatives.

ARARs relevant to recycling, if recycling is performed, also would be complied with.

7.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Each of the alternatives, as well as a recycling program, if implemented, is considered to be effective and permanent in the long-term. Under both the No Action and Off-Site Alternatives, CERCLA-generated waste would be disposed of at the Energy*Solutions* facility in Utah. Under the On-Site Alternative, only waste meeting the landfill WAC would be disposed of on-site. Each of the alternatives, with the exception of the high-end waste volume for the Off-Site Alternative, includes continued use of the C-746-U Landfill for disposal of waste meeting the WAC of the C-746-U Landfill.

The long-term effectiveness of an on-site disposal facility relies on the use of engineered barriers and institutional controls, as well as required SM&M that would be continued for as long as the material placed in the facility posed an unacceptable risk to human health and environment. The PWAC modeling analysis assumes that such controls and engineered barriers last for at least 100 years postclosure (assumed to be 170 years postclosure for the purposes of this RI/FS), with gradual failure of the engineered barriers thereafter. The final cover (cap) and intrusion barrier would be designed to discourage penetration of the cover by humans, burrowing animals, or tree roots, and a fence with posted signs and a locked gate would prohibit access to the site. Institutional controls would restrict use of or unauthorized access to the site and would prohibit actions that could penetrate the cover, expose waste, or withdraw groundwater near the site. The effectiveness of the engineering and institutional controls would decrease after active maintenance ceases.

Barring deliberate efforts to penetrate the cover, it would remain effective for hundreds to thousands of years. As long as the cover remains in place, migration of contaminants into groundwater and surface water is the only viable pathway for exposure. Groundwater and exposure modeling indicates that exposure would be acceptable at designated receptor locations downgradient of the disposal facility. This modeling assumes that degradation of the disposal cell containment occurs under various degradation/failure scenarios. DOE will provide engineering controls, SM&M, and institutional controls for as long as the waste disposed of in the facility could pose an unacceptable risk to human health or the environment, as assessed during the CERCLA five-year reviews. Such controls would prevent unacceptable uses of the disposal site.

The greatest uncertainty in the long-term effectiveness and permanence of an on-site disposal facility is the potential for damage from seismic activity. Potential damage that could result from seismic events include slope failure, differential settlement leading to tearing of the FML or breach of the clay liner or cover, and damage to the leachate collection and drainage system. The facility would be designed to withstand the appropriate level of ground motion and would incorporate engineering controls to reduce the risk of failure of critical systems. The design techniques that could be incorporated into the facility to reduce potential seismic damage include the following:

- Decrease side slopes to reduce potential for slope failure.
- Use textured FML materials to increase friction coefficient and decrease potential for slope failure.
- Increase compaction and/or use stabilizing agents in foundation soils to reduce settlement.
- Dewater and/or stabilize subsurface zones susceptible to liquefaction.
- Increase stability of containment dikes by incorporating materials such as roller-compacted concrete, geo-grids, or geotextile materials.
- Design leachate collection systems with flexible connections that allow movement without failure.

- Increase tensile strength of leachate collection piping.

- Incorporate seismic design into leachate pumps and tanks.

- Use passive design elements such as gravity drains to minimize reliance on mechanical systems such as pumps.

- Increase stabilization of waste prior to placement to reduce potential for settlement during seismic events.

- Increase compaction of waste during waste placement to reduce potential for settlement during seismic events.

The No Action and Off-Site Alternatives also rely on institutional and engineering controls at the off-site disposal facilities to prevent inadvertent intrusion. Maintenance of these controls would be the responsibility of the off-site disposal facilities. The engineered barriers to intrusion and waste migration at Energy*Solutions* and NNSS are similar to the barriers proposed for the on-site disposal cell; therefore, the risk of direct exposure to the waste would be roughly similar for each of the alternatives. Energy*Solutions*, where most wastes are assumed to be disposed of for the purposes of this RI/FS, is in an arid climate that reduces the likelihood of contaminant migration or exposure via groundwater or surface water pathways compared to the humid climate in Paducah. Fewer T&E species exist in the vicinity of Energy*Solutions* than in the vicinity of PGDP.

There would be no adverse socioeconomic impacts from either an on-site waste disposal facility or off-site disposal in the long-term. Aesthetic impacts from an aboveground, on-site disposal facility would depend on the final site location; however, the facility would not be visible from major highways and would be visible only relatively close to the site, such as by recreational users in the area. No change in aesthetics would result from the No Action or Off-Site Alternatives.

Cumulative impacts resulting from on-site disposal could include future land use decisions on adjacent property that might increase industrial development or result in loss of wetlands and wildlife habitat. Potential impacts to the environment due to increased stormwater runoff from an on-site disposal facility would be mitigated by the use of best management practices. There would be no significant cumulative impacts to the environment from off-site disposal. Removal of contamination from the SWMUs, AOCs, and buildings and transporting the waste off-site would result in positive long-term environmental benefits at PGDP.

Potential direct and indirect environmental impacts would be greater for on-site waste disposal than for off-site disposal. Land use would be restricted in perpetuity, representing an irreversible and irretrievable commitment of 110 acres of land that would be utilized for the waste disposal footprint and earth berm. On-site environmental impacts could include disturbance of small areas of potential wetlands and potential summer habitat areas for the endangered Indiana bat, which would need to be mitigated. Measures that mitigate the adverse effects of actions in a wetland may include, but are not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically-sensitive areas; however; any necessary mitigation activities would be identified at a later date. Off-site facilities already are committed to waste disposal, so land use and long-term environmental impacts would not change.

7.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Treatment to reduce toxicity, mobility, or volume of waste from individual remediation sites would be evaluated in project-specific CERCLA decision documents, regardless of the alternative selected. Treatment of each waste stream, as required to meet the WAC of the selected disposal facility, would be similar for each of the alternatives. For the low-end volume scenarios for the Off-Site and On-Site Alternatives, volume reduction is assumed through various waste reduction actions (e.g., recycling of scrap metal, recycling/reuse of concrete debris). For the No Action Alternative, no waste reduction effort is assumed. Recycling is considered to meet the long-term effectiveness of the On- and Off-Site Alternatives by decreasing the volume of waste being disposed of on-site or in the C-746-U Landfill and returning the materials to a state where they may be reused.

7.5 SHORT-TERM EFFECTIVENESS

Under the No Action and Off-Site Alternatives, risk related to off-site transport of waste would be a short-term impact to workers and/or the public because of the long transportation routes to the off-site disposal facilities in Utah or Nevada. Potential risks from exposure to waste during incident-free transport or as the result of an accidental spill are very low.

Potential short-term direct and indirect environmental impacts would be greater for on-site waste disposal than for off-site disposal. Approximately 110 acres would be disturbed during construction and operations. Environmental impacts at an on-site facility could include disturbance of areas of potential wetlands and potential summer habitat areas for the endangered Indiana bat. If it is determined that adverse impacts would occur to potential wetlands or critical habitat, appropriate mitigation measures would be required. Measures that mitigate the adverse effects of actions in a wetland may include, but are not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically-sensitive areas; however; any necessary mitigation activities would be identified at a later date. Off-site facilities already are operating, so short-term environmental impacts would not change.

There would be no adverse socioeconomic impacts from either an on-site waste disposal facility or off-site disposal. For the On-Site Alternative, construction jobs would be created, as well as jobs for facility operation, security, and closure, and long-term monitoring and maintenance. Because the census tracts closest to PGDP do not have a higher proportion of minorities or low-income populations than the national average, there would be no disproportionate or adverse environmental justice impacts for on-site disposal. For off-site transport and disposal, there would be minimal manpower requirements at PGDP, and personnel at the receiving facilities are already in place. Outside contractors likely would be used to transport the waste; waste hauler jobs would be created, but their geographical location is not known.

The duration of active waste operations would be similar for all alternatives. Active waste operations or shipments would last approximately 25 years. SM&M activities would continue indefinitely at both on-site and off-site disposal facilities, but such activities at off-site facilities would be performed by the permitted disposal facility operator, not by DOE. DOE will provide engineering controls, SM&M, and institutional controls for as long as the waste disposed of in the facility could pose an unacceptable risk to human health or the environment, as assessed during the CERCLA five-year reviews.

Recycling is considered to meet the long-term effectiveness of the On- and Off-Site Alternatives by decreasing the volume of waste being disposed of on-or off-site or in the C-746-U Landfill and returning the materials to a state where they may be reused.

7.6 IMPLEMENTABILITY

Each of the alternatives is implementable. The No Action and Off-Site Alternatives are implementable because there are licensed and permitted facilities with available capacity to accept the waste, and truck and rail transport systems to these facilities are established. The On-Site Alternative is implementable because the containment technologies are readily available and have proven to be reliable at other hazardous/mixed waste disposal facilities. However, an ARAR waiver would be required for the TSCA requirement for a 50-ft buffer between the base of the liner and the top of the water table.

The schedule to initiate and complete construction of an on-site disposal facility would require some early actions so that the facility is available to accept ER wastes generated prior to D&D activities (although D&D waste is the largest component of the waste forecast). These actions could include, for example, field characterization of the selected site for seismic design and WAC development, and pre-ROD design work beyond the conceptual design. A majority of the forecast PGDP CERCLA waste is generated by D&D, which is not scheduled to commence until 2019.

The off-site facilities at Energy*Solutions* and NNSS are available immediately, have sufficient capacity, and are readily implementable in the near-term. In the long-term, there is greater uncertainty about whether sufficient off-site disposal capacity would be available to receive PGDP waste due to unknowns about the volume of other waste to be received at the off-site disposal facilities throughout the life of the PGDP actions. Also, availability of off-site facilities at Energy*Solutions* and NNSS is less certain in the long-term due to possible state equity issues or future changes in waste acceptance and capacity. New off-site waste disposal facilities may become available in the future and could provide the needed disposal space.

The off-site disposal alternative is administratively implementable. There is uncertainty with regard to sufficient capacity at NNSS and Energy*Solutions* through 2040. The on-site disposal alternative provides a greater level of certainty that long-term disposal capacity would be available.

The only technical uncertainty relative to the Off-Site/No Action Alternatives is the availability of treatment and disposal options for waste exceeding the WACs of the off-site facilities. If significant volumes of waste were generated and no treatment or disposal options could be identified for that waste, a technical challenge to implementability ultimately could result. Currently, all waste volumes are estimated to meet an off-site disposal facility WAC. In the event that waste is generated that does not meet the off-site facilities' WACs, the waste would require storage in on-site facilities that could meet the requirements for storage, pending the availability of treatment technologies or disposal options. No costs for long-term storage and eventual disposal of wastes not meeting the WAC for off-site disposal facilities are included, because these would be the responsibility of the generating project. Because the expected volumes of such waste streams are small and the resulting cost differential between disposal options is not critical, management of waste exceeding WAC is not analyzed in detail in this FS.

There is sufficient disposal capacity at the C-746-U Landfill for estimated volumes of CERCLA-generated nonhazardous solid waste; however, it would require full build-out of the landfill to accommodate these waste volumes, with associated requirements for regulatory review and approval. For the Off-Site Alternative high-end volume scenario, it is assumed that the nonhazardous solid waste would be shipped to Energy*Solutions* at substantially higher cost and transportation risk than for on-site disposal. For the On-Site Alternative high-end volume scenario, nonhazardous solid waste would be disposed of on-site in a new CERCLA waste disposal facility, so that there would be no uncertainty regarding nonhazardous solid waste disposal capacity.

Incorporation of a recycling program into the On-Site Alternative is considered implementable as described below. Review of state and federal regulations (Appendix G) indicates that there are no provisions that would prohibit implementation of a recycling program on-site. Several technologies exist that may be applied to potential recycling operations on-site, as described in Section 4.1.4.

7.7 COST

Table 7.3 compares costs for the three alternatives. Cost for the Off-Site and On-Site Alternatives vary according to the waste volume scenario. For comparable waste volumes, on-site disposal is substantially less costly.

The cost of on-site disposal is not heavily dependent on the particular site chosen for locating a facility. The reason the costs are not significantly different is that the construction components of the designed facility would be essentially the same for each of the prototype sites, and the cost of long-term monitoring and institutional and engineering controls would be essentially the same. Minor site-specific differences result from site development concerns, such as power transmission-line relocation, road distances, potential wetland and Indiana bat habitat mitigation, and cell configuration. The cost difference between Site 3A and Site 11 is less than the level of accuracy of the estimate.

Table 7.3. Alternatives Cost Comparison

	Total Present Value Cost	Cost ($)/cy
Base Case Volume Scenario (3.6 mcy)		
No Action Alternative	$1,310,982,000	$364
On-Site Alternative	$765,378,000	$213
Low-end Volume Scenario (3.2 mcy)		
Off-Site Alternative	$796,473,000	$248
On-Site Alternative	$637,059,000	$199
High-end Volume Scenario (4.0 mcy)		
Off-Site Alternative	$2,065,394,000	$516
On-Site Alternative	$843,262,000	$211

Note: Site 3a Costs used for On-Site Alternative.

7.8 SUMMARY OF DIFFERENTIATING CRITERIA

7.8.1 Overall Differentiating Criteria

Five key criteria differentiate the overall feasibility of the No Action, On-Site Disposal, and Off-Site Disposal Alternatives: (1) long-term effectiveness and reliability, (2) short-term transportation risk, (3) environmental impact, (4) availability of disposal capacity, and (5) cost. These differentiators are briefly discussed in this section.

Long-term Effectiveness and Reliability. While the No Action, Off-Site, and On-Site Alternatives are considered protective of human health and the environment, waste would be disposed of in a landfill designed for site-specific conditions. The On-Site Alternative would be less effective than the No Action or Off-Site Alternatives in preventing releases at PGDP.

The only technical uncertainty relative to the Off-Site/No Action Alternatives is the availability of treatment and disposal options for waste exceeding the WACs of the off-site facilities. If significant volumes of waste were generated and no treatment or disposal options could be identified for that waste, a technical challenge to implementability ultimately could result. Currently, all waste volumes are estimated to meet an off-site disposal facility WAC. In the event that waste is generated that does not meet the off-site facilities' WACs, the waste would require storage in on-site facilities and could meet the requirements for storage, pending the availability of treatment technologies or disposal options. No costs for long-term storage and eventual disposal of wastes not meeting the WAC for off-site disposal facilities are included, because these would be the responsibility of the generating project. Because the expected volumes of such waste streams are small and the resulting cost differential between disposal options is not critical, management of waste exceeding WAC is not analyzed in detail in this FS.

Short-term Transportation Risk. Waste transportation off-site presents a greater risk of accident, injury, or death than disposal on-site because of the long transportation routes to the off-site disposal facilities in Utah and Nevada. Potential risks are low from exposure to waste during incident-free transport or as the result of an accidental spill.

Environmental Impact. Use of either of the prototype sites for on-site disposal would result in both direct and indirect environmental impacts. Approximately 110 acres would be disturbed during construction and operations, with an irreversible and irretrievable commitment of 95 acres. The portions of land used for short-term support facilities would be restored (~15 acres) and returned to a natural state that could include natural creation of wetlands.

Environmental impacts could include disturbance or destruction of potential wetlands, a 500-year floodplain at Site 11, and potential disturbance to summer habitat areas for the Indiana bat at Site 11. If it were determined that adverse impacts would occur to jurisdictional wetlands or critical habitat, appropriate mitigation measures would be required. Mitigation costs to address these potential impacts are included in the cost estimate for the On-Site Alternative (Appendix I).

The availability of an on-site disposal facility could facilitate remediation of OUs with more certainty than off-site disposal because of lower cost, greater convenience, and guaranteed disposal capacity.

Availability of Disposal Capacity. Implementation of a comprehensive long-term, on-site waste disposal strategy would not be particularly sensitive to construction start, as the majority of waste to be disposed of would be generated by D&D activities, which are not scheduled to begin until 2019. Availability of off-site facilities at Energy*Solutions* and NNSS is less certain in the long-term due to possible state equity issues and possible future changes in waste acceptance, as well as potential limitations on available capacity at off-site facilities. Because CERCLA waste generation at PGDP is likely to continue for at least 25 years, on-site disposal would provide much greater certainty that sufficient disposal capacity is actually available at the time the wastes are generated.

Cost. Present value and 2010 constant dollar costs for on-site disposal are much lower than for off-site disposal (Table 7.3). Because the cost of off-site disposal is much greater, there could be fewer dollars available for timely or more aggressive implementation of ER and D&D remediation projects.

7.8.2 Nonhazardous Solid Waste Disposal—Differentiating Criteria

Waste that meets the WAC of the C-746-U Landfill would be disposed of in the C-746-U Landfill as part of the No Action Alternative, Off-Site low-end waste volume scenario, and the On-Site low-end and base case volume scenarios. The high-end volume scenarios assume that the C-746-U Landfill is no longer available due to economic, technical, or regulatory issues and include disposing of waste that would otherwise meet the WAC for the C-746-U Landfill in a new on-site waste disposal facility or at an off-site facility. The following are the differentiating criteria among these three approaches for nonhazardous solid waste disposal.

Cost. Placement of nonhazardous solid waste in a facility designed for hazardous waste and LLW would result in a relatively high disposal cost for nonhazardous materials. The new on-site facility will be compliant with ARARs. If the C-746-U Landfill were closed and the waste that meets that facility WAC was placed in the new on-site facility, a potential tradeoff could be the operation of a single waste disposal facility, instead of two or more facilities, resulting in more efficient operations and related cost savings. In the long-term, nonhazardous solid waste could be diverted from the C-746-U Landfill to the new on-site waste disposal facility, which would allow closure of the C-746-U Landfill during D&D of the plant buildings.

Availability of Disposal Capacity. The design capacity of the C-746-U Landfill is sufficient to accommodate the forecast volume of nonhazardous solid waste. For the off-site, high-end volume scenario, nonhazardous solid waste would be disposed of at Energy*Solutions* at higher cost and transportation risk. For the On-Site high-end volume scenario, wastes would be disposed of on-site in a new CERCLA waste disposal facility. In general, disposal capacity for the forecast volume of nonhazardous solid waste is reasonably assured.

Waste Acceptance. Inclusion of nonhazardous solid waste with hazardous waste and LLW waste would result in a lower overall average contaminant concentration or activity per yd^3 of waste disposed. As a result, there would be less uncertainty that the wastes could meet the WAC and be accepted for disposal in an on-site waste disposal facility.

7.9 SITE SELECTION

An on-site waste disposal facility would be protective of human health and the environment, regardless of which of the candidate sites was ultimately selected. RAOs would be met through compliance with the WAC established for a new on-site waste disposal facility. PWAC for two prototype sites (Site 3A and Site 11) are presented in Section 5.4.6 and Appendix C, and conceptual designs are presented in Appendix F. Both prototype sites were found to meet the criteria for an on-site waste disposal facility through the site screening process. Similarly, each of the other sites that pass the threshold criteria screening would be suitable for a potential on-site waste disposal facility.

7.10 SUMMARY AND CONCLUSIONS

The On-Site Alternative provides the lowest cost of the alternatives evaluated by a substantial margin. The CERCLA-generated waste, however, would remain on-site. The on-site disposal facility would be designed to meet ARARs, including design to withstand the ground motion associated with a 2,500-year return period New Madrid seismic event.

Both the No Action and Off-Site Alternatives would be more costly to implement than the On-Site Alternative, future disposal capacity availability is uncertain (although disposal capacity is available in the short-term). Both the No Action and Off-Site Alternatives would result in significant transportation risks, but the CERCLA-generated waste would be removed from the PGDP site, and would be more effective in preventing future releases at PGDP.

8. REFERENCES

Beavers, J. E. 2001. *Seismic Design Criteria Assessment for the C-746-U Contained Landfill—A White Paper*, submitted to Bechtel Jacobs Company LLC, James E. Beavers Consultants, Urbana, Illinois, February 20.

BJC (Bechtel Jacobs Company LLC) 2002. *Paducah Gaseous Diffusion Plant: Re-evaluation of Site-specific Soil Column Effects on Ground Motion*, BJC/PAD-356, Bechtel Jacobs Company LLC, Kevil, KY, March.

BJC 2000. *Recycled Uranium Mass Balance Project: Paducah Recycled Uranium Mass Balance Project: Paducah Gaseous Diffusion Plant Site Report*, BJC/DOE-167, Bechtel Jacobs Company LLC, Kevil, KY, June 14.

CDM Federal 1994. *Investigations of Sensitive Ecological Resources Inside the Paducah Gaseous Diffusion Plant*, 7916-003-FR-BBRY, CDM Federal Programs Corporation, August.

CH2M HILL 1991. *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant*, KY/ER-4, CH2M HILL Southeast, Inc., Oak Ridge, TN, March.

CH2M HILL 1992. *Results of the Site Investigation, Phase II, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/Sub/13B-97777C P03/1991/1, CH2M HILL Southeast, Inc., Oak Ridge, TN, April.

COE (U.S. Army Corps of Engineers) 1994. *Environmental Investigations at the Paducah Gaseous Diffusion Plant, and Surrounding Area, McCracken County, Kentucky*, U.S. Army Corps of Engineers, Nashville, TN, May.

Daniel, D. E. and Gross, B. A. (1996), "Caps," Section 6 in *Assessment of Barrier Containment Technologies*, R. R. Rumer and J. K. Mitchell (eds.), National Technical Information Services, PB96-180583, Springfield, VA, pp. 119-140.

DOC (U.S. Department of Commerce) 2011. McCracken County Quick Facts from the U.S. Census Bureau, http://quickfacts.census.gov/gfd/states/21/21145.html (accessed June 7, 2011).

DOE (U.S. Department of Energy) 1994. *Memorandum for Secretarial Officers and Head of Field Elements: National Environmental Policy Act Statement*, DOE Headquarters, Washington, DC, June 13.

DOE 1996. *Identification and Screening of Candidate Sites for the Environmental Management Waste Management Facility, Oak Ridge, Tennessee*, DOE/OR/02-1508&D1, U.S. Department of Energy, Oak Ridge, TN, September.

DOE 1997. *Ground-Water Conceptual Model for the Paducah Gaseous Diffusion Plant, Paducah Kentucky*, DOE/OR/06-1628&D0, U.S. Department of Energy, Paducah, KY, August.

DOE 1998. *Remedial Investigation/Feasibility Study for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Action of 1980 Waste*, DOE/OR/02-1637&D2, U.S. Department of Energy, Oak Ridge, TN, January.

DOE 1999. *Isotopic Distribution of Contamination Found at the U.S. Department of Energy Gaseous Diffusion Plants*, U.S. Department of Energy, National Center of Excellence for Metals Recycle, October 29.

DOE 2000. *Initial Assessment of Consideration of On-Site Disposal of CERCLA Waste Facility as a Potential Disposal Option at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1893&D1, U.S. Department of Energy, Paducah, KY, July.

DOE 2001. *Identification and Screening of Candidate Sites for a Potential Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1939&D1, U.S. Department of Energy, Paducah, KY, March.

DOE 2003. *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2041&D2/R1, U.S. Department of Energy, Paducah, KY, September.

DOE 2004. *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2038&D2, U.S. Department of Energy, Paducah, KY, March.

DOE 2006. *Paducah-Final Cost and Schedule Summary Report, Scenarios I-II*, U.S. Department of Energy, Paducah, KY, October 13.

DOE 2008. *Scoping Document for CERCLA Waste Disposal Alternatives Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0035&D1, U.S. Department of Energy, Paducah, KY, April.

DOE 2009. *Remedial Investigation Report for the Burial Grounds Operable Unit at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-0030&D1/R1, U.S. Department of Energy, Paducah, KY, April.

DOE 2009a. *DOE Headquarters Independent Review Team Report on Paducah Gaseous Diffusion Plant Seismic Characterization*. U.S. Department of Energy Independent Review Team, Washington, DC, June.

DOE 2011a. *Work Plan for CERCLA Waste Disposal Alternative Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Plant, Paducah, Kentucky,* DOE/LX/07-0099&D2/R1, September.

DOE 2011b. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Volume 1, Human Health,* U.S. Department of Energy, Paducah, KY, DOE/LX/07-0107&D2/V1, July.

DOE 2013. *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Annual Revision–FY 2013*, DOE/LX/07-1284&D2, U.S. Department of Energy, Paducah, KY, January.

Dwyer, S. F. 2003, "Water Balance Measurements and Computer Simulations of Landfill Covers," University of New Mexico, Civil Engineering Department, May.

EDGe 1990. *Groundwater Monitoring Phase II, C-404 Aquifer Testing Program, ESO 16749, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, EDGe Group, Inc., Nashville, TN, February.

EPA (U.S. Environmental Protection Agency) 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, interim final EPA/540/G-89/004. Office of Solid Waste and Emergency Response, Washington, DC.

EPA 1991. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*, OSWER Directive 9355.0-30, Office of Solid Waste and Emergency Response, Washington, DC.

EPA 1998. *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant*, U.S. Environmental Protection Agency, Atlanta, GA, February 13.

EPA 2003. Evapotranspiration Landfill Cover System Fact Sheet, EPA 542-F-03-015, Office of Solid Waste and Emergency Response, Washington, DC.

GEO (GEO Consultants, LLC) 2009. *Assessment of the Adequacy of Geotechnical and Hydrogeological Data in the Terrace Setting to Support a Remedial Investigation/Feasibility Study (RI/FS)-Level Evaluation of Potential Waste Disposal Sites, Paducah, Kentucky*, GEO/09-207 R2, Kevil, KY, August.

Geosyntec 2011. "*Evaluation of Seismic Design Adequacy for C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*," Technical Report, Geosyntec Consultants, Huntington Beach, CA.

Hough, S. E., J. G. Armbruster, L. Seeber, and J. F. Hough 2000, "On the Modified Mercalli Intensities and Magnitudes of the 1811-1812 New Madrid Earthquakes," *Journal of Geophysical Research*, 23, 839-23, 864.

Hough, S. E. and S. Martin 2002. "Magnitude Estimates of Two Large Aftershocks of the 16 December 1811 New Madrid Earthquake," *Bulletin of the Seismological Society of America*, 92, 3259-3268, December.

JEB 2011. "Seismic Hazard Reevaluation for the C-746-U Contained Landfill: A Deterministic Approach," James E. Beavers Consultants, Oak Ridge, TN, revision date July 15.

Johnston, A. C. and E. S. Schweig 1996. *The Enigma of the New Madrid Earthquakes of 1811-1812*, Annual Review Earth Planetary Sciences. 24, 339-384.

KRCEE (Kentucky Research Consortium for Energy and Environment) 2006. *Investigation of Holocene Faulting, Proposed C-746-U Landfill Expansion, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, William Lettis and Associates, Inc. (author) UK/KRCEE Doc #: 17.6 2006, July. (Available electronically at http://www.uky.edu/krcee/Reports.html).

KRCEE 2007. *Final Report: Seismic Hazard Assessment of the Paducah Gaseous Diffusion Plant*. UK/FRCEE Doc #: 11.6 2007, Series XII**,** Kentucky Geological Survey, University of Kentucky, Lexington, KY.

KSNPC (Kentucky State Nature Preserves Commission) 1991. *Biological Inventory of the Jackson Purchase Region of Kentucky*, Kentucky State Nature Preserves Commission, Frankfort, KY.

Infomine 2012. http://www.infomine.com/investment/metal-prices, Accessed on March 12, 2012.

Lee, D. W., J. C. Wang, and D. C. Kocher 1995. *Operating Limits Study for the Proposed Solid Waste Landfill at Paducah Gaseous Diffusion Plant,* ORNL/TM-13008, Oak Ridge National Laboratory, Oak Ridge, TN, June.

LMES (Lockheed Martin Energy Systems, Inc.) 1996. *Aquifer Test Analysis of the Northwest Plume, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-145, Lockheed Martin Energy Systems, Inc., Kevil, KY, June.

McDonald, M. G. and A. W. Harbaugh 1988. MODFLOW; A modular three-dimensional finite difference ground-water flow model, U.S. Geological Survey.

MMES (Martin Marietta Energy Systems) 1992. *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III*, KY/E-150, Martin Marietta Energy Systems, Inc., Paducah, KY, November.

Nelson, W. J., F. B. Denny, J. A. Devera, L. R. Follmer, and J. M. Masters 1997. *Tertiary and Quaternary Tectonic Faulting in Southern Illinois*, Engineering Geology, 46, 235-258.

Nelson, W. J., F. B. Denny, L. R. Follmer, and J. M. Masters 1999. "Quaternary Grabens in Southernmost Illinois: Deformation near an Active Intraplate Seismic Zone," *Tectonophysics*, 305, pp. 381-397, May.

Nelson, W. J. and F. B. Denny 2008. *Bedrock Geology of Brownfield Quadrangle Massac and Pope Counties, Illinois*, Illinois State Geological Survey, Champaign, IL.

Nelson, W. J., J. M. Masters, and L. R. Follmer 2002. Surficial Geology, Metropolis Quadrangles, Massac County, Illinois, scale: Illinois Geological Survey, Illinois geologic quadrangle map, IGQMetropolis- SG, 1:24,000, two sheets.

NHTSA (National Highway Traffic Safety Administration) 2006. Fatality Analysis Reporting System and General Estimates System at http://www.fmcsa.dot.gov/facts-research/analysis-statistics/cmvfacts.

NOAA (National Oceanic and Atmospheric Administration) 1974. *Climatic Atlas of the United States. US Department of Commerce*, Environmental Science Services Administration, Nation Climatic Center, Ashville, NC, 80 pp.

NOAA (National Oceanic and Atmospheric Administration) 2004. *NOAA Atlas 14: Precipitation-Frequency Atlas of the United States, Volume 2*, Version 3.0. National Oceanic and Atmospheric Administration, Silver Spring, MD.

Nuttli, O. 1982. "Damaging Earthquakes of the Central Mississippi Valley," pp. 15–20 in *Investigations of the New Madrid Earthquake Region*, U.S. Geologic Survey, Prof. Paper 1236.

NWS (National Weather Service) 2011. National Weather Service Climatological Report (Annual - 2010), issued by NWS, Paducah, KY, reported January 2011, accessed July 28.

Oak Ridge Institute for Science and Education (ORISE) 2011. *Dose Modeling Evaluations and Technical Support Document for the Authorized Limits Request for the C-746-U Landfill at the Paducah Gaseous Diffusion Plant*, DCN 5090-TR-01-05, May.

Olive, W. W. 1980. *Geologic Maps of the Jackson Purchase Region*, Kentucky, U.S. Geological Survey Miscellaneous Investigations Series, Map I-1217, U.S. Geological Survey, Reston, VA.

OMB (Office of Budget and Management) 2011. Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Office of Management and Budget, December.

Owenby, J. R., and D. S. Ezell 1992. *Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Days, 1961-90,* U.S. Department of Commerce, Climatic Data Center, Washington, DC.

Pollack, D. W. 1994. *User's Guide for MODPATH/MODPATH-PLOT,* Version 3: A particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model, U.S. Geological Survey Open-File Report 94-464.

PRS (Paducah Remediation Services, LLC) 2010. *2008 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow and Transport Model*, PRS-ENR-0028, February.

REI (Risk Engineering, Inc.) 1999. *Updated Probabilistic Seismic Hazard Analysis for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Final Report (Revision 3),* prepared for Lockheed Martin Utility Systems, Inc., April 26.

Ruffner, J. A. 1985. *Climates of the States, National Oceanic and Atmospheric Administration Narrative Summaries, Tables, and Maps for Each State, Volume 1, Alabama-New Mexico, and Volume 2, New York-Wyoming and Territories,* Gale Research Company, Detroit, MI, 758 pp. and 1,572 pp.

Schroeder, P. R., T. S. Dozier, P. A. Zappi, B. M. McEnroe, J. W. Sjostrom, and R. L. Peyton 1994. "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3," EPA/600/R-94/168b, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC, September.

Sullivan, T. M. 2001. *Disposal Unit Source Term: Multiple Species (DUSTMS) Data Input Guide.* Brookhaven National Laboratory, Upton, NY.

Terekhov, D. S. and M. F. O'Meara 2000. "Recycling Metals Using the Metal Organic Chemical Vapour Deposition Process," Fourth International Symposium on Recycling of Metals and Engineered Materials (2000), pp 487-491, TMS Fall Extraction and Process Metallurgy Meeting, TMS Pittsburgh, PA.

USDA (U.S. Department of Agriculture) 1976. *Soil Survey of Ballard and McCracken Counties, Kentucky*, USDA Soil Conservation Service and Kentucky Agriculture Experiment Station, Washington, DC.

USFWS (U.S. Fish and Wildlife Service) 2011. Revised Indiana Bat Mitigation Guidance for the Commonwealth of Kentucky. http://www.fws.gov/frankfort/pdf/Jan2011%20Indiana%20bat%20Mitigation%20Guidance.pdf.

USGS (United States Geological Survey) 1966. *Availability of Ground Water in the Heath Quadrangle, Jackson Purchase Region, Kentucky*, Hydrologic Investigations Atlas HA-168, U.S. Department of the Interior, U.S. Geological Survey, Denver, CO.

USGS 1973. *Subsurface Geology and Ground-Water Resources of the Jackson Purchase Region, Kentucky*, Geological Survey Water-Supply Paper 1987, U.S. Department of the Interior, U.S. Geological Survey, Denver, CO.

USGS 2009. "Earthquake Hazard in the New Madrid Seismic Zone Remains a Concern," Fact Sheet 2009-3071, U.S. Department of the Interior, U.S. Geological Survey, Denver, CO, August.

APPENDIX A

SUMMARY OF SEISMIC CONDITIONS

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A.1 INTRODUCTION

If selected, the On-Site Alternative for waste disposal will include the siting, design, construction, and operation of a waste disposal facility. Because there are seismic sources that have potential to affect Paducah Gaseous Diffusion Plant (PGDP), siting and design criteria for an on-site waste disposal facility must consider regional and site-specific seismicity.

This appendix provides information that supports this remedial investigation/feasibility study (RI/FS), specifically, Chapter 3 "Evaluation of Seismic Conditions." Included in this appendix are summaries of the two site-specific fault studies conducted at PGDP (Sections A.2 and A.3) that are referenced in Chapter 3 (DOE 2004; KRCEE 2006). Also included as attachments to this appendix are the following:

(1) Attachment A1: Responses to comments from the Commonwealth of Kentucky on the May 2004 version of *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2004);

(2) Attachment A2: Seismic Presentation Slides and Meeting Minutes from the "Seismic Issues Workshop" held in Oak Ridge, TN on June 25, 2009; and

(3) Attachment A3: Memorandum of the "Bedrock Shear-wave Velocity Sensitivity Analysis," Jacobs, September 29, 2009.

Additional information on sheer wave velocity testing can be found in *DOE Headquarters Independent Review Team Report on Paducah Gaseous Diffusion Plant Seismic Characterization* (DOE 2009).

A.2 DOE 2004 SEISMIC INVESTIGATION

NOTE: A comprehensive seismic investigation was conducted by the U.S. Department of Energy (DOE) from 2001 to 2003 that consisted of both PGDP site-specific and regional studies. The results of that investigation are presented in *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plan, Paducah, Kentucky* (DOE 2004). Section A.2 is a reproduction of the Executive Summary that appeared in DOE 2004.

A.2.1 INTRODUCTION

This Seismic Investigation report has been prepared to summarize and present conclusions from a regional and site-specific Seismic Investigation at the Paducah Gaseous Diffusion Plant (PGDP), Paducah, Kentucky. This investigation has been performed to characterize a portion of DOE property that is under consideration for potentially siting a disposal facility for wastes generated from future environmental restoration activities implemented under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) at PGDP. PGDP was placed on the National Priorities List (NPL) in May 1994. In 1998, the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Commonwealth of Kentucky entered into a Federal Facility Agreement.

The Project Core Team (consisting of representatives from DOE, EPA, and the Commonwealth of Kentucky) has been evaluating options for disposing of future CERCLA wastes. One option under consideration is the disposal of those wastes in a potential on-site facility. A Siting Study was initiated in 2000 to support DOE's selection of a site for such a facility. Site 3A, located south of the plant, is a reconfiguration of one such site as presented in the Siting Study. The Seismic Investigation program consists of field characterization at PGDP, specifically at Site 3A, to determine whether it is feasible as a candidate site.

The Project Core Team developed the following seven questions that, when answered, would fully address the seismic issues at Site 3A. Table ES.1 repeats these questions and presents a summary of the answers developed during the Seismic Investigation.

1. Is there evidence of paleoliquefaction at or near PGDP?
2. Is there paleoseismic evidence of local strong motion?
3. Is there potential for future liquefaction in Site 3A?
4. Is there evidence of Holocene displacement of faults at PGDP?
5. Are there faults underlying the potential disposal facility site?
6. What is the peak ground acceleration (PGA) at the potential disposal facility site?
7. What are the characteristics of the design ground motion?

The Seismic Investigation program includes three primary tasks: (1) a Paleoliquefaction Study, (2) a Fault Study, and (3) a Geotechnical Study. Initial field activities began September 28, 2001, and were stopped March 27, 2002, when DOE postponed the evaluation of disposal options. After reconsidering the project, DOE resumed the seismic assessment of Site 3A. The additional field activities were performed during August and September 2003. Concurrent with these additional field activities, an assessment of recent applicable seismic research was performed to determine if revising the seismic design model was appropriate. The following sections summarize the investigation activities completed and the conclusions reached in each study.

A.2.1.1 Results of the Paleoliquefaction Study

The Paleoliquefaction Study was developed to address Questions 1 and 2, and to support answering Questions 3, 6, and 7. The study included a review of historical information on liquefaction in the region, a search for evidence of paleoliquefaction features in the region, an evaluation of borehole cores taken from Site 3A for evidence of past liquefaction, and an evaluation of the results of laboratory testing of soil samples collected from Site 3A to assess liquefaction potential. Paleoliquefaction is defined here as seismically induced liquefaction features associated with prehistoric Holocene or late Pleistocene earthquakes.

The purpose of the Paleoliquefaction Study is to determine (1) the existence of liquefaction features in Quaternary-age deposits in the PGDP region and (2) whether this liquefaction, if found, is the result of past New Madrid-type earthquakes or local earthquakes that originated in the PGDP vicinity. The regional study was conducted within a 15-mile radius of PGDP. The study consisted of reviewing historical data and conducting a field survey, which included ground inspections of target streams. The ground inspections consisted of surveying the banks of the Ohio River, Mayfield Creek, Bayou and Little Bayou Creeks, and a limited number of private land areas. Priority sites were identified and the landowners were contacted to obtain permission for entry. Detailed field studies were then performed at priority sites located along the Ohio River and creeks in southern Illinois. Landowners refused access to several priority locations.

Table A.1. Summary Answers to Project Core Team Questions to Address Seismic Issues at Site 3A

Question	Summary Answer
1. Is there evidence of paleoliquefaction at or near PGDP?	Field observations made along the Ohio River in the vicinity of PGDP found no large liquefaction features. Smaller scale paleoliquefaction features may have been present, but remained unobserved because of their relatively small size or veneer of river deposits and vegetative cover. Further, age dating performed in 2003 determined that the sediments are relatively young. There is no definitive evidence of paleoliquefaction at PGDP based on results of field investigations conducted along portions of Bayou and Little Bayou Creeks. The literature does report some small liquefaction features located along the banks of the Ohio River, about 8 miles northeast of PGDP, and along the Post Creek Cutoff, about 12 miles northwest of PGDP.
2. Is there paleoseismic evidence of local strong ground motion?	The absence of large paleoliquefaction features within 15 miles of PGDP suggests that local strong ground motion has not occurred since these surficial sediments were deposited. The small liquefaction features that have been reported in the literature are located in sediments that are especially prone to liquefaction and probably are associated with large historical earthquakes originating outside the area. It should be stressed that because ^{14}C dating determined that most of the observed sediment along the Ohio River is less than 1,000 years old, the available exposures provide only a paleoseismic record for the very late Holocene.
3. Is there potential for future liquefaction at Site 3A?	Many of the soils present at the site are clays and silts that, by their very composition, are not prone to liquefaction. In addition, laboratory evaluation of these materials found that they do not meet the criteria that distinguish those fine-grained soils that could experience large-scale strain, similar to liquefaction. The sands encountered at Site 3A are generally firm and are not expected to liquefy under low to moderate levels of ground motion. Some liquefaction within the sands and deformation within the silts and clays could occur at PGAs approaching 0.5 g.
4. Is there evidence of Holocene displacement of faults at PGDP?	This study did not find Holocene displacement of faults at Site 3A. Several faults identified in seismic reflection data at Site 3A have been confirmed to extend through the Porters Creek Clay and into the materials underlying the surficial loess deposits. Three of these faults are interpreted to extend to within approximately 20 ft of the ground surface. One deeper DPT borehole encountered three fault planes at depths between 22 ft and 28 ft. Tightly spaced, shallower DPT boreholes at these locations found no faults in the overlying loess. The radiocarbon dating at Site 3A found that the loess is late Pleistocene in age, and the deposits are at least as old as the oldest roots that grew into them (17,100 years old). At the Barnes Creek site located 11 miles northeast of PGDP, this study found Holocene age displacement of faults in deposits with ^{14}C dates ranging from 5,000 to 7,000 years BP.
5. Are there faults underlying the potential disposal facility site?	The site-specific fault study identified a series of faults beneath Site 3A. For most of the faults beneath Site 3A, relative movement along the main fault plane is normal, with the downthrown side to the east. These normal faults, along with their associated splays, either form a series of narrow horst and graben features, or divide the local sediments into a series of rotated blocks. Several of the faults extend through the Porters Creek Clay and into the materials underlying the surficial loess. Three of these faults extend to within approximately 20 ft of the ground surface. Tightly spaced shallower DPT boreholes found no evidence that these faults extend upward into the Pleistocene loess deposits and, therefore, are not Holocene in age.
6. What is the PGA at the potential disposal facility site?	Based upon data collected from Site 3A, the PGA at Site 3A is calculated to be 0.48 g for a 2,500 year return period earthquake.
7. What are the characteristics of the design ground motion?	The design ground motions at Site 3A would be the same as those presented in a 1999 study performed by Risk Engineering, Inc. The shear-wave velocities in the soil column at Site 3A are similar to those determined previously at other locations on the DOE property, resulting in similar design ground motions.

Field investigations conducted as part of the Seismic Investigation found no large liquefaction features along the Ohio River in the vicinity of PGDP. The riverbank afforded adequate exposure of the sediments such that if large liquefaction features were present they should have been obvious. Smaller-scale paleoliquefaction features may have been present, but were not observed because of their relatively small size or the typical veneer of river deposits and vegetative cover.

Field investigations conducted along portions of Bayou and Little Bayou Creeks found no definitive evidence of paleoliquefaction at PGDP.

The literature does report some small liquefaction features within 15 miles of PGDP. The closest are located along the banks of the Ohio River, about 8 miles to the northeast. These features are in the general vicinity of Fort Massac, Illinois, a location where liquefaction was reported during the February 7, 1812, New Madrid earthquake. These features were small and relatively unweathered, suggesting that they were probably outlying liquefaction features resulting from the 1811 and 1812 New Madrid earthquakes. Small liquefaction features are also reported in the literature along the Post Creek Cutoff, about 12 miles northwest of PGDP.

The absence of large paleoliquefaction features within 15 miles of PGDP suggests that local strong ground motion has not occurred since the surficial sediments were deposited. In this context "local strong ground motion" is defined as strong ground motion resulting from a local earthquake. The small liquefaction features that have been reported in the literature are located in sediments that are especially prone to liquefaction and are probably associated with large historical earthquakes originating outside the area. It should be stressed that because ^{14}C dating determined that most of the observed sediments along the Ohio River are less than 1,000 years old, the available exposures only provide a paleoseismic record for the very late Holocene.

The site-specific evaluation consisted of evaluating data collected during the Geotechnical Study for liquefaction potential at Site 3A. Many of the soils present at the site are fine-grained clays and silts that by their very composition are not prone to liquefaction. In addition, laboratory evaluation of these materials found that they do not meet criteria that distinguish those fine-grained soils that could experience large-scale strain, similar to liquefaction. The sands encountered at Site 3A are generally firm and are not expected to liquefy under low to moderate levels of ground motion. However, based on calculations presented in this report, it was concluded that some liquefaction within the sands and deformation within the silts and clays could occur at a PGA approaching 0.48 g.

A.2.1.2 Results of the Fault Study

The purpose of the Fault Study is to determine whether Holocene-age faulting has occurred in the PGDP vicinity. The Fault Study is to answer Questions 4 and 5 posed by the Project Core Team and to assist in any subsequent facility design activities. The Fault Study included both regional and site-specific components.

A.2.1.3 Results of the Regional Fault Study

The regional Fault Study collected data to support the design of a potential on-site CERCLA waste disposal facility. Such data include displacement, earthquake magnitude, recurrence interval, and age of the most recent event. The regional Fault Study was conducted at a site in Massac County, Illinois, at/near Barnes Creek, which is located approximately 11 miles northeast of PGDP. Tasks completed at the Barnes Creek site included visual observations and measurements of features in the banks of Barnes Creek, a ground penetrating radar (GPR) calibration survey, and follow-up GPR survey and direct push technology (DPT) boreholes in the target fault area. These tasks were implemented to identify the key geologic units, their relationship with observed faults, and their dates of deposition to establish ages of past fault movements. Although excavation of test pits and a trench was originally planned to collect visible evidence of shallow faulting, data collected from the creek banks and DPT boreholes were sufficient in dating of the deposits and in determining that no correlation exists between the topography and faulting.

Therefore, the DOE investigation team decided not to perform the test pits and trench excavation. The bank study was conducted along an approximately 2,600-ft-long portion of Barnes Creek. Visible faulting and other geologic features were studied at 12 locations. Fourteen organic samples were collected and sent to an off-site laboratory for ^{14}C age dating. The GPR survey was conducted across the suspected location of a terrace graben, approximately 1,100 ft north of Barnes Creek. Three parallel 900-ft lines were surveyed using a 200 MHz antenna; the survey provided high-resolution data of the uppermost sediments and was used to identify areas where the DPT boreholes should be located.

The DPT survey was conducted across the terrace graben area to identify potential Holocene faults, displacement at shallow depths, and surface morphology. Ten DPT boreholes were driven across a 450-ft section of the middle GPR survey line. The depths of the DPT boreholes varied between 32 and 63 ft, producing a total of nearly 404 ft of continuous core from the ten boreholes. Six organic samples were collected and sent to an off-site laboratory for ^{14}C age dating.

Geologic structures observed in Barnes Creek included individual joints, faults, clay dikes, and paired faults forming down-dropped blocks known as grabens. Neotectonic studies were carried out in a portion of Barnes Creek to determine if mapped faults have moved within the Holocene Epoch (within the last 10,000 to 12,000 years). Investigations in the creek identified five geologic units. The three oldest units, the Cretaceous McNairy Formation, and the gravels, sands, and silts of both the upper and lower Metropolis Formation, exhibit faults, clay dikes, and joints. The two youngest units, a surficial light brown sandy alluvium and an underlying light gray alluvium, did not exhibit faulting.

The trends (generally northeast-southwest) of the geologic structures in the oldest units and style of deformation is consistent with bedrock faults mapped to the north of the study area by the Illinois State Geological Survey (ISGS). The northeast-southwest trends are also consistent with the trend of the New Madrid seismic zone to the southwest, suggesting that these features may be related.

The relative timing of the observed deformations in the geologic structures varies. A number of geologic structures are limited to the McNairy Formation and clearly pre-date deposition of the Metropolis materials. Other features involve both the McNairy and Metropolis materials to the same extent, while others appear to be re-activation of old features in the McNairy after or during deposition of the Metropolis materials.

Radiocarbon ages confirm that repeated deformation has occurred along some of the observed faults. Deformation began prior to the deposition of the lower Metropolis (late Pleistocene), continued during the deposition of the upper Metropolis (which is 5,000 to 7,000 years old), and most recently occurred in the mid-Holocene, after the deposition of the upper Metropolis (within the last 5,000 years). Therefore, faults observed at the Barnes Creek site did extend into Holocene-age deposits. The maximum displacement observed in a single event is approximately 1 ft in the lower Metropolis.

Investigation of the terrace graben area concluded that the observed stratigraphy is consistent with a combination of two models: (1) a graben with up to 50 ft of displacement within the past 12,000 years, and (2) an erosional feature with up to 50 ft of infilling within the past 12,000 years. Radiocarbon ages in the terrace graben area at the Barnes Creek site indicate that the deep fine-grained sediments beneath the

Metropolis are approximately 11,000 years old, indicating that the overlying Metropolis dates from the late Pleistocene or early Holocene.

A.2.1.4 Results of the Site-Specific Fault Study

The site-specific Fault Study at Site 3A was developed to answer Questions 4 and 5. The site-specific Fault Study was conducted to determine whether evidence of Holocene faulting exists at Site 3A. Because Site 3A is entirely underlain by the Porters Creek Clay, initial activities were conducted to determine whether deformation of the Porters Creek Clay is apparent, based on results of a seismic compression wave (p-wave) reflection survey. Follow-up activities were then conducted to provide higher resolution data in order to determine whether displacement is apparent at relatively shallow depths. These follow-up activities included a seismic horizontal shear-wave (s-wave) reflection survey and DPT boreholes within a target fault zone at Site 3A. Although excavation of test pits and a trench was originally planned so as to collect visible evidence of shallow faulting, field conditions (e.g., water levels, excessive excavation depths, obstructions, and wetlands) were not amenable to excavation nor to successful data collection. Therefore, the DOE investigation team decided not to perform the test pits and trench excavation. Instead, a series of additional, tightly spaced, DPT boreholes were drilled in the overlying materials to determine if faulting is present in these younger units.

The initial p-wave survey evaluated four combinations of energy sources and selected the T-15000 iVi Minivib as providing the highest resolution at Site 3A. Approximately 16,000 lin. ft of survey data were collected along five lines (seven segments) using a geophone group interval of 5 ft, shot spacing of 10 ft, 144-channel, 36-fold survey configuration. Several horizons were successfully imaged beneath Site 3A, including the top of limestone bedrock, the McNairy Formation (lower sand facies), and portions of the Porters Creek Clay. The results indicated potential young faults extending from the limestone bedrock up into the Porters Creek Clay.

A GPR calibration survey was conducted to determine whether GPR was capable of penetrating local clays and silts to identify subsurface features. At the Barnes Creek site, four GPR tests were conducted using 200, 100, 80, and 16 MHz antennas along a 1500-ft test line. The 200 MHz antenna was selected as providing the greatest resolution at the Barnes Creek site. At Site 3A, two GPR tests were conducted using 200 and 40 MHz antennas along a 750-ft test line. Because neither of these antennas provided suitable resolution of the geology at Site 3A, no follow-up GPR survey was recommended for Site 3A.

The follow-up s-wave survey focused on two areas at Site 3A where potential young faults were suggested by the p-wave survey. Approximately 2300 lin. ft of data were collected along two lines using a MicroVib source, 96-channel seismograph, 48-fold survey, and 40-Hz horizontal component geophones at a group interval of 2 ft and shot spacing of 2 ft. Several horizons were successfully imaged, including the Porters Creek Clay, an overlying firm sand unit, and portions of the loess. Several potential faults extending up to or near the bottom of the loess unit were identified.

During the field investigations conducted in 2001 and 2002, ten DPT boreholes were driven along the two s-wave survey lines to depths ranging from 21 to 40 ft. In addition, an 11th DPT borehole was driven at one of the planned shallow boring locations (SB-04). The 2001–2002 DPT survey produced a total of nearly 400 ft of continuous core from the 11 boreholes. Three fault planes were observed at depths of 22 ft to 28 ft in a DPT borehole near the southern boundary of Site 3A. Five organic samples were collected from the 2001–2002 DPT survey and sent to an off-site laboratory for ^{14}C age dating.

Three test pits and a trench originally were planned to determine if the faulting also is present in the youngest deposits. Based on the results of the initial DPT survey and the site-specific Geotechnical Study, the DOE investigation team determined that the test pits and trench would not be constructed during the

2001–2002 investigation. This decision also was based on field conditions that would prohibit these activities as planned (e.g., high groundwater; excessive excavation required to reach required depths; and obstructions, including trees/woods, paved roads, an underground utility, and potential wetlands). These conditions presented safety and environmental impact issues that were not anticipated in the planning phase of the project. Instead, in 2003 a second round of DPT boreholes was substituted for the pits and trench.

During the 2003 DPT survey, tightly spaced DPT boreholes were driven into the loess deposits overlying the faulting observed in the deeper DPTs and interpreted in the seismic reflection data. The DPT locations targeted the interpreted faults. The 2003 DPT survey produced a total of approximately 400 ft of continuous core from 19 boreholes. Twenty-two organic samples were collected from the 2003 DPT survey and were sent to an off-site laboratory for ^{14}C age dating.

The site-specific Fault Study identified a series of faults beneath Site 3A. For most of the faults, relative movement along the main fault plane is normal, with the downthrown side to the east. These normal faults, along with their associated splays, either form a series of narrow horst and graben features, or divide the local sediments into a series of rotated blocks.

Several of the faults identified in the p-wave survey extend through the Porters Creek Clay at an approximate depth of 30 to 60 ft and into the materials underlying the surficial loess deposits. Three of these faults were interpreted to extend to within approximately 20 ft of the ground surface. A DPT borehole drilled adjacent to one of the postulated shallow faults encountered three fault planes at depths between 22 and 28 ft. No faults were observed in the overlying loess sampled in this same DPT borehole or in the tightly spaced boreholes driven during the 2003 DPT survey. The radiocarbon dating at Site 3A found that the unfaulted loess is late Pleistocene in age and is at least 17,100 years old.

Therefore, this study did not find Holocene displacement of faults at Site 3A.

A.2.1.5 Results of the Geotechnical Study

The purpose of the Geotechnical Study is to determine the variability of the lithology underlying Site 3A and to acquire seismic and geotechnical characteristics of the deposits at Site 3A for use in the design of a potential on-site CERCLA waste disposal facility. The Geotechnical Study is to provide data that support answers to Questions 3, 6, and 7 posed by the Project Core Team. Field activities included drilling, sampling, and testing of two deep boreholes, one using a Rotosonic drilling technique (DB-01) and an adjacent one using a mud rotary drilling technique (DB-02). The activities also included drilling, sampling, and testing of shallow mud rotary boreholes and seismic cone penetrometer test (SCPT) soundings.

The deep Rotosonic borehole (DB-01) was drilled to a total depth of 359 ft, producing a continuous core. A downhole natural gamma log of the borehole was conducted. The deep mud rotary borehole (DB-02) was drilled to bedrock, which was encountered at a total depth of approximately 400 ft. Standard Penetration Test (SPT) sampling was conducted continuously to a depth of 75 ft, and at approximately 20-ft intervals thereafter to 186 ft. A downhole seismic velocity log of the borehole was conducted. Five mud rotary boreholes were drilled to depths ranging from 52 to 70 ft. Two additional boreholes were planned; however, because heavy rainfall prevented access by the drill rig, the DOE investigation team converted the planned borings into one DPT borehole (SB-04) and one SCPT sounding (SB-07) so that a lighter track-mounted rig could be used. SPT sampling was acquired continuously throughout the depth of the boreholes. Three organic samples were collected and sent to an off-site laboratory for ^{14}C age dating.

Forty-four Shelby tube samples and 153 split spoon samples were collected from the borings and sent to an off-site geotechnical laboratory for analysis. Forty of the Shelby tube samples were analyzed for in-place density, vertical permeability, triaxial compressive strength, and one-dimensional consolidation.

Forty-eight split spoon samples were analyzed for index properties and contaminant transport properties. Fourteen SCPT soundings were completed at 11 locations at Site 3A to depths ranging from 10 ft (refusal) to 70 ft, for a total of 623 ft. Continuous tip, sleeve, and pore pressure measurements were collected from 6 ft to total depth in each SCPT sounding. Twenty-nine pore pressure dissipation tests were conducted in varying lithologies. Seismic s-wave velocities were measured at approximate 3-ft intervals.

Bedrock was encountered at a depth of 400 ft below ground surface (bgs) in borehole DB-02 at Site 3A. The McNairy Formation was encountered overlying bedrock to a depth of 155 ft bgs, for a total thickness of 245 ft. The Porters Creek Clay was encountered overlying the McNairy to a depth varying between 30 and 60 ft bgs. Terrace Deposits typically overlay the Porters Creek Clay to a depth of 15 to 20 ft bgs. Surficial loess deposits were encountered overlying the Terrace Deposits. In some areas there are younger alluvial deposits of Holocene age that fill former erosional features incised in the loess.

Results of settlement calculations predict that the total settlement of a potential disposal cell constructed to a height of 102 ft above ground surface would result in more than 5 ft of settlement in the center of the cell area. Differential settlement may be as large as 2 to 3 ft across the disposal cell. Detailed design would need to account for such differential settlement by increasing the slopes of the base grades, bottom liner, and drain lines, and by selecting appropriate construction materials. It should be noted that the amount of disposal cell settlement may be overestimated because of difficulties in retrieving undisturbed samples in the Porters Creek Clay. Settlement would occur relatively rapidly, with 90% of the settlement occurring in less than 2 years of fill placement so that settlement would be essentially completed by the time the cell is filled.

Results of bearing capacity analysis indicate that the bearing capacity of the foundation soils is adequate to support a potential CERCLA waste disposal facility at Site 3A.

A.2.1.6 Results of the Seismic Hazard Study Design Model

A seismic design model was developed for Site 3A to answer Questions 6 and 7; namely, to determine the PGA and design ground motions for a potential on-site CERCLA waste disposal facility. The model was developed based on the data collected during the site-specific Fault Study and Geotechnical Study.

A probabilistic seismic hazard analysis was performed to determine what the PGA and other related ground motions (ground shaking frequency, velocity, and displacements) would be at Site 3A for an earthquake having a 2500-year return period. The corresponding PGA value at the top of rock (400-ft deep) was determined to be 0.71 g.

Because the potential on-site CERCLA waste disposal facility would be founded on soil materials up to 400 ft thick, further analysis was needed to calculate the PGA at the top of the soil (at the base of the disposal cell). Soils typically amplify the top-of-rock PGA; therefore, a factor, called the "soil amplification factor," is used to convert top-of-rock PGA to top-of-soil PGA. A site-specific soil amplification factor was calculated for Site 3A based on the s-wave velocities measured in the deep borehole (DB-02) and SCPT soundings using the methodology employed by Risk Engineering, Inc., in its 1999 study. The soil amplification factor for a top-of-rock PGA of 0.71 g was calculated to be 0.67. This results in a top-of-soil PGA of 0.48 g for a 2500-year return period earthquake at Site 3A.

This value is equal to the top-of-soil PGA value of 0.48 g interpolated from Risk Engineering, Inc., in a previous reevaluation study at PGDP. Therefore, the recommended top-of-soil PGA for the design of a potential CERCLA waste disposal facility at Site 3A is 0.48 g.

The s-wave velocities in the soil column at Site 3A are similar to those determined previously at other locations on the DOE property, resulting in similar design ground motions. Therefore, the design ground motions at Site 3A would be the same as those determined by Risk Engineering, Inc. A uniform hazard spectra that relates ground acceleration to the ground shaking frequency is presented in this report to define the design ground motions at Site 3A.

As a result of a July 10, 2003, meeting with the Kentucky Department for Environmental Protection, DOE agreed to review other ongoing earthquake hazard studies. This review consisted of an assessment of literature published by the Seismological Society of America and the American Geophysical Union, as well as independent publications and publications of Engineering Geology. Appendix J provides an overview of this work.

Over 3000 papers and abstracts published from 1999 to 2003 were reviewed to determine potential applicability. A summary of each was written, and the potential impact on the Seismic Investigation of Site 3A determined in one of three ways:

1. No immediate impact—findings would not enhance report; does not affect study.

2. Immediate impact—findings would affect conclusion-requires revision of report.

3. Potential long-term impact—findings, if applied to study, might change conclusion of study.

No papers or abstracts were found that would warrant a change in the current report. (NOTE: Many of the articles that potentially could change the seismic hazard would result in a less conservative value.)

A.3 KRCEE 2006 SEISMIC INVESTIGATION

NOTE: A fault study investigation was performed at the C-746-U Landfill area in 2005 to assess whether or not Holocene-active fault displacement is present beneath the footprint of the proposed landfill expansion. *Investigation of Holocene Faulting, Proposed C-746-U Landfill Expansion, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, which was prepared for the University of Kentucky Research Consortium for Energy and Environment, Frankfort, Kentucky, by William Lettis & Associates, Inc., (KRCEE 2006) provides the details of collecting and interpreting closely-spaced direct push technology (DPT) soil cores along the two seismic lines. Section A.3 is a reproduction of the Executive Summary that appeared in KRCEE 2006.

A.4 EXECUTIVE SUMMARY

This report presents the findings of a fault hazard investigation for the C-746-U landfill's proposed expansion located at the Department of Energy's (DOE) Paducah Gaseous Diffusion Plant (PGDP), in Paducah, Kentucky. The planned expansion is located directly north of the present-day C-746-U landfill. Previous geophysical studies within the PGDP site vicinity interpret possible northeast-striking faults beneath the proposed landfill expansion, although prior to this investigation the existence, locations, and ages of these inferred faults have not been confirmed through independent subsurface exploration. The *Code of Federal Regulations* (*CFR*), Subtitle D, Title 40, Part 258, subpart B (258.13) requires that disposal facilities (such as the C-746-U landfill and possible expansions) be located more than 200 ft from a fault that has had surface displacement within Holocene time (i.e., approximately the past 11,000 years). The purpose of this investigation is to assess whether or not Holocene-active fault displacement is present beneath the footprint of the proposed landfill expansion. This information can be used to address compliance of the proposed expansion with *CFR*, Subtitle D, Title 40, Part 258, subpart B (258.13). The investigation was completed as a collaborative effort involving William Lettis & Associates, Inc., the Geology Department of the University of Kentucky, the University of Kentucky-Kentucky Research Consortium Energy and Environment (KRCEE), and the University of Chicago. Technical peer review of the approach, methods, results and conclusions of this study have been provided by scientists and technical experts with the Kentucky Geological Survey, the Illinois Geological Survey, the University of Memphis, the University of Illinois—Champaign, Science Applications International Corporation (SAIC), and M. Tuttle & Associates.

The geologic assessment included (a) review of relevant geologic and geotechnical data from the site vicinity, (b) analysis of detailed aerial photography, (c) field reconnaissance of the site vicinity and other important sites of previous investigations, (d) collection and stratigraphic analysis of 86 subsurface sediment cores, (e) laboratory chronological (age-dating) analyses, and (f) preparation of this report. All of these activities were completed at or above the accepted standard-of-practice for geologic investigations in the mid-continent region; overall this investigation represents an effort that exceeds previous levels of investigation for site-specific fault-rupture assessments in the mid-continent. Detailed subsurface geologic information was collected along several transects at the proposed landfill site to define buried strata and assess the possibility of fault-related differences in elevation of the strata. Stratigraphic data were collected from 86, 30-ft-long continuous soil cores (a total of 2,580 ft) using direct push technology (DPT). The DPT coring method involves pushing a hollow, 1-11/16 inch diameter, cylindrical coring tube into subsurface material and extracting the core sample for laboratory analysis. Immediately upon extraction at the proposed landfill site, the cores were sealed and transported to the Kentucky Geological Survey Core Laboratory (in Lexington), where they were unsealed and analyzed for lithologic and pedogenic (soil) characteristics. The analytical process included simultaneous exposure of multiple cores, arranged within the laboratory facility according to depth and position along a given transect, and detailed logging of each core in its entirety. This arrangement facilitated core logging and enabled definitive correlation of stratigraphy among several cores. Strata exposed by the cores are identified and differentiated based on lithologic characteristics, such as grain size (texture), sorting, color, contact irregularities, soil (pedogenic) structure, pedogenic clay or iron-oxide accumulation, and other characteristics. A total of 12 samples of wind-blown loess deposits were sent to the University of Chicago for age-dating via the optically stimulated luminescence (OSL) dating method.

Geologic cross-sections prepared from the DPT data identified laterally continuous horizontal strata for assessing the possibility of fault displacement, and for evaluating the timing of such displacements. Seven primary geologic units are present beneath the site at depths of less than 30 ft, as generalized in the table below. Based on the OSL age-dating analyses, the deposits encountered in the cores range in age from about 16 ka to greater than 125 ka (see table below), which is in good agreement with ages determined for similar loess and fluvial packages elsewhere in the central United States.

Table A.2. Geologic Unit

Unit Name	Unit Number	Depth Below Ground Surface (Ft)	Unit Age (1000 x years)	Potential Fault- or Fold-related Deformation?	Number of Potential Fault related or Fold related Features
Upper Peoria	Unit 1	0–6	15.4–25.2	No	0
Lower Peoria	Unit 2	7–9	21.8–30.9	Possibly	1
Roxana Silt	Unit 3	9–11	32.1–50.7	Possibly	3
Unnamed Intermediate Silt	Unit 4	12–13	53.6–75.5	Possibly	14
Metropolis Formation	Units 5.1, 5.2, and 5.3	> 15	> 125–180	Possibly	25

Geologic cross-sections developed from the DPT data show that the upper three units (i.e., the Upper Peoria Loess, Lower Peoria Loess, and Roxana Silt) generally are flat-lying and mantle pre-existing topography. In contrast, the lower, older units (Unnamed Intermediate Loess and the Metropolis Formation) exhibit occasional subtle to abrupt undulations of basal contacts, which may reflect fluvial processes and/or tectonic-related deformation. The geologic cross sections allow for as many as four folds and 21 features with noticeable elevation changes along stratigraphic and/or pedologic boundaries, as summarized in the table above. These possible elevation changes represent differences in the elevation of a given stratigraphic boundary that exceed the uncertainty in the boundary depths based on laboratory measurements, and thus probably are related to natural (tectonic or non-tectonic) processes.

Of the 25 features interpreted to represent elevation changes of stratigraphic boundaries within the Metropolis Formation (units 5.1 to 5.3), 14 may extend upward into the Unnamed Intermediate Silt (unit 4). Similarly, only three of these 14 features possibly extend upward into the Roxana Silt (unit 3) and only one may extend into the Lower Peoria Loess (unit 2). None of the features extends into the Upper Peoria Loess. Any of these 25 features may have formed as a result of non-tectonic processes, such as local fluvial or wind erosion. In particular, the three elevation changes in the base of the Roxana Silt are unlikely to be related to fault displacement, because the sense of vertical separation differs among the various boundaries. Also, if any of these features were to be interpreted as a fault, it would have an anomalously shallow dip, and thus the differences in sense of displacement upsection would imply both normal and reverse faulting, depending on the stratigraphic level. The absence of similar elevation differences elsewhere in the sections lends support to the interpretation of a non-tectonic origin for these three features.

Therefore, if late Quaternary displacement has occurred beneath the site, the most-recent displacement occurred following deposition of the Unnamed Intermediate Silt between approximately 53,600 and 75,500 years ago. Although unlikely, the data do not preclude the possibility of displacement of the Roxana Silt beneath the site, which is approximately 34,600 to 47,200 years old. There is no perceptible displacement of the base of the Upper Peoria Loess, which is approximately 16,600 to 23,500 years old. If late Pleistocene faulting occurred at the site, the age of such deformation would be similar to the youngest age of faulting previously interpreted along northeast-striking faults in southern Illinois.

Thus, the detailed coring data collected during this investigation show no evidence for Holocene (< 11,000 years) displacement along previously interpreted faults underlying the site. The data and interpretations do not preclude the possibility of late Pleistocene displacements at a few localities beneath the site, although the stratigraphic elevation changes may also be interpreted as stratigraphic variability related to erosional or depositional processes. Based on these data, we conclude that the latest Pleistocene strata have not been displaced, and that faults beneath the site, if they exist, have been inactive during the

Holocene. On the basis of the findings of this study, and in compliance with *CFR*, Subtitle D, Title 40, Part 258, subpart B (258.13), a setback of 200 ft from the previously interpreted faults is not warranted.

ATTACHMENT A1

RESPONSE TO KENTUCKY COMMENTS ON THE 2004 SEISMIC INVESTIGATION REPORT

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Responses to Kentucky Division of Waste Management Comments on the *Seismic Investigation Report for Siting of a Potential On-Site Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2038&D2), March 2004

The following comments were received on June 19, 2009, from the Kentucky Division of Waste Management (Kentucky) following a DOE request in May 2009 to review the referenced report that previously was sent for information. During the Seismic Issues Workshop held in Oak Ridge, TN, June 25, 2009, there was an agreement between DOE and Kentucky that the responses to their comments would be included in this RI/FS report.

General Comment 1: Risk Engineering Inc. (1999) utilized a bedrock shear-wave velocity of 2,000 feet/sec (f/s). The Bechtel Jacobs Company re-evaluation report suggests 8,500 f/s based on Street, et al. (1997). However, the ~8,500 f/s velocity was derived from one sounding several kilometers to the east (i.e., I-24 Bridge). Although this level of extrapolation is permissible for academic investigations, it is unacceptable for design-level work. An uncertain site-specific bedrock shear-wave velocity will result in poorly defined soil-rock impedance contrast thus an uncertainty in the ground motions site-effect calculations. At least one high-quality compressional and shear-wave velocity measurement of UNWEATHERED bedrock is required prior to the Department of Energy (DOE) presenting a preliminary or final design for a potential onsite disposal cell.

Response: DOE performed a "sensitivity analysis" to determine whether a bedrock shear-wave velocity measurement is required to support the remedial investigation/feasibility study (RI/FS), detailed design, or not required at all. The sensitivity analysis approach was presented during the June 25, 2009 Seismic Issues Workshop in Oak Ridge, TN. This analysis revealed that the surface peak ground acceleration values were not particularly sensitive to changes in the bedrock shear-wave velocities. This appendix (Attachment A3) contains the summary report from that analysis. Based on the results of the analysis, DOE has decided to delay the acquisition of a Paducah Gaseous Diffusion Plant (PGDP) bedrock shear-wave velocity until after the decision on whether to build an on-site disposal facility has been made and a site for the facility has been selected. Regardless of the site selected, some characterization of that site is expected. A deep borehole into competent bedrock may be drilled and the requested information may be obtained at that time.

General Comment 2: Averaging of standard penetration test data by "soil zone" is invalid for preliminary or final engineering design. Ideally, the goal of standard penetration tests is to evaluate the physical properties of the soil for stability and liquefaction analysis. Averaging of the data results in the potential "filtering" or sorting out of any small or localized anomalous areas. Moreover, an "averaged" profile can potentially be uncharacteristic of any discrete measured soil characteristic at the site. Areas that possess low blow counts- and are consequently liquefaction-susceptible- would be considered areas of potential failure. Regions of low blow counts should be mapped so areas of potential liquefaction can be determined. Provide layered isopach maps, cross-sections, or fence diagrams that visually indicate the three-dimensional distribution of blow count data at Site 3A. This same exercise- including an evaluation of liquefaction potential- must be completed for any other site on the DOE reservation that may be selected as the footprint for any future Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA) waste disposal cell. In other words, if Site 3A is not selected then liquefaction potential must be re-evaluated- using geophysical data unique to the selected site- for any other site that may be selected.

Response: DOE has provided the requested information for Site 3A. DOE recognizes that a similar evaluation of liquefaction potential will be required if a site other than Site 3A is selected [and the on-site disposal alternative is selected in the Record of Decision (ROD)].

General Comment 3: This document fails to include adequate documentation detailing how differential settlement and total settlement figures for Site 3A were derived. Given the importance of these calculations in terms of site screening, it is not unreasonable to request that the methodology and derivative calculations be provided along with any assumptions inherent to those calculations. Please provide any and all calculations that substantiate the stated claim that 2 to 3 feet of differential settlement and 5.2 feet of settlement (at the center of the cell) will take place given the current waste type/volume assumptions

Response: The calculation package for the total settlement of 5.2 feet. The calculation package was provided in a separate transmittal to Kentucky and EPA vie e-mail on February 5, 2010. The calculation package shows total settlement estimates and rates of settlement, but does not derive the range of differential settlement. In talking with the PE who performed the original calculation, it appears that a proportional amount (~50%) was used as an assumption for the 2-3 ft range of differential settlement. If on-site disposal is selected as the preferred remedy, additional differential settlement calculations would be performed to determine design parameters for the disposal facility and its system components to address critical items such as leachate collection, cover cracking, ponding of water on the cell cover, etc.

Specific Comment 1 (Section 3.5.5, Page3-28, 2nd paragraph): The last sentence in the paragraph describes flow in the Terrace Deposits Flow System. It is inferred that groundwater flow on top of the terrace is to the northwest and that the horizontal gradient is approximately 0.009 ft/ft. It is also stated that this flow primarily discharges to the upper continental recharge system (UCRS) beneath the plant but that some of the flow may discharge to nearby creeks. In fact, this flow system is not well understood. The assumption that most of the terrace groundwater flow discharges to the UCRS was not incorporated into recent re-evaluation of the PGDP groundwater flow and contaminant transport model. The draft *2008 Update of the Paducah Gaseous Diffusion Plant Sitewide Flow and Groundwater Model* states that "a likely discharge location for Terrace Gravel groundwater is little Bayou Creek." Additional hydrologic data will be needed to better characterize the Terrace Deposits Flow System in order to evaluate Site 3A as a potential waste disposal site. Without this information in hand, uncertainties may force the waste acceptance criteria at this location to be overly restrictive, thereby resulting in an increase in waste disposal costs.

Response: The report *Assessment of the Adequacy of Geotechnical and Hydrogeological Data in the Terrace Setting to Support a Remedial Investigation/feasibility Study (RI/FS) Level Evaluation of Potential Waste Disposal Sites, Paducah, Kentucky* (GEO/09-207 R2) was prepared to assess the adequacy of existing geotechnical and hydrogeological data at and near the PGDP for use in this RI/FS. The review concluded that existing geotechnical and hydrogeological data were adequate for this use. DOE recognizes that additional geotechnical and hydrogeological data may be required to support a site-specific facility design and finalization of the waste acceptance criteria if on-site disposal is selected in the ROD.

Specific Comment 2 (Section 5.5, Page 5-16): This section fails to provide the "simplified analysis" to each borehole (along with their specifically associated geotechnical properties) and to present a table of resulting factors-of-safety. Such an analysis will assist decision-makers in their task of determining the appropriateness of Site 3A (or any other site on the DOE reservation) as a location for a future CERCLA waste disposal cell. Provide discrete simplified analyses for each borehole.

Response: DOE plans to perform the requested evaluations to support the site-specific design if on-site disposal alternative is selected in the ROD.

Specific Comment 3 (Section 7.1.5, Page 7.4): It is unclear from the text's description of "Method 1" which recognized algorithm, along with associated input parameters (e.g., geotechnical index properties, shear and damping moduli, etc.) were utilized to calculate the site's transfer function. The current state-of-practice is to define a top-of-rock ground motion from a probabilistic seismic hazard analysis or deterministic seismic hazard analysis, then generate a synthetic (stochastic or composite-source modeled) and/or shaped observed time history as an input bedrock motion for the transfer function calculation using the standard one-dimensional (1D) linear-equivalent algorithm (e.g., SHAKE, WAVES, etc.). It does not appear the Method 1 utilized *Shake* but another "equivalent linear method." Identify the algorithm that was used to derive the transfer function for Site 3A and provide citations that support the decision to use a 1D program that may be viewed as non-conventional.

Response: As discussed in the June 25th Seismic Issues Workshop, DOE expects to repeat the modeling to derive the transfer function during site-specific facility design (if on-site disposal is selected in the ROD). The level of detail and information requested in this comment will be provided following completion of that modeling to allow it to be independently reviewed and repeated.

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ATTACHMENT A2

PRESENTATION SLIDES AND MEETING MINUTES FROM THE SEISMIC ISSUES WORKSHOP
OAK RIDGE, TN
JUNE 25, 2009

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Paducah Gaseous Diffusion Plant Seismic Characterization

DOE Headquarters Independent Review Team Report Recommendations

June 25, 2009

Introduction

- Independent Review Team (IRT) formed in August 2008
  - Dr. Brent Gutierrez, PE, CEM
    - Department of Energy Savannah River, Team Lead
  - Dr. Stephen McDuffie
    - Department of Energy Chief of Nuclear Safety Staff
  - Jeffrey Munsey
    - TVA River Operations Dam Safety
  - Frederick Loceff, PE
    - Frederick Loceff Technical Services

Team Review Activities

- September 3, 2008 Review Kick-Off Meeting
  - PPPO
  - Contractor Staff
  - Commonwealth of Kentucky representatives
- September 3 – December 2008
  - Independent review conducted
- Review Report
  - January 2009 Issued Report
  - May 2009 Comment resolution
  - June 2009 Final Report

Report Recommendations

- Overall – IRT finds that the Site and regional characterization work is sufficient for the PPPO to move forward with an RI/FS, which will then enable PPPO to decide whether to build a CERCLA landfill.

Report Recommendations

- Eight specific recommendations
  - Made in the context of future cell design work for on-site disposal decision
  - Recommendations 4, 5, and 8 should be pursued regardless of decision

Report Recommendations

Recommendation 1: Propose to the State of Kentucky and EPA regulators, and reach agreement on, a design ground motion, a method for determining it, and landfill performance criteria.

- This recommendation refers only to design and performance criteria for a landfill.
- The current body of site information is sufficient to move forward with an RI/FS to decide whether to construct a disposal cell at the PGDP.
- If PPPO decides to construct a cell, then PPPO, Kentucky DWM, and the EPA regulators must agree on:
  - the ground motion to which the cell will be designed, and
  - the cell's performance criteria.

Report Recommendations

Recommendation 2: Discuss with Kentucky DWM whether a study of landfill sensitivity to bedrock Vs is necessary, and if so, will it be sufficient to resolve their concern.

- The IRT finds the current limestone bedrock Vs data are sufficient to proceed with the decision on whether to construct a cell.
- The KY DWM need for additional Vs data should be determined before a sensitivity study is performed, and before any plans for future site data collection are finalized.

Report Recommendations

Recommendation 3: Perform characterization and analysis to investigate Holocene faulting at the candidate CERCLA cell site(s) following the two-phased approach outlined in the report.

- The IRT believes that the difficulty in proving the absence of Holocene faulting should be considered by owners and regulators in determining an appropriate and reasonable level of investigation.
- The IRT believes that the Holocene faulting investigation approach for site 3A should be followed for any future candidate site that does not already have at least the same level of investigation as that performed for site 3A.
- The IRT strongly recommends that future fault investigations include inclined boreholes to increase the chance of intersecting vertical or near vertical faults.

Report Recommendations

Recommendation 3 continued:

- The IRT recognizes the difficulties with trenching at the site, but given the potential value of trenching investigations, this method should continue to be considered as an investigation tool where feasible.
- The IRT believes that high resolution, shallow electrical resistivity surveys have the potential to further define disturbed or faulted strata and should, therefore, be explored as investigation tools by performing testing similar to that which was performed for ground penetrating radar surveys.
- The IRT suggests that downhole geophysical logging be tested as a means of differentiating the near surface stratigraphy.

Report Recommendations

Recommendation 4: Update to the PGDP Probabilistic Seismic Hazard Assessment (PSHA). The most recent conventional PSHA, performed by REI (1999), is a decade old. A Level 2 PSHA using the Senior Seismic Hazard Analysis Committee (SSHAC) process would serve to improve the state of knowledge at PGDP, and it could consider new information as outlined in Section 3.1.

- Considerable additional data and models have been generated since the 1990 analysis.
- The forthcoming model from the Central and Eastern U.S. (CEUS) Seismic Source Characterization Project (due mid-2010) should be very helpful in producing an updated PSHA for the Site.

Report Recommendations

<u>Recommendation 5</u>: Further investigate the sand dikes east of Paducah to better determine the timing, location, and magnitude of their seismic source(s). If these can be determined, they may impact PGDP PSHA results.

Report Recommendations

Recommendation 6: Although some analytical methods require use of peak horizontal ground acceleration (PGA), ground motions near 1 Hz are likely close to the fundamental frequency of the disposal cell and should, therefore, be considered when characterizing the seismic hazard and vulnerability of a PGDP disposal cell.

- This recommendation is nothing more than a reminder that sidewalls of a disposal cell are likely to have a fundamental frequency close to 1 Hz, so accelerations in this frequency range must be a primary consideration when designing the cell.

Report Recommendations

Recommendation 7: Adopt a clear position on the definition of an active fault if this is a useful term for design or regulatory purposes.

- The IRT simply recommends a single definition be employed in the future.

Report Recommendations

Recommendation 8: Continue microearthquake and strong motion monitoring at and near the PGDP.

SEISMIC ISSUES WORKSHOP

PGDP Waste Disposal Options Project
Jacobs Technical Center
Oak Ridge, TN
June 25-26, 2009

Seismic Issues Workshop

- Welcome-John Gadd
- Introductions
- Agenda-Marshall Davenport

Agenda

- DOE-HQ Independent Review Team Report
- Holocene Faulting on the PGDP
- Bedrock Shear-wave Velocity Sensitivity Analysis
- Seismic Hazard Analysis Methodology
- General Ground Motion Design Parameters
- Comments on the 2004 Seismic Investigation Report
- Future DOE/Regulator Meetings

DOE-HQ Independent Review Team

- Dr. Brent Gutierrez (DOE-Savannah River Site)
- Dr. Stephen McDuffie (DOE-Chief of Nuclear Safety Staff)
- Jeffrey Munsey (TVA)
- Frederick Loceff (Frederick Loceff Technical Services)

DOE-HQ Independent Review Team

Summary of IRT Recommendation	PGDP Waste Disposal Options Project Action
1. Propose to the regulators and reach agreement on a design ground motion, a method for determining it, and the performance criteria for the cell. The 2500-year ground motion is a reasonable design standard, but the specific value should be determined using an updated probabilistic seismic hazard analysis (PSHA). Complete as soon as possible to support decision on whether to develop a disposal cell.	Initial discussions on the design ground motion, a methodology for determining a design ground motion, and seismic performance criteria will be held during this workshop.
2. Discuss with Kentucky Division of Waste Management whether a study of landfill sensitivity to bedrock shear wave velocity is necessary and, if so, will it be sufficient to resolve their concern. A study to test the sensitivity to the range of shear-wave velocities has been proposed. The IRT finds this prudent. Pursue as soon as feasible if on-site disposal is selected.	A bedrock shear-wave velocity sensitivity analysis will be performed to support the RI/FS and to develop a recommendation as to if/when site-specific bedrock shear-wave velocity data are required. The methodology will be detailed at this workshop. Comments received will be considered and appropriately incorporated into the analysis.
3. Develop a Holocene faulting investigation methodology to be applied to potential CERCLA cell sites. The approach applied at Site 3A should be followed for any other candidate site that does not have at least the same level of investigation as Site 3A; however, additional investigation is warranted at Site 3A and other sites to be considered. Pursue as soon as feasible if on-site disposal is selected.	No field investigations related to Holocene faulting are planned for the RI/FS. A map showing the correlation of faults and earthquake locations from monitoring networks in the PGDP area will be prepared for the RI/FS.

DOE-HQ Independent Review Team

Summary of IRT Recommendation	PGDP Waste Disposal Options Project Action
4. The most recent conventional PSHA (Risk Engineering 1999) should be updated using a Level 2 PSHA Senior Seismic Hazard Analysis Committee process. Consider commissioning an update to the PGDP Probabilistic Seismic Hazard Analysis. Adopt regardless of on-site disposal decision.	This recommendation will be considered following discussions on the seismic hazard analysis in this workshop.
5. Consider performing additional characterization of the sand dikes east of Paducah mentioned in WLA 2006 to better determine the timing, location, and magnitude of their seismic source(s). If these can be determined, that may impact the PGDP PSHA update. Adopt regardless of on-site disposal decision.	Should the on-site disposal alternative be selected, additional characterization of the sand dikes will be conducted during the site-specific characterization activities to support the facility design.
6. Seismic cell design should focus on ground motion frequencies near 1 Hz. The sidewalls of a disposal cell are likely to have a fundamental frequency close to 1 Hz, so acceleration in this range must be a primary consideration in the design of a potential PGDP disposal cell. Pursue as soon as feasible if on-site disposal is selected.	This recommendation will be considered when determining design ground motion information.

DOE-HQ Independent Review Team

Summary of IRT Recommendation	PGDP Waste Disposal Options Project Action
7. Adopt a single definition of "active fault" for future use. Pursue as soon as feasible if on-site disposal is selected.	The definition of an active fault was agreed upon between DOE and the Core Team when developing the seismic investigation. This is supported by KRCEE 2006.
8. Continue microearthquake and strong motion monitoring at and near PGDP. Adopt regardless of on-site disposal decision.	Applicable information from this monitoring will be considered when determining design ground motion information.

Holocene Faulting on the PGDP

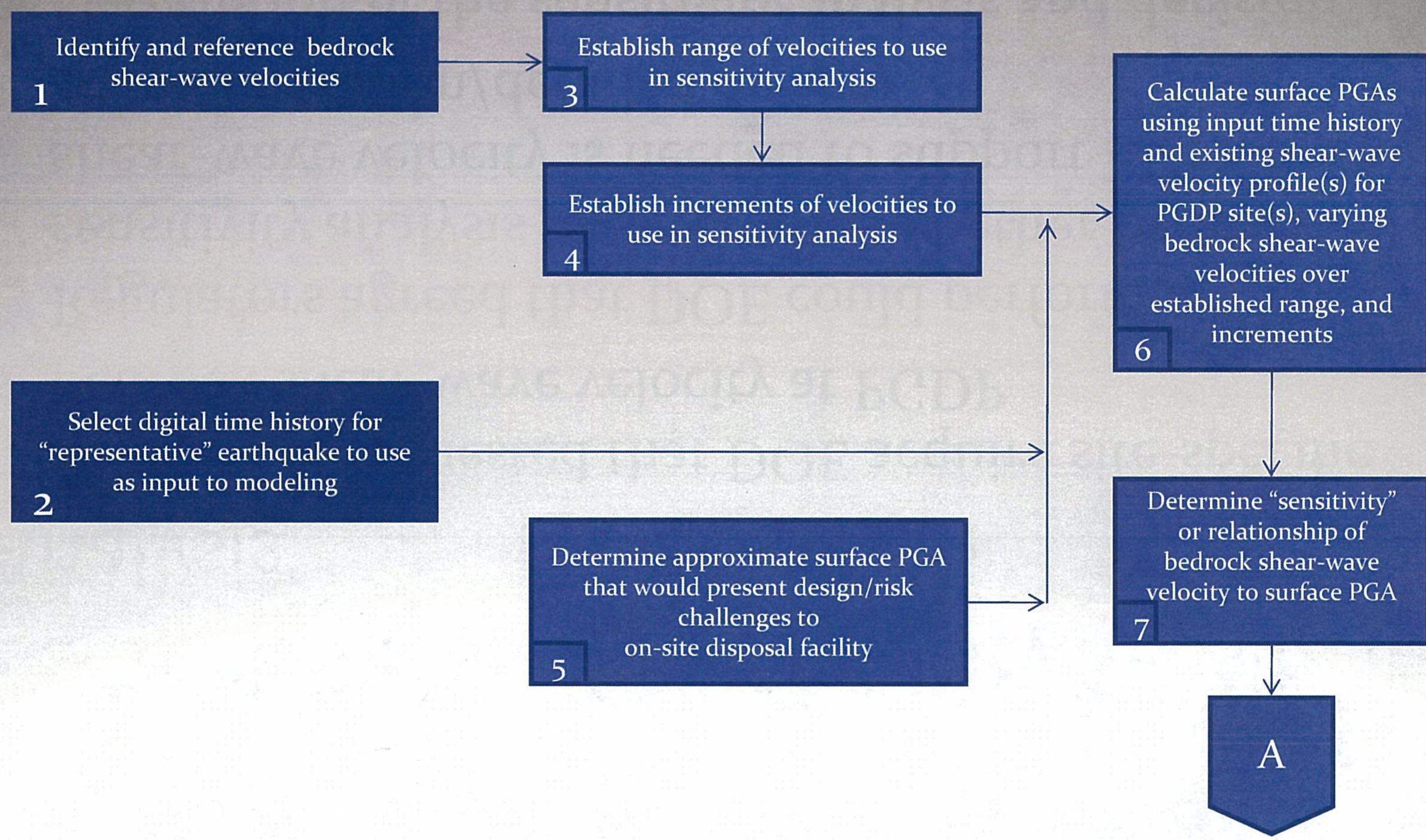
- DOE and Regulators agreed in 2001 Holocene Faulting defined as movement within the last 10,000 to 12,000 years (Holocene Epoch)
- No evidence of Holocene Faulting on the PGDP
  - Site 3A (DOE 2001-2003)
  - U Landfill (DOE/KRCEE 2003-2005)

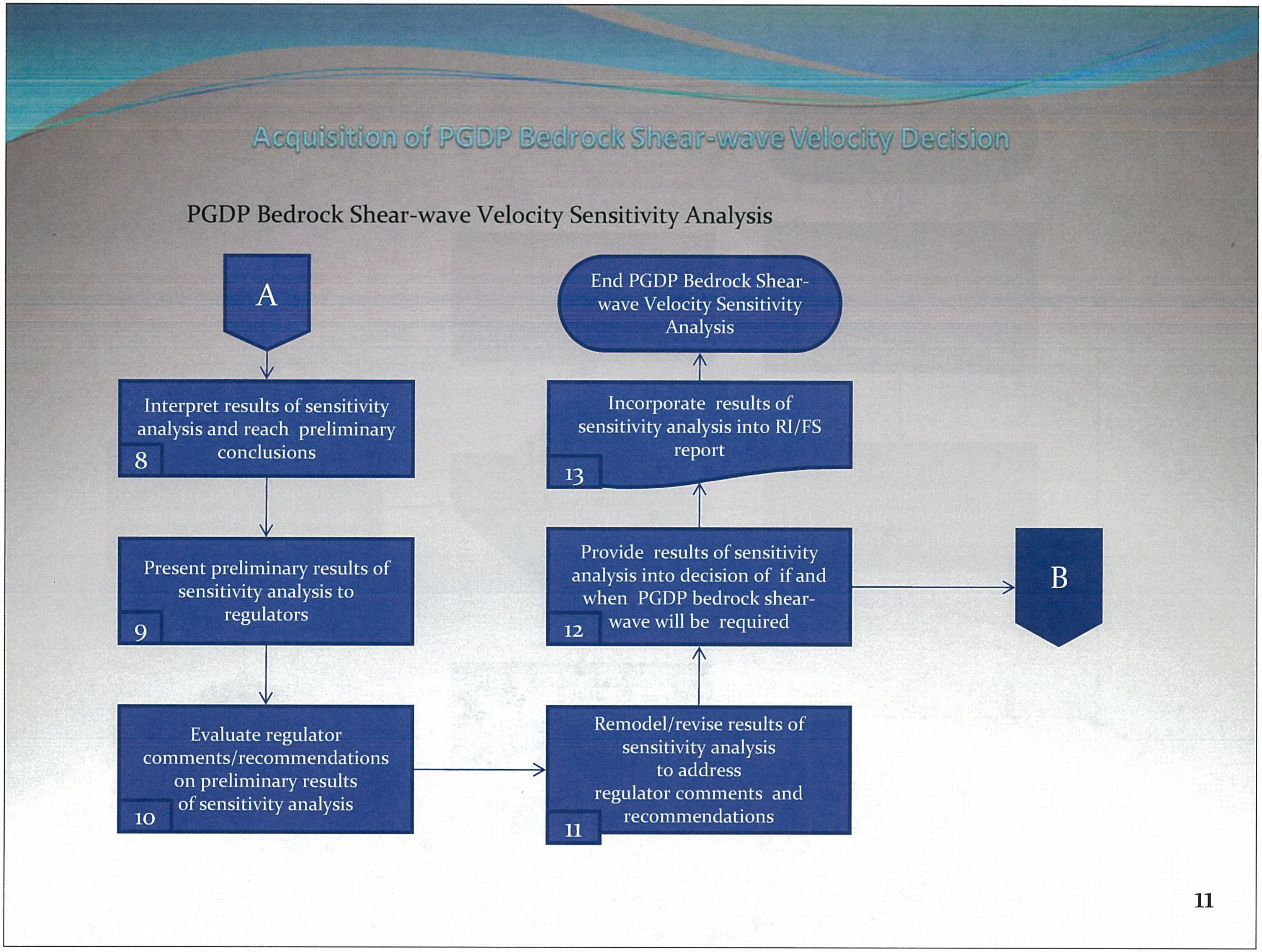
Bedrock Shear-wave Velocity Sensitivity Analysis

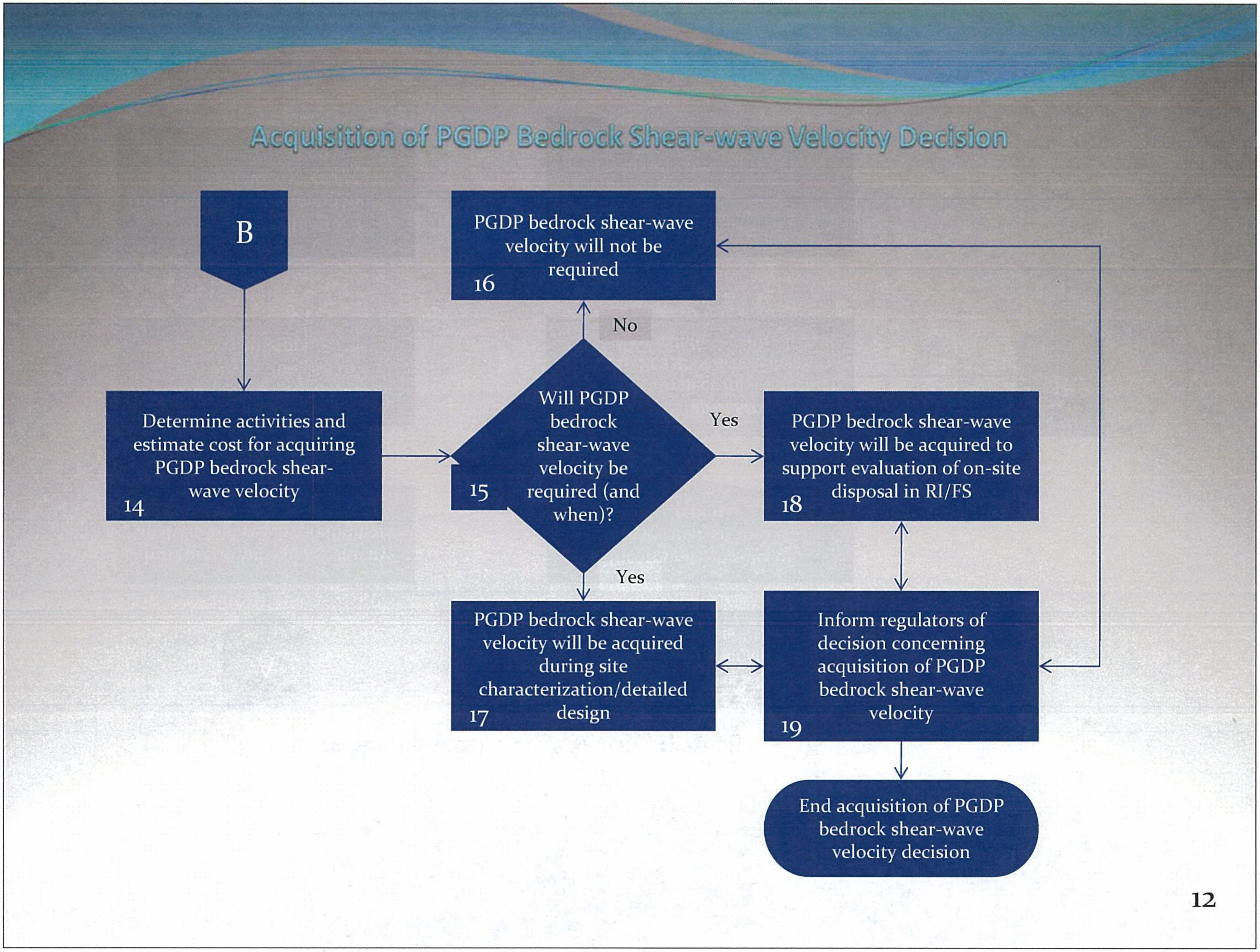
- Regulators requested that DOE acquire site-specific bedrock shear-wave velocity at PGDP
- Regulators agreed that DOE could perform a sensitivity analysis to determine whether bedrock shear-wave velocity is needed to support RI/FS or site characterization/detailed design
- Description of the sensitivity analysis and decision regarding when to acquire bedrock shear-wave velocity
- Status of the sensitivity analysis

Acquisition of PGDP Bedrock Shear-wave Velocity Decision

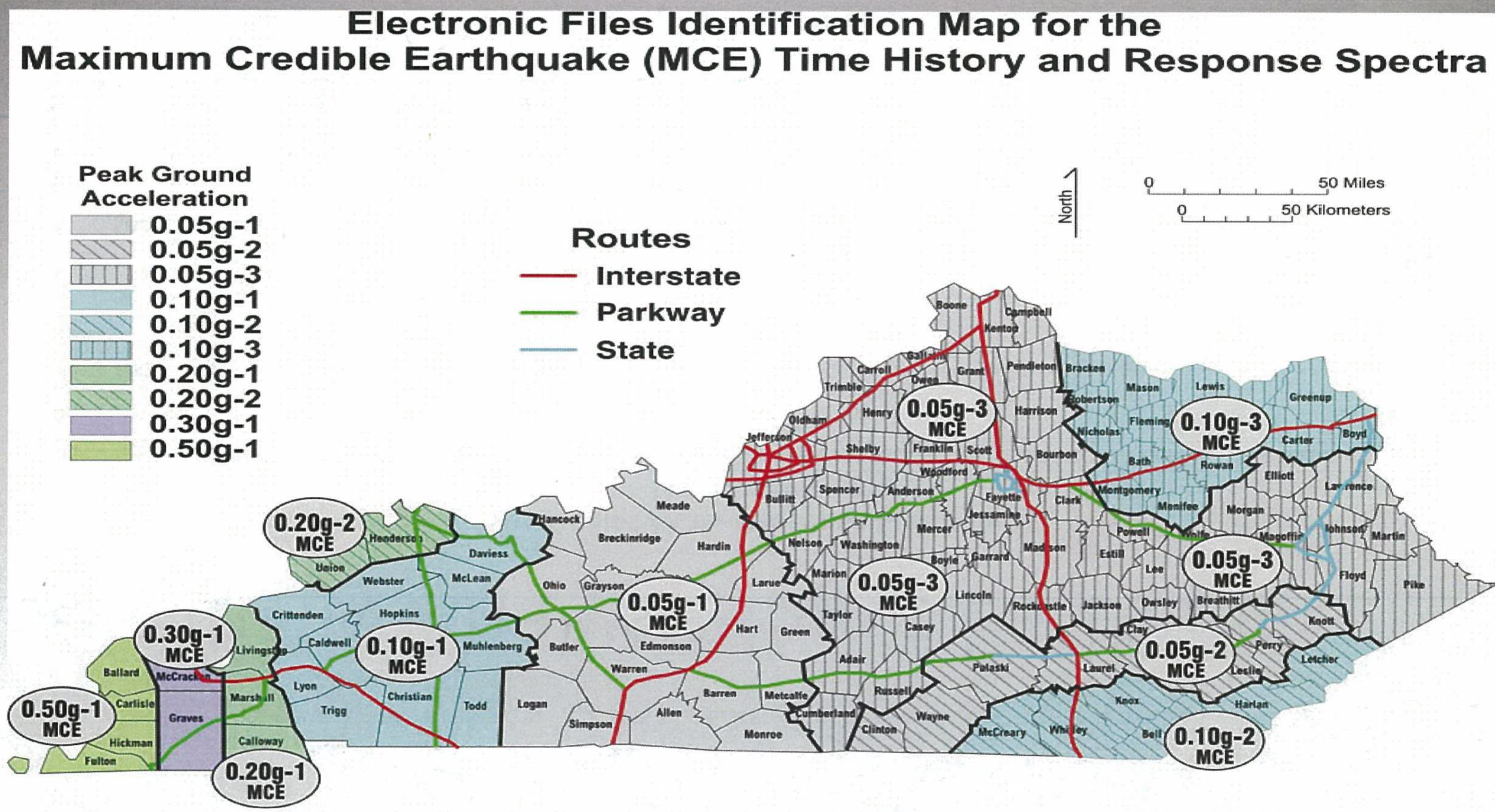
PGDP Bedrock Shear-wave Velocity Sensitivity Analysis




Acquisition of PGDP Bedrock Shear-wave Velocity Decision
PGDP Bedrock Shear-wave Velocity Sensitivity Analysis
A
8 Interpret results of sensitivity analysis and reach preliminary conclusions
9 Present preliminary results of sensitivity analysis to regulators
10 Evaluate regulator comments/recommendations on preliminary results of sensitivity analysis
11 Remodel/revise results of sensitivity analysis to address regulator comments and recommendations
12 Provide results of sensitivity analysis into decision of if and when PGDP bedrock shear-wave will be required
B
13 Incorporate results of sensitivity analysis into RI/FS report
End PGDP Bedrock Shear-wave Velocity Sensitivity Analysis
11

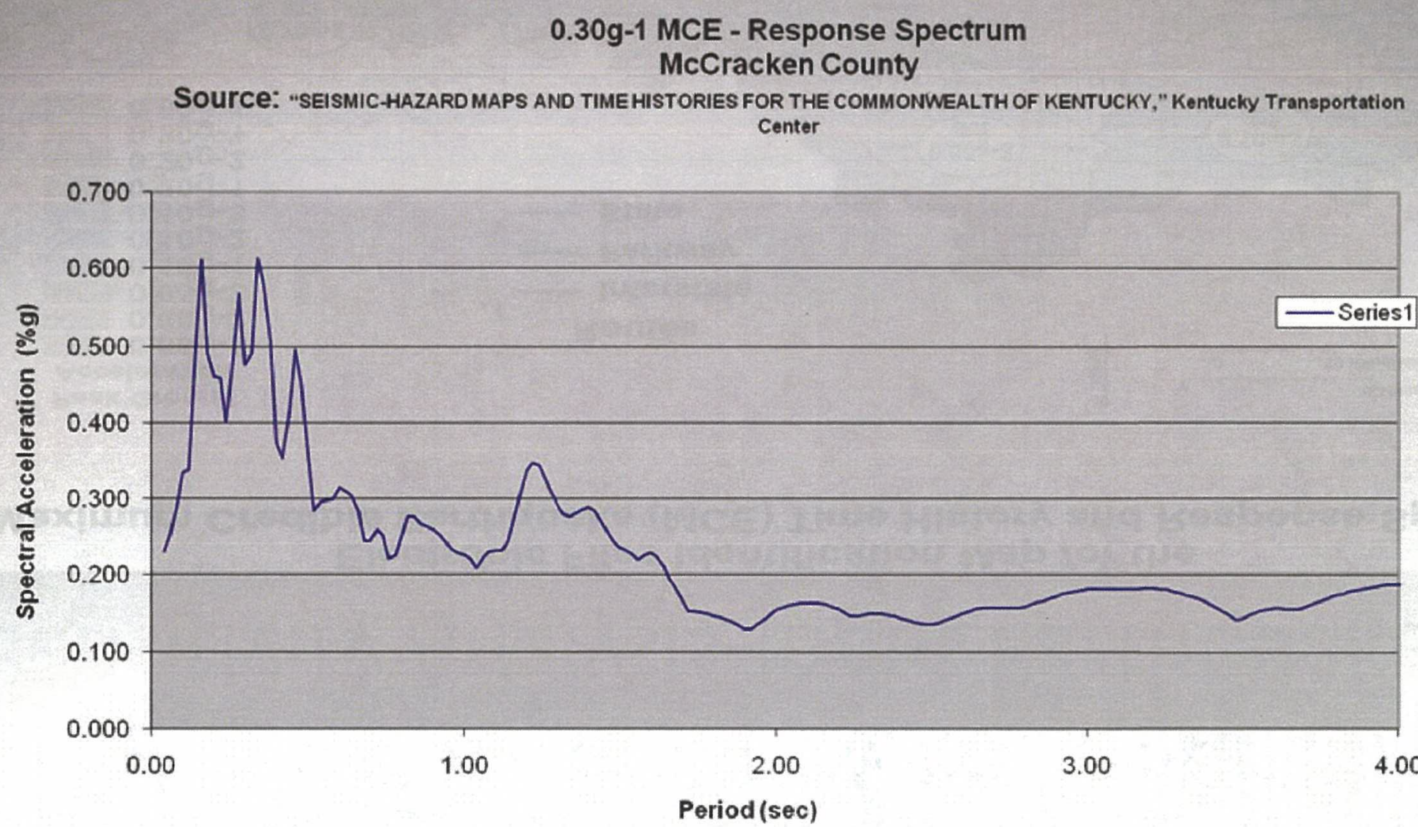

Acquisition of PGDP Bedrock Shear-wave Velocity Decision
B
PGDP bedrock shear-wave velocity will not be required
16
No
Determine activities and estimate cost for acquiring PGDP bedrock shear-wave velocity
14
Will PGDP bedrock shear-wave velocity be required (and when)?
15
Yes
PGDP bedrock shear-wave velocity will be acquired to support evaluation of on-site disposal in RI/FS
18
Yes
PGDP bedrock shear-wave velocity will be acquired during site characterization/detailed design
17
Inform regulators of decision concerning acquisition of PGDP bedrock shear-wave velocity
19
End acquisition of PGDP bedrock shear-wave velocity decision
12

PGDP Bedrock Shear-wave Velocity Sensitivity Analysis-Input Earthquake

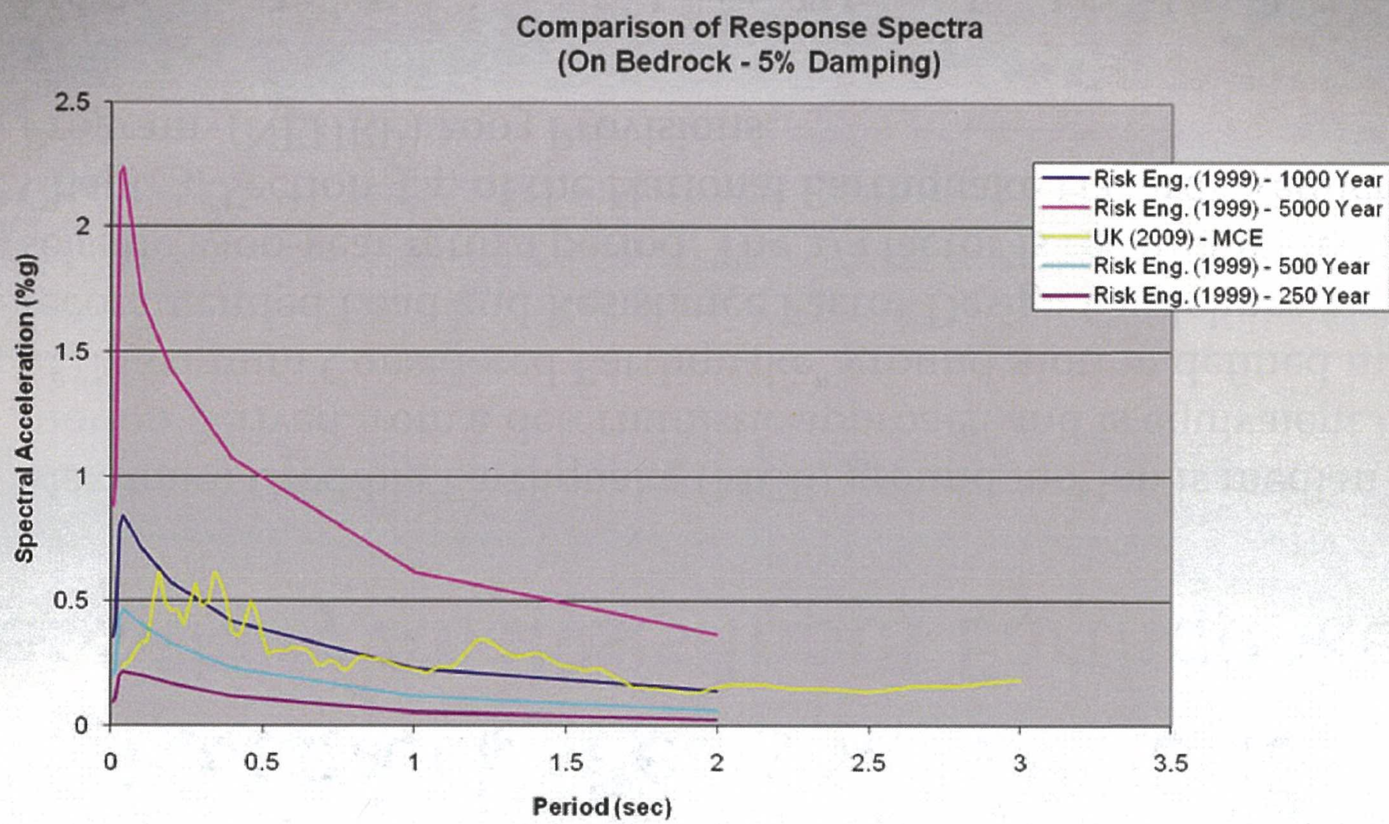


A2-29

PGDP Bedrock Shear-wave Velocity Sensitivity Analysis-Input Earthquake



PGDP Bedrock Shear-wave Velocity Sensitivity Analysis-Input Earthquake



PGDP Bedrock Shear-wave Velocity Sensitivity Analysis-Input Earthquake

- Maximum Credible Earthquake (MCE) ground motion is median motion derived from a deterministic approach and is equivalent to 2/3 of "Maximum Considered Earthquake" ground motion defined in 2003 recommended Load and Resistance Factor Design Guidelines for seismic 2500-year return period. The 2/3 factor is recommended in Chapt. 3, Section 3.4, of the National Earthquake Hazards Reduction Program (NEHRP) 2003 Provisions.

- MCE ground motion is equivalent to "Upper-level Earthquake" ground motion specified in 2006 "Seismic Retrofitting Manual for Highway Structures," which is derived from a probabilistic approach and has a 5% probability of exceedance in 50 years or a 1000-year return period.

PGDP Bedrock Shear-wave Velocity Sensitivity Analysis-Input Earthquake

- MCE is also equivalent to "Large Earthquake" defined in 2002 American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications.

- Probability of exceedance of MCE in 75 years is 7% (or 1000-year return period) to 14% (or 500-year return period) for New Madrid, 2% (or 4000-year return period to 4% (or 2000-year return period) for Wabash Valley, and less than 2% (or 4000-year return period) for all other seismic zones.

- It should be noted that, due to consideration of the local (or background) earthquakes in the study, maximum accelerations in response spectra may exceed maximum accelerations derived from United States Geological Survey, AASHTO, or NEHRP.

Seismic Hazard Analysis Methodology

- Regulators stated in 2007 they did not prefer "hybrid" seismic hazard analysis methodology used in 2004 Seismic Investigation Report
- RI/FS Work Plan states that DOE will perform fully probabilistic seismic hazard analysis
- KY solid waste regulation to be promulgated in spring 2010 will require deterministic seismic hazard analysis
- Reach agreement on seismic hazard analysis methodology to support potential on-site disposal facility

A2-35

General Ground Motion Design Parameters

- Regulators requested blow count data collected at Site 3A in 2001 to be presented on a boring by boring analysis
- Data will be provided pending DOE review
- Identify and define ground motion parameters required to perform detailed design of the disposal cell
- Identify relevant non-DOE studies (e.g., KGS) that could support characterization of seismic hazard/disposal cell design

2004 Seismic Investigation Report Review

- Regulators requested opportunity to review 2004 Seismic Investigation Report
- DOE provided report for regulatory review beginning of May 2009
- Received KY comments June 19, 2009
- Discussion of comments

Potential DOE/Regulator Future Meetings

- Seismic issues follow-up
- Site screening for potential on-site disposal facility
- Potential on-site disposal facility conceptual model
- Potential on-site disposal facility performance modeling/performance criteria
- Off-site disposal scenario and cost
- Preliminary on-site disposal waste acceptance criteria
- Results of hydrologic and geotechnical data review

Oak Ridge EMWMF Tour

- Meet at Jacobs Engineering at 8:00 (EDT) tomorrow morning
- Will require DOE badge and sturdy shoes for entry
- Travel to EMWMF-approximately 45 minutes
- Tour/overview discussion expected to take about 3 hours

All-day Participants	**Phone**	**Affiliation**	**Email**
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Janet Miller	270-441-6816	PRC	Janet.miller@lex.doe.gov
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James Skridulis	270-441-5382	Jacobs/PRS	Jim.skridulis@prs-llc.net
Jeff Snook	270-441-6814	DOE	Jeff.snook@lex.doe.gov
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Edward Winner	502-564-6120	KY HWB	Edward.winner@ky.gov
Edward Woolery	859-257-3016	UK	woolery@uky.edu

IRT Participants (on phone for their presentation & following Q&A)	
Brent Gutierrez	DOE
Stephen McDuffie	DOE
Jeffrey Munsey	TVA

PGDP Waste Disposal Options Project
Seismic Workshop Meeting Minutes
June 25, 2009

The purpose of the meeting is to bring together the decision-makers from DOE, the regulatory community, and the seismic experts to discuss the current seismic information data set to reach consensus on the information to be presented in the Remedial Investigation/Feasibility Study Report for the Waste Disposal Options Project and the methods to close identified data gaps if the on-site disposal alternative is selected. Below are the specific issues identified in the scoping meetings and the Work Plan upon which DOE is seeking resolution.

AGENDA

8:00 – 8:15	Welcome/Opening remarks
8:15 – 9:15	Presentation of the ITR Report – DOE and Dr. Gutierrez ***
9:15 – 9:45	Holocene faults – definition of Holocene faulting and discussion of Holocene faulting at the PGDP
9:45 – 10:00	Break
10:00 – 11:00	Bedrock Shear-wave Velocity Sensitivity Analysis - Work Plan methodology and status
11:00 – 12:00	Seismic Hazard Analysis methodology and input parameters –selection of a single method
12:00- 1:00	Lunch – Provided (may be a working lunch if required to make up schedule)
1:00 – 2:00	Ground motion general design parameters (liquefaction, etc.) – Confirm past agreements
2:00 – 2:15	Break
2:15 – 3:30	Seismic Investigation Report (DOE 2004) – Regulatory comments
3:30 – 4:30	Plans for future meetings (if time permits)

Note: DOE and PRS personnel will be available in the evening if anyone would like further discussions.

The meeting will be held at Jacobs Engineering, 125 Broadway Ave., Oak Ridge, Tennessee 37830, beginning at 8 AM (Eastern) and is scheduled to last the entire day.

The following day, Friday June 26, 2009, there will be a tour of the Environmental Management Waste Management Facility (EMWMF) beginning at 8 AM, originating at the Jacobs office. The tour is expected to last approximately three hours.

*** Presentation will be by conference call. Call in # 1-866-365-4406; code 2633645

PGDP Waste Disposal Options Project
Seismic Workshop Meeting Minutes
June 25, 2009

------Discussion Summary------

8:20 Safety topic: Driving safety

8:20-8:30 Introductions

8:30 Goals for the meeting: Decision-makers & experts to discuss openly the issues pertinent to the RI/FS

J. Snook: We want your input up front, to hopefully come to agreement before the RI/FS report is sent to you. We want you to understand our position, and why we proposed the methods found in our RI/FS Work Plan. Thank you to the IRT. We might not agree with everything in their review, but the point was to get an independent review, and we got that. (J. Snook also offered to continue discussing issues tonight, after the meeting.)

DOE HQ Independent Review Team (IRT) Report Recommendations

Presentation by: B. Gutierrez (see slides)

Specific Slide Discussion

- Slide 3: Added there has been a lot of work and effort over the years, which is a sound basis for moving forward with the RI/FS.
- Slide 6: Clarified that "landfill performance criteria" refers to structural performance criteria – what the cell should look like. And also clarified that the occurrence/performance interval they considered was a 2500-year event (adequately conservative)
- Slide 7: Point-to-point variances in shear wave velocity have little to do with surface effects, based on what was learned at Savannah River Project
- Slide 9: The ER surveys (2^{nd} bullet) could have higher resolution than GPR and could be a complimentary tool with seismic reflection
- Slide 10: Correction: the first bullet should read "since the 1999 analysis", not "since the 1990 analysis."

8:50 **Comments/Questions and Answers on Presentation**

E. Winner: How would the IRT's recommendations change if the design were done before the ROD rather than after the ROD?

IRT/B. Gutierrez: It may depend on timing/schedule for the conceptual design, and how that relates to the Central and Eastern US (CEUS) Seismic Source Characterization project completion. The CEUS (scheduled for mid-2010) could impact the conceptual design. Their recommendations might also depend on whether the design was done for Site 3A or another site. You could probably do a preliminary design at 3A, but you would have to assume you would not find evidence of Holocene faulting.

E. Winner: Inquired about the adequacy of bedrock shear wave data.

IRT/B. Gutierrez: The IRT thinks DOE does not need to do a shear wave velocity testing at Site 3A because nearby data are good enough to use for extrapolating velocities for the Paducah site.

E. Winner: How does the electrical resistivity survey work?

IRT: It is a subsurface imaging technique that shows resistivity vs. depth. It can be used to see differences in stratigraphy or water content, or past water bearing units. It is not as accurate as seismic reflection, but has been proven effective at mapping landslides & shallow faulting.

T. Mullins: Did IRT contradict themselves, or have a difference of opinion whether or not Site 3A had adequate data?

IRT: The IRT thinks data at Site 3A are adequate to move forward with the RI/FS, but they think it would need additional characterization if DOE were to build on the site. For example, the inclined borings could be done. 90%-95% of work at Site 3A is done. J. Skridulis pointed out it took ~18 months to complete the Seismic study in 2001. If a site other than 3A is selected, that's approximately how long it would take to get data similar to Site 3A.

J. Snook stated that he thought that DOE and KY/EPA had put to bed the issue of Holocene faulting. DOE was surprised to see it in the IRT report. This is one of the points where DOE and the IRT disagree.

J. Skridulis & J. Gadd explained that in 2001 the stakeholders developed a seismic study for Site 3A to address seismic issues, and they all agreed those issues were all settled. It is hard to prove the negative, but they had agreed on the criteria, and have not seen any evidence, so they have a no-evidence opinion w.r.t. Holocene faulting. The participants in the room (IRT was on the phone) seemed to be of the mind that they will take "under advisement" IRT's recommendations related to purely strike/slip Holocene faulting and inclined borings.

9:10-9:20 Break

9:30 **Resume IRT Q&A**

E. Winner asked the IRT to tell us more about the update to the PSHA. What does "Level 2" mean?

IRT: The Senior Seismic Hazard Analysis Committee (SSHAC) has endorsed a process, with 4 different levels, for the analysis. The levels are scaled 1 to 4, with 4 being the most rigorous level of study. Level 2 for example, uses existing information to come up with the seismic hazard. We need to wait for the CEUS study (3rd level), which will consider New Madrid data. Then there will be a CEUS model into which one can put latitude & longitude to get hazard information. We will need to update it with local features like the sand dikes, so the PSHA hazard assessment can consider local features.

J. Beavers inquired about the PSHA looking at attenuation.

IRT: The PSHA looks at sources, not attenuation, to come up with source models for nuclear facilities. It is designed to be better than the USGS maps since it follows the SSHAC process.

Z. Wang: KGS is happy to see Recommendation #8. Collecting this data (microearthquake and strong motion monitoring) is important. He agrees with the assessment overall- there is a lot of data. However, some of the reports have inconsistencies, which make it difficult for the decision-makers. Part of this is the definition of “active fault.”

E. Winner asked what the issue is w.r.t. the three different definitions for “active fault.”

IRT: If the regulators think the definition is important, we need to clarify the meaning. In 2001-203 when working on Site 3A, they agreed to a faulting definition that included Holocene faulting. They acknowledge inconsistencies with past definitions, but DOE and the Core Team agreed the definition of a Holocene age fault was that occurred within the last 10,000-12,000 years ago.

Z. Wang: We need to communicate to the public what the seismic concerns are (New Madrid, 2500-yr design event, return periods, or what?) How do we explain to the public?

IRT: Ground motion is the issue, not necessarily related to a specific earthquake.

Z. Wang: With respect to Recommendation #4, he is not sure what the NGA East project is.

IRT: It is not a concern for Paducah because it is so far off (it is just getting started now and 5 years away from completion.)

Z. Wang: The final product from PSHA is a seismic curve and time history. If we are looking for a 2500-year return period, the DOE should provide the complete curve and history.

IRT: Agrees.

Z. Wang: With respect to recommendation #6, what technical document supports the 1Hz design?

IRT: This is based on experience with large earthen structures and engineering judgment.

Z. Wang: With large structures and large earthen structures, don’t just focus on PGA-focus on anticipated frequencies for the structure(s).

E. Woolery: What attenuation relationship would IRT use?

IRT: The 2003 values were updated in 2006 by TVA and used as the basis for licensing.

E. Winner: Inquired about Deterministic analysis vs. Probabilistic analysis.

IRT/ S. McDuffie: PSHA is a widely accepted standard (purely probabilistic). Use this, and modify locally as necessary. He referenced NRC (#229) Standards for doing PSHA, and DOE Standard 1023. The Department has established that they should use PSHAs. In general, they like probabilistic analysis, but there could be situations (close to certain faults, for example) where both probabilistic and deterministic (as a comparison) would be appropriate.

E. Winner: What is the authority of 1023?

IRT: It is a department standard used by DOE Order 420.1B, Section 4.4.

E. Winner asked if it comes down to being a contract requirement and the discussion that followed concluded that the standard applies.

Z. Wang: If one were to do a deterministic check, you would do this for the singular event that drives your hazard.

E. Woolery: How would the PSHA help you understand if New Madrid goes through Paducah or not?

IRT: You can assign weights to both options, since we do not know.

*** (End of the IRT Q&A; the telecom with IRT participation was concluded.) ***

9:55 **PGDP Waste Disposal Options - Seismic Issues Workshop Slides**

Presentation by: Marshall Davenport (see slides)

- Rather than a formal presentation, the slides are intended and used for facilitating group discussion, and to make decisions on future work.

- Slides 5-7 summarize the actions taken or proposed in response to each of IRT's 8 recommendations. Of note, M.Davenport explained that (related to recommendation #4) the discussions in this meeting would decide if the project would use PSHA, or a deterministic approach, both, or some alternative analysis. M. Davenport also explained that the microearthquake and motion monitoring in recommendation #8 is expected to continue.

- Slide 8 (Holocene Faulting on the PGDP). M. Davenport asked whether the group can agree that "active faulting" be defined as movement within the last 10,000 to 12,000 years (Holocene Epoch). KY said yes, and that state regulations use this definition. Meeting participants reached consensus that "active faulting" is defined as 10,000 to 12,000 years before present.

- It was noted that a 2500-year return period on an earthquake is a different issue.

Discussion on the Evidence of Holocene Faulting

DOE's preference/position was to move forward under the assumption that there is no Holocene faulting because there is no evidence of it based on studies at Site 3A and the U-Landfill. IRT had suggested earlier that more data should be collected. S. Hampson agrees that no additional data are needed. E. Woolery also agreed. A few problems with the data quality associated with angular borings were raised by S. Hampson and E. Woolery. M. Davenport pointed out that both PGDP site-specific fault investigations included DPTs as close as 10 feet apart. It was generally agreed that the conclusions resulting from those investigations were valid (no evidence of Holocene faulting was found) and going back to those areas to perform inclined drilling or DPT would not reveal any information that would contradict the previous conclusions.

E. Winner asked to clarify whether there was no evidence at PGDP or at Site 3A.

E. Woolery stated the commerce geophysical lineament is the closest thing to Paducah that has shown evidence. They have not found anything in the PGDP region.

E. Winner asked what if they chose another site?

E. Woolery: he would be surprised if any evidence would be found at the PGDP based on his experience.

T. Mullins mentioned the D2 Seismic Investigation Report (DOE 2004) that mentions a Holocene fault 11 miles away in Barnes Creek (Illinois), but E. Woolery doesn't believe that interpretation at Barnes Creek. M. Davenport described it as a crack in the soil and no visible displacement. Illinois Geological Survey geologists, John Nelson and Roy Van Arsdale, also agree it was misinterpreted. M. Davenport recommends (and the group agrees) that the conclusion in the SIR would be mentioned in the RI/FS and opposing conclusions and references be provided. The RI/FS would then state that although there was some evidence for Holocene faulting at Barnes Creek, others have concluded that no Holocene faulting is present. J. Skridulis indicated that the wording in the report ("there is evidence of Holocene faulting") was because the writers were trying to be honest brokers, but it was known at the time that the conclusion might be disputed later. The issue is the apparent lack of displacement on a crack thought to be evidence of a fault. Carbon-14 dating is suspect due to the post-depositional contamination on stream banks.

DOE's position is there is no Holocene faulting at the site. DOE believes they have the scientific basis to support that claim. With respect to what is required for further study if another site is evaluated, they will have to look at the regulations and guidance documents to see if anything else is required.

J. Snook pointed out that a decision regarding offsite vs. onsite disposal has not been made. Also, if onsite disposal is chosen, a specific site has not been selected.

S. Hampson pointed out that the trenching proposed by the IRT is cost-prohibitive and not allowed by OSHA.

10:25 **Slide 9 (Bedrock Shear-wave Velocity Sensitivity Analysis)**

Background: KY stated in a letter that they wanted DOE to measure PGDP site specific shear wave velocities in the bedrock. On a conference call it was decided that DOE could do a sensitivity study to determine if a shear-wave velocity was needed to support the RI/FS. Also, M. Davenport mentioned a digital time of an earthquake is available to be used.

<u>Discussion on proposed sensitivity analysis</u>

J. Beavers reminded the group that the IRT said that the shear wave velocity isn't needed, period.

T. Mullins: KY's position is that when/if a site is picked, a bedrock shear wave will be needed for design. It may not be needed for the RI/FS, but eventually if onsite disposal is chosen. It possibly could be needed for the RI/FS if the critical PGA from the sensitivity analysis is close to the go/no-go point.

E. Woolery mentioned a few logistical challenges with keeping a borehole open for the test.

M. Davenport presented slides 9-17, which outlines the proposed approach for the shear-wave velocity sensitivity analysis.

- M. Davenport explained that the numbers in the boxes on the flowcharts on slides 10-12 had no particular meaning, and were there only for reference.
- On slide 10, box 2 refers to PGA at the top of bedrock.
- On slide 10, box 5 relates to finding the critical upper-limit surface PGA that impacts design (go/no-go).
- On slide 10, box 6, the shear-wave velocity profile used will be that from Site 3A.
- On slide 12, M. Davenport and J. Gadd explained that when the DOE/PRS team comes up with the findings from the preliminary analysis, they will share the information with the KY and EPA regulators. A conference call will be held to discuss the results and gather input.

KGS (Z. Wang) agreed with the use of the UK study earthquake (shown in yellow on slide 15) for the sensitivity study. Z. Wang also recommended using another one (a real earthquake time history record) to do a comparison- something with a smaller magnitude and distance. Z. Wang and J. Beavers discussed how the time history record from the real earthquake can be modified to get closer to the one used for the sensitivity study, as is common practice. Z. Wang did mention that the "real" earthquake would probably be a California earthquake; that would result in some difference in the comparison that would need to be explained in the comparison. The group agreed with the proposed approach. When the work is presented, the DOE/PRS project team will make sure to provide the information needed to reproduce their work. J. Gadd and M. Davenport explained that they are not planning to prepare a detailed report- just a summary. M. Davenport pointed out that the sensitivity study will primarily be used just to answer the question about when/if the bedrock shear-wave velocity would be needed. J. Snook said that the reviewers should let DOE know up front if there is a certain level of detail they want to see in the documentation of the sensitivity analysis.

*** (end of discussion on shear-wave velocity sensitivity analysis) ***

E. Winner advised that his cabinet secretary would not sign a ROD for on-site disposal without sufficient data for a "preliminary" design

J. Snook pointed out that it will be difficult to get the design done on time (the CERCLA-required 15-month start of remediation after the ROD is signed) if a decision is made to build on site. They will need to start some of the design work early (that is, before the ROD). Some of the seismic work may have to be done early due to the durations involved. Much of the issue is how much detail goes into the conceptual design (representing what percent design). These drive the decision-makers' comfort level in what the cell might look like. For the public's concerns, they need to have enough certainty in the things that the public will want to understand. M. Davenport indicated that at EMWMF, not much changed in the detailed design from the conceptual design that was in the FS, and that he doesn't think it would at Paducah, either.

11:50 **Slide 18 (Seismic Hazard Analysis Methodology)**

Background: The Work Plan proposed a purely probabilistic seismic hazard analysis approach. The project team now understands that upcoming solid waste regulations will require a deterministic approach.

<u>Discussion on Seismic Hazard Analysis Methodology</u>

Z. Wang indicated that the team should focus on science- what is known about the site and New Madrid. Z. Wang shared a paper[1] with the group (KGS comments to the ACEHR panel and USGS on the 2008 National Seismic Hazard Maps) that explains why KGS does not recommend PSHA. Their two primary issues are that PSHA uses a point source assumption and the range of uncertainty involved. PSHA provides a range, which makes policy-setting difficult- ranging from too conservative to not conservative enough. Clear design standards are easier to understand. KGS recommends a fully deterministic approach, but recognizes that recommendation is from a scientific point-of-view and the regulations may drive the final decision. The Kentucky Research Consortium for Energy and Environment (KRCEE) used a deterministic approach in a report prepared for PGDP in 2007.

M. Davenport pointed out that KRCEE has already done a deterministic analysis for PGDP, and asked if the project could perform DOE's required probabilistic approach and then compare the results with the deterministic analysis that KRCEE has already done for PGDP in 2007.

The group inquired about the applicability of NRC regulations that PGDP has to comply with. There could be low level waste in the cell. Are the regulations "applicable" or "to be considered"? J. Snook stated that he has lawyers looking at ARARs now. Some of the ARARs are state (KY) regulations, some are more stringent (KY RHB), and some depend on the site location.

The group discussed some of the economic implications of the seismic hazards regulations. The cost of implementing the regulations has regional economic development implications, outside of the potential CERCLA waste disposal facility.

E. Winner: KY wants whichever model is most accurate, not just one that can be used in a way so extra conservatism can be built in.

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[1] Zhenming Wang, 31 July 2007, *Comments on "Preliminary Documentation for the 2007 Update of the United States National Seismic Hazard Maps",* Kentucky Geological Survey

S. Hampson also said that they want the answer that is closest to the truth-probabilistic analysis doesn't get you there.

There was some discussion on the 2500-yr earthquake that IRT had picked, which is just a point on a curve (the product of a PSHA). A lot of subjectivity goes into selecting the design standard point/target, and which point is used depends on the regulations involved.

J. Beavers pointed out that recently the DUF6 project was designed for a PGA of 1.6g. It was a short-term ground motion(0.2 seconds).

S. Hampson said the number KRCEE has come up with at PGDP is much lower. The median is 0.3g at PGDP. Another calculated value is 0.5g.J. Beavers mentioned that TVA designed to 0.25g at their nuclear power plants. M. Davenport mentioned that the EMWMF was designed to 0.22g, but also mentioned that seismicity was not a concern with the regulators during the RI/FS process on that disposal facility.

J. Skridulis asked whether the regulators would let them design to a mean. KY's design standards are 2 percent/50 years (2500-year return). They use means plus one standard deviation in bridges.

M. Davenport explained that we don't know exactly what these numbers mean to the actual design of the cells. What would the engineers have to do to meet higher standards (to withstand accelerated motions)? It was mentioned that there would be a hand-off between characterizing the seismicity of the PGDP and the design of the potential disposal facility that would be required.

J. Skridulis said 0.48g is the highest he has seen near to PGDP. Z. Wang says there are some that are higher. J. Beavers pointed out that when DUF6 was designed to code, it met 1.6g. J. Skridulis asked what it is the project team needs to do.

T. Mullins said that Weldon Spring used a deterministic analysis, so DOE needs to find out why they used a deterministic analysis there, and also find out what is the appropriate approach/analysis for PGDP (0.26g PGA at Weldon Spring). J. Snook said DOE wants to do whatever is the best/right way, even if it means delaying the project a bit. DOE/PRS will look into how Weldon Spring arrived at the 0.26g PGA.

E. Winner said that he thinks both methods should be used, and to explain why the results may not agree, which would be covered in explaining how the models work.

J. Snook said that he is not necessarily opposed to doing both, but would prefer one analysis if there is a clearly more appropriate method. They (DOE) needs to research its orders and standards and get back to the group. DOE/PRS took this as an action item, to figure out what the requirements are (deterministic analysis or probabilistic analysis) found in DOE orders, and inform the KY and EPA of their proposed approach.

M. Davenport pointed out that we have a range in hand now. We have the deterministic analysis that KRCEE did in 2007, plus the probabilistic hybrid analysis from 2001 Seismic Investigation at Site 3A that is essentially complete. He suggested that maybe just a few things would be changed in the source modeling. J. Beavers said he thought that the result might come down a little (it was 0.48g then). DOE could evaluate the range, decide on an appropriate design earthquake/ground motion and justify its decision.

12:55 **Slide 19 (General Ground Motion Design Parameters)**

M. Davenport asked the KY representatives what seismic design parameters the state would be using to evaluate the disposal cell design. T. Mullins said they weren't prepared to discuss this today. When KY reviews the design, they will need to evaluate how well the cell will withstand a certain level of seismicity. M. Davenport indicated that in the past, they designed to the PGA, and asked if there was anything else KY will evaluate. E. Winner asked that the project team provide KY and EPA with the design parameters so they can (for the conceptual design) let the team know what KY might need. M. Davenport indicated the EMWMF used PGA as the primary design parameter.

J. Gadd said it is assumed that seismic issues are the only issues/parameters of concern because all of the rest of the parameters are uniform (size, slope, berm widths, leachate collection systems, etc.). T. Mullins suggested that the team look at the 1 Hz frequency because the team had said they might look at that during the detailed design phase. J. Skridulis said that the 2001 Siting Study provides some background on the parameters considered in the conceptual design phase.

J. Gadd said that in the past, things like slope have not greatly impacted FS-level costs, so the team will keep it general- conservative but realistic (for example, out-slopes of 6:1).

E. Winner said that it is up to the DOE/PRS project team to defend the conservatism of their designs. Z. Wang mentioned PGA (acceleration), PGV (velocity), PGD (displacement), and 5% damping (response spectrum, time history). . J. Gadd indicated that the team doesn't expect to go into a lot of detail in the RI/FS. However, they can start discussing these things early in the process.

M. Davenport asked if there are any non-DOE relevant studies (particularly from KGS) that would help. He indicated that the team has looked at Olmsted. Z. Wang indicated he was happy that the team used his study. Z. Wang said that DOE needs to be able to explain their process and conclusions to anybody. The team should ask themselves if the results make sense because there is so much subjectivity in the interpretation. The difficulty is with the return period (be it 500 years, 1000 years, 2500 years, etc.). E. Woolery gave T. Mullins a paper[2] to share that was Z. Wang's source, and indicated that it is the best available published peer-reviewed study.

*** (End of discussion on general ground motion design parameters) ***

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[2] A.C. Johnston and E.S. Schweig, 1996, *The Enigma of the New Madrid Earthquakes of 1811-1812*, Annu. Rev. Earth Planet. Sci. 1996. 24:339-84

1:40 **Slide 20 (2004 Seismic Investigation Report Review)**

Review Comments Discussion – June 2009 KY Comments on DOE's 2004 Seismic Investigation Report

The comments dated 19 June 2009 are all the comments DOE will receive from KY on the subject report. No comments have been received from EPA.

M. Davenport and J. Gadd indicated that the Seismic Investigation Report document will not be revised to incorporate responses to the comments (SAIC prepared that report and is no longer a contractor at PGDP). The RI/FS will include responses/resolutions to these comments. If anything changes, it will be explained in the RI/FS. This was an agreeable approach for responding to the comments.

Gen. Comment 1 – M. Davenport explained that the first comment concerned the acquisition of bedrock shear-wave velocity at the PGDP. He summarized that the sensitivity study that was previously discussed would be used to resolve this comment and assist in the decision of whether this parameter is needed to support an RI/FS or for detailed design. M. Davenport did mention the bedrock shear-wave velocity values (8,500 to 9,000 fps) that have been used in the Paducah area, and asked E. Woolery if a value in that range was appropriate for the conceptual design. E. Woolery stated that he believed so.

Gen. Comment 2– The second comment was summarized as a previous request for actual blow counts during the Site 3A drilling and the appropriateness of averaging the blow counts across the site. M. Davenport stated that the requested data had been assembled and is in the process of going through DOE review prior to submittal to KY and EPA.

Gen. Comment 3 – DOE and PRS do not have the backup documentation KY requested relating to the derivation of the differential settlement and total settlement for Site 3A that was presented in the 2004 SIR. DOE/PRS will try to get it from SAIC. Otherwise, the calculations may have to be repeated.

Specific Comment 1 – (not relevant to seismic issues and was not discussed)

Specific Comment 2 – This comment is related to the General Comment 2 and will be addressed along with General Comment 2.

Specific Comment 3 – The DOE/PRS project team will provide more detail on the approach. Although it was mentioned that DOE would be preparing another seismic hazard analysis to support the detailed design rather than specifically preparing a response to this particular comment.

*** (End of discussion on 2004 Seismic Investigation Report Comments) ***

2:15 **Slide 21 (Potential DOE/Regulator Future Meetings)**

With respect to the Waste Disposal Options Project, what other topics should be considered? The slide includes seven topics. None were eliminated. Interest was expressed in WAC development and performance modeling (already included on list) plus ARARs (which is handled through another process). PRS will prioritize the topics in order to be discussed. Some topics can be accomplished through teleconferences, others may be better as face-to-face meetings. J. Skridulis mentioned that from a project schedule perspective, having at least a conference call to discuss the siting study approach was an ASAP priority.

*** (End of Seismic Issues Workshop Discussion) ***

AGREEMENTS

(1) "Active faulting" is defined as faulting more recent than10,000 to 12,000 years before present (in Holocene Epoch)

(2) There is no evidence of Holocene faulting at PGDP.

(3) A sensitivity analysis will be used to address the bedrock shear-wave velocity issue for the RI/FS. We used 8,000 or 9,000 ft/sec for an initial value. E. Woolery thinks a direct measurement will be needed at the design phase, but the group agrees that one is not needed for the RI/FS. Sensitivity test findings will be shared with KY and EPA, who will be given an opportunity to review and comment. Documentation will be streamlined. DOE will use a real earthquake time/history record (picked from a global catalog) as a comparison, in addition to the 2009 UK curve. The DOE/PRS project team will provide enough information to allow reviewers to check/reproduce the work.

ACTION ITEMS

(1) The DOE/PRS project team will include sufficient information in the RI/FS to explain/resolve the issue regarding at the presence/absence of Holocene faulting at the Barnes Creek site.

(2) DOE/PRS will determine which seismic hazard analysis approach (probabilistic vs. deterministic) to use in the RI/FS, and communicate their proposed approach to KY and EPA. DOE/PRS will research DOE orders and how they apply and also research Weldon Spring deterministic seismic hazard analysis.

(3) DOE/PRS will determine what type of site characterization/confirmation would be required to address Holocene faulting if a site other than Site 3A or Site 11 is selected.

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ATTACHMENT A3

SUMMARY OF THE BEDROCK SHEAR-WAVE VELOCITY SENSITIVITY ANALYSIS

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JACOBS

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Memorandum

Date	September 29, 2009
To	Marshall Davenport
From	Jonathan Taylor/Jean Habimana
Subject	Paducah Gaseous Diffusion Plant (PGDP) Seismic Analysis of On-site Disposal Alternative Bedrock Shear Wave Sensitivity Analysis

Introduction

An estimated 3.6 million yd^3 of waste is forecast to be generated during the environmental cleanup of the Paducah Gaseous Diffusion Plant (PGDP) in Paducah KY. One alternative being studied for disposal of the waste is to build a new landfill at the PGDP site. In addition to the environmental requirements, the landfill design will need to consider regional seismicity, particularly the impacts of an earthquake in the New Madrid Seismic Zone (NMSZ).

Previous studies for the PGDP site (Risk Engineering Inc. 1993, 1999) and more recently for a potential landfill site (DOE 2004) evaluated the seismic hazard and included investigations of the static and dynamic properties of the subsurface materials. However, the shear wave velocity of the hard limestone base rock at a depth of around 400 feet at PGDP has not been directly measured.

Since the local site response under seismic loading and the resulting peak ground acceleration at ground surface depend on the shear wave velocity of the base rock, the project team proposed that the potential impact of this deficiency in the known material properties be evaluated by performing a sensitivity analysis. The general approach for conducting a PGDP bedrock shear wave velocity sensitivity analysis was presented in a July 8, 2008, scoping teleconference and in the D1 version of the remedial investigation/feasibility study (RI/FS) work plan (DOE 2009). It was then detailed with the regulators in the June 2009 Seismic Issues Workshop in Oak Ridge, TN.

This memorandum report presents the results of that sensitivity analysis. A brief project description is provided; followed by a summary of previous seismic studies performed at the PGDP site. Geotechnical conditions at the potential landfill site and the design input earthquakes used in the analysis are then described. The site response analyses that were conducted with the variable base rock properties are then presented, and the results discussed. Finally, conclusions on the potential variability of the site response and peak ground acceleration at ground surface due to the variability of bedrock shear wave velocity are provided.

Project Description

U.S. Department of Energy (DOE) is responsible for cleanup of the Paducah Gaseous Diffusion Plant (PGDP) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). An estimated 3.6 million yd^3 of waste is forecasted to be generated by CERCLA response actions at PGDP from 2014 to 2039. To date, CERCLA cleanup and waste management projects at

PGDP have generated and disposed of hundreds of thousands of cubic yards of waste and visible progress has been made by the clearing of scrap yards, demolition of excess facilities, and removal or mitigation of sources of contaminants presenting unacceptable risk to human health and the environment or exceeding concentrations established in applicable or relevant and appropriate requirements. Disposal alternatives for large volumes of waste to be generated are being evaluated using the CERCLA process and in collaboration with the U.S. Environmental Protection Agency (EPA), the Commonwealth of Kentucky, and site stakeholders. The cleanup of the PGDP will generate low-level radioactive waste, hazardous waste, non-hazardous solid waste, and mixtures of these waste types; therefore, both on- and off-site disposal alternatives will be evaluated during the remedy selection process.

The On-site Disposal Alternative includes the disposal of CERCLA waste into a newly constructed on-site waste disposal facility located on property currently owned by DOE (see DOE 2009). This disposal alternative will include the design of a potential waste cell and the necessary support facilities. Siting and design considerations of a potential on-site waste disposal facility will be evaluated in a remedial investigation/feasibility study (RI/FS) and must consider regional and site specific seismicity.

Should a Record of Decision (ROD) select the On-site Disposal Alternative for implementation, detailed ground motion modeling and future characterization of the bedrock will be required to support the design of the on-site waste disposal facility.

Previous Seismic Studies

Numerous seismic hazard studies have been conducted at the PGDP over the past 25 years. In 1999, Risk Engineering Inc. (REI) performed a Probabilistic Seismic Hazard Assessment (PSHA) and developed top-of-soil Uniform Hazard Spectra (UHS) plots for return periods of 250, 500, 1,000, and 5,000 years (REI 1999). In 2001, a study was conducted to develop ground motion values for an earthquake having a return period of 2,500 years (Beavers 2001). Results of the 1999 REI study were interpolated (using a linear interpolation) for a return period of 2,500 years, resulting in a peak ground acceleration (PGA) of about 0.8 g at bedrock and 0.5 g at the top of soil.

In 2004, DOE completed a seismic evaluation of the potential landfill site to determine what the PGA and other related ground motion characteristics (ground shaking frequency, velocity, and displacements) would be at the site for a ground motion having a 2,500-year return period (DOE 2004). This study reviewed material soil properties from the REI data, but also conducted detailed field investigations into the static and dynamic soil properties at the landfill site (including a shear wave velocity profile for the 400 feet of unconsolidated materials above the bedrock). Based on their analyses, they determined the PGA value at the top of rock (400 ft deep) to be 0.71g. The investigation also included site amplification studies to determine the corresponding top of soil PGA, which was calculated to be 0.48g (at the higher level of shaking associated with the 2,500-year return period ground motion, the soil profile de-amplified the PGA from the input base rock motion by approximately 33%.)

Although the evaluation included a detailed investigation of the dynamic properties of the soil column, it did not include sampling and characterizing the limestone bedrock. The ground motion modeling used bedrock shear wave velocities from references and measurements used to support construction projects in the vicinity of PGDP. The current evaluation of waste disposal options assumes the acquisition of a site-specific bedrock shear wave velocity is not needed to support the RI/FS. It can be deferred to site-specific characterization in a later phase of the project if the On-site Disposal Alternative is selected in the ROD. In order to confirm this assumption, the project team proposed conducting a sensitivity analysis of the bedrock shear wave velocity on the local site response.

The sensitivity analysis is intended to determine the effects of a range of bedrock shear wave velocities on surface PGA values for PGDP. If the results indicate large variations in surface PGA values in response to small changes in bedrock shear wave velocity, it could be concluded that a PGDP-specific bedrock shear wave velocity would be required to adequately evaluate the On-site Disposal Alternative in the RI/FS.

Sensitivity Analysis of Base Bedrock Properties

The sensitivity of the site response (surface PGA) to the base rock shear wave velocity was analyzed using the SHAKE91 code (Idriss and Sun 1992). In order to provide some form of independent check on the computer code used, we also performed analyses using an alternative version of the software called Shake2000 (Ordonez 2000).

The steps in the analysis are described in the following paragraphs and are summarized as follows:

- Determine subsurface profile and dynamic properties;
- Evaluate range of bedrock shear wave velocity to be studied;
- Select input earthquakes;
- Perform site response analysis using SHAKE;
- Evaluate the results

Design Soil Profile for Potential Landfill Site

The soil properties for the potential landfill site presented in the 2004 study were reviewed (DOE 2004) during this analysis. The study conducted a detailed geotechnical characterization of the site and Table 1 below presents the shear wave velocity profile for the unconsolidated materials above the bedrock that was acquired during that study. Figure 1 was taken from the DOE report and shows a generalized geologic column below the site.

The soil stratigraphy presented in Table 1 was used in this sensitivity analysis. The computation of the site response requires shear modulus and damping degradation curves to be input for all strata. The curves from published data commonly used in seismic studies (EPRI 1993, Vucetic and Dobry 1987) were selected and assigned a curve based on the material descriptions in the DOE study.

Bedrock Properties

The base limestone bedrock, a Mississippian-age Limestone, subcrops beneath the PGDP site. Deep borings at PGDP have typically encountered limestone bedrock at depths of approximately 335 to 350 feet below grade. At the potential landfill site, bedrock was encountered at a depth of 400 feet, which is deeper than usual at PGDP.

Based on measurements and other information from nearby sites, the Mississippi limestone is thought to have a shear wave velocity around 10,000 ft/sec. Based on this information and other referenced velocities for hard limestone bedrock, it was determined that studying the shear wave velocity between 6,000 and 14,000 feet/sec would provide sufficient range to evaluate the effect on ground surface PGA at PGDP. It was also determined that 2,000 feet/sec intervals should be adequate for the analysis. Therefore, a site response analysis was performed with the limestone at a depth of 400 feet below grade with a shear wave velocity of 6,000, 8,000, 10,000, 12,000 and 14,000 feet/sec.

Layer Thickness **(ft)**	**Elevation bottom of Layer** **(ft msl)**	**Shear-wave velocity** **(ft/sec)**
20	380	607
12	368	921
8	360	1250
12	348	913
8	340	1068
40	300	1028
58	242	1141
25	217	1430
77	140	1532
150	-10	1700

Table 1 Dynamic Shear Wave Velocities of Soil Profile

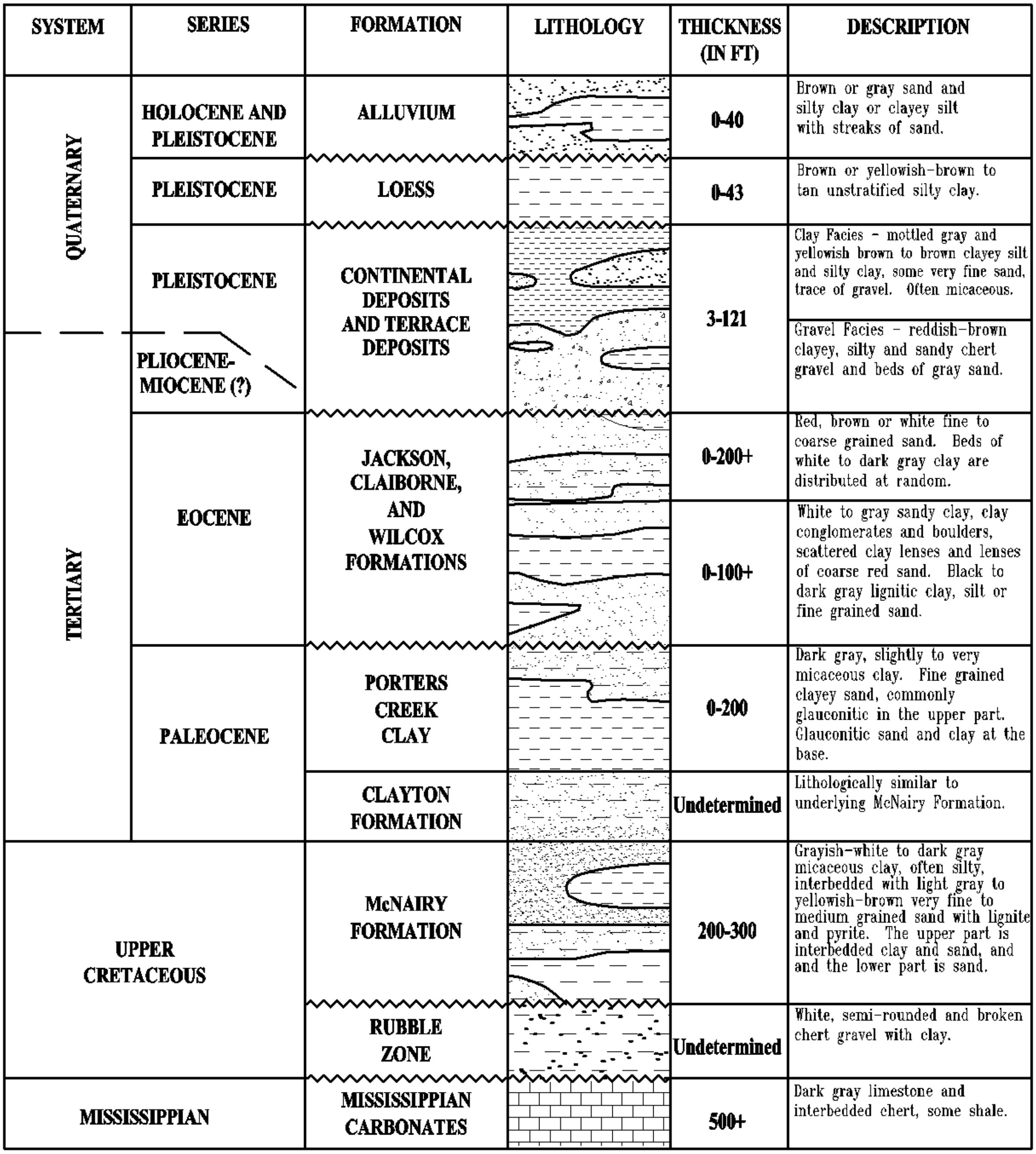

Figure 1 Geologic Columnar Section of the PGDP Vicinity (after DOE 2004)

Input Time Histories

The electronic files of the design earthquakes used in the previous studies were not available for use in our analyses, so time histories were obtained from other sources. For the NMSZ, there are no recorded earthquakes with a magnitude comparable to that required for design, so synthetic earthquakes are typically generated for use in seismic analyses. Since there are well-documented problems with relying solely on synthetic (instead of natural) time histories (e.g. Christian, 1988) it was decided to use both simulated and natural (i.e., recorded) time histories in the site response analyses. (This was suggested by the Kentucky Geologic Survey at the Seismic Issues Workshop.)

For a synthetic earthquake representative of the NMSZ, a time history developed by the University of Kentucky (Wang et al 2009) was used. This report developed time histories for three levels of earthquake magnitudes for use in the seismic analysis of highway structures in Kentucky. The report has links to websites where synthetic time histories and response spectra representative of hard rock sites for each county in Kentucky can be downloaded. This sensitivity analysis used the largest magnitude earthquake in the report, the Maximum Credible Earthquake (MCE), for McCracken County, which has a PGA of 0.23g. The time history is shown in Figure 2.

A comparison of the synthetic time history to design earthquakes provided in earlier PGDP studies (REI 1993, 1999) was performed. The MCE for McCracken County has a similar PGA to the 1,000-year REI event, but the duration of maximum shaking is almost 3 times as long (60 seconds vs 20 seconds). Despite this, it was concluded that the MCE for McCracken County would be somewhat representative of a 1,000-year event at PGDP. It should be noted that the DOE 2004 considered a 2,500 year event as the basis of their analyses for the landfill. However, for the purposes of this sensitivity analysis, it was concluded that the 1,000 year event would provide a representative comparison for the different bedrock shear wave velocities, since at higher earthquake magnitudes, increased damping of the motions in the soil column would tend to reduce the impact of variations in the base bedrock.

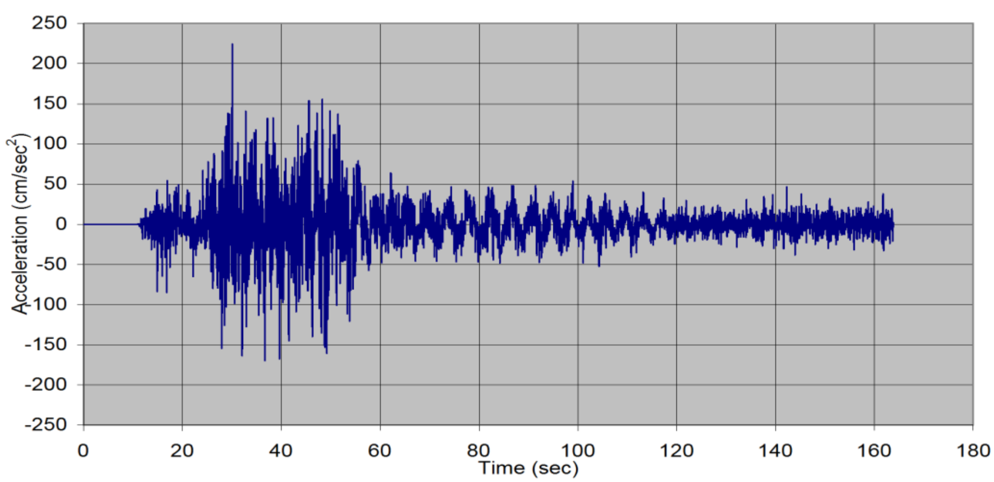

Figure 2 Synthetic Time History for the McCracken County, KY MCE (Wang et al 2009)

For a natural time history, a California earthquake commonly used in seismic studies (e.g., Taylor 1992) was selected. This time history is from the 1979 Imperial Valley earthquake recorded at Superstition Mountain (N135 component) and was recorded on bedrock with a PGA of 0.19g, similar to the MCE for

McCracken County (see Figure 3). In the site response analysis, the natural time history was scaled to provide the same PGA as the synthetic one.

A comparison of the response spectra for the input base motions is provided in Figure 4.

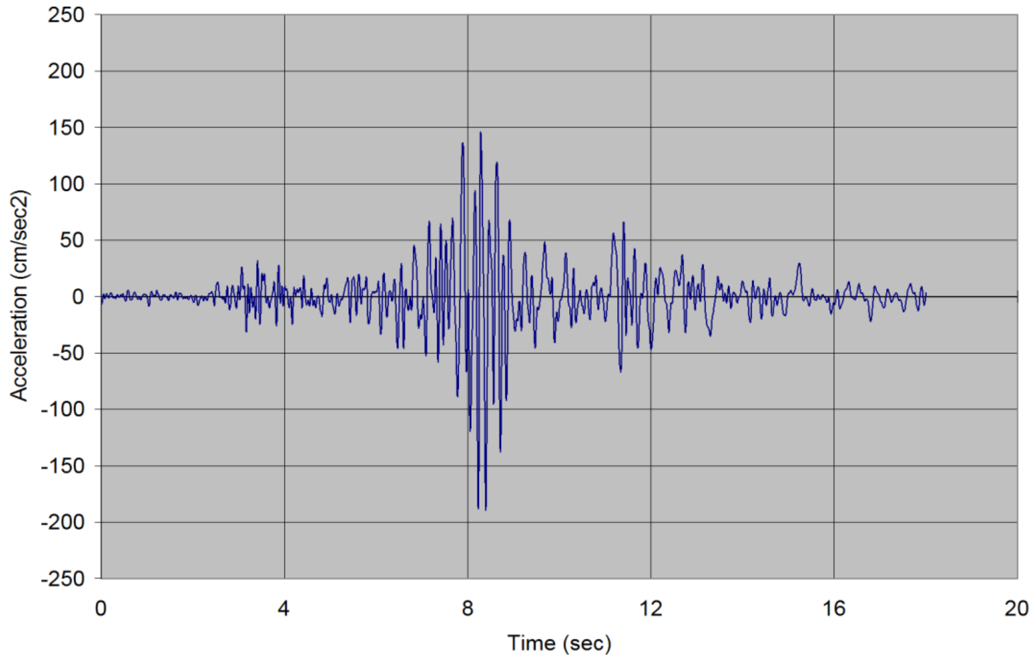

Figure 3 Natural Time History – Imperial Valley 1979 (Taylor 1992)

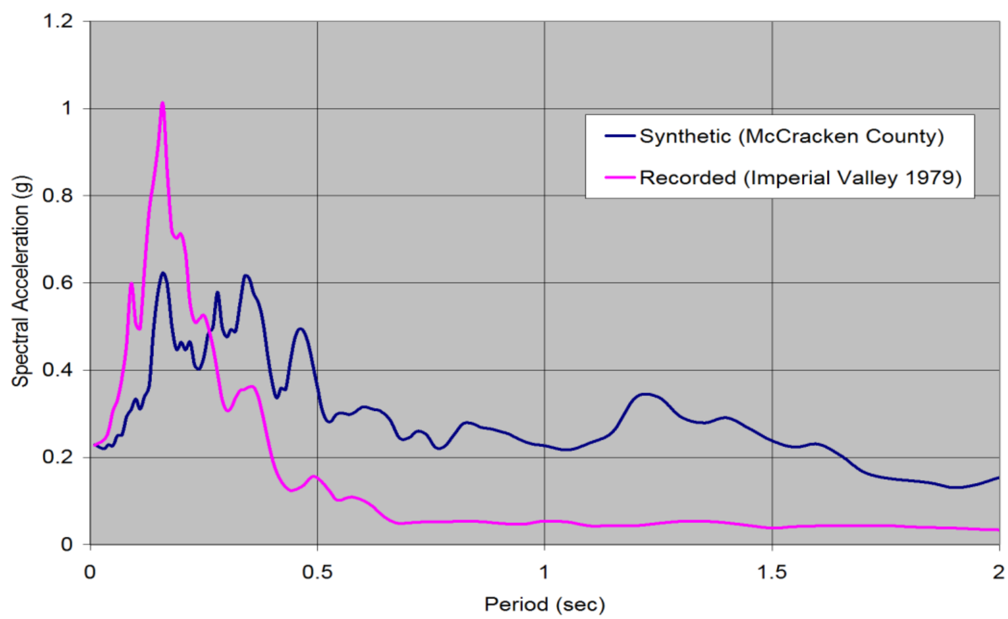

Figure 4 Comparison of Response Spectra for Input Base Motion

Results of Site Response Analyses

The SHAKE 91 software was used to propagate the input base motions through the soil column described earlier in this memorandum, and the response spectra and PGA were computed at the ground surface. The base rock shear wave velocity was varied from 6,000 to 14,000 feet/sec for both input earthquakes. The computed surface response spectra for the synthetic and natural earthquakes are shown on Figures 5 and 6 respectively, and the PGA values are shown in Table 2 below:

Input Base Time History	**Peak Ground Acceleration**					
	Base Input	Base Bedrock Shear Wave Velocity (ft/sec)				
		6000	8000	10000	12000	14000
Synthetic - McCracken County	0.23g	0.34g	0.36g	0.38g	0.39g	0.40g
Natural - Imperial Valley (1979)	0.23g	0.37g	0.39g	0.40g	0.40g	0.41g

Table 2 Computed Peak Ground Acceleration at Ground Surface

It can be seen from Table 2, that varying the base bedrock shear wave velocity from 6,000 to 14,000 feet/sec. causes the ground surface PGA to vary from 0.34g to 0.40g for the synthetic earthquake, and 0.37g to 0.41g for the natural one. Relative to the surface PGA computed with the 10,000 feet/sec bedrock, the sensitivity analysis showed that for a variation of plus or minus 40% in base shear wave velocity, the resulting surface PGA variation is plus 2% and minus 6% for the synthetic earthquake, and plus 4% and minus 10% for the natural earthquake.

The response spectra in Figures 5 and 6 show the site response for each earthquake for structures with a period from 0 to 2 seconds. For the landfill design, the period range around zero seconds, where the spectral acceleration corresponds to PGA, is the most relevant. The amplification between the group of surface spectra and the lower base spectrum for each earthquake can be readily observed. From the graph at zero seconds, and from Table 2, the input base motion with a PGA of 0.23g, was amplified by a factor of around 1.7 to provide the surface PGA of 0.4g. At other periods, particularly around 1.2 seconds, corresponding to the fundamental period of the profile, the amplification was much higher, but this should not be relevant to evaluation of a conceptual landfill design in the RI/FS. The earlier landfill seismic study (DOE 2004) analyzed the 2,500-year event and concluded that the base motions would be de-amplified, which is probably because the higher shaking levels caused greater damping.

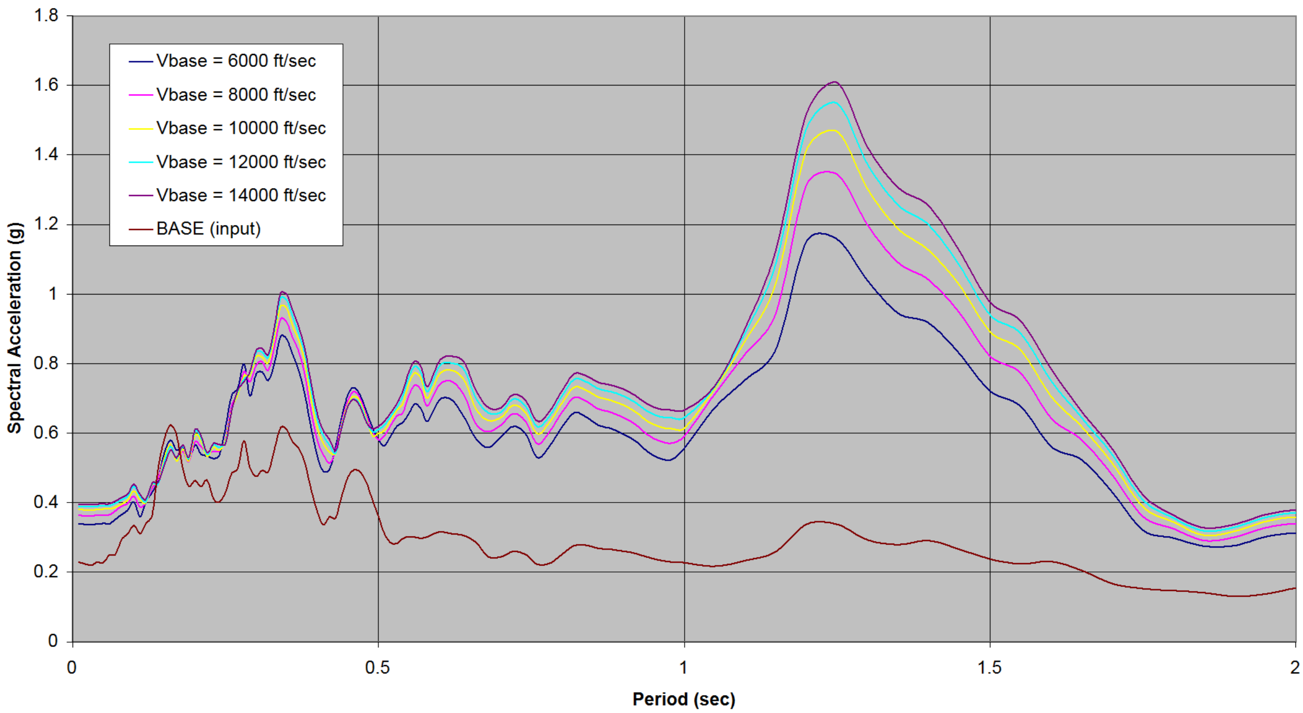

Figure 5   Comparison of Surface Response Spectra for McCracken County (Synthetic) Base Motion

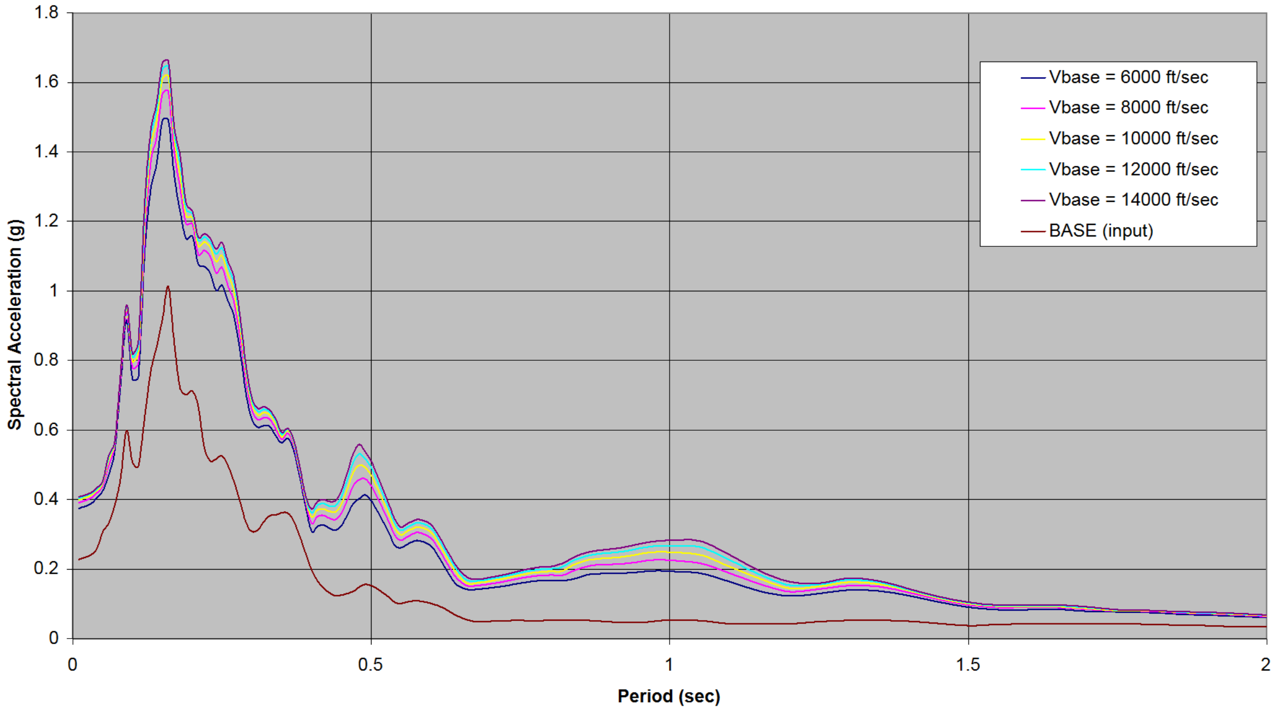

Figure 6 Comparison of Surface Response Spectra for Imperial Valley (Natural) Base Motion

Conclusions

The sensitivity analysis showed that for the seismic evaluation of the proposed landfill site, large variations in the shear wave velocity of the base bedrock will cause very minor variations in PGA at the ground surface.

The order of magnitude of the variation in the PGA is less than 10% for the 1,000 year earthquakes included in the study. For larger events, such as the 2,500 year earthquake, the variation in PGA will be less since damping effects will be larger.

It is therefore concluded that the base limestone bedrock is sufficiently well characterized for the seismic evaluation of the On-site Disposal Alternative in the RI/FS. A PGDP-specific bedrock shear wave velocity investigation is not required at this stage of the project.

References

Beavers, J. 2001. "Seismic Design Criteria Assessment for the C-746-U Contained Landfill—A White Paper," submitted to Bechtel Jacobs Company LLC, James E. Beavers Consultants, Urbana, IL, February 20.

Christian J. T. 1988. "Developing Ground Motions in Practice," Earthquake Engineering and Soil Dynamics II, Geotech. Spec. Pub. No. 20, June, pp. 405-429.

DOE 2004. *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR-07-2038&D2, March.

DOE (U.S. Department of Energy) 2009. *Work Plan for CERCLA Waste Disposal Alternative Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0099&D1, March.

EPRI (Electric Power Research Institute). "Guidelines for Site Specific Ground Motions," TR-102293, Palo Alto, CA, November.

Idriss, I, J. Sun, 1992. "SHAKE91: A Computer Program for Conducting Equivalent Linear Seismic Response Analysis of Horizontally Layered Soil Deposits," Center for Geotechnical Modeling, University of California, Davis, CA, November.

Ordonez G. 2000. "SHAKE2000—A Computer Program for the 1-D Analysis of Geotechnical Earthquake Engineering Problems."

Risk Engineering Inc. 1993. "Seismic Hazard Evaluation for the Paducah Gaseous Diffusion Plant, Paducah, KY," January.

Risk Engineering Inc. 1999. "Updated Probabilistic Seismic Hazard Analysis for the Paducah Gaseous Diffusion Plant, Paducah, KY," April 26.

Schnabel P. B., J. Lysmer, and H. B. Seed, 1972. "SHAKE: A Computer Program for Earthquake Response Analysis of Horizontally Layered Sites," Report No. EERC 72/12, UCB, Berkeley, CA.

Taylor J. 1992. "An Evaluation of Site Factors in Building Codes," Masters Thesis, Massachusetts Institute of Technology.

Vucetic, M. and R. Dobry 1987. "Dynamic Properties and Seismic Response of Soft Clay Deposits." Proceedings, International Symposium on Geotechnical Engineering of Soft Soils. Mexico City, Vol. 2. Pages 51-87.

Wang Z., I. Halik, E. Woolery, B. Shi, and A. Peiris 2009. "Seismic-Hazard Maps and Time Histories for the Commonwealth of Kentucky," Kentucky Transportation Center, Research Report No. KTC-07-07_SPR246-02-6F," University of Kentucky, Lexington, KY, June.

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APPENDIX B

WASTE FORECAST

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B. WASTE FORECAST

The waste inventory as presented in Section 4.1 provided a description of the environmental restoration (ER) projects and Paducah Gaseous Diffusion Plant (PGDP) decontamination and decommissioning actions that comprise the waste volumes in this Comprehensive Environmental Response, Compensation, and Liability Act waste disposal alternatives evaluation Remedial Investigation/Feasibility Study. The tables included in this appendix provide a detailed waste volume, by waste type, for each ER project and each PGDP building (Table B.1).

Table B.1. Waste Volume Estimates by Project (yd^3)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
BGOU	263,658	0	30,971	0	71	0	46,853	341,552
DD-C-100	0	0	0	0	0	154	12,006	12,160
DD-C-100-B	0	0	0	0	0	0	1,070	1,070
DD-C-100-T04	0	0	0	0	0	0	204	204
DD-C-100-T05	0	0	0	0	0	0	204	204
DD-C-100-T06	0	0	0	0	0	0	204	204
DD-C-100-T08	0	0	0	0	0	0	109	109
DD-C-101	0	0	0	0	0	33	3,657	3,690
DD-C-102	0	0	0	0	0	21	2,359	2,380
DD-C-102-B-T01	0	0	0	0	0	0	40	40
DD-C-102-T01	0	0	0	0	0	0	204	204
DD-C-102-T02	0	0	0	0	0	0	204	204
DD-C-102-T03	0	0	0	0	0	0	204	204
DD-C-102-T04	0	0	0	0	0	0	204	204
DD-C-102-T05	0	0	0	0	0	0	204	204
DD-C-102-T06	0	0	0	0	0	0	204	204
DD-C-102-T07	0	0	0	0	0	0	270	270
DD-C-102-T08	0	0	0	0	0	0	15	15
DD-C-102-T09	0	0	0	0	0	0	28	28
DD-C-103	0	0	0	0	0	0	1,621	1,621
DD-C-200	0	0	0	0	0	35	4,298	4,333
DD-C-200-A	0	0	0	0	0	0	166	166
DD-C-201	0	0	0	0	0	0	193	193
DD-C-201-A	0	0	0	0	0	0	40	40
DD-C-201-B	0	0	0	0	0	0	40	40
DD-C-201-C	0	0	0	0	0	0	40	40
DD-C-201-D	0	0	0	0	0	0	40	40
DD-C-202	0	0	0	0	0	0	841	841
DD-C-203	0	0	0	0	0	0	454	454
DD-C-204	0	0	0	0	0	0	77	77
DD-C-205	0	0	0	0	0	0	754	754
DD-C-206	0	0	0	0	0	0	88	88
DD-C-206-A	0	0	0	0	0	0	40	40
DD-C-206-B	0	0	0	0	0	0	103	103
DD-C-207	0	0	0	0	0	0	171	171

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-212	0	0	0	0	0	6	590	596
DD-C-212-A	0	0	0	0	0	0	64	64
DD-C-212-U	0	0	0	0	0	0	296	296
DD-C-215	0	0	0	0	0	0	262	262
DD-C-216	0	0	0	0	0	0	107	107
DD-C-216-T01	5	0	0	0	0	0	27	32
DD-C-216-T02	1	0	0	0	0	0	468	469
DD-C-217	0	0	0	0	0	0	31	31
DD-C-219	0	0	0	0	0	0	66	66
DD-C-224	0	0	0	0	0	0	337	337
DD-C-225	0	0	0	0	0	0	337	337
DD-C-225-A	0	0	0	0	0	0	1,367	1,367
DD-C-226	0	0	0	0	0	0	11	11
DD-C-227	0	0	0	0	0	0	11	11
DD-C-228	0	0	0	0	0	0	11	11
DD-C-229	0	0	0	0	0	0	43	43
DD-C-300	0	0	0	0	2	28	13,628	13,658
DD-C-301	705	0	0	0	0	0	0	705
DD-C-302	0	0	0	0	0	15	1,585	1,600
DD-C-302-T01	0	0	0	0	0	0	36	36
DD-C-303	0	0	0	0	0	0	459	459
DD-C-304	0	0	0	0	0	16	1,717	1,733
DD-C-304-T01	0	0	0	0	0	0	131	131
DD-C-310	25,819	0	1,838	0	11	2	0	27,671
DD-C-310-331-A	407	0	0	0	0	0	40	448
DD-C-310-331-B	333	0	0	0	0	0	21	353
DD-C-310-410	837	0	0	0	0	0	52	889
DD-C-310-A	1,012	0	0	0	3	0	0	1,016
DD-C-310-B	0	0	0	0	0	0	31	31
DD-C-315	4,415	0	0	0	17	0	0	4,433
DD-C-315-331	301	0	0	0	0	0	19	319
DD-C-320	0	0	0	0	0	2	315	317
DD-C-320-A	0	0	0	0	0	0	31	31
DD-C-320-B	0	0	0	0	0	0	36	36
DD-C-331	210,084	0	5,777	0	11	15	0	215,886
DD-C-331-333-A	573	0	0	0	0	0	60	634
DD-C-331-333-B	491	0	0	0	0	0	31	522
DD-C-331-333-C	491	0	0	0	0	0	31	522
DD-C-331-335	2,129	0	0	0	0	0	139	2,268
DD-C-331-410	1,008	0	0	0	0	0	63	1,071
DD-C-331-A	0	0	0	0	0	0	285	285
DD-C-331-B	0	0	0	0	0	0	285	285
DD-C-331-C	0	0	0	0	0	0	765	765
DD-C-331-T01	0	0	0	0	0	0	103	103
DD-C-331-T02	0	0	0	0	0	0	44	44
DD-C-331-T04	0	0	0	0	0	0	43	43
DD-C-331-T05	0	0	0	0	0	0	173	173
DD-C-331-T06	0	0	0	0	0	0	771	771
DD-C-331-T07	0	0	0	0	0	0	771	771
DD-C-331-T08	21	0	0	0	0	0	0	21
DD-C-331-T09	83	0	0	0	0	0	0	83

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-333	474,309	0	8,230	0	11	15	0	482,565
DD-C-333-A	5,484	0	0	0	17	0	0	5,501
DD-C-333-T06	3	0	0	0	0	0	18	21
DD-C-333-T07	3	0	0	0	0	0	18	21
DD-C-333-T08	0	0	0	0	0	0	0	0
DD-C-333-T09	0	0	0	0	0	0	0	0
DD-C-335	210,084	0	5,777	0	11	15	0	215,886
DD-C-335-337-A	407	0	0	0	0	0	40	448
DD-C-335-337-B	333	0	0	0	0	0	21	353
DD-C-335-337-C	333	0	0	0	0	0	21	353
DD-C-335-T01	0	0	0	0	0	0	17	17
DD-C-335-T02	0	0	0	0	0	0	17	17
DD-C-335-T03	197	0	0	0	0	0	0	197
DD-C-335-T04	21	0	0	0	0	0	0	21
DD-C-335-T05	69	0	0	0	0	0	0	69
DD-C-337	474,309	0	8,230	0	11	15	0	482,565
DD-C-337-A	5,725	0	0	0	18	19	0	5,763
DD-C-337-T01	3	0	0	0	0	0	18	21
DD-C-337-T02	3	0	0	0	0	0	18	21
DD-C-337-T03	31	0	0	0	0	0	0	31
DD-C-340-A	16,949	0	0	0	0	0	0	16,949
DD-C-340-B	7,230	0	0	0	0	0	0	7,230
DD-C-340-C	444	0	0	0	0	0	0	444
DD-C-340-D	1,570	0	0	0	0	0	0	1,570
DD-C-340-E	0	0	0	0	0	0	11	11
DD-C-342	0	0	0	0	0	0	131	131
DD-C-342-A	0	0	0	0	0	0	129	129
DD-C-342-B	0	0	0	0	0	0	243	243
DD-C-350	505	0	0	0	0	15	560	1,079
DD-C-360	8,635	0	139	0	37	44	193	9,048
DD-C-360-A	0	0	0	0	0	15	2,363	2,378
DD-C-360-T01	3	0	0	0	0	0	18	21
DD-C-360-T02	15	0	0	0	0	0	0	15
DD-C-370-E	22	0	0	0	0	0	0	22
DD-C-370-W	22	0	0	0	0	0	0	22
DD-C-375-04	1	0	0	0	0	0	0	1
DD-C-375-E2	300	0	0	0	0	0	0	300
DD-C-375-E3	300	0	0	0	0	0	0	300
DD-C-375-E4	150	0	0	0	0	0	0	150
DD-C-375-E5	150	0	0	0	0	0	0	150
DD-C-375-E6	150	0	0	0	0	0	0	150
DD-C-375-S6	300	0	0	0	0	0	0	300
DD-C-375-W7	300	0	0	0	0	0	0	300
DD-C-375-W8	150	0	0	0	0	0	0	150
DD-C-375-W9	300	0	0	0	0	0	0	300
DD-C-400	50,802	0	0	0	43	109	21,509	72,461
DD-C-400-A	34	0	0	0	0	0	46	80
DD-C-400-L	0	0	0	0	0	0	3	3
DD-C-400-T01	0	0	0	0	0	0	31	31
DD-C-402	0	0	0	0	0	0	184	184
DD-C-404-A	22	0	0	0	0	0	0	22

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-405	409	0	0	0	0	0	0	409
DD-C-406	96	0	0	0	0	0	22	118
DD-C-407	29	0	0	0	0	0	33	62
DD-C-408	12	0	0	0	0	0	43	55
DD-C-409	236	0	0	0	0	0	7,854	8,090
DD-C-410	22,615	0	0	0	0	0	0	22,615
DD-C-410-A	119	0	0	0	0	0	43	162
DD-C-410-C	0	0	0	0	0	0	115	115
DD-C-410-D	0	0	0	0	0	0	161	161
DD-C-410-F	0	0	0	0	0	0	158	158
DD-C-410-G	0	0	0	0	0	0	129	129
DD-C-410-H	0	0	0	0	0	0	129	129
DD-C-410-I	0	0	0	0	0	0	211	211
DD-C-410-J	0	0	0	0	0	0	213	213
DD-C-410-K	0	0	0	0	0	0	158	158
DD-C-411	1,372	0	0	0	0	0	1,030	2,402
DD-C-411-A	0	0	0	0	0	0	285	285
DD-C-412	0	0	0	0	0	0	4,199	4,199
DD-C-412-A	0	0	0	0	0	0	10	10
DD-C-412-T01	0	0	0	0	0	0	204	204
DD-C-412-T02	0	0	0	0	0	0	204	204
DD-C-412-T03	0	0	0	0	0	0	204	204
DD-C-412-T04	0	0	0	0	0	0	204	204
DD-C-412-T05	0	0	0	0	0	0	204	204
DD-C-412-T06	0	0	0	0	0	0	204	204
DD-C-412-T07	0	0	0	0	0	0	204	204
DD-C-412-T08	0	0	0	0	0	0	204	204
DD-C-412-T09	0	0	0	0	0	0	204	204
DD-C-412-T10	0	0	0	0	0	0	204	204
DD-C-412-T11	0	0	0	0	0	0	204	204
DD-C-412-T12	0	0	0	0	0	0	204	204
DD-C-412-T13	0	0	0	0	0	0	204	204
DD-C-412-T14	0	0	0	0	0	0	204	204
DD-C-412-T1A	0	0	0	0	0	0	23	23
DD-C-415	1,692	0	0	0	0	0	329	2,021
DD-C-415-T01	0	0	0	0	0	0	0	0
DD-C-416	0	0	0	0	0	0	161	161
DD-C-416-T01	0	0	0	0	0	0	31	31
DD-C-420	18,905	0	0	0	0	0	0	18,905
DD-C-531-1	2,422	0	0	0	6	1,136	7,942	11,506
DD-C-531-2	43,551	0	0	0	0	85	21,744	65,380
DD-C-531-3A	14	0	0	0	0	3	32	49
DD-C-531-3B	14	0	0	0	0	3	27	44
DD-C-532	295	0	0	0	3	65	1,116	1,479
DD-C-533-1	2,524	0	0	0	6	1,145	8,379	12,053
DD-C-533-2	70,521	0	0	0	0	85	33,869	104,475
DD-C-533-3A	14	0	0	0	0	1	27	42
DD-C-533-3B	14	0	0	0	0	3	28	44
DD-C-533-3C	14	0	0	0	0	3	28	44
DD-C-533-3D	14	0	0	0	0	3	28	44
DD-C-535-1	1,715	0	0	0	6	1,131	5,765	8,617

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-535-2	53,385	0	0	0	0	85	18,172	71,642
DD-C-535-3A	0	0	0	0	0	0	63	63
DD-C-535-3B	0	0	0	0	0	0	2,711	2,711
DD-C-535-4	47	0	0	0	0	0	99	146
DD-C-536	295	0	0	0	3	65	1,116	1,479
DD-C-537-1	2,789	0	0	0	6	1,152	9,275	13,221
DD-C-537-2	91,575	0	0	0	0	85	43,332	134,992
DD-C-537-3A	0	0	0	0	0	0	63	63
DD-C-537-3B	0	0	0	0	0	0	63	63
DD-C-537-3C	0	0	0	0	0	0	63	63
DD-C-537-3D	0	0	0	0	0	0	63	63
DD-C-537-4	47	0	0	0	0	0	99	146
DD-C-540-A	30	0	0	0	0	6	62	98
DD-C-540-B	29	0	0	0	0	0	37	66
DD-C-540-C	29	0	0	0	0	0	37	66
DD-C-540-D	29	0	0	0	0	0	37	66
DD-C-540-E	29	0	0	0	0	0	36	65
DD-C-541-A	30	0	0	0	0	1	55	86
DD-C-541-B	29	0	0	0	0	0	36	65
DD-C-541-C	29	0	0	0	0	0	36	65
DD-C-541-D	24	0	0	0	0	0	31	55
DD-C-541-E	29	0	0	0	0	0	36	65
DD-C-600	0	0	0	0	0	182	36,308	36,489
DD-C-601	0	0	0	0	0	9	673	682
DD-C-601-A	0	0	0	0	0	0	215	215
DD-C-601-B	0	0	0	0	0	0	215	215
DD-C-601-C	0	0	0	0	0	6	33	39
DD-C-601-D	0	0	0	0	0	0	375	375
DD-C-601-E	0	0	0	0	0	0	55	55
DD-C-602	0	0	0	0	0	0	2,541	2,541
DD-C-604	0	0	0	0	0	0	513	513
DD-C-604-A	0	0	0	0	0	0	76	76
DD-C-605	0	0	0	0	0	0	269	269
DD-C-606	0	0	0	0	0	0	162	162
DD-C-607	0	0	0	0	0	0	432	432
DD-C-611	0	0	0	0	0	0	4	4
DD-C-611-A	0	0	0	0	0	0	153	153
DD-C-611-A1	0	0	0	0	0	0	404	404
DD-C-611-B	0	0	0	0	0	0	412	412
DD-C-611-B1	0	0	0	0	0	0	86	86
DD-C-611-C	0	0	0	0	0	0	2,188	2,188
DD-C-611-D	0	0	0	0	0	0	4,409	4,409
DD-C-611-E	0	0	0	0	0	0	4,429	4,429
DD-C-611-F	0	0	0	0	0	0	4,429	4,429
DD-C-611-F1	0	0	0	0	0	0	1,781	1,781
DD-C-611-F2	0	0	0	0	0	0	163	163
DD-C-611-F3	0	0	0	0	0	0	49	49
DD-C-611-G	0	0	0	0	0	0	4,429	4,429
DD-C-611-H	0	0	0	0	0	0	2,807	2,807
DD-C-611-M	0	0	0	0	0	0	43	43
DD-C-611-N	0	0	0	0	0	0	43	43

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-611-O	0	0	0	0	0	0	162	162
DD-C-611-P	0	0	0	0	0	5	298	303
DD-C-611-Q	0	0	0	0	0	0	112	112
DD-C-611-R	174	0	0	0	0	0	188	362
DD-C-611-S	0	0	0	0	0	0	291	291
DD-C-611-T	0	0	0	0	0	0	292	292
DD-C-611-T01	0	0	0	0	0	0	103	103
DD-C-611-U	0	0	0	0	0	0	375	375
DD-C-611-X	0	0	0	0	0	0	322	322
DD-C-611-Z	0	0	0	0	0	0	517	517
DD-C-612	0	0	0	0	0	0	575	575
DD-C-612-A	0	0	0	0	0	0	378	378
DD-C-612-B	0	0	0	0	0	0	17	17
DD-C-612-T01	0	0	0	0	0	0	107	107
DD-C-612-T02	0	0	0	0	0	0	107	107
DD-C-612-T03	0	0	0	0	0	0	107	107
DD-C-612-T04	0	0	0	0	0	0	23	23
DD-C-612-T05	0	0	0	0	0	0	0	0
DD-C-612-T06	0	0	0	0	0	0	0	0
DD-C-612-T07	0	0	0	0	0	0	0	0
DD-C-612-T08	0	0	0	0	0	0	0	0
DD-C-612-T09	0	0	0	0	0	0	0	0
DD-C-612-T10	0	0	0	0	0	0	0	0
DD-C-612-T11	0	0	0	0	0	0	0	0
DD-C-612-T12	0	0	0	0	0	0	0	0
DD-C-613-A	0	0	0	0	0	0	80	80
DD-C-614-A	0	0	0	0	0	0	144	144
DD-C-615	2	0	0	0	0	1	326	329
DD-C-615-01	8	0	0	0	0	0	27	35
DD-C-615-A	184	0	0	0	0	0	0	184
DD-C-615-B	184	0	0	0	0	0	0	184
DD-C-615-C	131	0	0	0	0	0	346	477
DD-C-615-D	549	0	0	0	0	0	0	549
DD-C-615-E	466	0	0	0	0	0	0	466
DD-C-615-F	208	0	0	0	0	0	0	208
DD-C-615-G	0	0	0	0	0	0	58	58
DD-C-615-H	0	0	0	0	0	0	59	59
DD-C-615-H1	0	0	0	0	0	0	58	58
DD-C-615-H2	0	0	0	0	0	0	58	58
DD-C-615-H3	0	0	0	0	0	0	58	58
DD-C-615-H4	0	0	0	0	0	0	58	58
DD-C-615-H5	0	0	0	0	0	0	58	58
DD-C-615-H7	0	0	0	0	0	0	58	58
DD-C-615-H8	0	0	0	0	0	0	58	58
DD-C-615-J	0	0	0	0	0	0	89	89
DD-C-615-K	0	0	0	0	0	0	0	0
DD-C-615-L	14	0	0	0	0	0	55	69
DD-C-615-M	131	0	0	0	0	0	342	473
DD-C-615-N	242	0	0	0	0	0	0	242
DD-C-615-O	14	0	0	0	0	0	44	58
DD-C-615-T01	0	0	0	0	0	0	31	31

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-615-T02	0	0	0	0	0	0	31	31
DD-C-615-T03	0	0	0	0	0	0	31	31
DD-C-615-T04	0	0	0	0	0	0	31	31
DD-C-615-T05	0	0	0	0	0	0	31	31
DD-C-616	889	0	0	0	0	0	0	889
DD-C-616-17	0	0	0	0	0	0	204	204
DD-C-616-18	0	0	0	0	0	0	204	204
DD-C-616-19	0	0	0	0	0	0	204	204
DD-C-616-20	0	0	0	0	0	0	580	580
DD-C-616-21	0	0	0	0	0	0	169	169
DD-C-616-22	0	0	0	0	0	0	204	204
DD-C-616-23	0	0	0	0	0	0	204	204
DD-C-616-24	0	0	0	0	0	0	204	204
DD-C-616-A	199	0	0	0	0	0	494	693
DD-C-616-B	0	0	0	0	0	0	1,032	1,032
DD-C-616-C	1	0	0	0	0	0	159	160
DD-C-616-D	12	0	0	0	0	0	73	85
DD-C-616-E	65,355	0	0	0	0	0	0	65,355
DD-C-616-F	20,755	0	0	0	0	0	0	20,755
DD-C-616-G	0	0	0	0	0	0	49	49
DD-C-616-H1	0	0	0	0	0	0	44	44
DD-C-616-H2	0	0	0	0	0	0	44	44
DD-C-616-J	0	0	0	0	0	0	33	33
DD-C-616-K	41	0	0	0	0	0	110	151
DD-C-616-L	7	0	0	0	0	0	50	57
DD-C-616-M	0	0	0	0	0	0	1,032	1,032
DD-C-616-N	0	0	0	0	0	0	33	33
DD-C-616-P	12	0	0	0	0	0	73	85
DD-C-616-Q	770	0	0	0	0	0	0	770
DD-C-617-A	0	0	0	0	0	0	71	71
DD-C-620	3,222	0	0	0	0	0	2,521	5,743
DD-C-631-1	368	0	0	0	0	28	3,017	3,413
DD-C-631-10	0	0	0	0	0	0	54	54
DD-C-631-11	0	0	0	0	0	0	109	109
DD-C-631-12	0	0	0	0	0	0	75	75
DD-C-631-13	0	0	0	0	0	0	30	30
DD-C-631-14	0	0	0	0	0	0	47	47
DD-C-631-15	0	0	0	0	0	0	44	44
DD-C-631-16	0	0	0	0	0	0	27	27
DD-C-631-2	790	0	0	0	0	0	5,389	6,179
DD-C-631-3	4	0	0	0	0	0	493	497
DD-C-631-4	116	0	0	0	0	5	490	611
DD-C-631-5	156	0	0	0	0	0	1,213	1,369
DD-C-631-6	78	0	0	0	0	0	661	739
DD-C-631-7	0	0	0	0	0	0	146	146
DD-C-631-8	0	0	0	0	0	0	36	36
DD-C-631-9	0	0	0	0	0	0	117	117
DD-C-632-B	0	0	0	0	0	0	27	27
DD-C-633-1	389	0	0	0	0	29	3,186	3,604
DD-C-633-2A	834	0	0	0	0	0	5,669	6,503
DD-C-633-2B	834	0	0	0	0	0	5,669	6,503

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-633-3	150	0	0	0	0	5	623	779
DD-C-633-4	235	0	0	0	0	0	1,746	1,981
DD-C-633-5	235	0	0	0	0	0	1,746	1,981
DD-C-633-6	26	0	0	0	0	0	58	84
DD-C-634-B	0	0	0	0	0	0	60	60
DD-C-635-1	645	0	0	0	0	11	2,544	3,200
DD-C-635-2	790	0	0	0	0	0	5,389	6,179
DD-C-635-3	150	0	0	0	0	5	623	779
DD-C-635-4	130	0	0	0	0	0	1,032	1,162
DD-C-635-5	156	0	0	0	0	0	1,213	1,369
DD-C-635-6	194	0	0	0	0	6	793	993
DD-C-637-1	389	0	0	0	0	29	3,186	3,604
DD-C-637-2A	1,141	0	0	0	0	0	7,636	8,777
DD-C-637-2B	1,141	0	0	0	0	0	7,636	8,777
DD-C-637-3	155	0	0	0	0	6	662	822
DD-C-637-4	183	0	0	0	0	0	1,392	1,575
DD-C-637-5	183	0	0	0	0	0	1,392	1,575
DD-C-637-6	26	0	0	0	0	0	58	84
DD-C-637-T01	0	0	0	0	0	0	31	31
DD-C-709	4,080	0	0	0	0	0	988	5,068
DD-C-710	25,907	0	0	0	0	28	2,165	28,100
DD-C-710-A	0	0	0	0	0	0	99	99
DD-C-710-B	0	0	0	0	0	0	40	40
DD-C-711	0	0	0	0	0	0	213	213
DD-C-712	0	0	0	0	0	0	3	3
DD-C-720	113,074	0	0	0	0	192	51,452	164,718
DD-C-720-A	624	0	0	0	0	7	386	1,017
DD-C-720-B	548	0	0	0	0	0	488	1,036
DD-C-720-C	10,580	0	0	0	0	34	5,330	15,944
DD-C-720-C1	1,649	0	0	0	0	0	835	2,484
DD-C-720-D	128	0	0	0	0	0	82	210
DD-C-720-E	0	0	0	0	0	0	945	945
DD-C-720-G	0	0	0	0	0	0	2,121	2,121
DD-C-720-H	0	0	0	0	0	0	500	500
DD-C-720-J	426	0	0	0	0	0	112	538
DD-C-720-K	489	0	0	0	0	0	271	760
DD-C-720-L	0	0	0	0	0	0	25	25
DD-C-720-M	0	0	0	0	0	0	204	204
DD-C-720-M-T01	0	0	0	0	0	0	31	31
DD-C-720-M-T02	0	0	0	0	0	0	31	31
DD-C-720-M-T03	0	0	0	0	0	0	37	37
DD-C-720-N	0	0	0	0	0	0	54	54
DD-C-720-P	0	0	0	0	0	0	80	80
DD-C-720-Q	0	0	0	0	0	0	45	45
DD-C-720-R	0	0	0	0	0	0	44	44
DD-C-720-S	0	0	0	0	0	0	44	44
DD-C-720-T	0	0	0	0	0	0	46	46
DD-C-720-U	0	0	0	0	0	0	44	44
DD-C-721	0	0	0	0	0	0	213	213
DD-C-722	0	0	0	0	0	0	2	2
DD-C-724-A	0	0	0	0	0	0	612	612

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-724-B	0	0	0	0	0	0	2,693	2,693
DD-C-724-C	8	0	0	0	0	0	271	279
DD-C-724-D	0	0	0	0	0	0	658	658
DD-C-724-T01	0	0	0	0	0	0	32	32
DD-C-725	2	0	0	0	0	0	87	89
DD-C-726	52	0	0	0	0	4	461	518
DD-C-727	0	0	0	0	0	0	918	918
DD-C-728	514	0	0	0	0	10	464	988
DD-C-729	0	0	0	0	0	0	105	105
DD-C-730	0	0	0	0	0	0	276	276
DD-C-730-A	0	0	0	0	0	0	19	19
DD-C-730-B	0	0	0	0	0	0	49	49
DD-C-730-T01	0	0	0	0	0	0	109	109
DD-C-730-T02	0	0	0	0	0	0	107	107
DD-C-730-T03	0	0	0	0	0	0	80	80
DD-C-730-T05	0	0	0	0	0	0	191	191
DD-C-730-T06	0	0	0	0	0	0	204	204
DD-C-730-T08	0	0	0	0	0	0	40	40
DD-C-731	0	0	0	0	0	0	285	285
DD-C-732	0	0	0	0	0	0	367	367
DD-C-733	169	0	0	0	0	11	853	1,033
DD-C-740	1,359	0	0	0	0	0	19,685	21,044
DD-C-740-A	5	0	0	0	0	0	58	63
DD-C-740-B	0	0	0	0	0	0	594	594
DD-C-740-C	161	0	0	0	0	0	2,337	2,498
DD-C-741	0	0	0	0	0	0	1,140	1,140
DD-C-742	0	0	0	0	0	0	771	771
DD-C-742-B	0	0	0	0	0	0	68	68
DD-C-743	0	0	0	0	0	18	1,948	1,966
DD-C-743-A	76	0	0	0	0	0	0	76
DD-C-743-B	0	0	0	0	0	0	19	19
DD-C-743-C	0	0	0	0	0	0	19	19
DD-C-743-D	0	0	0	0	0	0	31	31
DD-C-743-T01	0	0	0	0	0	0	204	204
DD-C-743-T02	0	0	0	0	0	0	204	204
DD-C-743-T03	0	0	0	0	0	0	173	173
DD-C-743-T04	0	0	0	0	0	0	204	204
DD-C-743-T07	0	0	0	0	0	0	60	60
DD-C-743-T09	0	0	0	0	0	0	204	204
DD-C-743-T11	0	0	0	0	0	0	224	224
DD-C-743-T12	0	0	0	0	0	0	224	224
DD-C-743-T13	0	0	0	0	0	0	224	224
DD-C-743-T14	0	0	0	0	0	0	224	224
DD-C-743-T15	0	0	0	0	0	0	224	224
DD-C-743-T16	0	0	0	0	0	0	224	224
DD-C-743-T17	0	0	0	0	0	0	233	233
DD-C-744	2,061	0	0	0	0	0	1,326	3,387
DD-C-745-A	999	0	0	0	0	0	14,478	15,477
DD-C-745-B	2,358	0	0	0	0	0	34,141	36,499
DD-C-745-B1	0	0	0	0	0	0	39	39
DD-C-745-C	2,199	0	0	0	0	0	31,845	34,044

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-745-D	238	0	0	0	0	0	3,455	3,693
DD-C-745-E	435	0	0	0	0	0	6,307	6,742
DD-C-745-F	780	0	0	0	0	0	11,301	12,081
DD-C-745-G	1,885	0	0	0	0	0	27,294	29,179
DD-C-745-G1	0	0	0	0	0	0	59	59
DD-C-745-G2	0	0	0	0	0	0	1,163	1,163
DD-C-745-G3	0	0	0	0	0	0	1,163	1,163
DD-C-745-G4	0	0	0	0	0	0	1,163	1,163
DD-C-745-G5	0	0	0	0	0	0	1,163	1,163
DD-C-745-G6	0	0	0	0	0	0	80	80
DD-C-745-H	1,435	0	0	0	0	0	20,781	22,216
DD-C-745-J	2,088	0	0	0	0	0	0	2,088
DD-C-745-K	900	0	0	0	0	0	13,038	13,938
DD-C-745-L	1,560	0	0	0	0	0	22,590	24,150
DD-C-745-M	600	0	0	0	0	0	8,695	9,295
DD-C-745-N	900	0	0	0	0	0	13,038	13,938
DD-C-745-P	480	0	0	0	0	0	6,958	7,438
DD-C-745-Q	600	0	0	0	0	0	8,695	9,295
DD-C-745-R	589	0	0	0	0	0	8,529	9,118
DD-C-745-R1	0	0	0	0	0	0	760	760
DD-C-745-S	650	0	0	0	0	0	9,419	10,069
DD-C-745-T	2,614	0	0	0	0	0	37,837	40,451
DD-C-745-U	1,089	0	0	0	0	0	15,773	16,862
DD-C-745-V	871	0	0	0	0	0	12,621	13,492
DD-C-745-W	136	0	0	0	0	0	1,537	1,673
DD-C-746-A	3,998	0	0	0	0	0	3,665	7,663
DD-C-746-B	3,646	0	0	0	0	0	7,423	11,070
DD-C-746-B1	0	0	0	0	0	0	228	228
DD-C-746-C-T01	0	0	0	0	0	0	60	60
DD-C-746-E-T01	0	0	0	0	0	0	60	60
DD-C-746-G	0	0	0	0	0	0	513	513
DD-C-746-G-T1	0	0	0	0	0	0	24	24
DD-C-746-G-T2	0	0	0	0	0	0	43	43
DD-C-746-H1	49	0	0	0	0	0	553	602
DD-C-746-H2	53	0	0	0	0	0	602	655
DD-C-746-H3	561	0	0	0	0	0	3,169	3,730
DD-C-746-H4	316	0	0	0	0	0	2,752	3,068
DD-C-746-M	72	0	0	0	0	0	65	137
DD-C-746-P2	0	0	0	0	0	0	23	23
DD-C-746-P-T01	0	0	0	0	0	0	204	204
DD-C-746-P-T02	0	0	0	0	0	0	204	204
DD-C-746-P-T03	0	0	0	0	0	0	204	204
DD-C-746-P-T04	0	0	0	0	0	0	204	204
DD-C-746-P-T05	0	0	0	0	0	0	28	28
DD-C-746-P-T06	0	0	0	0	0	0	77	77
DD-C-746-Q	5,462	0	0	0	0	0	2,271	7,733
DD-C-746-Q1	2,694	0	0	0	0	0	1,192	3,887
DD-C-746-R	253	0	0	0	0	0	117	370
DD-C-747-A-T01	0	0	0	0	0	0	52	52
DD-C-747-A-T03	0	0	0	0	0	0	0	0
DD-C-747-D	0	0	0	0	0	0	883	883

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-747-E	0	0	0	0	0	0	883	883
DD-C-747-F	0	0	0	0	0	0	80	80
DD-C-750	0	0	0	0	0	42	3,544	3,586
DD-C-751	0	0	0	0	0	0	19	19
DD-C-752	3,047	0	0	0	0	0	499	3,546
DD-C-752-A	1,130	0	0	0	0	0	8,547	9,677
DD-C-752A-T9	0	0	0	0	0	0	80	80
DD-C-752-B	0	0	0	0	0	0	239	239
DD-C-752-C	1,572	0	0	0	0	0	745	2,317
DD-C-752-C-T11	0	0	0	0	0	0	25	25
DD-C-752-D	0	0	0	0	0	0	369	369
DD-C-752-T01	0	0	0	0	0	0	31	31
DD-C-752-T02	0	0	0	0	0	0	31	31
DD-C-752-T03	0	0	0	0	0	0	31	31
DD-C-752-T04	0	0	0	0	0	0	31	31
DD-C-752-T05	0	0	0	0	0	0	31	31
DD-C-752-T06	0	0	0	0	0	0	31	31
DD-C-752-T07	0	0	0	0	0	0	31	31
DD-C-752-T08	0	0	0	0	0	0	31	31
DD-C-752-T09	0	0	0	0	0	0	73	73
DD-C-752-T10	0	0	0	0	0	0	80	80
DD-C-753-A	0	0	0	0	0	0	6,226	6,226
DD-C-754	0	0	0	0	0	0	883	883
DD-C-754-A	0	0	0	0	0	0	437	437
DD-C-755	0	0	0	0	0	0	211	211
DD-C-755-A	572	0	0	0	0	0	317	889
DD-C-755-B	0	0	0	0	0	0	513	513
DD-C-755-C	190	0	0	0	0	0	0	190
DD-C-755-D	0	0	0	0	0	0	25	25
DD-C-755-E	0	0	0	0	0	0	19	19
DD-C-755-F	0	0	0	0	0	0	19	19
DD-C-755-G	0	0	0	0	0	0	19	19
DD-C-755-H	0	0	0	0	0	0	19	19
DD-C-755-J	0	0	0	0	0	0	0	0
DD-C-755-K	0	0	0	0	0	0	0	0
DD-C-755-L	0	0	0	0	0	0	0	0
DD-C-755-M	0	0	0	0	0	0	39	39
DD-C-755-N	0	0	0	0	0	0	10	10
DD-C-755-P	0	0	0	0	0	0	1,695	1,695
DD-C-755-Q	0	0	0	0	0	0	0	0
DD-C-755-R	0	0	0	0	0	0	0	0
DD-C-755-S	0	0	0	0	0	0	0	0
DD-C-755-T	0	0	0	0	0	0	115	115
DD-C-757	0	0	0	0	0	0	2,060	2,060
DD-C-757-T01	5	0	0	0	0	0	27	32
DD-C-759	173	0	0	0	0	0	285	458
DD-C-759-A	0	0	0	0	0	0	198	198
DD-C-759-B	0	0	0	0	0	0	3,932	3,932
DD-C-760	0	0	0	0	0	0	567	567
DD-C-761	0	0	0	0	0	0	39,235	39,235
DD-C-761-T01	0	0	0	0	0	0	204	204

Table B.1. Waste Volume Estimates by Project (yd^3) (Continued)

LCB Project	LLW	LLW/ RCRA	LLW/ RCRA/ TSCA	LLW/ TSCA	RCRA	TSCA	Nonhazardous Solid	Total
DD-C-770	0	0	0	0	0	0	172	172
DD-C-800	0	0	0	0	0	0	189	189
DD-C-801	0	0	0	0	0	0	131	131
DD-C-802	0	0	0	0	0	0	22	22
DD-C-802-A	0	0	0	0	0	0	59	59
DD-C-802-B	0	0	0	0	0	0	11	11
DD-C-810	0	0	0	0	0	0	13,718	13,718
DD-C-811	0	0	0	0	0	0	10,202	10,202
DD-other	8,057	0	1,030	0	0	102	19,017	28,205
GWOU—Fenceline Action	0	0	0	0	0	0	6,007	6,007
GWOU—Off-site Plume	0	0	0	0	0	0	107	107
GWOU—Pump & Treat	0	0	37	0	0	0	1,236	1,273
Soils OU—Remedial Action	8,523	0	0	0	199	0	76,999	85,721
SWOU—Off-site	0	0	4,615	0	0	0	11,055	15,669

Overall Total Volume:	**3,592,840**

BGOU = Burial Grounds Operable Unit
DD = decontamination and decommissioning
DMSA = DOE Material Storage Area
GWOU = Groundwater Operable Unit
LCB = Life Cycle Baseline
LLW = low-level waste
RCRA = Resource Conservation and Recovery Act of 1976
Soils OU = Soils Operable Unit
SWOU = Surface Water Operable Unit
TSCA = Toxic Substances Control Act of 1976
Source: DOE 2006. Paducah-Final Cost and Schedule Summary Report, Scenarios I-II, U.S. Department of Energy, October 13.

APPENDIX C

PRELIMINARY WASTE ACCEPTANCE CRITERIA MODELING SUPPORTING INFORMATION

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C.1. INTRODUCTION

This appendix provides supporting information for the preliminary waste acceptance criteria (PWAC) modeling and calculations presented in Section 5.4.6. Section C.2 provides a description of the hydrogeologic environment as well as groundwater flow modeling performed within the Terrace Gravel and Regional Gravel Aquifer (RGA). A discussion of the derivation of the PWAC values calculated prior to comparison with saturation, mass, and risk criteria limits are provided in Section C.3, and calculated PWAC values accounting for saturation, mass, and risk criteria limits for each point of assessment (POA) are provided in Section C.4. Appropriate figures and tables also are provided in the appropriate sections.

The following information also is included in Appendix C.

- A description of the predicted source depletion due to leachate removal and treatment during the assumed 30-year operational/closure period is presented in Attachment C1.

- GEO Consultants (2009) study of hydrogeologic data for Site 3A is presented in Attachment C2.

- A description of the groundwater flow model developed to simulate hydrogeologic conditions at Site 3A is presented in Attachment C3.

- Hydrogeochemical parameters assigned to the HELP and DUSTMS models are presented in Attachment C4.

- Predicted groundwater concentration time series graphs at the waste disposal facility (WDF) boundary for Site 3A and 11 is presented in Attachment C5.

- An evaluation of the potential receptors and exposure pathways that were considered and the rationale for selecting the receptor as the maximum exposed individual that was used when preparing the PWAC modeling is presented in Attachment C6.

- A discussion on inadvertent intruder scenarios is presented in Attachment C7. The intruder scenarios are defined and then evaluated based on the likely site-specific conditions. A determination is made about whether each intruder scenario would result in a complete exposure pathway for a potential receptor from an on-site disposal facility. The U.S. Department of Energy (DOE) will provide long-term care of the facility such that an inadvertent intruder is not a likely scenario; however, the inadvertent intruder scenarios are summarized and screened in this report based on the assumption that long-term care is lost in the future.

- An evaluation of the potential for "facilitated transport" of contaminants from the waste cell, which was conducted during the performance modeling and PWAC development, is presented in Attachment C8. Facilitated transport refers to the enhanced migration of contaminants from the disposal cell into the surrounding environment. The evaluation considers this potential phenomenon and provides a conclusion on whether facilitated transport would be expected to occur in a disposal cell at Paducah Gaseous Diffusion Plant (PGDP).

- Uncertainty analyses, both quantitative and qualitative, conducted as part of the PWAC development are included in Attachment C9.

- The PWAC modeling results indicated that some of the radionuclide contaminants (and decay products from ingrowth) would not reach their peak concentration prior to the 1,600-year evaluation period. As a result, an uncertainty analysis to examine growth and risk beyond 10,000 years was completed for uranium-238 (U-238) as a parent compound and thorium-230 (Th-230) as its progeny. This analysis is presented in Attachment C10.

- A comparative assessment of final calculated PWAC values is included in Attachment C11.

C.2. GROUNDWATER FLOW MODELING

There are two separate groundwater settings at PGDP: the southern Terrace Gravel setting over the Porters Creek Clay and the northern setting over the RGA. Potential sites that passed the threshold screening are located in each setting. Site 3A is located in the southern setting and Site 11 is located in the northern setting. These sites were included in the remedial investigation/feasibility study (RI/FS) report to evaluate the two separate groundwater settings at PGDP and are referred to as the "prototype" sites. The hydraulic gradients, flow distances, and hydraulic conductivities along site-to-receptor flow paths for prototype Site 11 were obtained directly from the updated PGDP groundwater flow model (PRS 2010). The PGDP groundwater flow model covers most of PGDP except for the southern portion above the Porters Creek Clay terrace; therefore, the model does not cover the area of interest at prototype Site 3A. GEO Consultants (2009) prepared a study of the hydrologic data for Site 3A, which was used to determine the appropriate hydrological parameters for development of a Terrace Gravel groundwater flow model. The GEO report is included as Attachment C2 to Appendix C. A description of the Terrace Gravel groundwater flow model comprises Attachment C3.

C.3. PWAC DERIVATION AND GROUNDWATER CONCENTRATION TIME HISTORIES

As discussed in Section 5.4.6 of the main report, the PWAC is used in evaluating the viability of an on-site disposal facility. If selected as the preferred alternative, the PWAC values for an on-site disposal facility would require modification after the disposal facility design is finalized. It is important to recognize that the PWAC values, in addition to assessing the viability of the On-Site Alternative, are intended to inform the design as it progresses from the conceptual level to final design. In other words, the PWAC and the findings of the sensitivity modeling for the PWAC,[1] may be used to inform design elements or design element modifications such that increased waste concentrations or contaminant masses may be achieved while still meeting the remedial action objectives.

As the PWAC considers migration of chemicals in groundwater, the contaminant inventory limits defined by the PWAC apply only to mobile forms of a contaminant (e.g., nickel as a component of soil that is capable of dissolving into percolating water, etc.). Wastes placed in a non-mobile form, such as nickel ingots, etc., will not be subject to the contaminant inventory limits defined by the PWAC.

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[1] Section 5.4.6.8 and Appendix C, Attachment C9 discusses the findings of the sensitivity modeling.

The PWAC is based on groundwater modeling performed to Year 1,600, as specified in the RI/FS Work Plan (DOE 2011a). The first calculation of the PWAC-edge of waste (EOW) does not take into account soil saturation, facility mass, or risk-based limitations; these values are presented in Tables 5.15 and 5.16 from the main report for Site 11 and Site 3A, respectively. Corrections for soil saturation are performed for those chemicals that in their pure form are liquids at 25°C (Table C.1). Results for the PWAC-EOW accounting for soil saturation and total mass limits for the disposal facility are included in Table 5.17 for Site 11 and Table 5.18 for Site 3A as well as Table C.2 for Site 11 and Table C.3 for Site 3A.

Time histories of the groundwater concentrations are provided for representative contaminants (i.e., several contaminants such as metals exhibit similar time histories of concentrations; therefore, only representative metals and radionuclides are provided) in Attachment C5 for the gradual failure, instantaneous failure, and no failure scenarios at a receptor located at the WDF boundary. The failure scenario details are described in Section 5.4.6.1. The groundwater concentrations presented in these graphs are the values calculated specifying the PWAC values as initial concentrations in the waste form. For the failure scenarios, some constituents are not predicted to reach the WDF boundary receptor location in the modeling period.

Recognizing that the historical nature of PGDP operations primarily involved the processing of uranium isotopes, a primary assumption was made in this evaluation that radionuclides from the U-238 and actinium (U-235) decay series did not exist in secular equilibrium with their decay products. Furthermore, the absence of secular equilibrium also was assumed for radionuclides associated with the thorium series (beginning with Th-232). None of the other targeted radionuclides in this analysis were members of a naturally occurring radioactive decay series. Thus, for purposes of this analysis, the uranium (U-238) and actinium (U-235) decay series did not exist in secular equilibrium with their decay products. This assumption is not related to the short-lived daughters, as ingrowth still occurs and that is considered in the model when deriving PWAC values. Uranium also was modeled as pure uranium (or uranium as a soluble salt or oxide) in the waste for comparison to the maximum contaminant levels (MCLs).

C.4. COMPARISON OF PWAC-EOW, PWAC-WDF, AND PWAC-DOE/SURFACE WATER VALUES

The PWAC-EOW, PWAC-WDF, and PWAC-DOE/surface water take into account soil saturation, facility mass limitations,[2] and cumulative risk limitations and is based on modeling performed to Year 1,600 in accordance with the RI/FS Work Plan (DOE 2011a). Identical PWAC values may be predicted for contaminants under different scenarios if the compound is not predicted to reach a POA or if soil saturation or total mass/activity limits are exceeded for the evaluated scenarios. PWAC values at each POA for the gradual failure scenario are provided in Tables C.2 and C.3 for Site 11 and Site 3A, respectively. Predicted PWAC values are provided for the following POAs: EOW (PWAC-EOW WDF boundary (PWAC-WDF), and DOE property line (Site 11) or surface water outcrop (Site 3A) (PWAC-DOE/SW). PWAC-WDF values for the instantaneous failure, gradual failure, and no failure scenarios are presented in Tables C.4 and C.5 for Site 11 and Site 3A, respectively. Generally, the PWAC values are greater for Site 11 than Site 3A.

[2] Recognizing that the waste will not be comprised of a single contaminant, a facility mass limit of 1E+05 mg/kg is used in lieu of 1E+06 mg/kg. This rule is also applied to radionuclides such that the specific activity (pCi/g), which would be the theoretical maximum activity for a radionuclide, is divided by 10.

Table C.1 Summary of Chemical Melting Points

Chemical Groups	Melting Point (ºC)	Liquid at 25ºC? (Yes or No)	Reference
Nonaromatic, Straight-Chain Halogenated Hydrocarbons			
Chloroform	-63.5	Yes	http://www.osha.gov/SLTC/healthguidelines/chloroform/recognition.html
cis-1,2-DCE	-80.5	Yes	http://www.osha.gov/SLTC/healthguidelines/1_2-dichloroethylene/recognition.html
Methylene chloride	-97	Yes	http://www.osha.gov/dts/sltc/methods/organic/org080/org080.html#ref510
Vinyl Chloride	-153.8	Yes	http://www.osha.gov/dts/sltc/methods/organic/org075/org075.html
TCE	-86.5	Yes	http://www.osha.gov/dts/sltc/methods/mdt/mdt1001/1001.html
PCE	-22.7	Yes	http://www.osha.gov/dts/sltc/methods/mdt/mdt1001/1001.html
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons			
Acetone	-123.5	Yes	http://www.osha.gov/dts/sltc/methods/organic/org069/org069.html
2-Butanone	-86.4	Yes	http://www.osha.gov/dts/sltc/methods/organic/org084/org084.html
Butanal	-99	Yes	http://www.cdc.gov/niosh/ipcsneng/neng0403.html
Hexanone (2-)	-57	Yes	https://www.osha.gov/dts/sltc/methods/partial/pv2031/2031.html
Methyl-2-pentanone (4-)	-84	Yes	http://webbook.nist.gov/cgi/cbook.cgi?ID=C108101&Units=SI&Mask=4#Thermo-Phase
Aromatic, Ring-Structured Halogenated Hydrocarbons			
Chlorobenzene	-45	Yes	http://www.cdc.gov/niosh/ipcsneng/neng0642.html
Dimethylbenzene (1,2-)	-25	Yes	http://www.osha.gov/dts/sltc/methods/mdt/mdt1002/1002.html
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons			
Benzene	5.5	Yes	http://www.osha.gov/dts/sltc/methods/validated/1005/1005.html
Cumene	-96	Yes	http://www.osha.gov/dts/sltc/methods/partial/pv2137/pv2137.html
Ethylbenzene	-95	Yes	https://www.osha.gov/dts/sltc/methods/mdt/mdt1002/1002.html
Toluene	-95	Yes	http://www.osha.gov/dts/sltc/methods/organic/org111/org111.html
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)			
Acenaphthene	92.5	No	http://www.osha.gov/dts/chemicalsampling/data/CH_216285.html
Acetophenone	20	Yes	http://www.osha.gov/dts/chemicalsampling/data/CH_216750.html
Benzoic Acid	122	No	http://www.inchem.org/documents/icsc/icsc/eics0103.htm
Carbazole	244.5	No	http://www.wolframalpha.com/entities/chemicals/carbazole/zi/mo/8i/
Chloro-3-methylphenol (4-)	66	No	http://www.inchem.org/documents/icsc/icsc/eics0131.htm

Table C.1. Summary of Chemical Melting Points (Continued)

Light Semivolatile Organic Compounds (molecular weight < 200 g/mole) (Continued)			
o-Cresol	31	No	http://www.inchem.org/documents/sids/sids/95487.pdf
p-Cresol	35	No	http://www.cdc.gov/niosh/ipcsneng/neng0031.html
Dibenzofuran(s)	81	No	http://www.wolframalpha.com/input/?i=dibenzofuran
Methyl Naphthalene (2-)	35	No	http://www.osha.gov/dts/chemicalsampling/data/CH_254442.html
Methylphenol (3-)	12	Yes	http://www.cdc.gov/niosh/ipcsneng/neng0646.html
Phenol	43	No	http://www.osha.gov/SLTC/healthguidelines/phenol/recognition.html
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group			
Anthracene	218	No	http://www.osha.gov/dts/chemicalsampling/data/CH_219000.html
Benzo(a)Anthracene	162	No	http://www.inchem.org/documents/icsc/icsc/eics0385.htm
Butyl benzyl phthalate	-35	Yes	http://www.inchem.org/documents/icsc/icsc/eics0834.htm
Chrysene	254	No	http://www.osha.gov/dts/chemicalsampling/data/CH_228725.html
Diethyl phthalate	-41	Yes	https://www.osha.gov/dts/sltc/methods/organic/org104/org104.html
Di-n-butyl phthalate	-35	Yes	http://www.osha.gov/dts/chemicalsampling/data/CH_232600.html
Di-n-octyl phthalate	-30	Yes	https://www.osha.gov/dts/sltc/methods/organic/org104/org104.html
Fluoranthene	107.5	No	http://www.wolframalpha.com/input/?i=fluoranthene
Fluorene	112.5	No	http://www.wolframalpha.com/input/?i=fluorene
Naphthalene	80.2	No	http://www.osha.gov/dts/sltc/methods/organic/org035/org035.html
Pentachlorophenol	184	No	http://www.osha.gov/dts/sltc/methods/organic/org039/org039.html
Phenanthrene	100	No	http://www.osha.gov/dts/chemicalsampling/data/CH_261000.html
Pyrene	158	No	http://www.osha.gov/dts/chemicalsampling/data/CH_265100.html
Tetrachlorophenol (2,3,4,6-)	70	No	http://www.osha.gov/dts/sltc/methods/organic/org045/org045.html
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group			
BEHP	-50	Yes	http://www.inchem.org/documents/icsc/icsc/eics0271.htm
Benzo(a)pyrene	176.5	No	http://www.osha.gov/dts/chemicalsampling/data/CH_220327.html
Benzo(b)Fluoranthene	168	No	http://www.osha.gov/SLTC/healthguidelines/benzo-b-fluoranthene/recognition.html
Benzo(k)Fluoranthene	252.3	No	https://www.osha.gov/dts/chemicalsampling/data/CH_220235.html
Benzo(g,h,i)perylene	276.3	No	https://www.osha.gov/dts/chemicalsampling/data/CH_220320.html
Dibenzo(a,h)Anthracene	267	No	http://www.inchem.org/documents/icsc/icsc/eics0431.htm

Table C.1. Summary of Chemical Melting Points (Continued)

Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group (Continued)			
Indeno(1,2,3-cd)pyrene	164	No	http://www.inchem.org/documents/icsc/icsc/eics0730.htm
PCBs			
Aroclor-1016	(a)	Yes	
Aroclor-1221		Yes	
Aroclor-1232		Yes	
Aroclor-1242		Yes	
Aroclor-1248		Yes	
Aroclor-1254		Yes	
Aroclor-1260		Yes	
Total PCBs		Yes	
Pesticides			
beta-BHC	113	No	http://www.cdc.gov/niosh/ipcsneng/neng0053.html
DDD (4,4-)	109-110	No	http://www.atsdr.cdc.gov/ToxProfiles/tp35-c4.pdf
DDE (4,4-)	89	No	http://www.atsdr.cdc.gov/ToxProfiles/tp35-c4.pdf
DDT (4,4-)	109	No	http://www.atsdr.cdc.gov/ToxProfiles/tp35-c4.pdf
Dieldrin	176.5	No	http://www.osha.gov/dts/chemicalsampling/data/CH_234600.html
Endosulfan II	70-100	No	http://www.osha.gov/dts/sltc/methods/partial/pv2023/2023.html
Endosulfan sulfate	181	No	http://www.wolframalpha.com/input/?i=endosulfan+sulfate
Endrin	381	No	https://www.osha.gov/dts/chemicalsampling/data/CH_238600.html
Endrin Aldehyde	163	No	http://www.wolframalpha.com/input/?i=endrin+aldehyde
gamma-chlordane	95-96	No	http://www.osha.gov/SLTC/healthguidelines/chlordane/recognition.html
Heptachlor epoxide	161	No	http://www.wolframalpha.com/input/?i=heptachlor+epoxide
Metals			
Sb	NA		
As			
Ba			
Be			
Cd			
Cr			
Cu			
Pb			
Mn			
Hg			
Ni			
Se			
Ag			
Tl			
V			

Table C.1. Summary of Chemical Melting Points (Continued)

Metals (Continued)

Zn U	NA

Radionuclides

Pu-238 U-238 U-234 Pu-239 U-235 Pu-240 Np-237 Cs-137 Tc-99 Am-241 Th-230	NA

[a] Melting point temperatures are not available for Aroclors, as these are mixtures of individual PCB congeners. These mixtures are known to form waxy, resinous materials that cannot be easily poured at low temperatures. At 25ºC Aroclors are assumed to be liquids with variable viscosities.

NA = not applicable

Table C.2. Comparison of the Site 11 PWAC for the Gradual Failure Scenario

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Nonaromatic, Straight-Chain Halogenated Hydrocarbons						
Chloroform	1.40E+03	8.65E+06	1.40E+03	8.65E+06	1.40E+03	8.65E+06
cis-1,2-DCE	5.73E+02	3.53E+06	5.73E+02	3.53E+06	5.73E+02	3.53E+06
Methylene chloride	1.86E+03	1.15E+07	1.86E+03	1.15E+07	1.86E+03	1.15E+07
Vinyl Chloride	4.14E+02	2.55E+06	4.14E+02	2.55E+06	4.14E+02	2.55E+06
TCE	2.32E+02	1.43E+06	2.32E+02	1.43E+06	2.32E+02	1.43E+06
PCE	6.95E+01	4.28E+05	6.95E+01	4.28E+05	6.95E+01	4.28E+05
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons						
Acetone	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
2-Butanone	1.04E+04	6.42E+07	1.04E+04	6.42E+07	1.04E+04	6.42E+07
Butanal	4.82E+03	2.97E+07	4.82E+03	2.97E+07	4.82E+03	2.97E+07
Hexanone (2-)	2.53E+03	1.56E+07	2.53E+03	1.56E+07	2.53E+03	1.56E+07
Methyl-2-pentanone (4-)	2.76E+03	1.70E+07	2.76E+03	1.70E+07	2.76E+03	1.70E+07
Aromatic, Ring-Structured Halogenated Hydrocarbons						
Chlorobenzene	1.48E+02	9.15E+05	1.48E+02	9.15E+05	1.48E+02	9.15E+05
Dimethylbenzene (1,2-)	7.87E+01	4.85E+05	7.87E+01	4.85E+05	7.87E+01	4.85E+05
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons						
Benzene	3.23E+02	1.99E+06	3.23E+02	1.99E+06	3.23E+02	1.99E+06
Cumene	4.25E+01	2.62E+05	4.25E+01	2.62E+05	4.25E+01	2.62E+05
Ethylbenzene	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.05E+01	3.11E+05
Toluene	1.30E+02	8.02E+05	1.30E+02	8.02E+05	1.30E+02	8.02E+05
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)						
Acenaphthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Acetophenone	1.08E+03	6.68E+06	1.08E+03	6.68E+06	1.08E+03	6.68E+06
Benzoic Acid	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Carbazole	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Chloro-3-methylphenol (4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
o-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
p-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzofuran(s)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methyl Naphthalene (2-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methylphenol (3&4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group						
Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(a)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Butyl benzyl phthalate	2.99E+01	1.84E+05	2.99E+01	1.84E+05	2.99E+01	1.84E+05
Chrysene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Diethyl phthalate	2.17E+02	1.34E+06	2.17E+02	1.34E+06	2.17E+02	1.34E+06
Di-n-butyl phthalate	1.56E+01	9.61E+04	1.56E+01	9.61E+04	1.56E+01	9.61E+04

Table C.2. Comparison of the Site 11 PWAC for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Di-n-octyl phthalate	1.33E+03	8.21E+06	1.33E+03	8.21E+06	1.33E+03	8.21E+06
Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Fluorene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Naphthalene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pentachlorophenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenanthrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tetrachlorophenol (2,3,4,6-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group						
BEHP	3.03E+01	1.87E+05	3.03E+01	1.87E+05	3.03E+01	1.87E+05
Benzo(a)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(b)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(k)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(g,h,i)perylene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzo(a,h)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Indeno(1,2,3-cd)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
PCBs						
Arochlor-1016	1.61E+01	9.92E+04	1.61E+01	9.92E+04	1.61E+01	9.92E+04
Arochlor-1221	1.03E+02	6.34E+05	1.03E+02	6.34E+05	1.03E+02	6.34E+05
Arochlor-1232	9.77E+01	6.02E+05	9.77E+01	6.02E+05	9.77E+01	6.02E+05
Arochlor-1242	1.74E+01	1.07E+05	1.74E+01	1.07E+05	1.74E+01	1.07E+05
Arochlor-1248	6.13E+00	3.78E+04	6.13E+00	3.78E+04	6.13E+00	3.78E+04
Arochlor-1254	4.50E+00	2.77E+04	4.50E+00	2.77E+04	4.50E+00	2.77E+04
Arochlor-1260	4.04E+00	2.49E+04	4.04E+00	2.49E+04	4.04E+00	2.49E+04
Total PCBs	1.73E+02	1.07E+06	1.73E+02	1.07E+06	1.73E+02	1.07E+06
Pesticides						
beta-BHC	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDD (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDE (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDT (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dieldrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan II	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan sulfate	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin Aldehyde	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
gamma-chlordane	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heptachlor epoxide	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Metals						
Sb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
As	2.27E+02	1.40E+06	9.83E+01	6.06E+05	1.13E+00	6.97E+03
Ba	1.00E+05	6.16E+08	3.07E+04	1.89E+08	3.07E+04	1.89E+08

Table C.2. Comparison of the Site 11 PWAC for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Be	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cd	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cr	5.44E+03	3.36E+07	5.44E+03	3.36E+07	5.44E+03	3.36E+07
Cu	2.68E+02	1.65E+06	3.19E+02	1.97E+06	3.19E+02	1.97E+06
Pb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Mn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Hg	1.90E+03	1.17E+07	3.16E+02	1.95E+06	3.16E+02	1.95E+06
Ni	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Se	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Ag	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tl	1.00E+05	6.16E+08	2.45E+03	1.51E+07	2.45E+03	1.51E+07
V	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Zn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
U[b]	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Radionuclides						
Pu-238	1.71E+12	1.05E+13	1.71E+12	1.05E+13	1.71E+12	1.05E+13
U-238	3.36E+04	2.07E+05	3.36E+04	2.07E+05	3.36E+04	2.07E+05
U-234	6.25E+08	3.85E+09	6.25E+08	3.85E+09	6.25E+08	3.85E+09
Pu-239	6.20E+09	3.82E+10	6.20E+09	3.82E+10	6.20E+09	3.82E+10
U-235	2.16E+05	1.33E+06	2.16E+05	1.33E+06	2.16E+05	1.33E+06
Pu-240	2.27E+10	1.40E+11	2.27E+10	1.40E+11	2.27E+10	1.40E+11
Np-237	2.58E+02	1.59E+03	2.58E+02	1.59E+03	3.41E+01	2.10E+02
Cs-137	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.65E+12	5.33E+13
Tc-99	2.67E+01	1.65E+02	3.70E+01	2.28E+02	3.70E+01	2.28E+02
Am-241	3.43E+11	2.12E+12	3.13E+06	1.93E+07	2.92E+05	1.80E+06
Th-230	2.02E+09	1.24E+10	2.02E+09	1.24E+10	2.02E+09	1.24E+10

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.

[b] Applying natural abundance mass ratios to elemental uranium PWAC would result in the following uranium isotope PWAC: 3.34E+04 of U-238, 1.56E+03 pCi/g of U-235, and 3.44E+04 pCi/g of U-234.

PWAC - Preliminary Waste Acceptance Criteria

EOW - Edge of Waste

WDF - Waste Disposal Facility boundary

DOE/SW - DOE property (Site 11)/surface water outcrop (Site 3A)

Table C.3. Site 3A PWAC for the Gradual Failure Scenario

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Nonaromatic, Straight-Chain Halogenated Hydrocarbons						
Chloroform	1.40E+03	8.64E+06	1.40E+03	8.64E+06	1.40E+03	8.64E+06
cis-1,2-DCE	5.73E+02	3.53E+06	5.73E+02	3.53E+06	5.73E+02	3.53E+06
Methylene chloride	1.86E+03	1.15E+07	1.86E+03	1.15E+07	1.86E+03	1.15E+07
Vinyl Chloride	4.14E+02	2.55E+06	4.14E+02	2.55E+06	4.14E+02	2.55E+06
TCE	2.32E+02	1.43E+06	2.32E+02	1.43E+06	2.32E+02	1.43E+06
PCE	6.95E+01	4.28E+05	6.95E+01	4.28E+05	6.95E+01	4.28E+05
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons						
Acetone	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
2-Butanone	1.04E+04	6.41E+07	1.04E+04	6.41E+07	1.04E+04	6.41E+07
Butanal	4.82E+03	2.97E+07	4.82E+03	2.97E+07	4.82E+03	2.97E+07
Hexanone (2-)	2.53E+03	1.56E+07	2.53E+03	1.56E+07	2.53E+03	1.56E+07
Methyl-2-pentanone (4-)	2.76E+03	1.70E+07	2.76E+03	1.70E+07	2.76E+03	1.70E+07
Aromatic, Ring-Structured Halogenated Hydrocarbons						
Chlorobenzene	1.48E+02	9.14E+05	1.48E+02	9.14E+05	1.48E+02	9.14E+05
Dimethylbenzene (1,2-)	7.87E+01	4.84E+05	7.87E+01	4.84E+05	7.87E+01	4.84E+05
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons						
Benzene	3.23E+02	1.99E+06	3.23E+02	1.99E+06	3.23E+02	1.99E+06
Cumene	4.25E+01	2.62E+05	4.25E+01	2.62E+05	4.25E+01	2.62E+05
Ethylbenzene	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.05E+01	3.11E+05
Toluene	1.30E+02	8.01E+05	1.30E+02	8.01E+05	1.30E+02	8.01E+05
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)						
Acenaphthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Acetophenone	1.08E+03	6.67E+06	1.08E+03	6.67E+06	1.08E+03	6.67E+06
Benzoic Acid	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Carbazole	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Chloro-3-methylphenol (4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
o-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
p-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzofuran(s)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methyl Naphthalene (2-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methylphenol (3&4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group						
Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(a)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Butyl benzyl phthalate	2.99E+01	1.84E+05	2.99E+01	1.84E+05	2.99E+01	1.84E+05
Chrysene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Diethyl phthalate	2.17E+02	1.34E+06	2.17E+02	1.34E+06	2.17E+02	1.34E+06
Di-n-butyl phthalate	1.56E+01	9.61E+04	1.56E+01	9.61E+04	1.56E+01	9.61E+04
Di-n-octyl phthalate	1.33E+03	8.21E+06	1.33E+03	8.21E+06	1.33E+03	8.21E+06
Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08

Table C.3. Site 3A PWAC for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Fluorene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Naphthalene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pentachlorophenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenanthrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tetrachlorophenol (2,3,4,6-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group						
BEHP	3.03E+01	1.86E+05	3.03E+01	1.86E+05	3.03E+01	1.86E+05
Benzo(a)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(b)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(k)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(g,h,i)perylene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzo(a,h)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Indeno(1,2,3-cd)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
PCBs						
Arochlor-1016	1.61E+01	9.92E+04	1.61E+01	9.92E+04	1.61E+01	9.92E+04
Arochlor-1221	1.03E+02	6.34E+05	1.03E+02	6.34E+05	1.03E+02	6.34E+05
Arochlor-1232	9.77E+01	6.02E+05	9.77E+01	6.02E+05	9.77E+01	6.02E+05
Arochlor-1242	1.74E+01	1.07E+05	1.74E+01	1.07E+05	1.74E+01	1.07E+05
Arochlor-1248	6.13E+00	3.77E+04	6.13E+00	3.77E+04	6.13E+00	3.77E+04
Arochlor-1254	4.50E+00	2.77E+04	4.50E+00	2.77E+04	4.50E+00	2.77E+04
Arochlor-1260	4.04E+00	2.49E+04	4.04E+00	2.49E+04	4.04E+00	2.49E+04
Total PCBs	1.73E+02	1.07E+06	1.73E+02	1.07E+06	1.73E+02	1.07E+06
Pesticides						
beta-BHC	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDD (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDE (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDT (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dieldrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan II	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan sulfate	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin Aldehyde	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
gamma-Chlordane	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heptachlor epoxide	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Metals						
Sb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
As	6.09E+00	3.75E+04	2.84E+00	1.75E+04	5.09E-01	3.13E+03
Ba	5.11E+03	3.15E+07	7.92E+02	4.88E+06	5.11E+03	3.15E+07
Be	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cd	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cr	1.27E+02	7.85E+05	1.27E+02	7.85E+05	1.27E+02	7.85E+05
Cu	2.10E+01	1.29E+05	2.24E+01	1.38E+05	2.24E+01	1.38E+05

Table C.3. Site 3A PWAC for the Gradual Failure Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Pb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Mn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Hg	1.81E+01	1.11E+05	7.46E+00	4.59E+04	1.81E+01	1.11E+05
Ni	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Se	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Ag	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tl	3.79E+03	2.34E+07	4.45E+01	2.74E+05	3.79E+03	2.34E+07
V	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Zn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
U[b]	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Radionuclides						
Pu-238	1.71E+12	1.05E+13	1.71E+12	1.05E+13	1.71E+12	1.05E+13
U-238	3.36E+04	2.07E+05	3.36E+04	2.07E+05	3.36E+04	2.07E+05
U-234	6.25E+08	3.85E+09	6.25E+08	3.85E+09	6.25E+08	3.85E+09
Pu-239	6.20E+09	3.82E+10	6.20E+09	3.82E+10	6.20E+09	3.82E+10
U-235	2.16E+05	1.33E+06	2.16E+05	1.33E+06	2.16E+05	1.33E+06
Pu-240	2.27E+10	1.40E+11	2.27E+10	1.40E+11	2.27E+10	1.40E+11
Np-237	8.91E-01	5.49E+00	8.91E-01	5.49E+00	1.54E-01	9.49E-01
Cs-137	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.65E+12	5.33E+13
Tc-99	2.08E+00	1.28E+01	2.27E+00	1.40E+01	2.28E+00	1.40E+01
Am-241	3.43E+11	2.11E+12	4.86E+03	3.00E+04	1.27E+03	7.82E+03
Th-230	2.02E+09	1.24E+10	2.02E+09	1.24E+10	2.02E+09	1.24E+10

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.

[b] Applying natural abundance mass ratios to elemental uranium PWAC would result in the following uranium isotope PWAC: 3.34E+04 of U-238, 1.56E+03 pCi/g of U-235, and 3.44E+04 pCi/g of U-234.

PWAC - Preliminary Waste Acceptance Criteria

EOW - Edge of Waste

WDF - Waste Disposal Facility boundary

DOE/SW - DOE property (Site 11)/surface water outcrop (Site 3A)

Table C.4. Comparison of the Site 11 PWAC-WDF for the Gradual Failure, Instantaneous Failure, and No Failure Scenarios

Chemical Groups[a]	Gradual Failure (T+400)		Instantaneous Failure		No Failure	
	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)
Nonaromatic, Straight-Chain Halogenated Hydrocarbons						
Chloroform	1.40E+03	8.65E+06	1.40E+03	8.65E+06	1.40E+03	8.65E+06
cis-1,2-DCE	5.73E+02	3.53E+06	5.73E+02	3.53E+06	5.73E+02	3.53E+06
Methylene chloride	1.86E+03	1.15E+07	1.86E+03	1.15E+07	1.86E+03	1.15E+07
Vinyl Chloride	4.14E+02	2.55E+06	4.14E+02	2.55E+06	4.14E+02	2.55E+06
TCE	2.32E+02	1.43E+06	2.32E+02	1.43E+06	2.32E+02	1.43E+06
PCE	6.95E+01	4.28E+05	6.95E+01	4.28E+05	6.95E+01	4.28E+05
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons						
Acetone	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
2-Butanone	1.04E+04	6.42E+07	1.04E+04	6.42E+07	1.04E+04	6.42E+07
Butanal	4.82E+03	2.97E+07	4.82E+03	2.97E+07	4.82E+03	2.97E+07
Hexanone (2-)	2.53E+03	1.56E+07	2.53E+03	1.56E+07	2.53E+03	1.56E+07
Methyl-2-pentanone (4-)	2.76E+03	1.70E+07	2.76E+03	1.70E+07	2.76E+03	1.70E+07
Aromatic, Ring-Structured Halogenated Hydrocarbons						
Chlorobenzene	1.48E+02	9.15E+05	1.48E+02	9.15E+05	1.48E+02	9.15E+05
Dimethylbenzene (1,2-)	7.87E+01	4.85E+05	7.87E+01	4.85E+05	7.87E+01	4.85E+05
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons						
Benzene	3.23E+02	1.99E+06	3.23E+02	1.99E+06	3.23E+02	1.99E+06
Cumene	4.25E+01	2.62E+05	4.25E+01	2.62E+05	4.25E+01	2.62E+05
Ethylbenzene	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.05E+01	3.11E+05
Toluene	1.30E+02	8.02E+05	1.30E+02	8.02E+05	1.30E+02	8.02E+05
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)						
Acenaphthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Acetophenone	1.08E+03	6.68E+06	1.08E+03	6.68E+06	1.08E+03	6.68E+06
Benzoic Acid	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Carbazole	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Chloro-3-methylphenol (4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
o-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
p-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzofuran(s)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methyl Naphthalene (2-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methylphenol (3&4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group						
Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(a)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Butyl benzyl phthalate	2.99E+01	1.84E+05	2.99E+01	1.84E+05	2.99E+01	1.84E+05
Chrysene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Diethyl phthalate	2.17E+02	1.34E+06	2.17E+02	1.34E+06	2.17E+02	1.34E+06
Di-n-butyl phthalate	1.56E+01	9.61E+04	1.56E+01	9.61E+04	1.56E+01	9.61E+04

Table C.4. Comparison of the Site 11 PWAC-WDF for the Gradual Failure, Instantaneous Failure, and No Failure Scenarios (Continued)

Chemical Groups[a]	Gradual Failure (T+400)		Instantaneous Failure		No Failure	
	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)
Di-n-octyl phthalate	1.33E+03	8.21E+06	1.33E+03	8.21E+06	1.33E+03	8.21E+06
Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Fluorene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Naphthalene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pentachlorophenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenanthrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tetrachlorophenol (2,3,4,6-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group						
BEHP	3.03E+01	1.87E+05	3.03E+01	1.87E+05	3.03E+01	1.87E+05
Benzo(a)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(b)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(k)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(g,h,i)perylene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzo(a,h)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Indeno(1,2,3-cd)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
PCBs						
Arochlor-1016	1.61E+01	9.92E+04	1.61E+01	9.92E+04	1.61E+01	9.92E+04
Arochlor-1221	1.03E+02	6.34E+05	1.03E+02	6.34E+05	1.03E+02	6.34E+05
Arochlor-1232	9.77E+01	6.02E+05	9.77E+01	6.02E+05	9.77E+01	6.02E+05
Arochlor-1242	1.74E+01	1.07E+05	1.74E+01	1.07E+05	1.74E+01	1.07E+05
Arochlor-1248	6.13E+00	3.78E+04	6.13E+00	3.78E+04	6.13E+00	3.78E+04
Arochlor-1254	4.50E+00	2.77E+04	4.50E+00	2.77E+04	4.50E+00	2.77E+04
Arochlor-1260	4.04E+00	2.49E+04	4.04E+00	2.49E+04	4.04E+00	2.49E+04
Total PCBs	1.73E+02	1.07E+06	1.73E+02	1.07E+06	1.73E+02	1.07E+06
Pesticides						
beta-BHC	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDD (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDE (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDT (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dieldrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan II	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan sulfate	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin Aldehyde	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
gamma-Chlordane	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heptachlor epoxide	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Metals						
Sb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
As	9.83E+01	6.06E+05	2.80E+00	1.72E+04	1.00E+05	6.16E+08

Table C.4. Comparison of the Site 11 PWAC-WDF for the Gradual Failure, Instantaneous Failure, and No Failure Scenarios (Continued)

Chemical Groups[a]	Gradual Failure (T+400)		Instantaneous Failure		No Failure	
	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)
Ba	3.07E+04	1.89E+08	1.01E+04	6.23E+07	1.00E+05	6.16E+08
Be	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cd	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cr	5.44E+03	3.36E+07	2.48E+03	1.53E+07	1.00E+05	6.16E+08
Cu	3.19E+02	1.97E+06	8.87E+01	5.47E+05	1.00E+05	6.16E+08
Pb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Mn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Hg	3.16E+02	1.95E+06	7.25E+01	4.47E+05	2.35E+04	1.45E+08
Ni	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Se	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Ag	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tl	2.45E+03	1.51E+07	2.97E+02	1.83E+06	1.00E+05	6.16E+08
V	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Zn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
U[b]	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Radionuclides						
Pu-238	1.71E+12	1.05E+13	1.71E+12	1.05E+13	1.71E+12	1.05E+13
U-238	3.36E+04	2.07E+05	3.36E+04	2.07E+05	3.36E+04	2.07E+05
U-234	6.25E+08	3.85E+09	6.25E+08	3.85E+09	6.25E+08	3.85E+09
Pu-239	6.20E+09	3.82E+10	6.20E+09	3.82E+10	6.20E+09	3.82E+10
U-235	2.16E+05	1.33E+06	2.16E+05	1.33E+06	2.16E+05	1.33E+06
Pu-240	2.27E+10	1.40E+11	2.27E+10	1.40E+11	2.27E+10	1.40E+11
Np-237	2.58E+02	1.59E+03	6.57E+01	4.05E+02	7.05E+07	4.34E+08
Cs-137	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.65E+12	5.33E+13
Tc-99	3.70E+01	2.28E+02	2.65E+01	1.63E+02	3.90E+08	2.40E+09
Am-241	3.13E+06	1.93E+07	3.63E+05	2.24E+06	3.43E+11	2.12E+12
Th-230	2.02E+09	1.24E+10	2.02E+09	1.24E+10	2.02E+09	1.24E+10

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.

[b] Applying natural abundance mass ratios to elemental uranium PWAC would result in the following uranium isotope PWAC: 3.34E+04 of U-238, 1.56E+03 pCi/g of U-235, and 3.44E+04 pCi/g of U-234.

PWAC - Preliminary Waste Acceptance Criteria

WDF - Waste Disposal Facility boundary

Table C.5. Comparison of the Site 3A PWAC-WDF for the Gradual Failure, Instantaneous Failure, and No Failure Scenarios

Chemical Groups[a]	Gradual Failure (T+400)		Instantaneous Failure		No Failure	
	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)
Nonaromatic, Straight-Chain Halogenated Hydrocarbons						
Chloroform	1.40E+03	8.64E+06	1.40E+03	8.64E+06	1.40E+03	8.64E+06
cis-1,2-DCE	5.73E+02	3.53E+06	5.73E+02	3.53E+06	5.73E+02	3.53E+06
Methylene chloride	1.86E+03	1.15E+07	1.86E+03	1.15E+07	1.86E+03	1.15E+07
Vinyl Chloride	4.14E+02	2.55E+06	4.14E+02	2.55E+06	4.14E+02	2.55E+06
TCE	2.32E+02	1.43E+06	2.32E+02	1.43E+06	2.32E+02	1.43E+06
PCE	6.95E+01	4.28E+05	6.95E+01	4.28E+05	6.95E+01	4.28E+05
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons						
Acetone	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
2-Butanone	1.04E+04	6.41E+07	1.04E+04	6.41E+07	1.04E+04	6.41E+07
Butanal	4.82E+03	2.97E+07	4.82E+03	2.97E+07	4.82E+03	2.97E+07
Hexanone (2-)	2.53E+03	1.56E+07	2.53E+03	1.56E+07	2.53E+03	1.56E+07
Methyl-2-pentanone (4-)	2.76E+03	1.70E+07	2.76E+03	1.70E+07	2.76E+03	1.70E+07
Aromatic, Ring-Structured Halogenated Hydrocarbons						
Chlorobenzene	1.48E+02	9.14E+05	1.48E+02	9.14E+05	1.48E+02	9.14E+05
Dimethylbenzene (1,2-)	7.87E+01	4.84E+05	7.87E+01	4.84E+05	7.87E+01	4.84E+05
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons						
Benzene	3.23E+02	1.99E+06	3.23E+02	1.99E+06	3.23E+02	1.99E+06
Cumene	4.25E+01	2.62E+05	4.25E+01	2.62E+05	4.25E+01	2.62E+05
Ethylbenzene	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.05E+01	3.11E+05
Toluene	1.30E+02	8.01E+05	1.30E+02	8.01E+05	1.30E+02	8.01E+05
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)						
Acenaphthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Acetophenone	1.08E+03	6.67E+06	1.08E+03	6.67E+06	1.08E+03	6.67E+06
Benzoic Acid	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Carbazole	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Chloro-3-methylphenol (4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
o-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
p-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzofuran(s)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methyl Naphthalene (2-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methylphenol (3&4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group						
Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(a)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Butyl benzyl phthalate	2.99E+01	1.84E+05	2.99E+01	1.84E+05	2.99E+01	1.84E+05
Chrysene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Diethyl phthalate	2.17E+02	1.34E+06	2.17E+02	1.34E+06	2.17E+02	1.34E+06

Table C.5. Comparison of the Site 3A PWAC-WDF for the Gradual Failure, Instantaneous Failure, and No Failure Scenarios (Continued)

Chemical Groups[a]	Gradual Failure (T+400)		Instantaneous Failure		No Failure	
	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)
Di-n-butyl phthalate	1.56E+01	9.61E+04	1.56E+01	9.61E+04	1.00E+05	6.16E+08
Di-n-octyl phthalate	1.33E+03	8.21E+06	1.33E+03	8.21E+06	1.00E+05	6.16E+08
Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Fluorene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Naphthalene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pentachlorophenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenanthrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tetrachlorophenol (2,3,4,6-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group						
BEHP	3.03E+01	1.86E+05	3.03E+01	1.86E+05	3.03E+01	1.86E+05
Benzo(a)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(b)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(k)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(g,h,i)perylene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzo(a,h)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Indeno(1,2,3-cd)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
PCBs						
Arochlor-1016	1.61E+01	9.92E+04	1.61E+01	9.92E+04	1.61E+01	9.92E+04
Arochlor-1221	1.03E+02	6.34E+05	1.03E+02	6.34E+05	1.03E+02	6.34E+05
Arochlor-1232	9.77E+01	6.02E+05	9.77E+01	6.02E+05	9.77E+01	6.02E+05
Arochlor-1242	1.74E+01	1.07E+05	1.74E+01	1.07E+05	1.74E+01	1.07E+05
Arochlor-1248	6.13E+00	3.77E+04	6.13E+00	3.77E+04	6.13E+00	3.77E+04
Arochlor-1254	4.50E+00	2.77E+04	4.50E+00	2.77E+04	4.50E+00	2.77E+04
Arochlor-1260	4.04E+00	2.49E+04	4.04E+00	2.49E+04	4.04E+00	2.49E+04
Total PCBs	1.73E+02	1.07E+06	1.73E+02	1.07E+06	1.73E+02	1.07E+06
Pesticides						
beta-BHC	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDD (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDE (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDT (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dieldrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan II	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan sulfate	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin Aldehyde	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
gamma-Chlordane	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heptachlor epoxide	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Metals						
Sb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
As	2.84E+00	1.75E+04	7.15E-01	4.40E+03	1.00E+05	6.16E+08

C.5. CRITERIA USED TO SET PWAC

PWAC values take into account the following criteria:

- MCL
- Background concentration
- Excess lifetime cancer risk (ELCR)
- Hazard index (HI)

The Risk Methods Document PGDP Human Health Risk Methods Document was the basis of these calculations (DOE 2011b). These criteria were applied as shown below, with the 0-1,600 year time period used to calculate the PWAC.

- EOW (both time periods)

  (1) The target concentrations were the chemical-specific primary MCLs, if this value was greater than the constituent's background concentration. If the background concentration for the constituent was greater than the MCL, then the background concentration was selected.

  (2) If chemical-specific primary MCLs were not available, then chemical-specific risk and hazard-based targets based on residential use of groundwater were used to derive the constituent's target concentration in groundwater. The chemical-specific risk-based target was 1×10^{-6} and the chemical-specific hazard-based target was 1. If both a risk-based concentration and hazard-based concentration were derived for a constituent, then the lower of the two concentrations was selected. If the selected value was less than the background concentration, then the background concentration was used.

- At the boundary of the WDF[3]

  (1) Years 30 to 1,600

  (a) The risk-based target was a cumulative ELCR of 1×10^{-4}.
  (b) The hazard-based target was a cumulative HI of 1.
  (c) The dose-based target was a cumulative exposure (groundwater pathway) of 25 mrem/yr.

  (2) Beyond Year 1,600

  (a) The risk-based target was a cumulative ELCR of 1×10^{-4}.
  (b) The hazard-based target will be a cumulative HI of 3.
  (c) The dose-based target was a cumulative exposure (groundwater pathway) of 25 mrem/yr.

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[3] When groundwater modeling predicts that a single contaminant will be present in groundwater at a point of exposure at the waste facility boundary or DOE property boundary, the MCL for the chemical will be used as a protective value consistent with EPA guidance (EPA 1991). In making this determination, a "single contaminant" will be considered to be predicted to be present when concentrations of all other contaminants within the same time interval are predicted to be below their residential NAL (derived using a target HI of 0.1 and/or a target ELCR of 1E-06) or background concentration in groundwater.

Table C.5. Comparison of the Site 3A PWAC-WDF for the Gradual Failure, Instantaneous Failure, and No Failure Scenarios (Continued)

Chemical Groups[a]	Gradual Failure (T+400)		Instantaneous Failure		No Failure	
	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)	Average Concentration (mg/kg or pCi/g)	Allowable Inventory Limit (kg or Ci)
Ba	7.92E+02	4.88E+06	2.77E+02	1.70E+06	1.00E+05	6.16E+08
Be	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cd	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cr	1.27E+02	7.85E+05	7.62E+01	4.69E+05	1.00E+05	6.16E+08
Cu	2.24E+01	1.38E+05	3.39E+00	2.09E+04	1.00E+05	6.16E+08
Pb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Mn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Hg	7.46E+00	4.59E+04	1.84E+00	1.13E+04	2.35E+04	1.44E+08
Ni	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Se	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Ag	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tl	4.45E+01	2.74E+05	6.52E+00	4.01E+04	1.00E+05	6.16E+08
V	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Zn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
U[b]	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Radionuclides						
Pu-238	1.71E+12	1.05E+13	1.71E+12	1.05E+13	1.71E+12	1.05E+13
U-238	3.36E+04	2.07E+05	3.36E+04	2.07E+05	3.36E+04	2.07E+05
U-234	6.25E+08	3.85E+09	6.25E+08	3.85E+09	6.25E+08	3.85E+09
Pu-239	6.20E+09	3.82E+10	6.20E+09	3.82E+10	6.20E+09	3.82E+10
U-235	2.16E+05	1.33E+06	2.16E+05	1.33E+06	2.16E+05	1.33E+06
Pu-240	2.27E+10	1.40E+11	2.27E+10	1.40E+11	2.27E+10	1.40E+11
Np-237	8.91E-01	5.49E+00	4.29E-01	2.64E+00	7.05E+07	4.34E+08
Cs-137	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.65E+12	5.33E+13
Tc-99	2.27E+00	1.40E+01	2.27E+00	1.40E+01	3.90E+08	2.40E+09
Am-241	4.86E+03	3.00E+04	2.86E+03	1.76E+04	3.43E+11	2.11E+12
Th-230	2.02E+09	1.24E+10	2.02E+09	1.24E+10	2.02E+09	1.24E+10

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.

[b] Applying natural abundance mass ratios to elemental uranium PWAC would result in the following uranium isotope PWAC: 3.34E+04 of U-238, 1.56E+03 pCi/g of U-235, and 3.44E+04 pCi/g of U-234.

PWAC - Preliminary Waste Acceptance Criteria

WDF - Waste Disposal Facility boundary

(3) Consistent with chemical of potential concern (COPC) selection in the Risk Methods Document, the calculation of cumulative ELCR and cumulative HI at the boundary of the WDF excludes any constituents that use the constituent's background concentration as the chemical-specific target at the EOW (DOE 2011b).

- At the DOE property line or near surface water outcrop[4]

(1) Years 30 to 1,600

(a) The risk-based target was a cumulative ELCR of 1×10^{-6}.
(b) The hazard-based target was a cumulative HI of 1.
(c) The dose-based target was a cumulative exposure (groundwater pathway) of 25 mrem/yr.

(2) Beyond Year 1,600

(a) The risk-based target was a cumulative ELCR of 1×10^{-5}.
(b) The hazard-based target was a cumulative HI of 3.
(c) The dose-based target was a cumulative exposure (groundwater pathway) of 25 mrem/yr.

Consistent with COPC selection in the Risk Methods Document (DOE 2011b), the calculation of cumulative ELCR and cumulative HI at the DOE property line excludes any constituents that use the constituent's background concentration as the chemical-specific target at the edge of the waste unit. Additionally, to target the more important risk and hazard contributors, only constituents with a chemical-specific contribution to cumulative ELCR and/or HI at the boundary of the WDF greater than 1×10^{-7} or 0.05, respectively, were included in the calculation of cumulative ELCR and HI at the DOE property line.

The increased cumulative ELCR and/or HI targets of 1E-05 and 3, respectively, were used beyond 1,600 years at the boundary of the WDF and DOE property line to address the uncertainties in exposure (e.g., receptor location relative to groundwater flow) and constituent release and migration. The PWAC was set based on Year 0 through Year 1,600.

The target concentrations at the edge of the waste unit were used to establish the PWAC-EOW. This PWAC-EOW then was used to calculate the contaminant concentrations in water at the boundary of the WDF. If these calculated contaminant concentrations exceed the risk-based and hazard-based targets established for the boundary of the WDF, then the PWAC-EOW is adjusted until these target risks are met to obtain the PWAC-WDF. This iterative approach then is repeated for the DOE boundary for Site 11 and surface water outcrop (Bayou Creek) for Site 3A to obtain the PWAC-DOE/surface water values.

C.5.1 SITE 11 PWAC-WDF, PWAC-DOE/SW AND MODEL RESULTS

Time dependent ELCR, HI, and dose results based upon POA concentrations calculated from initial source concentrations of the minimum PWAC value for the POAs presented in Table C.2 are depicted in Figures C.1 through C.6. The figures have been simplified to solely include radionuclides, metals, or inorganics that are within three orders of magnitude of their risk-based cumulative criteria.

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[4] See note 3.

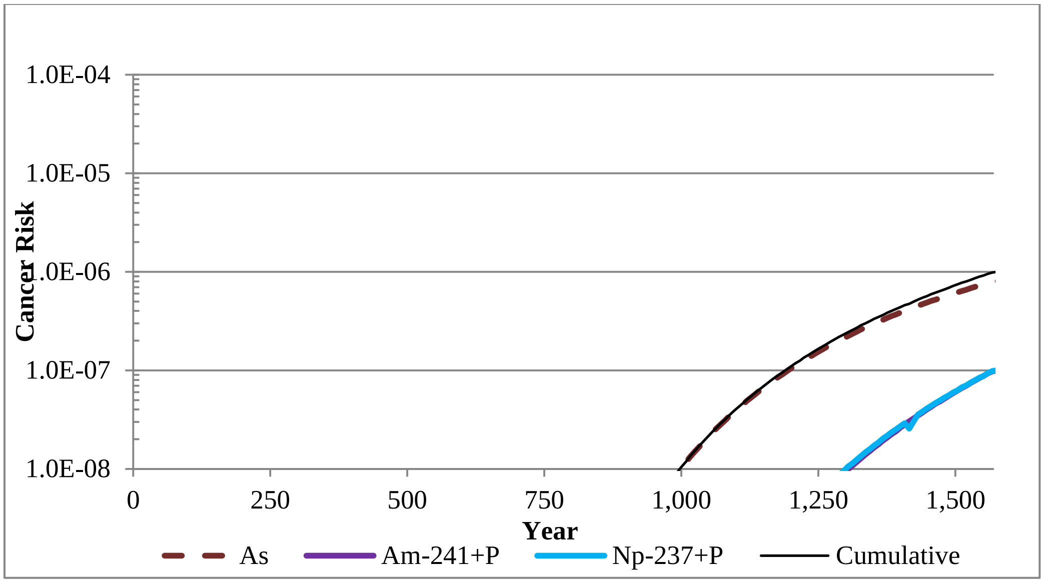

Figure C.1. Logarithmic-Linear Graph of Site 11 WDF Boundary Cumulative ELCR vs. Year
(COPCs not shown are less than three orders of magnitude of the WDF cumulative ELCR criteria, 1.0E-04.
"+P" indicates that the data series is a summation of the specified radionuclide isotope and its progeny.
Tc-99 has been omitted because it was subject to single peaking criteria using the MCL value.)

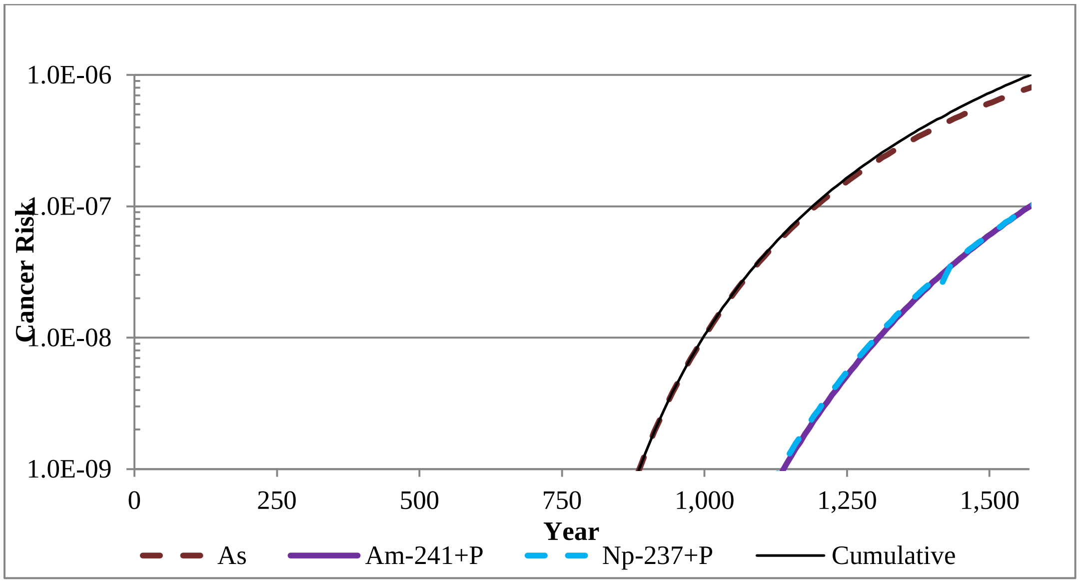

Figure C.2. Logarithmic-Linear Graph of Site 11 DOE Boundary Cumulative ELCR vs. Year
(COPCs not shown are less than three orders of magnitude of the DOE cumulative ELCR criteria, 1.0E-06.
"+P" indicates that the data series is a summation of the specified radionuclide isotope and its progeny.
Tc-99 has been omitted because it was subject to single peaking criteria using the MCL value.)

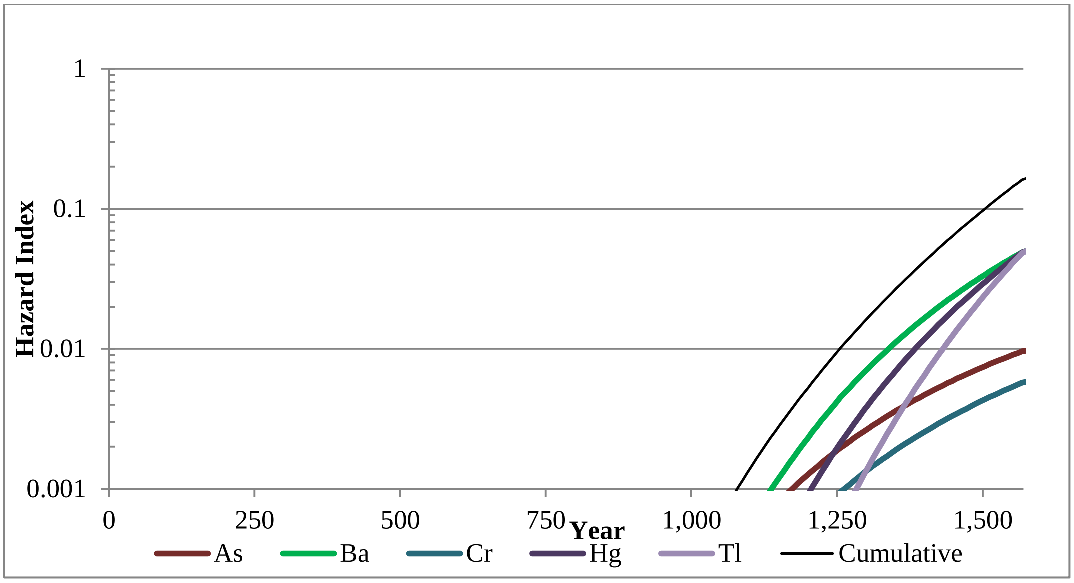

Figure C.3. Logarithmic-Linear Graph of Site 11 WDF Boundary Cumulative HI vs. Year
(COPCs not shown are less than three orders of magnitude of the WDF cumulative HI criteria, 1.0. Copper has been omitted because it was subject to single peaking criteria using the MCL value.)

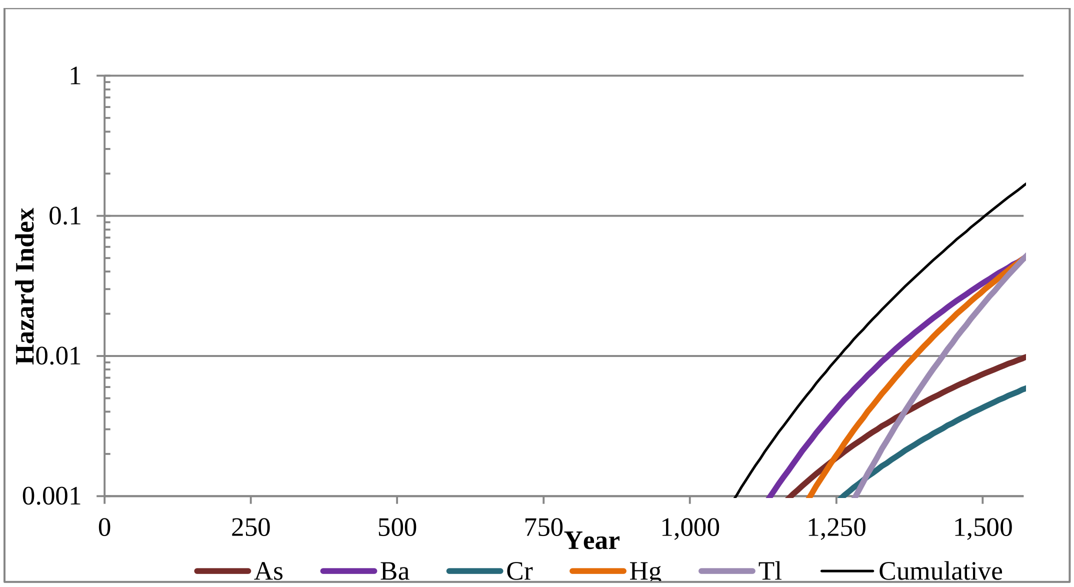

Figure C.4. Logarithmic-Linear Graph of Site 11 DOE Boundary Cumulative HI vs. Year
(COPCs not shown are less than three orders of magnitude of the DOE cumulative HI criteria, 1.0. Copper has been omitted because it was subject to single peaking criteria using the MCL value.)

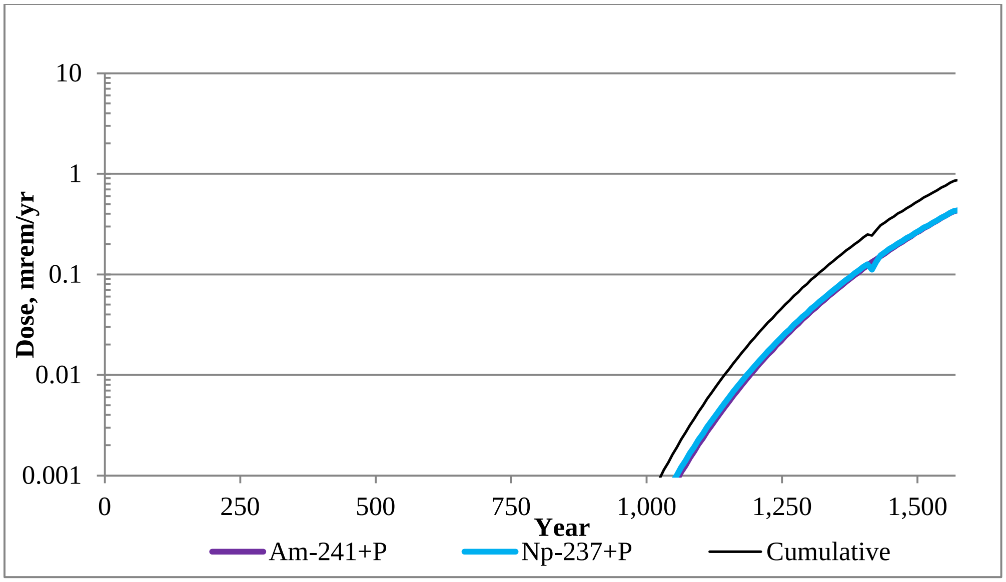

Figure C.5. Logarithmic-Linear Graph of Site 11 WDF Boundary Cumulative Dose vs. Year
(COPCs not shown are less than three orders of magnitude of the WDF cumulative dose criteria, 25 mrem/yr. "+P" indicates that the data series is a summation of the specified radionuclide isotope and its progeny. Tc-99 has been omitted because it was subject to single peaking criteria using the MCL value.)

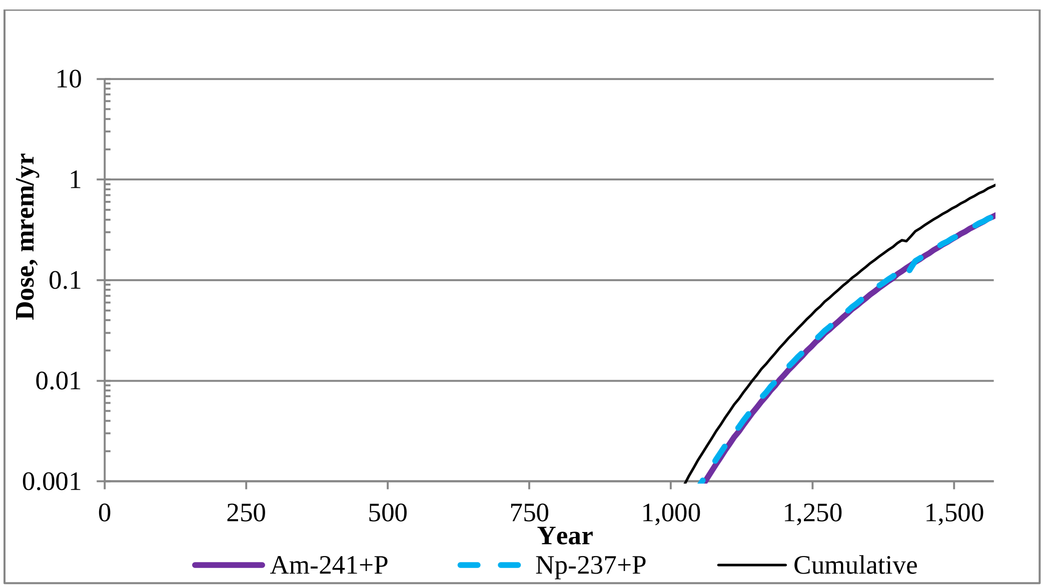

Figure C.6. Logarithmic-Linear Graph of Site 11 DOE Boundary Cumulative Dose vs. Year
(COPCs not shown were less than three orders of magnitude of the DOE cumulative dose criteria, 25 mrem/yr. "+P" indicates that the data series is a summation of the specified radionuclide isotope and its progeny. Tc-99 has been omitted because it was subject to single peaking criteria using the MCL value.)

C.5.2 SITE 3A PWAC-WDF, PWAC-DOE/PP, AND MODEL RESULTS

Time dependent ELCR, HI, and dose results based upon POA concentrations calculated from initial source concentrations of the minimum PWAC value for the POAs presented in Table C.3 are depicted in Figures C.7 through C.12. The figures have been simplified to solely include radionuclides, metals, or inorganics that are within three orders of magnitude of their risk-based cumulative criteria.

C.6. PWAC COMPARISON AT EOW, WDF BOUNDARY, AND DOE BOUNDARY

The groundwater receptors were assumed to be located at one of four locations for the development of the PWAC: EOW, WDF boundary, DOE boundary (Site 11), or Bayou Creek (Site 3A). Appendix C (Tables C.2 and C.3) presents predicted PWAC values for the gradual failure scenario for each receptor location (i.e., POA) for Site 11 and Site 3A, respectively.

C.7. PWAC COMPARISON OF INSTANTANEOUS, GRADUAL, AND NO FAILURE SCENARIOS

The no failure, gradual failure, and instantaneous failure scenarios were evaluated and compared for the uncertainty in the failure assumption. The lateral gravel drainage layer beneath the waste was assumed to degrade for the gradual and instantaneous failure scenarios. To account for degradation, the man-made flexible membrane liner layers are assumed to act no longer as barrier layers, and the two drainage layers below the waste are assumed to function no longer (i.e., they effectively became vertical percolation layers). The difference between the three scenarios involves the timing of the degradation. The instantaneous failure occurs at the end of the postclosure period (Year 200). The gradual failure begins at the end of the postclosure period and gradually continues until reaching the maximum degradation water flux at Year 600 (570 years after closure of the landfill). The no-failure scenario assumes that all components of the waste disposal facility would be in place, and the water flux would be equal to the postclosure period value until Year 10,000.

The results indicate, as expected, that the PWAC decreases for the instantaneous failure scenario in relation to the PWAC for the gradual failure scenario. PWAC values for the instantaneous failure and gradual failure scenarios are identical if soil saturation, total mass, or activity limits bound the PWAC for both scenarios. This is due to the increased groundwater concentrations predicted for the instantaneous failure scenario. The results of this analysis are provided in Appendix C, Tables C.4 and C.5 for Site 11 and Site 3A, respectively. In several instances, the PWAC did not change with POA location due to the requirement to meet the soil saturation limit or the mass concentration limit of the facility.

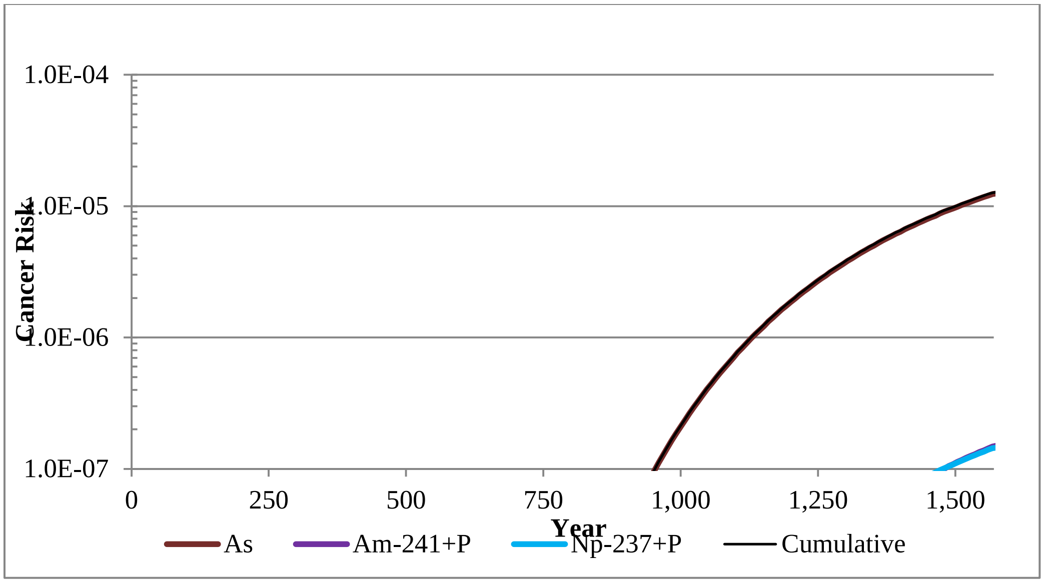

Figure C.7. Logarithmic-Linear Graph of Site 3A WDF Boundary Cumulative ELCR vs. Year
(COPCs not shown are less than three orders of magnitude of the WDF cumulative ELCR criteria, 1.0E-4. “+P” indicates that the data series is a summation of the specified radionuclide isotope and its progeny. Tc-99 has been omitted because it was subject to single peaking criteria using the MCL value.)

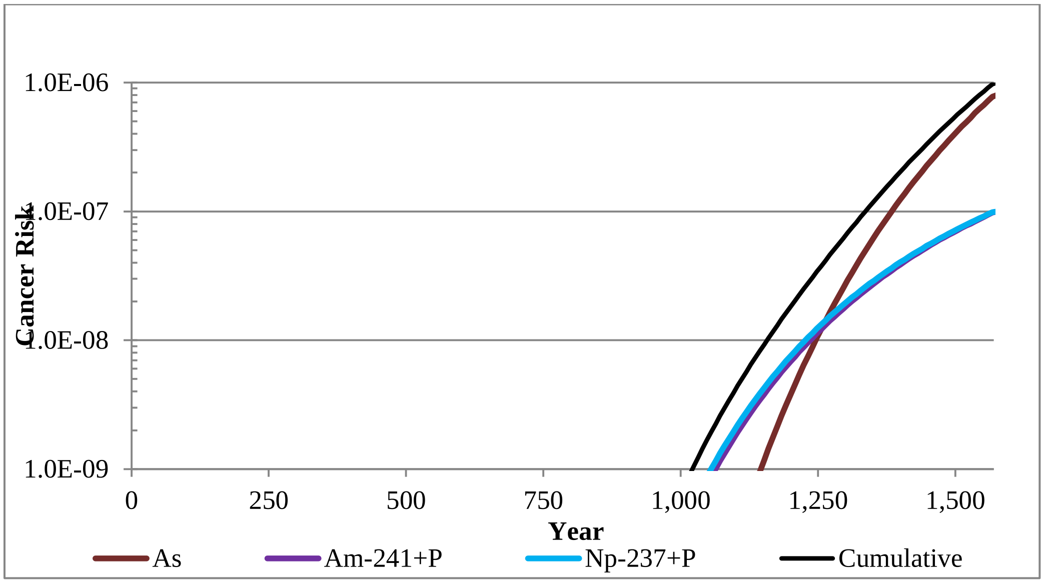

Figure C.8. Logarithmic-Linear Graph of Site 3A Surface Water Cumulative ELCR vs. Year
(COPCs not shown are less than three orders of magnitude of the surface water cumulative ELCR criteria, 1.0E-6. “+P” indicates that the data series is a summation of the specified radionuclide isotope and its progeny. Tc-99 has been omitted because it was subject to single peaking criteria using the MCL value.)

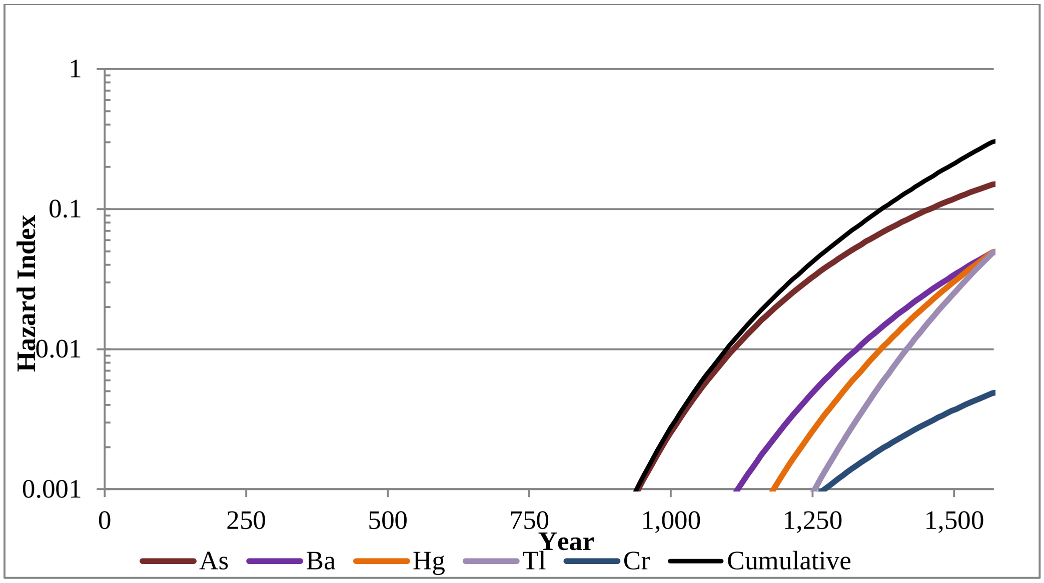

Figure C.9. Logarithmic-Linear Graph of Site 3A WDF Boundary Cumulative HI vs. Year
(COPCs not shown are less than three orders of magnitude of the WDF cumulative HI criteria, 1.0. Copper has been omitted because it was subject to single peaking criteria using the MCL value.)

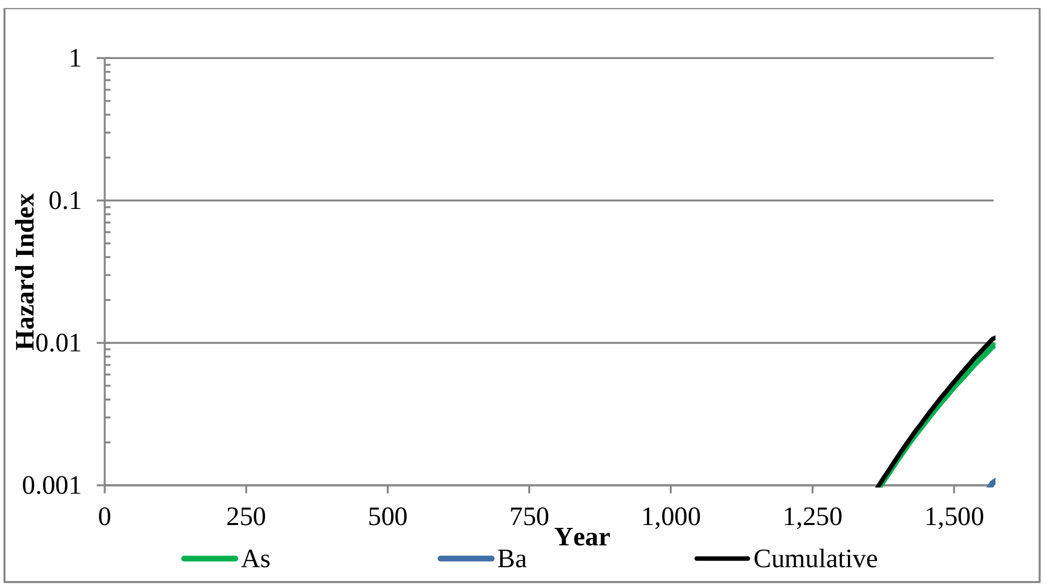

Figure C.10. Logarithmic-Linear Graph of Site 3A Surface Water Cumulative HI vs. Year
(COPCs not shown are less than three orders of magnitude of the surface water cumulative HI criteria, 1.0. Copper has been omitted because it was subject to single peaking criteria using the MCL value.)

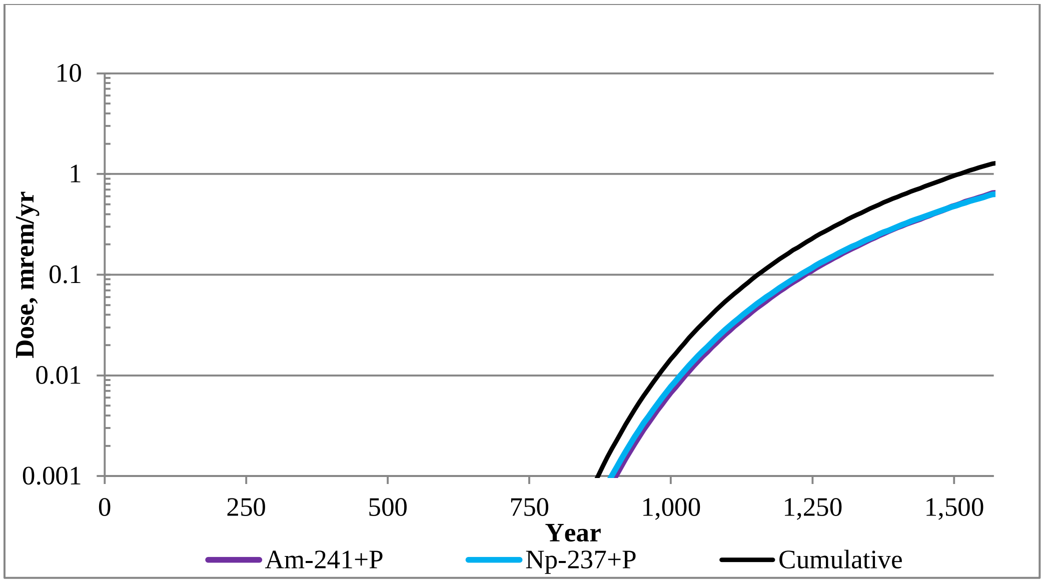

Figure C.11. Logarithmic-Linear Graph of Site 3A WDF Boundary Cumulative Dose vs. Year
(COPCs not shown are less than three orders of magnitude of the WDF cumulative dose criteria, 25 mrem/yr. "+P" indicates that the data series is a summation of the specified radionuclide isotope and its progeny. Tc-99 has been omitted because it was subject to single peaking criteria using the MCL value.)

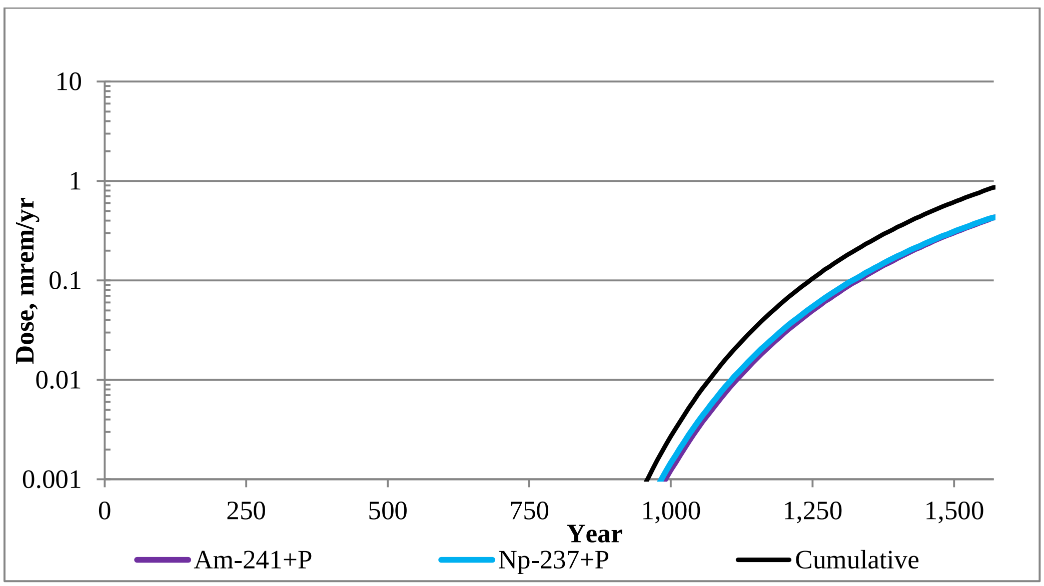

Figure C.12. Logarithmic-Linear Graph of Site 3A Surface Water Cumulative Dose vs. Year
(COPCs not shown are less than three orders of magnitude of the surface water cumulative dose criteria, 25 mrem/yr. "+P" indicates that the data series is a summation of the specified radionuclide isotope and its progeny. Tc-99 has been omitted because it was subject to single peaking criteria using the MCL value.)

Simulation results indicate that the PWAC increases dramatically for the no failure scenario in relation to the PWAC for the gradual failure scenario. This is because several contaminants never reach the groundwater receptor under this scenario; however, the PWAC upper bound is set to the limits established using the soil saturation limit or the mass concentration/activity limit of the facility.

C.8. REFERENCES

DOE (U.S. Department of Energy) 2011a. *Work Plan for CERCLA Waste Disposal Alternative Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Plant, Paducah, Kentucky,* DOE/LX/07-0099&D2/R1, U.S. Department of Energy, Paducah, KY, September.

DOE 2011b. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Volume 1, Human Health*, DOE/LX-07-0107&D2/R1/V1, U.S. Department of Energy, Paducah, KY, February.

EPA (U.S. Environmental Protection Agency) 1991. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*, OSWER Directive 9355.0-30, Office of Solid Waste and Emergency Response, Washington, DC.

GEO 2009. *Assessment of the Adequacy of Geotechnical and Hydrogeological Data in the Terrace Setting to Support a Remedial Investigation/Feasibility Study (RI/FS) - Level Evaluation of Potential Waste Disposal Sites Paducah, Kentucky,* GEO/09-207, R2, GEO Consultants, LLC, Kevil, KY, August.

PRS (Paducah Remediation Services, LLC) 2010. *2008 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model*, PRS-ENR-0028, February.

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ATTACHMENT C1

QUANTIFICATION OF CONTAMINANT SOURCE RINSING DURING THE OPERATIONAL/CLOSURE PERIOD

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C1.1. QUANTIFICATION OF CONTAMINANT SOURCE RINSING DURING THE OPERATIONAL/CLOSURE PERIOD

The leachate collected by the leachate collection system during the operational/closure period may contain contaminants from the landfill waste. The quantity of the contaminants in the collected leachate could be subtracted from the contaminant mass in the landfill, assuming the leachate contaminants are not put back into the landfill or are stabilized to prevent leaching prior to being placed back into the landfill; therefore, the allowable quantity of certain contaminants could be increased by the amount of the contaminant collected in the leachate.

Following is a description of modeling assumptions and procedures utilized to attempt to quantify the percentage of each contaminant anticipated to be collected by the leachate system during the operational/closure period. The following assumptions regarding the landfill construction schedule and sequencing were made.

- The landfill will be constructed according to the schedule outlined in Figure C1.1.
- The landfill will be constructed in four sequential phases, and each phase will be completed before beginning construction of the next phase (Figure C1.1).
- The percent (%) area of each phase of the landfill will be as outlined in the cost estimates included in Appendix I.
  - Phase 1—30%
  - Phase 2—25%
  - Phase 3—25%
  - Phase 4—20%
- A 1-ft thick temporary cap will remain at each phase until the end of the operational/closure period, at which time the final cap will be constructed.
- The total waste volume will equal 2.5 million cubic yards (mcy) (i.e., the base case waste volume).
- The bottom flexible membrane liner and leachate collection system will be in place and operating throughout the operational/closure period.
- The operational/closure period will last 30 years.
- The fill time waste height is an average of one half the full waste height for each phase (i.e., 85 ft/2 = 42.5 ft).
- The idle time waste height of each phase is the full waste height.

See Figure C1.1 for a chart of the operational/closure period time versus percent filled, as well as the fill time and idle time of each cell phase. See Figure C1.2 for the DUSTMS and HELP conceptual models.

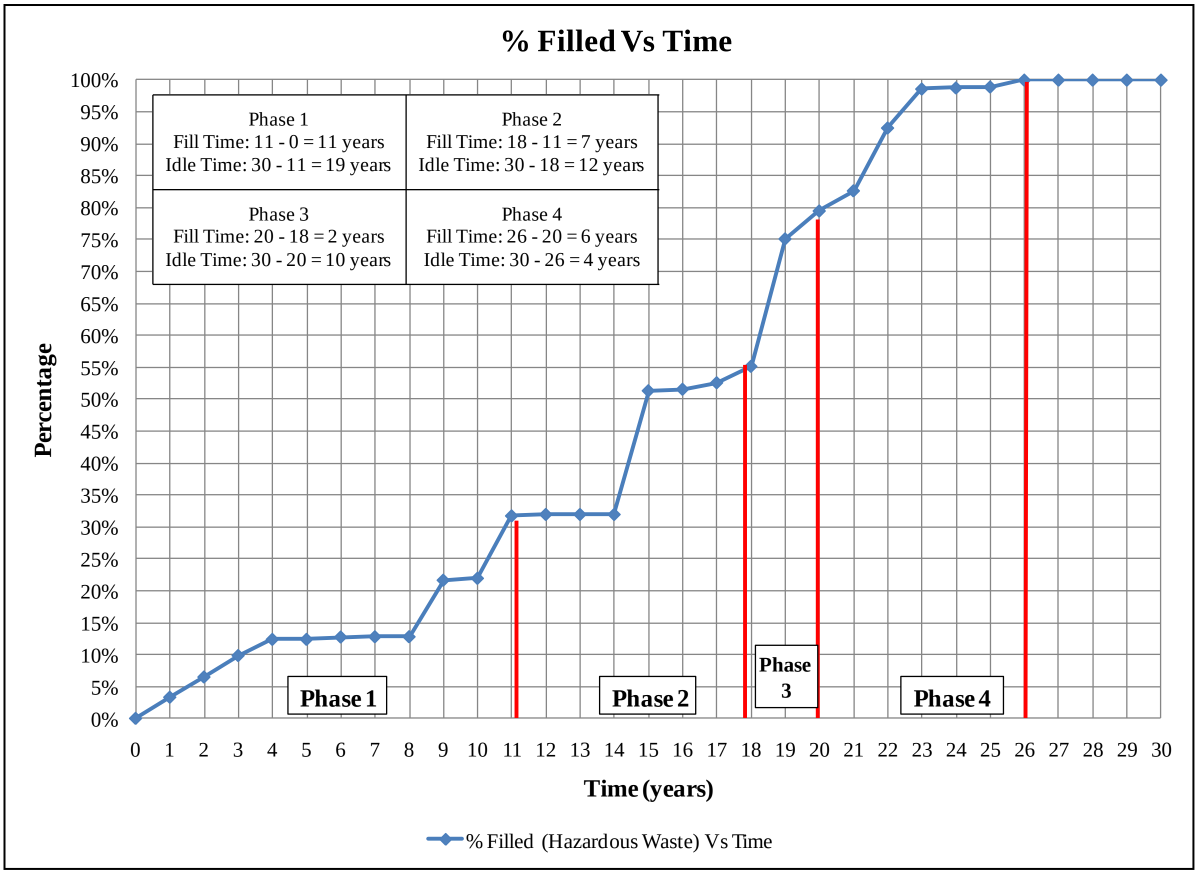

Figure C1.1. Percent (%) Filled over Time

Operational Period Conceptual Model

HELP, DUST-MS

DUST-MS Material	HELP Soil Layers	DUST-MS Number of Computational Nodes	Thickness (ft)	DUST-MS Bulk Density	DUST-MS Initial (t = 0 yrs) Volumetric Moisture Content	HELP Initial (t = 0 yrs) Volumetric Moisture Content
1	Soil Matrix (Temporary Soil Cover)	2	1	1.34	0.142	0.142
2	Waste Form	Varies by Phase	Varies by Phase	3.1	0.334	0.334
3	Clay (compacted)	2	1	1.8	0.404	0.404
4	Drainage Sand	2	1	1.4	0.1	0.1
FML (HDPE) Liner	Geocomposite Bottom of DUST-MS Model		0.02			
FML (HDPE) Liner	Clay Barrier		3	1.8		0.427
	Geologic Buffer (clay)		10			0.373
	Terrace Gravel (3A) Loess Deposit (11) Bottom of HELP Model		15 (3A) 20 (11)	1.41 (3A) 1.43 (11)		0.36

Figure C1.2. Operational/Closure Period Conceptual Model

Steady state percolation rates were predicted during the fill time (42.5-ft cell height) and idle time (85-ft cell height) using the HELP model. The HELP-predicted fill time percolation rate [1.62E-06 centimeters per second (cm/s) equal to 51.1 centimeters per year (cm/yr)] was applied to the fill time in DUSTMS, and the HELP-idle time percolation rate (1.61E-06 cm/s equal to 50.8 cm/yr) was applied to the idle time in DUSTMS.

A time weighted waste height for each phase was used in DUSTMS to account for the time in which the waste cell is not full during construction. The time weighted waste height was calculated using the following equation:

[(42.5ft x Fill Time) + (85ft x Idle Time)]/(Total Time) = (Time Weighted Waste Height)

The time weighted waste height calculated for each phase is included in Table C1.1.

Table C1.1. Weighted Waste Height Summary Table

Phase	**Fill Time (years)**	**Idol Time (years)**	**Total Time (years)**	**Time Weighted Waste Height (ft)**
1	11	19	30	69
2	7	12	19	69
3	2	10	12	78
4	6	4	10	60

Each phase of the landfill construction was simulated in a separate DUSTMS input file. The cumulative mass of each contaminant that passed through the drainage sand layer above the flexible membrane liner liner in DUSTMS was considered to be the mass that was captured by the leachate collection system. The total mass collected in the leachate during the operational/closure period was determined by summing mass rinsed from each phase. The percentage of the total contaminant mass collected in the leachate of each contaminant was determined by dividing the total mass collected by the full contaminant mass input to the waste (see Table C1.2 below for the operational/closure period modeling results). Source mass lost because of degradation that may occur while the landfill is operating was not quantified.

Table C1.2. Operational/Closure Period % Rinsed Results

Contaminant	Phase 1 (Composite Height = 69 ft, Time = 30 years)		Phase 2 (Composite Height = 69 ft, Time = 19 years)		Phase 3 (Composite Height = 78 ft, Time = 12 years)		Phase 4 (Composite Height = 60 ft, Time = 10 years)		Total Mass Rinsed (g)	% Rinsed (Mass Rinsed/ Total Mass)
	Contaminant Mass (g)*	Results Mass Rinsed (g)	Contaminant Mass (g)*	Results Mass Rinsed (g)	Contaminant Mass (g)*	Results Mass Rinsed (g)	Contaminant Mass (g)*	Results Mass Rinsed (g)		
Vinyl Chloride	2.27E+11	1.06E+11	1.89E+11	8.72E+10	1.89E+11	8.45E+10	1.51E+11	5.94E+10	3.37E+11	44.61%
TCE	3.39E+11	9.58E+10	2.82E+11	7.89E+10	2.82E+11	7.54E+10	2.26E+11	5.66E+10	3.07E+11	27.16%
2-Butanone	2.09E+11	2.10E+09	1.75E+11	1.75E+09	1.75E+11	1.75E+09	1.40E+11	1.40E+09	7.00E+09	1.00%
Chlorobenzene	5.30E+11	5.38E+10	4.42E+11	4.48E+10	4.42E+11	4.46E+10	3.53E+11	3.56E+10	1.79E+11	10.12%
Benzene	2.91E+11	5.27E+10	2.42E+11	4.39E+10	2.42E+11	4.38E+10	1.94E+11	3.43E+10	1.75E+11	18.04%
p-Cresol	3.34E+11	4.35E+09	2.79E+11	3.63E+09	2.79E+11	3.63E+09	2.23E+11	2.90E+09	1.45E+10	1.30%
Pentachlorophenol	1.08E+12	1.29E+11	8.96E+11	1.05E+11	8.96E+11	9.83E+10	7.17E+11	7.57E+10	4.08E+11	11.38%
Tc-99	7.21E+11	3.94E+11	6.00E+11	2.44E+11	6.00E+11	1.73E+11	4.80E+11	1.21E+11	9.32E+11	38.81%
Benzo(a)pyrene	1.43E+15	4.96E+10	1.20E+15	2.67E+10	1.20E+15	1.22E+10	9.56E+14	6.67E+09	9.52E+10	0.00%
Aroclor-1254	4.59E+14	1.03E+12	3.82E+14	4.41E+11	3.82E+14	1.92E+11	3.06E+14	1.06E+11	1.77E+12	0.12%
gamma-chlordane	7.62E+13	4.54E+11	6.35E+13	3.35E+11	6.35E+13	2.66E+11	5.08E+13	1.89E+11	1.24E+12	0.49%
Sb	8.34E+13	8.56E+11	6.95E+13	3.81E+11	6.95E+13	2.19E+11	5.56E+13	1.07E+11	1.56E+12	0.56%
As	5.38E+13	1.27E+12	4.48E+13	7.15E+11	4.48E+13	5.61E+11	3.59E+13	3.13E+11	2.86E+12	1.59%
Ba	7.60E+13	1.34E+12	6.33E+13	7.38E+11	6.33E+13	5.59E+11	5.06E+13	3.08E+11	2.95E+12	1.16%
Be	4.62E+14	2.83E+11	3.85E+14	8.04E+10	3.85E+14	2.82E+10	3.08E+14	1.13E+10	4.03E+11	0.03%
Cd	1.48E+14	5.60E+11	1.23E+14	2.08E+11	1.23E+14	9.72E+10	9.87E+13	4.36E+10	9.09E+11	0.18%
Cr	5.95E+13	1.29E+12	4.96E+13	7.23E+11	4.96E+13	5.62E+11	3.97E+13	3.13E+11	2.89E+12	1.46%
Cu	5.93E+12	7.20E+11	4.94E+12	4.33E+11	4.94E+12	3.72E+11	3.95E+12	2.18E+11	1.74E+12	8.82%
Pb	4.99E+14	7.02E+11	4.16E+14	2.41E+11	4.16E+14	9.94E+10	3.33E+14	4.20E+10	1.08E+12	0.07%

Table C1.2. Operational/Closure Period % Rinsed Results (Continued)

Contaminant	Phase 1 (Composite Height = 69 ft, Time = 30 years)		Phase 2 (Composite Height = 69 ft, Time = 19 years)		Phase 3 (Composite Height = 78 ft, Time = 12 years)		Phase 4 (Composite Height = 60 ft, Time = 10 years)		Total Mass Rinsed (g)	% Rinsed (Mass Rinsed/ Total Mass)
	Contaminant Mass (g)*	Results Mass Rinsed (g)	Contaminant Mass (g)*	Results Mass Rinsed (g)	Contaminant Mass (g)*	Results Mass Rinsed (g)	Contaminant Mass (g)*	Results Mass Rinsed (g)		
Mn	9.26E+13	1.02E+12	7.72E+13	4.83E+11	7.72E+13	2.96E+11	6.17E+13	1.48E+11	1.95E+12	0.63%
Hg	9.63E+13	1.37E+12	8.03E+13	7.43E+11	8.03E+13	5.47E+11	6.42E+13	2.97E+11	2.96E+12	0.92%
Ni	2.00E+14	1.40E+12	1.67E+14	6.91E+11	1.67E+14	3.74E+11	1.33E+14	2.29E+11	2.69E+12	0.40%
Se	2.78E+14	4.93E+11	2.31E+14	1.66E+11	2.31E+14	5.78E+10	1.85E+14	2.97E+10	7.47E+11	0.08%
Ag	1.67E+14	1.16E+12	1.39E+14	5.41E+11	1.39E+14	2.69E+11	1.11E+14	1.59E+11	2.13E+12	0.38%
Tl	1.31E+14	1.40E+12	1.10E+14	7.35E+11	1.10E+14	4.31E+11	8.76E+13	2.75E+11	2.84E+12	0.65%
V	1.85E+15	3.34E+11	1.54E+15	8.22E+10	1.54E+15	2.05E+10	1.23E+15	9.30E+09	4.46E+11	0.01%
Zn	3.70E+14	1.11E+11	3.08E+14	2.93E+10	3.08E+14	8.21E+09	2.47E+14	3.92E+09	1.52E+11	0.01%
Cs-137	5.18E+14	1.02E+11	4.31E+14	3.15E+10	4.31E+14	9.63E+09	3.45E+14	4.69E+09	1.48E+11	0.01%
Am-241	3.51E+15	8.45E+09	2.93E+15	1.47E+09	2.93E+15	2.81E+08	2.34E+15	1.18E+08	1.03E+10	0.00%
Np-237	9.44E+12	7.31E+11	7.87E+12	4.07E+11	7.87E+12	2.58E+11	6.29E+12	1.70E+11	1.57E+12	4.98%
Pu-238	1.02E+15	2.74E+10	8.47E+14	6.16E+09	8.47E+14	1.45E+09	6.78E+14	6.48E+08	3.57E+10	0.00%
Pu-239	1.02E+15	3.26E+10	8.47E+14	6.91E+09	8.47E+14	1.56E+09	6.78E+14	6.89E+08	4.18E+10	0.00%
Pu-240	1.02E+15	3.26E+10	8.47E+14	6.90E+09	8.47E+14	1.56E+09	6.78E+14	6.89E+08	4.17E+10	0.00%
Th-230	5.92E+15	1.27E+10	4.93E+15	2.11E+09	4.93E+15	3.91E+08	3.94E+15	1.62E+08	1.54E+10	0.00%
U-234	6.49E+13	1.27E+11	5.41E+13	3.91E+10	5.41E+13	1.32E+10	4.33E+13	6.84E+09	1.86E+11	0.09%
U-235	6.49E+13	1.27E+11	5.41E+13	3.91E+10	5.41E+13	1.32E+10	4.33E+13	6.84E+09	1.86E+11	0.09%
U-238	6.49E+13	1.27E+11	5.41E+13	3.91E+10	5.41E+13	1.32E+10	4.33E+13	6.84E+09	1.86E+11	0.09%

*The contaminant mass shown is the mass of the completed waste cell based on a concentration of 1 g/cc.

ATTACHMENT C2

GEO CONSULTANTS (2009) STUDY OF HYDROGEOLOGIC DATA FOR SITE 3A

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GEO/09-207
R2

Assessment of the Adequacy of Geotechnical and Hydrogeological Data in the Terrace Setting to Support a Remedial Investigation/Feasibility Study (RI/FS) - Level Evaluation of Potential Waste Disposal Sites Paducah, Kentucky

Prepared for
Paducah Remediation Services
761 Veterans Ave.
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Contract No. PRS-BA-014

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August 2009

GEO/09-207
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APPENDICES

Appendix A – Maps
Figure 1. Locations of potential waste disposal facility sites in the Terrace setting and supporting geotechnical and hydrogeological information
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ACRONYMS and ABBREVIATIONS

ASTM	American Society of Testing and Materials
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	Department of Energy
DUF_6	Depleted Uranium Hexafluoride
FS	Feasibility Study
GEO	GEO Consultants, LLC
KOW	Kentucky Ordnance Works
pcf	pounds per cubic foot
PGDP	Paducah Gaseous Diffusion Plant
PRS	Paducah Remediation Services
RI	Remedial Investigation
UCRS	Upper Continental Recharge System
wt	weight

1. INTRODUCTION

The Department of Energy (DOE) is responsible for cleanup of the Paducah Gaseous Diffusion Plant (PGDP) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. An estimated 3.7 million cubic yards of waste is forecast to be generated by CERCLA response actions at PGDP from 2010 until the completion of final site cleanup. Disposal alternatives for the large volumes of waste to be generated are being evaluated using the CERCLA process in collaboration with the U.S. Environmental Protection Agency, the Commonwealth of Kentucky, and stakeholders.

To support evaluation of the on-site alternative, 11 potential sites for the location of a waste disposal facility have been identified. These sites are located overlying two distinct hydrogeologic/geotechnical settings separated by the Porters Creek Terrace. The setting north of the terrace, identified in this report as the Alluvial setting, includes sites denoted as 5, 6, 7, 8, 9, and 11. Sites either completely or largely south of the terrace, identified herein as the Terrace setting, include sites 1, 2, 3A, 4, and 10.

GEO Consultants, LLC (GEO) was advised by Paducah Remediation Services (PRS) that the candidate disposal sites located in the Alluvial setting have sufficient data to support a Remedial Investigation (RI)/Feasibility Study (FS). However, there is uncertainty regarding the sufficiency of geotechnical and hydrogeological data available for providing evaluation of those five sites lying within the Terrace setting. Consequently, PRS requested that GEO focus on these five locations by assembling and reviewing available data and providing an assessment of data availability and adequacy for supporting an RI/FS.

PRS plans to proceed with the RI/FS that will include groundwater modeling, based on available geotechnical and hydrogeological data for sites within the Terrace setting. The question posed by PRS to GEO is:

"Is there sufficient geotechnical and hydrogeological data for relevant lithologic units within the Terrace setting to support RI/FS - level evaluation and selection activities for a waste disposal facility?"

2. SUMMARY CONCLUSIONS

GEO reviewed available geotechnical and hydrogeological data for the major lithologic units in the Terrace setting (loess, Terrace Gravels, Eocene Sand, and Porters Creek Clay). GEO concludes that existing data, although significantly limited for certain areas, are sufficient to support an RI/FS - level evaluation of the five sites in this region. If on-site disposal is the preferred remedy, it is understood that final evaluation and site selection may require PRS to obtain additional data to augment what is currently available to prepare a final design and waste acceptance criteria.

The following sections of this report support this conclusion.

3. DATA REVIEW METHODOLOGY

The approach of this report is to focus on a variety of geotechnical and hydrogeological data for the Terrace setting. The data will be required for conceptual design purposes as well as to support analytical and numerical modeling for these sites as part of the RI/FS. Specifically, the parameters that GEO was asked to review include the following:

- Geotechnical Data
  - Bulk density
  - Moisture content
  - Porosity

- Hydrogeological Data
  - Lithologic unit thicknesses
  - Saturated hydraulic conductivity
  - Depth to water table
  - Hydraulic gradient
  - Flow direction

The following sections address each of these parameters by developing maps of available data locations associated with boreholes and monitoring wells. Related summary tables segregate data by lithologic units (e.g. Terrace Gravel, Eocene Sand, Porters Creek Clay). Figure 1 (Appendix A; all figures are included in Appendix A) illustrates the five site locations in the Terrace setting that are the focus of attention in this report and identifies specific areas where geotechnical and hydrogeological data are available, as well as the sources of these data.

4. GEOTECHNICAL DATA

4.1 BULK DENSITY

Figure 2 identifies the location of Bulk Density data in the Terrace setting. Some data sources present density as "Dry Density" whereas one reference cites both Dry Density and Bulk Density values for each sample. The document prepared to report seismic investigation results for Site 3A (DOE, 2004) is specific about the definition of these two terms and GEO assumes that these definitions apply to all data sources that have been reviewed.

The following definitions apply:

Bulk Density = Wet weight (wt) of sample (dry wt + wt of moisture) / Volume of wet sample

Dry Density = Dry wt of sample / Volume of wet sample

Based on these definitions the two parameters can be related through the moisture percent (referred to as the American Society of Testing and Materials (ASTM) moisture percent or natural moisture content) as follows.

Bulk Density = Dry Density x (1 + ASTM Moisture % / 100)

Dry Density values are reported for samples from the Depleted Uranium Hexafluoride [DUF_6 (BJC, 2000)] and Cylinder Yard (LMES, 1996) areas. In addition, "natural moisture content" values are reported for DUF_6 samples. What is termed "moisture content" is reported for the Cylinder Yard samples (GEO assumes that "moisture content" is equivalent to "natural moisture content"). Consequently, Dry Density values for these two sites can be converted to Bulk Densities by the above relationship.

Therefore, Table 1 incorporates both Bulk Density data and Dry Density values converted to Bulk Density results and summarizes available information. Locations are keyed to those identified in Figure 2. The uncertainty of assignment of some samples to specific lithologic units in Table 1 (and subsequent tables) is indicated with a "(?)", but is not a major concern because the range of Bulk Density values is relatively narrow and similar for all lithologies.

Table 1. Bulk density data for samples from the Terrace setting.

Location	Bulk Density pcf* (Number of Samples)	Source
Site 3A		DOE (2004)
Loess	88.0 – 146.7 (10), as reported	
Terrace Gravel	124.3 – 136.4 (6), as reported	
Porters Creek Clay	89.3 – 101.4 (17), as reported	
DUF_6		BJC (2000)
Loess ?	116.5 – 124.8 (3), computed	
(samples from 4-7 feet bgs*)		
Terrace Gravel ?	131.6 (1), computed	
(samples from 20-22 feet bgs)		
Cylinder Yard		LMES (1996)
Loess ?	115.5 – 133.6 (8), computed	
(samples from 3-5 feet bgs)		

*pcf: pounds per cubic foot
*bgs: below ground surface
*?: Lithologic assignment is uncertain

4.2 MOISTURE CONTENT

The locations where moisture content information is available in subsurface samples from the Terrace setting are presented in Figure 3. The moisture content of a soil sample can be defined in several ways. For example, in DOE (2004), both ASTM and SW846 moisture contents are defined and reported for samples from Site 3A. They are defined as follows:

ASTM Moisture % = 100 x (wt of wet sample – wt of dry sample) / wt of dry sample

SW846 Moisture % = 100 x (wt of wet sample – wt of dry sample) / wt of wet sample

As noted above, several sources of information from the Terrace setting use the term "natural moisture content." Review of other geotechnical resources indicates that this term is identical to the ASTM moisture content. Table 2 summarizes available moisture content information. Locations are keyed to those identified in Figure 2. The uncertainty of assignment of some samples to specific lithologic units is not a major concern because the range of moisture content values is relatively narrow for each lithology. Loess and Terrace Gravel samples have a similar range of moisture values. Porters Creek Clay samples have distinctly higher moisture contents, a probable reflection of the high clay content of this unit.

Table 2. Moisture content data for samples from the Terrace setting.

Location	ASTM or Natural Moisture Content % (Number of samples)	Source
Site 3A		DOE (2004)
Loess	17 – 30.5 (18)*	
Terrace Gravel	11.2 – 30 (28)*	
Porters Creek Clay	48.6 – 67.6 (26)*	
DUF_6		BJC (2000)
Loess ?	22.6 – 36.3 (3)	
(samples from 4-7 feet bgs)		
Terrace Gravel ?	15.3 (1)	
(sample from 20-22 feet bgs)		
Cylinder Yard		LMES (1996)
Loess ?	15 – 33 (32)	
(samples from <10 feet bgs)		
Deeper samples – unit not identified	19-24 (3)	
(10-35 feet bgs)		
Kentucky Ordnance Works		TCT (1992)
Loess ?	19.7 – 22.0 (2)	
(samples from 9.5 feet bgs)		
Terrace Gravel ?	26.7 (1)	
(sample from 24 feet bgs)		

* A small number of samples were well out of the dominant ranges of values and have been omitted (Loess: one sample was 74.8%; Terrace Gravel: four samples ranged from 55.4 to 64.4%; Porters Creek Clay: two samples were 18.8 and 23.7%)
*?: Lithologic assignment is uncertain

4.3 POROSITY

Available porosity information for soil samples obtained in the Terrace setting is given in Figure 4. Some reports specifically cite porosity percent, whereas others provide information from which porosity can be computed. For example, porosity can be determined from the following relationship:

Porosity % = 100 x (1-Dry Density / particle density)

Particle density usually can be assumed as 2.65 g/cm^3 (165 lb/cu feet), the typical density of quartz. However, in DOE (2004), actual particle densities are reported for each sample and a small fraction of these values deviate significantly from 2.65 g/cm^3 (e.g. as low as 2.04 g/cm^3). Typically, particle density values this low are found in samples containing a significant quantity of low density organic matter. By looking at the lithologic descriptions in the boring logs, no obvious reason exists for this deviation and GEO is inclined to question the validity of these few, low density values. In this report, GEO assumed the particle density for all samples is 2.65 g/cm^3.

Alternatively, some data sources for Terrace setting samples provide the void ratio (void ratio = e = volume of voids / volume of solids) from which porosity can be determined as follows:

Porosity % = 100 x (e / (1+e))

Table 3 summarizes available and computed values of porosity of soils for the Terrace setting. Porosity values for samples from Site 3A, associated with DOE (2004), cover a large range that appears to reflect the different types of lithologic units represented. Silts, sands, and gravels typically fall in the range of 30% to 40%, whereas clays may be between 50% and 60%. The very high porosity values for some samples in Site 3A (>60%) often are reported as silts or clays in the boring logs that GEO reviewed. Porosity results from other areas in the Terrace setting are more representative of lithologies where clay is not the dominant phase present (e.g. Terrace Gravel).

Table 3. Porosity data for samples from the Terrace setting.

Location	Porosity % (Number of samples)	Source
Site 3A		DOE (2004)
Loess	29.2 – 47.3 (19)*	Computed from both Dry Density and void ratio data
Terrace Gravel	27.4 – 40.6 (12)	
Porters Creek Clay	58.7 – 69.1 (34)	
DUF_6		BJC (2000)
Loess ? (samples from 4-7 feet bgs)	38.2 – 47.4 (3)	Porosity computed from both Dry Density and void ratio data for each sample
Terrace Gravel ? (sample from 20-22 feet bgs)	30.8/31.9 (1)	
Cylinder Yard		LMES (1996)
Loess ? (samples from 3-5 feet bgs)	32 – 45.3 (8)	Computed from Dry Density data
Kentucky Ordnance Works		Maxim (1997a)
Sample depth not reported#	25-40 (24)	

* One sample was omitted because it was well outside of the typical range of data (55.9% porosity)

\# Sample depths not reported, but porosity values are consistent with Loess and Terrace Gravel

*?: Lithologic assignment is uncertain

5. HYDROGEOLOGICAL DATA

5.1 GEOLOGIC CROSS SECTIONS

A large number of boreholes have been drilled in the Terrace setting, for which boring logs are available. These boreholes typically were completed within the Porters Creek Clay lithologic unit so that a complete sequence of the lithologies from the uppermost loess, through the Terrace Gravels, and Eocene Sands (where present), are represented in addition to the upper part of the Porters Creek Clay. A significant number of these boreholes were converted into monitoring wells. Most of the wells are in the Kentucky Ordnance Works (KOW) site area, though several wells are located in both Sites 1 and 3A, with a number of additional wells located immediately to the north of Site 1.

Many geologic cross sections were constructed in the Terrace setting area and incorporated into a variety of documents (e.g. Clausen, et al., 1992; Phillips and Douthitt, 1993; TCT, 1994; Maxim, 1997b; and DOE, 1995; 1996; 2004). The locations of a selection of these cross sections are illustrated in Figure 5 (including the document sources) and indicate the richness of subsurface geological information that is available for evaluating the Terrace setting as a possible location for a waste disposal facility. Some cross sections subdivide the key lithologic units into loess, Terrace Gravel, Eocene Sand (where present), and Porters Creek Clay (e.g. cross section X-X' and A-A' and B-B' in Site 3A). Other cross sections identify lithologies that can be subdivided into these units in a straightforward fashion, based on their respective geologic descriptions [e.g. cross sections A-A' (TCT, 1994) and A-A' (Maxim, 1997b) in the KOW area and N-S that extends to the north of Site 3A (Clausen, et al. 1992)]. These cross sections (and others not shown in Figure 5) and the supporting borehole logs are a ready source of information on thickness of the lithologic units across much of the Terrace setting region, as well as the overall topographic configuration of the units in this area.

Several cross sections among those represented in Figure 5 (X-X' and N-S) are particularly important because they are oriented nearly normal to the Porters Creek Terrace and illustrate the transition of lithologies from the Terrace setting northward into those units representative of the Alluvial setting. The key features of these cross sections indicate that: (a) the surficial loess unit extends into the main part of PGDP and (b) the Terrace Gravels either pinch out (e.g. see cross section N-S) or merge with the upper half of the Upper Continental Recharge System [(UCRS) – see cross section X-X'] without demonstrable evidence that the gravels drape over the Terrace slope and merge with the Regional Gravel Aquifer[1]. Therefore, the most probable hydrogeological linkage between the Terrace and Alluvial settings appears to be the lateral transition of the Terrace Gravels into the UCRS.

Collectively, the many cross sections and boring logs available in the Terrace setting provide a rich source of geologic information in this region, especially within and adjacent to the KOW and in a region that includes Site 3A, the Cylinder Yard, and DUF_6 areas. GEO believes these resources adequately support estimates on lithologic thickness and depths of occurrence of specific units in these areas and should provide satisfactory geologic constraints on activities associated with initial evaluation of potential waste disposal sites. There is a significant gap between these two data-rich areas that should be considered as attempts are made to refine the geologic understanding of the broader Terrace setting.

5.2 HYDRAULIC CONDUCTIVITY

Figure 6 illustrates those locations in the Terrace setting where hydraulic conductivity data were obtained in several investigations. Table 4 summarizes the available results. Most results are from slug

[1] The presence of one or several discrete gravel-filled channels connecting the Terrace Gravel to the Regional Gravel Aquifer cannot be ruled out, although no specific evidence for such groundwater flow pathways exists.

tests. A large body of hydraulic conductivity data is covered in Clausen et al. (1992) and captures what was obtained prior to that time. A few of these data were obtained in the Terrace Gravels and Porters Creek Clay (Terrace setting) and those locations are found in Figure 6. In addition, a large number of measurements for hydraulic conductivity in wells from the KOW site were documented during two phases of site investigations and the well locations are included in Figure 6 (TCT, 1995; Maxim, 1997b). Laboratory results for vertical hydraulic conductivity measurements in a broad range of Shelby Tube samples from Site 3A also are included in Table 4.

Table 4. Hydraulic conductivity data for lithologic units in the Terrace setting.

Location	Hydraulic Conductivity cm/sec (number of measurements)	Method	Source
Several summaries of hydraulic conductivity data from PGDP:			
Terrace Gravel	5.3E-05 – 1.4E-03 (unknown)	Slug tests	Phillips and Douthitt (1993)
Porters Creek Clay	5.6E-07 – 3E-04 (unknown)	Slug tests	Clausen et al. (1992)
Site 3A:			
Terrace Gravels	5.2E-05 – 4.81E-03 (3 wells, repeat measurements)	Slug tests	Clausen, et al. (1992)
Porters Creek Clay	5.4E-07 – 3.04E-04* (3 wells, some repeats)	Slug tests	
Site 3A: Vertical K			
Loess	1.4E-07 – 9.3E-06 (8)	Lab tests	DOE (2004)
Terrace Gravel	3.2E-08 – 2.0E-06 (7)	Lab tests	
Porters Creek Clay	5.4E-08 – 5.0E-05 (13)	Lab tests	
KOW			
Terrace Gravel	2E-06 – 1.76E-03 (30)	Slug tests	Maxim (1997b)
Eocene Sands[#]			

* There were some old measurements cited, but well locations are not known.
[#] Most wells are screened across the Terrace Gravel-Porters Creek Clay contact.

5.3 GROUNDWATER LEVELS, FLOW DIRECTIONS, AND HYDRAULIC GRADIENTS

An important component of this data adequacy assessment is the integration of available potentiometric data for monitoring wells in the Terrace setting from which groundwater flow directions and hydraulic gradients can be estimated. As discussed above, several key geological cross sections that are available for this area support the transition of the Terrace Gravel into the UCRS from the Terrace setting into the southern part of the PGDP (Alluvial setting). Therefore, GEO combined observed groundwater level data for a broad spectrum of monitoring wells that are completed either in the Terrace Gravels or the UCRS in this region, in order to provide a framework from which a groundwater flow assessment can be made.

Figure 7 is a potentiometric map for the region integrating available data for Terrace Gravel and UCRS monitoring wells in 1996. Water level data for the KOW wells were obtained in December 1996. The contour lines in this area are a representation of those presented in Figure 3-23 from Maxim (1997b). Water level data obtained by DOE from PGDP monitoring wells completed in Terrace Gravel and the UCRS in December 1996 are limited. The most extensive collection of water level data in these wells is from May 1996 and, consequently, these results were selected for inclusion in Figure 7. The contour lines were drawn to honor all of these data and provide a realistic transition between the DOE and KOW data sets[2]. The region of the Terrace setting to the east of the KOW is a data poor region represented by only one isolated well and a cluster of three wells in a second location in site 3A. However, an attempt was made to extend potentiometric lines into this area by honoring the probable impact of Bayou Creek, as well as the few existing wells[3].

Fryar, et al. (2000) reports that Bayou Creek is a gaining stream along the reach that lies within the Terrace region. For that reason, it is realistic to adjust the configuration of potentiometric lines in this region to reflect potential groundwater discharge to the creek. In contrast, Fryar, et al. (2000) indicates that Little Bayou Creek is a losing stream until a point well to the north of the PGDP. Therefore, this stream probably is not a location of groundwater discharge on the Terrace and has little or no impact on groundwater flow in the area represented in Figure 7.

Although GEO recognizes that the data supporting the configuration of the potentiometric contour lines of the Terrace Gravels within Site 3A is limited, it is broadly consistent with what is observed further to the west (i.e. within the KOW), along the northern edge of the Porters Creek Terrace, which is a more data-rich region. Furthermore, the manner in which contour lines are shown in the vicinity of Bayou Creek is consistent with discharge of groundwater to this perennial stream. As illustrated in Figure 7, it is reasonable to hypothesize that lateral flow of groundwater from at least the western part of Site 3A is a source of recharge to Bayou Creek. In contrast, as noted above, Little Bayou Creek to the east of Site 3A probably has little, if any, impact on groundwater flow within 3A.

Within the context of the integrated picture of potentiometric data represented in Figure 7, GEO believes that several conclusions can be made regarding groundwater flow directions in the Terrace Gravels. First, and with a high degree of confidence, there is a groundwater mound centered on the KOW that supports outward radial flow. More specifically, information from the KOW, coupled with added water level data from DOE wells completed in the Terrace Gravel to the northeast of the KOW indicate that a clear northeasterly component of groundwater flow exists in this region into the UCRS in the southwestern part of PGDP. Secondly, but with less confidence, GEO believes that the configuration of potentiometric contour lines to the east of the KOW are a realistic (but not definitive) representation of hydrogeologic conditions in this region that honor both the presence of Bayou Creek as a gaining stream, and the limited monitoring well data from locations in the vicinity of Site 3A. These data also support a dominant northerly flow of groundwater in this area. In addition, some lateral flow of groundwater in the western part of Site 3A (in a westerly or northwesterly direction) may occur and result in discharge to Bayou Creek.

Another element of the Terrace Gravel – UCRS groundwater flow system that emerges from the water level data that supports Figure 7 is the ability to estimate the hydraulic gradients for the Terrace Gravel across this area. For example, Maxim (1997b) presents estimates of hydraulic gradients in the vicinity of many monitoring wells in the KOW, based on data collected in 1994 and 1996. Five wells located on the north side of the KOW (KW-1, 2, 5, 11, and 15) yield a tight range of hydraulic gradient values from 7.3×10^{-3} to 1×10^{-2} (no units) associated with the northeastern component of radial flow from the KOW. Further to the northeast are four PGDP wells, completed in the Terrace Gravel (GW-300, 301, 310, and 311), from which water level data supporting Figure 7 provide estimates of hydraulic

[2] There appears to be a relatively smooth transition between the KOW and PGDP water level data for both Terrace Gravel and UCRS wells. The detail of contours within the main plant area may be a reflection of the impact of plant activities (e.g. reduced infiltration due to buildings and roads and water losses from plant utility lines).

[3] The depth to water in the wells of the Terrace setting represented in Figure 7 range from approximately 5 feet to 11 feet bgs for the PGDP wells and from 3 feet to 46 feet bgs for the KOW wells and piezometers. The greater depths for some KOW locations are associated with the southern part of this area where ground surface elevations are higher and the groundwater levels are descending on the southern flank of the mound.

gradient that range between 8.5 x 10^{-3} to 1.2 x 10^{-2}. These values are entirely consistent with results from the KOW. An estimate of the hydraulic gradient in the Terrace Gravel in the vicinity of Site 3A is problematic due to the limited number of available monitoring wells and their location. A gradient estimate in this region is speculative and based on the projection of potentiometric contour lines through this area, the location of which are constrained by the factors described above. A rough approximation based on this approach is a gradient of about 7 x 10^{-3} (with a northward flow direction) that is comparable to the more reliable estimates from the vicinity of the KOW presented above.

6. CONCLUSIONS

Review of the geotechnical and hydrogeologic data presented in the preceding sections makes it possible to develop a conceptual understanding for the subsurface in the Terrace setting that is, for the most part, relatively straightforward. However, data availability for part of this region (especially the eastern half for some key parameters) is limited. On balance, and incorporating these data limitations and uncertainties into its evaluation, GEO concludes that available information can support evaluation of potential waste disposal sites at an RI/FS - level of detail with the understanding that a final site selection may require additional data (hydrogeological).

In general, the geotechnical data appears to be compelling. Available bulk density, moisture content, and porosity data lie within relatively well-constrained ranges. In fact, the Porters Creek results for moisture content and porosity properly reflect the impact of a clay-rich lithology.

The hydrogeologic data for the western half of the Terrace region clearly contributes to a conceptual understanding of that area. On the strength of this information, the role of Bayou Creek as a site of groundwater discharge, and a limited amount of water level data in the vicinity of Site 3A, a consistent hydrogeological picture for the rest of the Terrace region under consideration begins to emerge.

In summary, these factors are the basis for GEO's conclusion regarding data adequacy and limitations noted above.

7. REFERENCES

BJC, 2000. DUF6 Conversion Facility Site Characterization Report, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, BJC/PAD-207. September 2000

Clausen, J.L., J.W. Douthitt, K.R. Davis, B.E. Phillips, 1992. Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III. KY/E-150. Nov. 25, 1992

DOE, 1995. Feasibility Study for Waste Area Groups 1 and 7 and Kentucky Ordnance Works Solid Waste Management Units 94, 95, and 157 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky. DOE/OR/06-1416&D1. December 1995

DOE, 1996. Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Kentucky Ordnance Works solid waste management units 94, 95, and 157 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky, July 1996

DOE, 2004. Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Document. DOE/OR/07-2038&D2. March, 2004

Fryar, A.E., E.J. Wallin, and D.L. Brown, 2000. Spatial and temporal variability in seepage between a contaminated aquifer and tributaries to the Ohio River. Ground Water Monitoring and Remediation, Summer 2000, pp. 129-146

LMES, 1996. Geotechnical Investigation, Proposed Cylinder Storage yard, Phase IX, Paducah, Kentucky. Geotek Project No. 94-3832, July 26, 1996

Maxim, 1997a. Phase III Remedial Investigation Report of the Former Kentucky Ordnance Works, McCracken County, Kentucky, Volume II of VII, Appendix D. August 1997.

Maxim, 1997b. Phase III Remedial Investigation Report of the Former Kentucky Ordnance Works, McCracken County, Kentucky, Volume I of VII. August 1997.

Phillips, B.E. and J.W. Douthitt, 1993. Hydrogeologic assessment of the C-746-K landfill and vicinity. KY/ER-24, September 1993.

TCT, 1992. Phase I Remedial Investigation at the Former Kentucky Ordnance Works, McCracken County, Kentucky, Volume III of IV, Appendix D. October 1992.

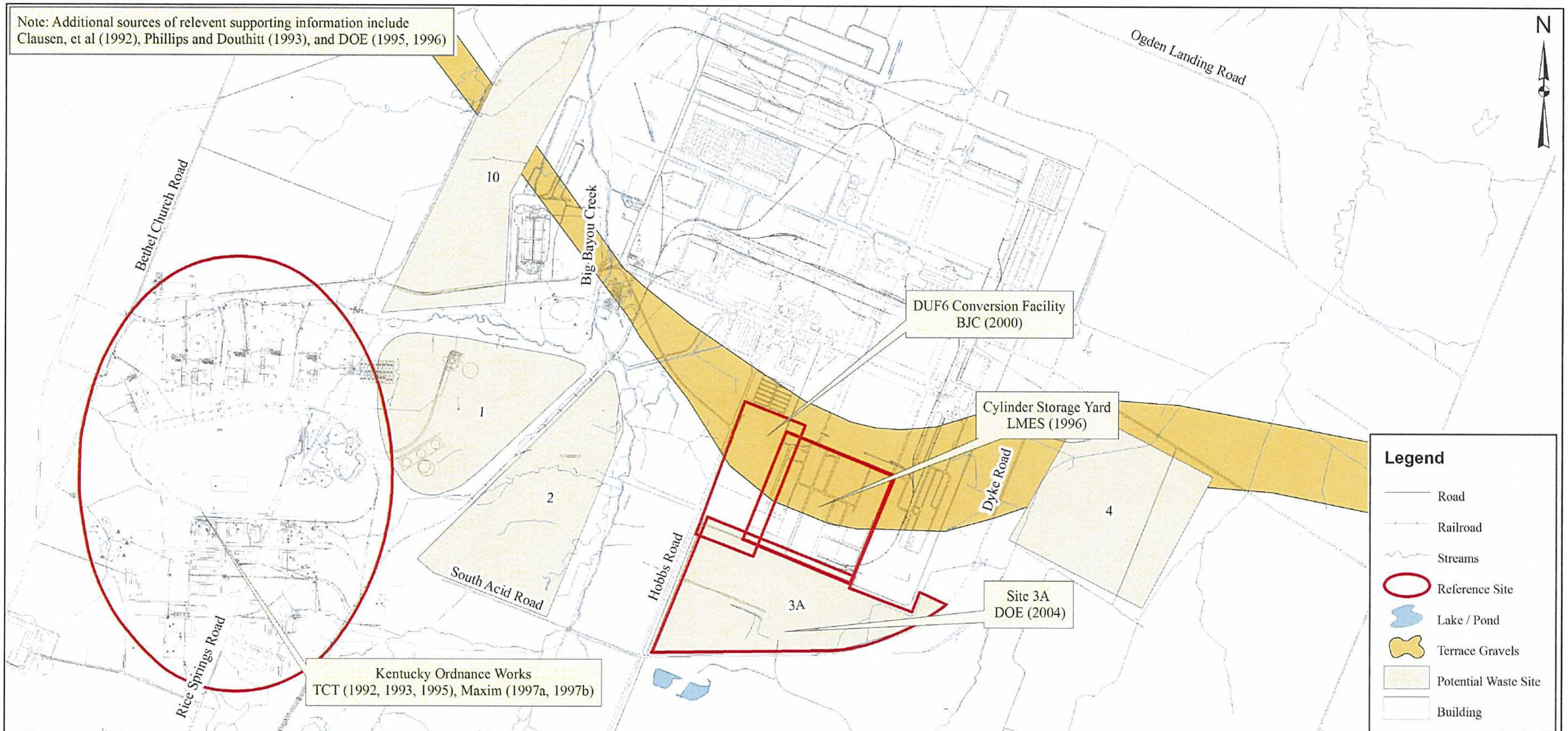
TCT, 1994. Addendum to the Final Kentucky Ordnance Works Sampling and Analysis Plan, September 1994

TCT, 1995. Final Phase II Remedial Investigation at the Former Kentucky Ordnance Works, McCracken County, Kentucky. August 1995

APPENDICES

APPENDIX A

MAPS



Comment:

Map Source: State Plane KY South, Feet, Nad 83

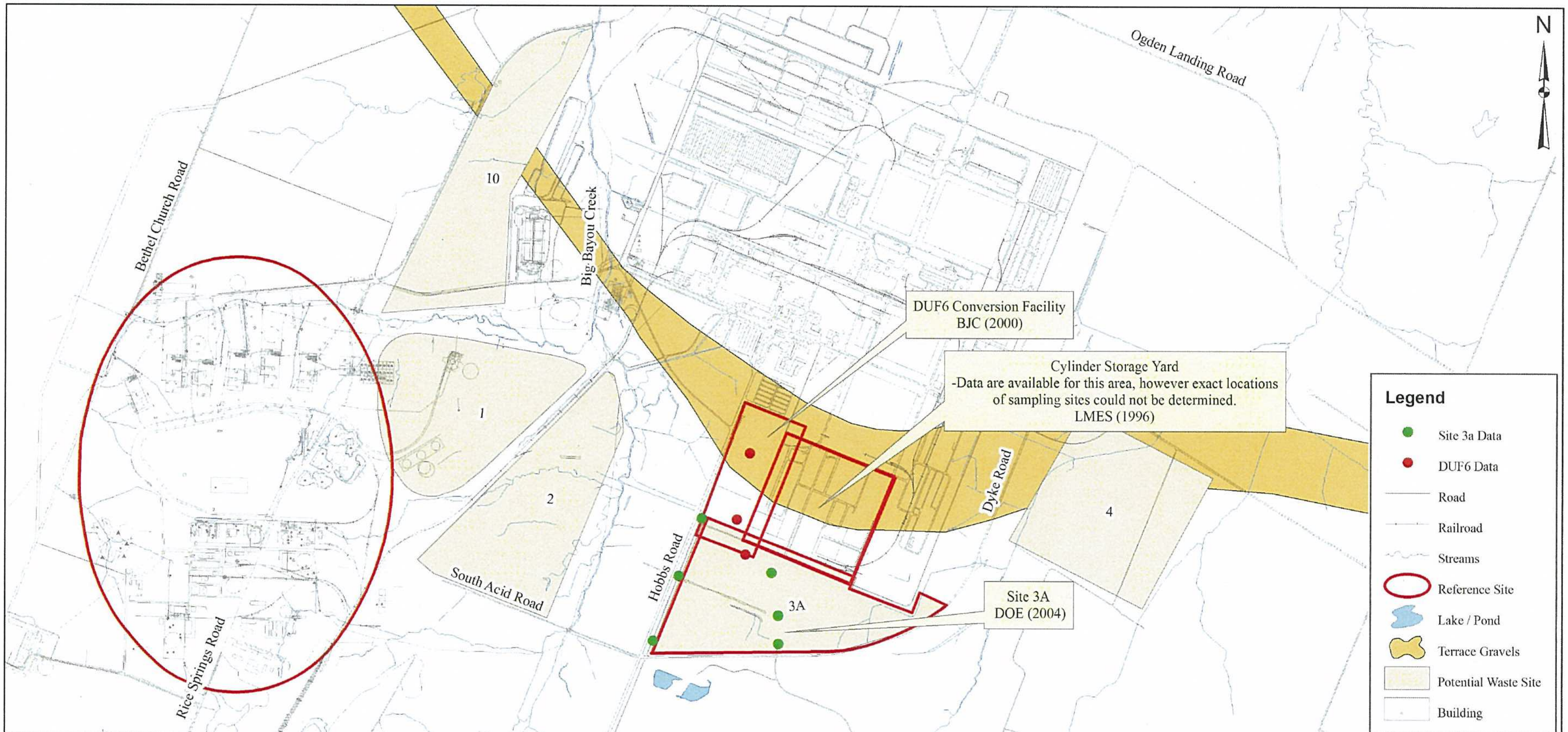
0 1,250 2,500 5,000 Feet

Figure 1: Locations of potential waste disposal facility sites in the Terrace setting and supporting geotechnical and hydrogeological information

Paducah Gaseous Diffusion Plant
Paducah, Kentucky

PADUCAH Remediation Services
A Portage Shaw Joint Venture Company

GEO Consultants, LLC
A Geological Engineering and Environmental Services Company
Kevil, Kentucky



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Map Source: State Plane KY South, Feet, Nad 83

0 1,250 2,500 5,000 Feet

Figure 2: Locations with available bulk density data

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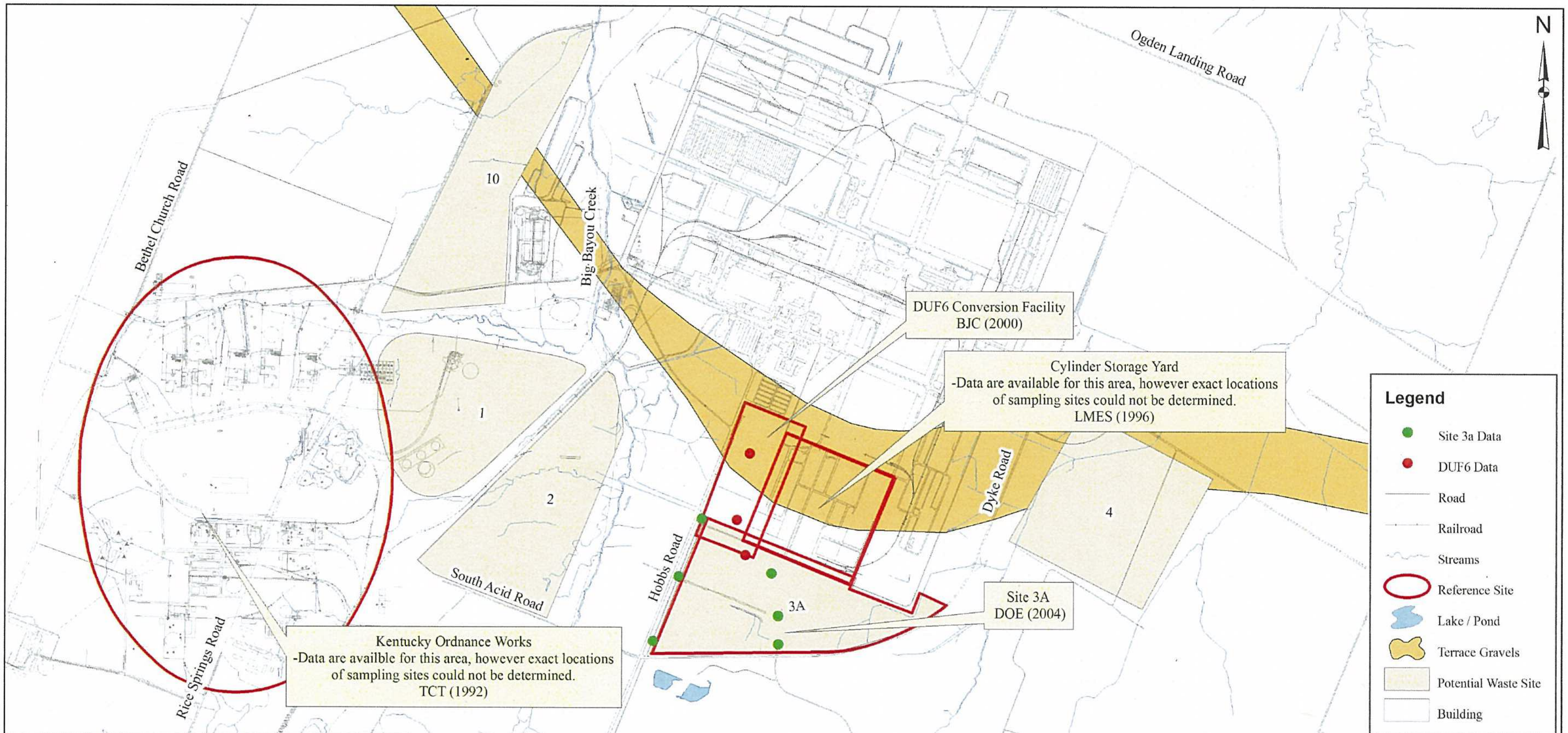

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Map Source: State Plane KY South, Feet, Nad 83

0 1,250 2,500 5,000 Feet

Figure 3: Locations with available moisture content data

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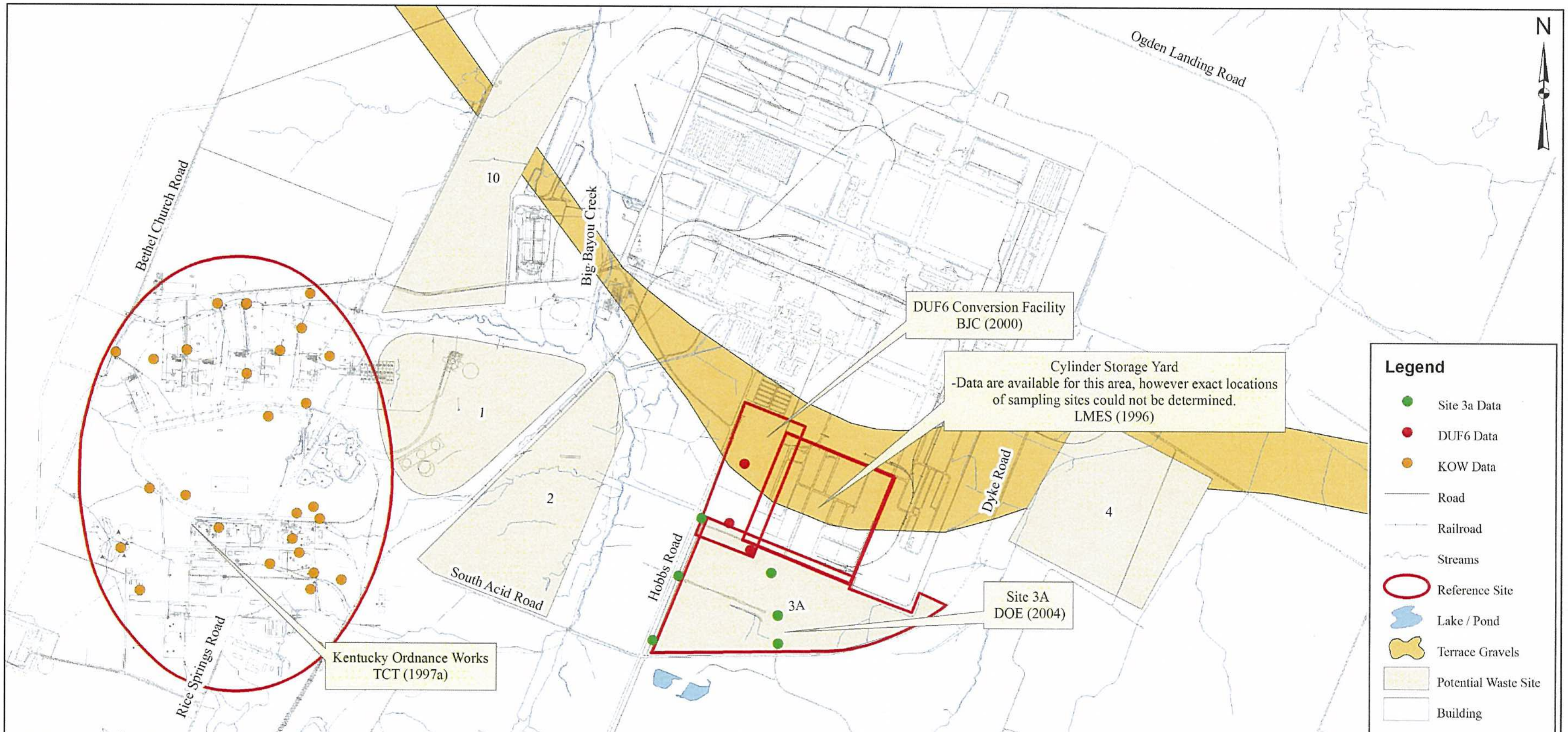

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Map Source: State Plane KY South, Feet. Nad 83

0 1,250 2,500 5,000 Feet

Figure 4: Locations with available porosity data

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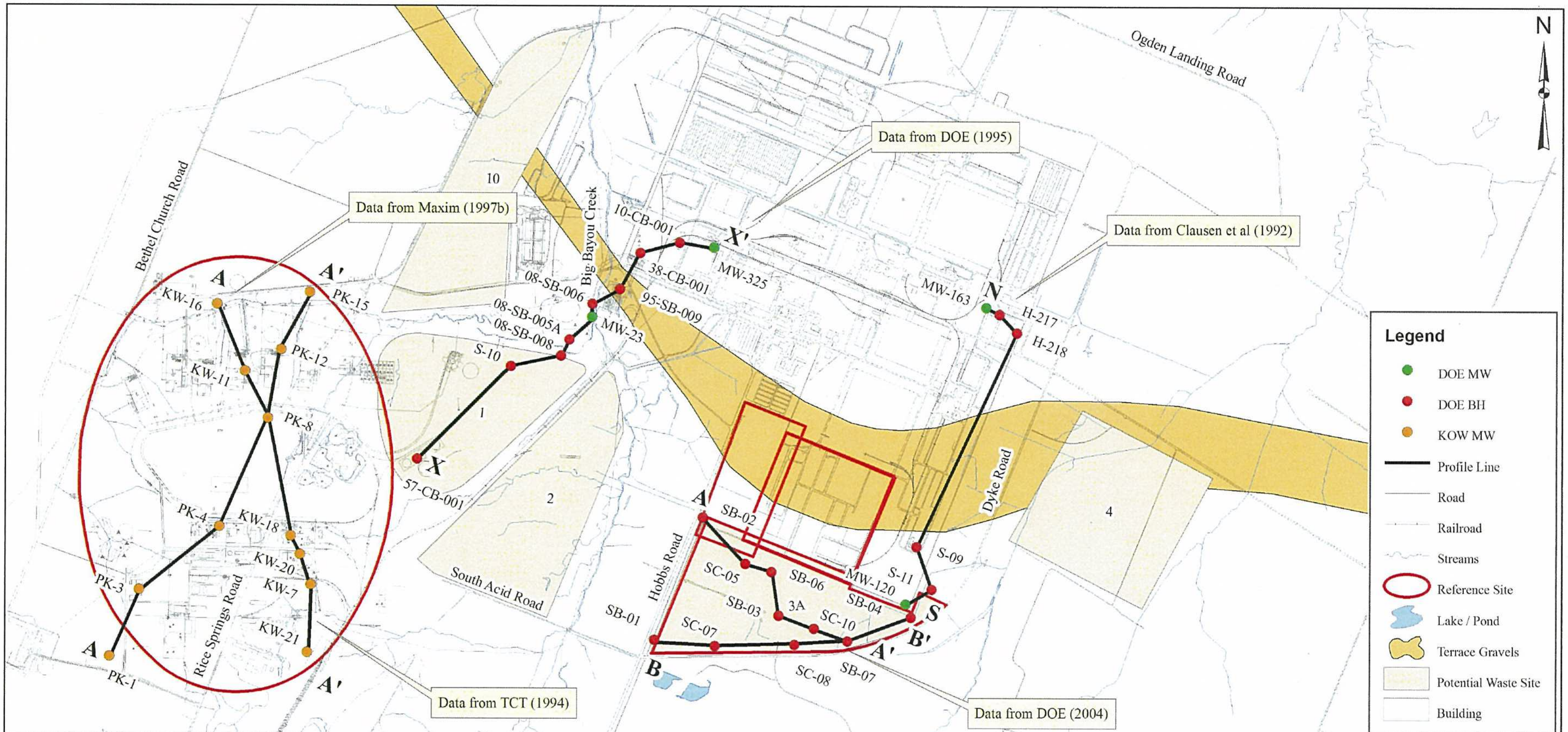

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Map Source: State Plane KY South, Feet, Nad 83

Figure 5: Profile lines for selected geologic cross sections

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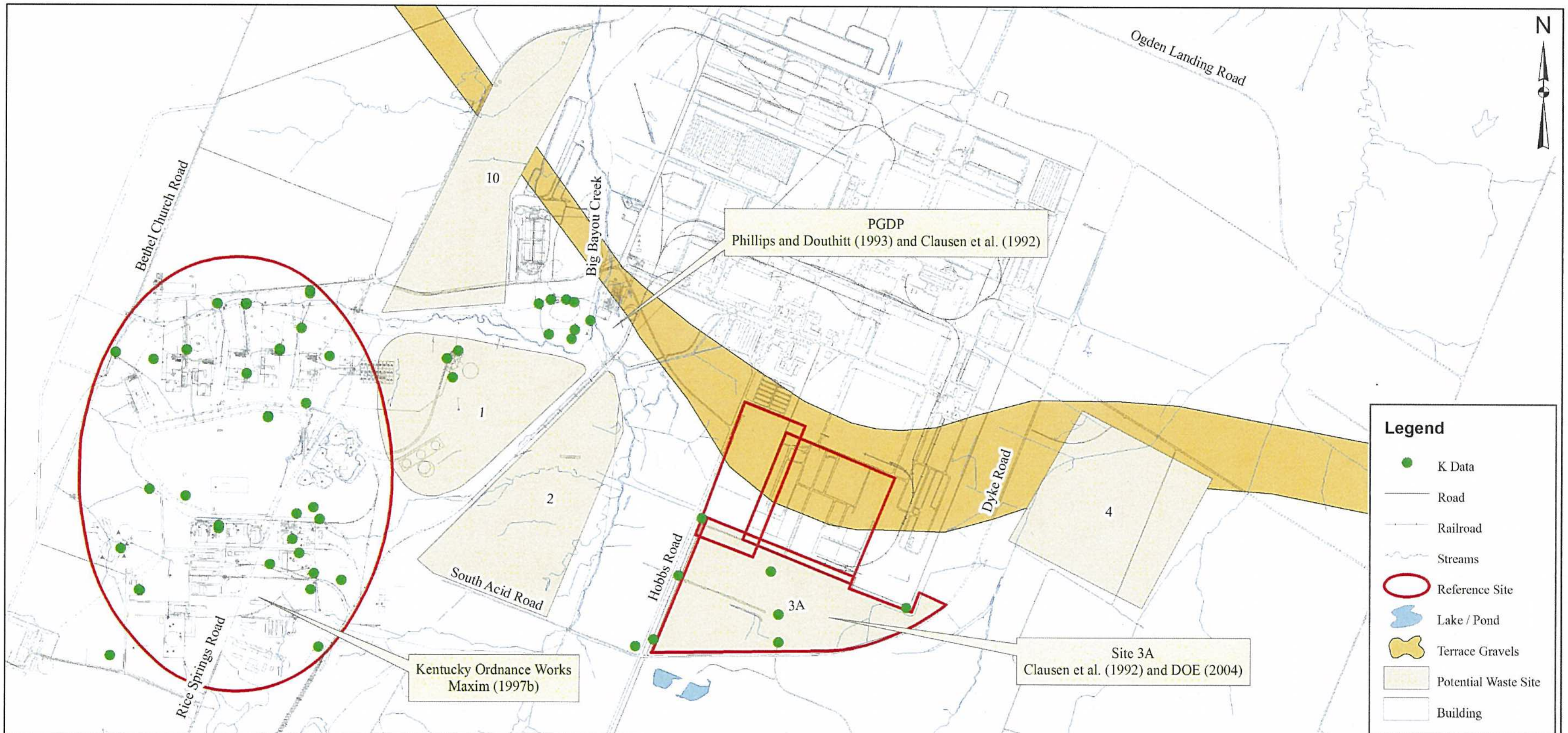

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Map Source: State Plane KY South, Feet, Nad 83

0 1,250 2,500 5,000 Feet

Figure 6: Locations with available hydraulic conductivity data for the Terrace Gravels and Porters Creek Clay

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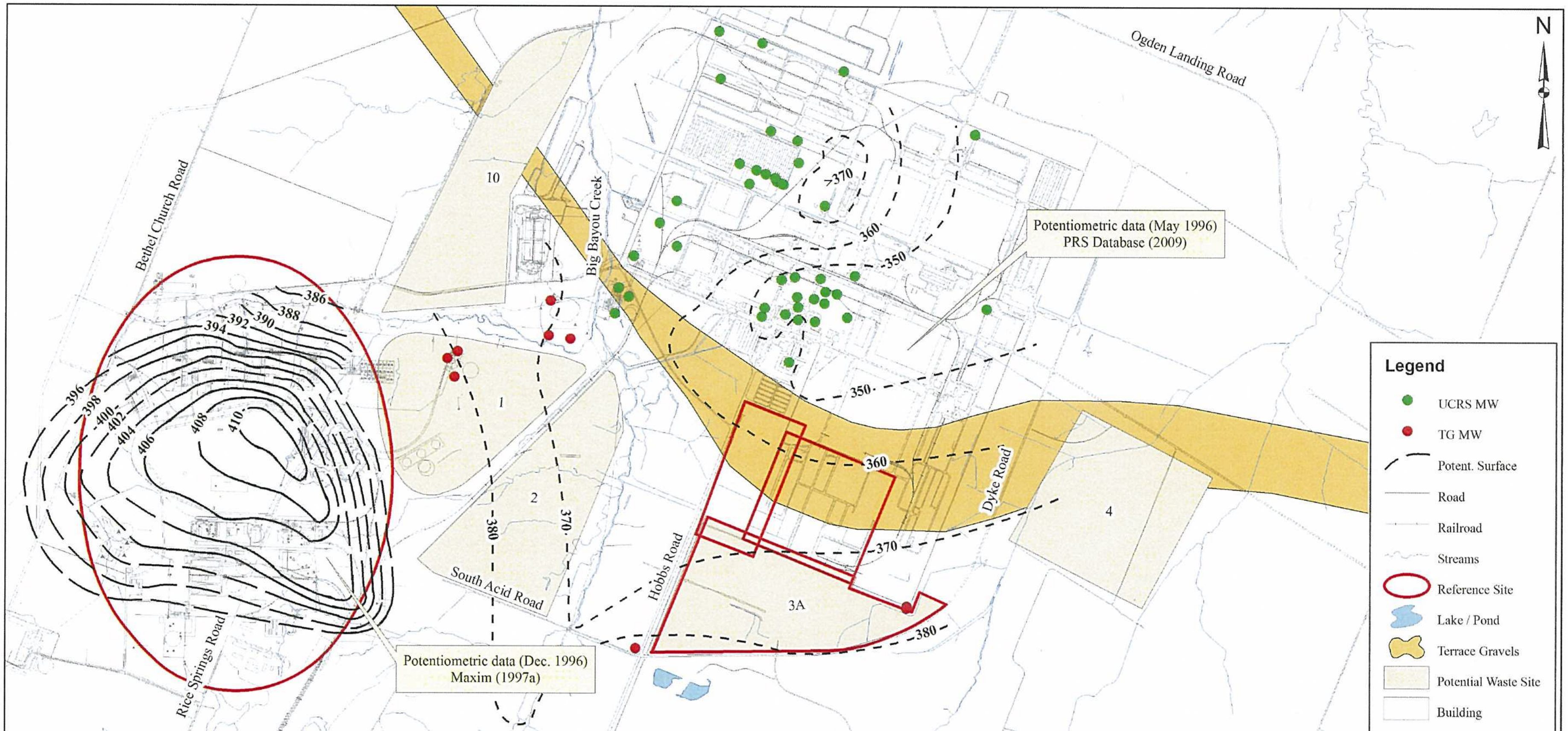

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Map Source: State Plane KY South, Feet. Nad 83

0 1,250 2,500 5,000 Feet

Figure 7: Locations with available water level data for the Terrace Gravels and UCRS units

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ATTACHMENT C3

CONSTRUCTION, CALIBRATION, AND PREDICTIONS OF THE 2011 PADUCAH GASEOUS DIFFUSION PLANT TERRACE GRAVEL GROUNDWATER FLOW MODEL

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C3.1. INTRODUCTION

A groundwater flow model was developed to predict groundwater flow paths from potential Comprehensive Environmental Response, Compensation, and Liability Act **(**CERCLA) cell waste disposal Sites 1 and 3A, located south of the Paducah Gaseous Diffusion Plant (PGDP) on the Terrace Gravel. These waste disposal sites, along with others, are being considered for disposal of demolition rubble and other materials associated with PGDP decommissioning.

The contents of this report are as follows.

- Section 2 discusses the technical approach used for the Terrace groundwater flow model development and calibration.
- Section 3 compiles and presents model input data used as part of the flow model.
- Section 4 presents the site hydrogeologic conceptual model that provides a summary of locations where water enters and leaves the groundwater system.
- Section 5 describes how the groundwater flow model was configured. Configuration, in this case, means the process by which the site hydrogeologic conceptual model is translated into a numerical model.
- Section 6 discusses the calibration and calibration results of the groundwater flow model.
- Section 7 presents the flow path predictions made using the groundwater flow model and includes an evaluation of parameter uncertainty on flow path predictions.
- Section 8 provides a summary of the modeling effort.
- Section 9 provides references used in the report.

C3.2. TECHNICAL APPROACH

Developing a Terrace Gravel groundwater flow model was problematic because of limited Terrace-specific hydrogeologic data and the absence of an accepted and verified Terrace conceptual model of groundwater flow. A groundwater flow system conceptual model is a description of where and in what quantity water enters and leaves the flow system, expected groundwater flow patterns, and factors influencing groundwater movement between recharge and discharge locations. One espoused conceptual model was that Terrace groundwater discharges to the Bayou Creek and associated tributaries. Another conceptual model hypothesized that Terrace groundwater flowed through the Gravel underlying the Terrace into the Upper Continental Recharge System (UCRS) and downward to the Regional Gravel Aquifer (RGA). The limited available hydrogeologic data made it impossible to determine which of these conceptual models was most representative or whether the "best" conceptual model was a hybrid of the two (Figure C3.1).

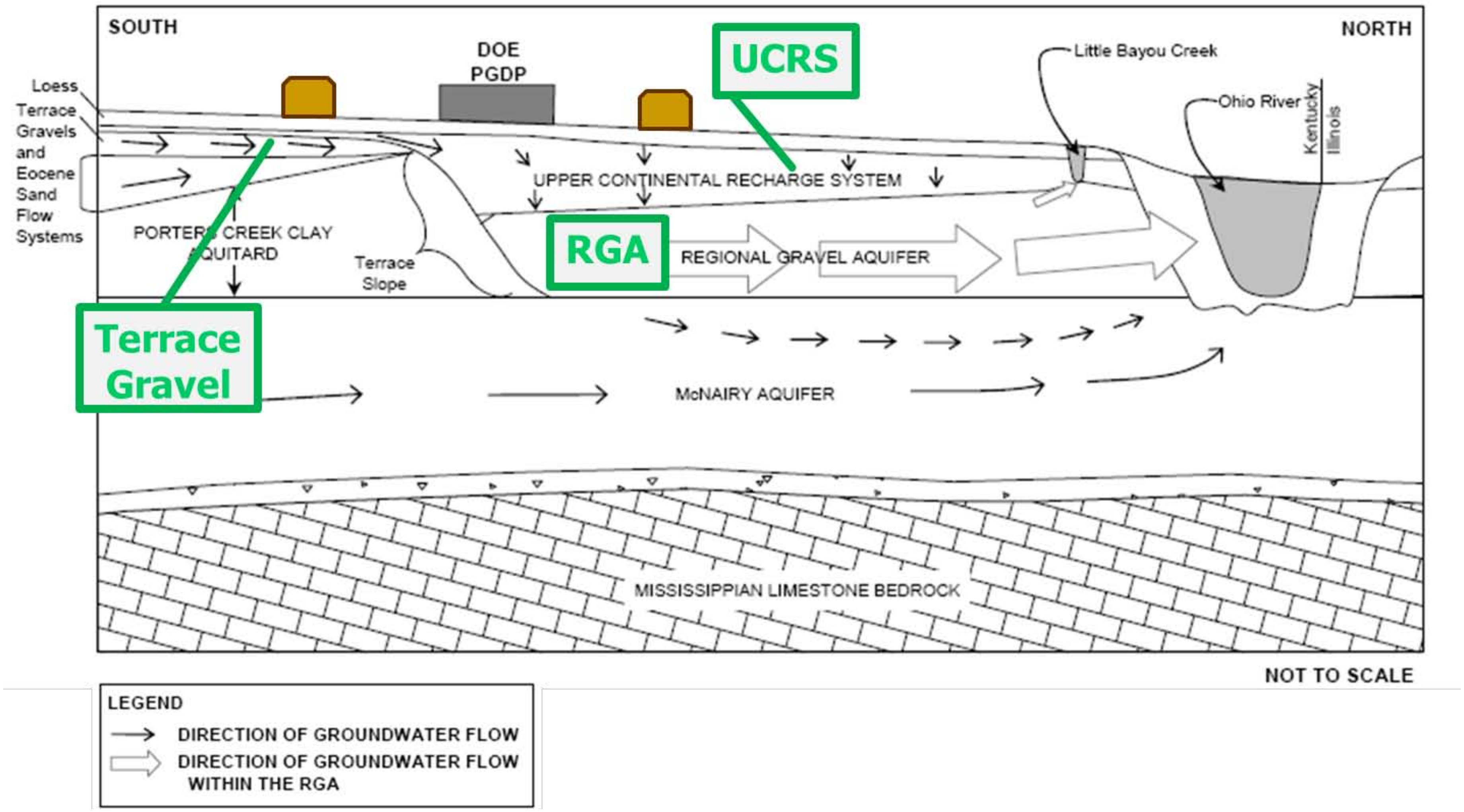


Figure C3.1. Geologic Cross-Section through PGDP

A solution to the Terrace groundwater flow system conceptual model uncertainty was to develop a MODFLOW (McDonald and Harbaugh 1988; and Harbaugh et al. 2000) groundwater flow model that combined what was known about the Terrace with the calibrated RGA groundwater flow model hydrologic parameters. Known Terrace information included topographic surface, locations of creeks and tributaries, and the top of the underlying impermeable Porters Creek Clay. The RGA model (PRS 2010) included anthropogenic and rainfall recharge rates and distributions, RGA hydraulic conductivities, and RGA model-predicted groundwater elevations. Combining known Terrace and RGA information yielded a model domain that allowed for unbiased evaluation of Terrace groundwater flow paths from potential CERCLA disposal cell Sites 1 and 3A.

After combining known entities, the Terrace groundwater flow model was calibrated by adjusting Terrace Gravel and UCRS bulk hydraulic conductivities and creek stage and conductance to best match Terrace groundwater levels. MODPATH (Pollack 1994) then was used to predict groundwater flow paths from the two sites of interest. Sensitivity analysis then was performed on the calibrated hydraulic conductivity values and creek stage and conductance to determine how variability in those parameter affects predicted groundwater flow paths.

C3.3. GROUNDWATER FLOW SYSTEM DATA COMPILATION

This section summarizes data collected during previous site characterization activities and RGA groundwater flow model calibration results. No additional characterization or data analysis has been performed as part of this modeling effort. These documents—GEO report (2009) and PGDP Sitewide Groundwater Flow Model (PRS 2010)—may be reviewed for a more in depth discussion of site hydrogeology and hydraulic properties and behavior of the groundwater flow system at the PGDP site.

C3.3.1 SITE GEOLOGY

The Terrace is underlain, from ground surface to depth, by a surficial loess, Terrace Gravel and the Porters Creek Clay (Figure C3.1). The Terrace Gravel connects to the lower permeability UCRS, which overlies the permeable RGA. Isolating the permeable Terrace Gravel from the permeable RGA is the impermeable Porters Creek Clay.

C3.3.2 SURFACE WATER FEATURES

Bayou and Little Bayou Creeks and associated tributaries flow across the Terrace (Figure C3.2). Of the two creeks, only Bayou Creek and associated tributary are perennial. Stream flow data for the Bayou Creek station near PGDP from 1991 to 2010 is available online from the U.S. Geological Survey (USGS) (station 03611800 Bayou Creek). The average, minimum, and maximum annual flow in the creek for the period of record is 6.6, 2.2, and 13.2 cubic feet per second (cfs), respectively. The flow rate used in the modeling is within this range of flows.

Bayou Creek flow rates have been measured in the lower portions of Bayou Creek north of the PGDP where the creek traverses the UCRS, at a rate of 166 gpm over a distance of 7,000 ft. On the Terrace, Bayou Creek and associated tributary have a combined length of 17,300 ft.

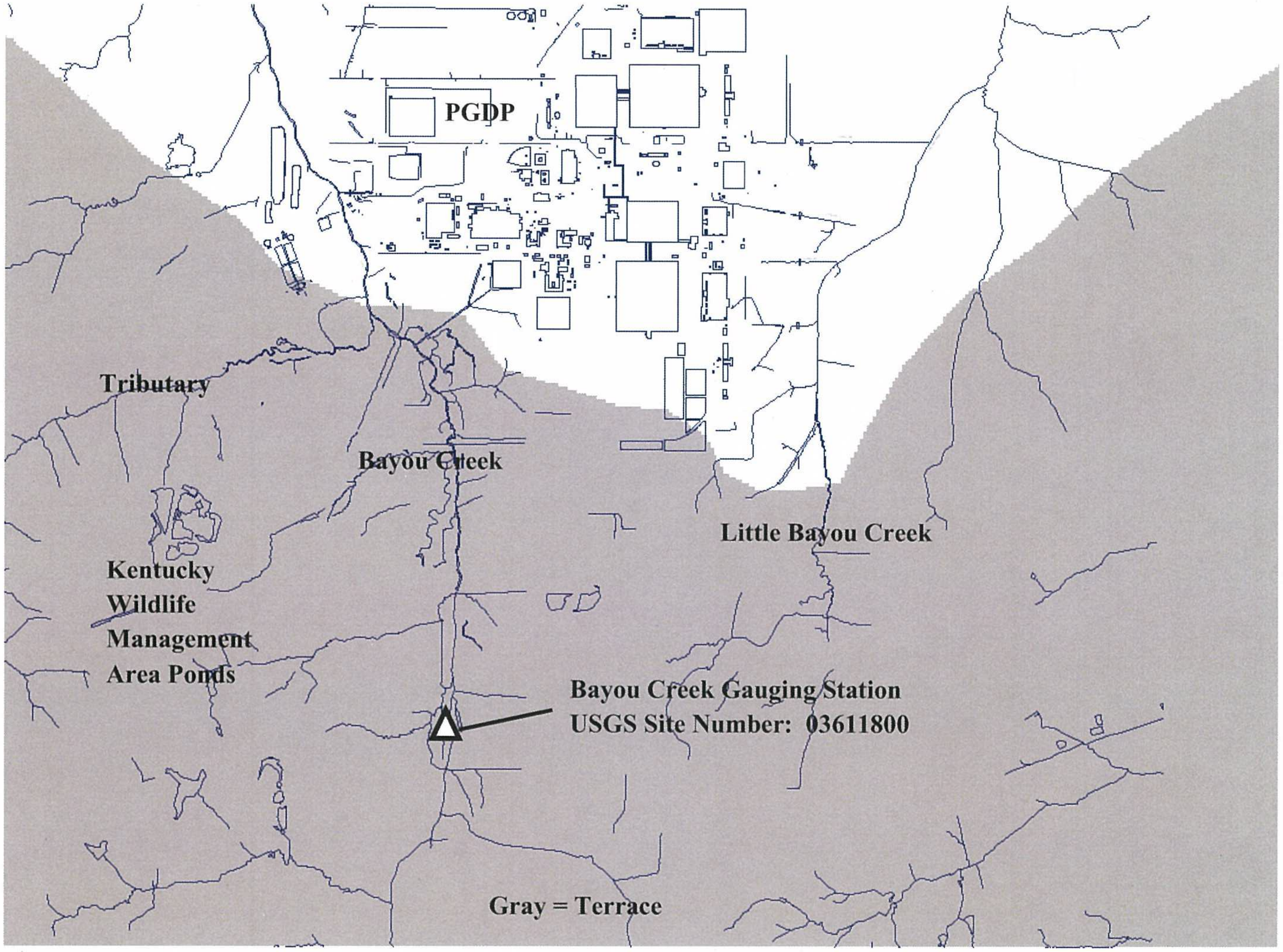


Figure C3.2. Terrace Surface Water Features

C3.3.3 GROUNDWATER WATER LEVELS

Groundwater levels have been collected sporadically from Terrace groundwater wells. Because of the inconsistency in collection frequencies and times, average groundwater levels were calculated for eight Terrace wells (Table C3.1). Also listed in the Table are 50 RGA groundwater levels, located within the PGDP, used to calibrate the current RGA groundwater flow model.

C3.3.4 HYDRAULIC PROPERTIES

Slug tests performed in Terrace wells yield hydraulic conductivity values ranging from 1 to 14 ft/d (GEO 2009). It is important to recognize that due to the limited volume of water added or removed during a slug test that the test results are only representative of the aquifer volume immediately surrounding the well screen, including the smear layer that typically develops along the borehole sides during drilling. Because of the measured hydraulic conductivity includes the low hydraulic conductivity smear layer, slug test determined hydraulic conductivity values typically underestimate hydraulic conductivity. Thus, it is likely that the actual Terrace hydraulic conductivity is greater than the reported range of 1 to 14 ft/d.

Slug testing also has been performed in 20 UCRS monitoring wells, which have yielded hydraulic conductivity estimates of between 2.9×10^{-5} and 1.96 ft/day, with an average value of 0.28 ft/day (PRS 2010). As with the Terrace slug test results, the UCRS slug test derived hydraulic conductivity measurements may undervalue the actual UCRS hydraulic conductivity.

C3.3.5 RECHARGE

Rainfall recharge at PGDP is estimated to range between 2.64 to 7.64 inches/year. The calibrated rainfall recharge value used in the groundwater flow model is 7.44 inches/year. It is assumed that this recharge rate is applicable to the Terrace.

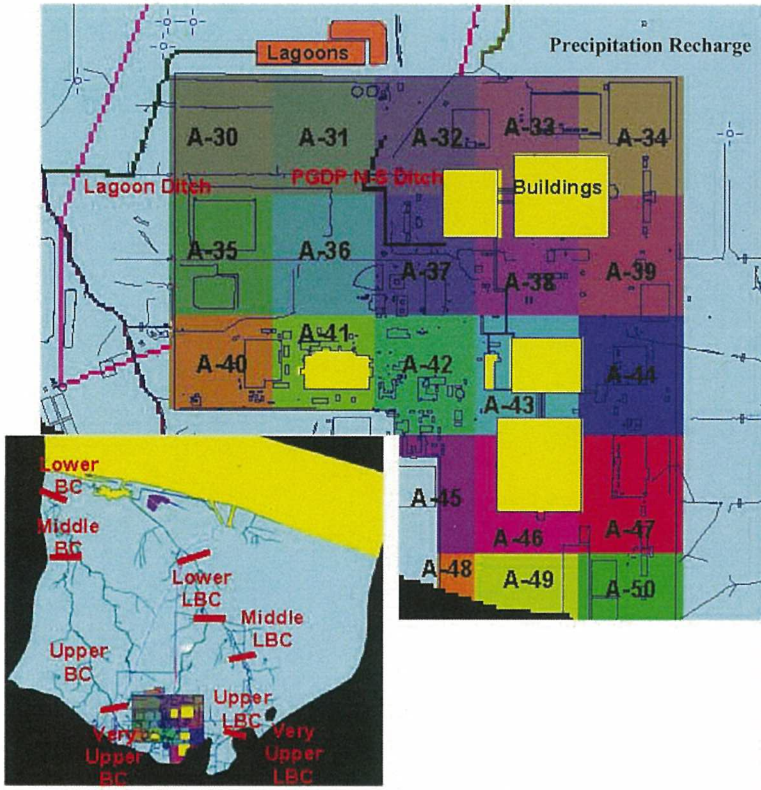
Flow model calibrated anthropogenic recharge values range from 0 to approximately 115 inches/year (Figure C3.3).

C3.4. GROUNDWATER FLOW SYSTEM CONCEPTUAL MODEL

A hydrological conceptual model is a description of how, where, and in what quantities water enters a groundwater flow system and the factors controlling groundwater movement between inflow and outflow locations. The conceptual model is derived from site-specific data and is intended to assimilate and condense concepts and ideas about the flow system into a series of statements that will guide model configuration and calibration. The following, based on the data presented in Section 3 of this attachment, constitutes the Terrace Gravel site conceptual model (Figure C3.1).

Table C3.1. Terrace (Average) and RGA Water-level Elevations

Well	Target (feet)	Hydrostratigraphic Unit	Type
MW196	378.32	Terrace	Average
MW300	366.66	Terrace	Average
MW301	365.36	Terrace	Average
MW302	374.50	Terrace	Average
MW309	375.00	Terrace	Average
MW310	378.15	Terrace	Average
MW311	380.72	Terrace	Average
MW317	374.42	Terrace	Average
MW191	325.24	RGA	RGA Model Calibration Target
MW327	326.62	RGA	RGA Model Calibration Target
MW106	325.41	RGA	RGA Model Calibration Target
MW126	325.29	RGA	RGA Model Calibration Target
MW145	325.68	RGA	RGA Model Calibration Target
PZ107	327.72	RGA	RGA Model Calibration Target
MW144	325.74	RGA	RGA Model Calibration Target
MW163	326.35	RGA	RGA Model Calibration Target
MW156	326.62	RGA	RGA Model Calibration Target
MW159	326.50	RGA	RGA Model Calibration Target
MW165	326.30	RGA	RGA Model Calibration Target
MW168	326.37	RGA	RGA Model Calibration Target
MW169	325.22	RGA	RGA Model Calibration Target
MW173	326.28	RGA	RGA Model Calibration Target
MW178	326.65	RGA	RGA Model Calibration Target
MW185	326.18	RGA	RGA Model Calibration Target
MW188	326.70	RGA	RGA Model Calibration Target
MW205	325.15	RGA	RGA Model Calibration Target
MW206	325.89	RGA	RGA Model Calibration Target
MW227	326.97	RGA	RGA Model Calibration Target
MW328	326.07	RGA	RGA Model Calibration Target
MW329	326.12	RGA	RGA Model Calibration Target
MW330	326.87	RGA	RGA Model Calibration Target
MW63	325.88	RGA	RGA Model Calibration Target
MW66	324.97	RGA	RGA Model Calibration Target
MW67	326.82	RGA	RGA Model Calibration Target
MW71	325.24	RGA	RGA Model Calibration Target
MW84	326.34	RGA	RGA Model Calibration Target
MW87	326.32	RGA	RGA Model Calibration Target
MW90	326.02	RGA	RGA Model Calibration Target
PZ107	327.72	RGA	RGA Model Calibration Target
PZ110	326.54	RGA	RGA Model Calibration Target
PZ117	327.03	RGA	RGA Model Calibration Target
MW161	326.65	RGA	RGA Model Calibration Target
MW175	326.71	RGA	RGA Model Calibration Target
MW325	325.64	RGA	RGA Model Calibration Target
MW326	326.76	RGA	RGA Model Calibration Target
MW327	326.62	RGA	RGA Model Calibration Target
MW79	326.43	RGA	RGA Model Calibration Target
MW93	326.32	RGA	RGA Model Calibration Target
PZ109	326.56	RGA	RGA Model Calibration Target
PZ118	326.31	RGA	RGA Model Calibration Target
W108	326.82	RGA	RGA Model Calibration Target
MW158	327.03	RGA	RGA Model Calibration Target
MW163	326.35	RGA	RGA Model Calibration Target
MW226	326.94	RGA	RGA Model Calibration Target
MW86	325.85	RGA	RGA Model Calibration Target
MW89	325.75	RGA	RGA Model Calibration Target
MW92	325.78	RGA	RGA Model Calibration Target
MW95	325.72	RGA	RGA Model Calibration Target



Parameter	In/yr	Ratio
Precipitation	7.44	1.00
Buildings	18.60	2.50
Lagoon	114.83	15.45
Lagoon Ditch	88.18	11.86
PGDP N-S Ditch	11.59	1.56
Very Upper BC	24.53	3.30
Upper BC	148.55	19.98
Middle BC	18.32	2.46
Lower BC	-986.18	-132.64
Tributary BC	6.94	0.93
Very Upper LBC	148.89	20.03
Upper LBC	40.77	5.48
Middle LBC	2.64	0.35
Lower LBC	-938.91	-126.28
Tributary LBC	41.69	5.61
A-30	25.60	3.44
A-31	4.33	0.58
A-32	71.38	9.60
A-33	17.23	2.32
A-34	65.09	8.75
A-35	9.53	1.28
A-36	0.00	0.00
A-37	0.00	0.00
A-38	0.00	0.00
A-39	41.50	5.58
A-40	0.23	0.03
A-41	2.79	0.38
A-42	6.37	0.86
A-43	114.83	15.45
A-44	12.43	1.67
A-45	55.45	7.46
A-46	1.65	0.22
A-47	0.03	0.00
A-48	0.02	0.00
A-49	0.23	0.03
A-50	0.05	0.01

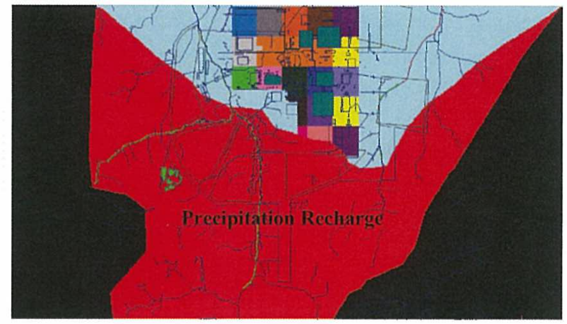


Figure C3.3. Anthropogenic Recharge Distribution and Recharge Rates

C3.4.1 HYDROSTRATIGRAPHY

Simplistically the Terrace hydrostratigraphy consists of the following units listed in descending order:

- Surficial loess
- Terrace Gravel
- Porters Creek Clay

The Terrace Gravel contacts the UCRS that overlies the RGA. The impermeable Porters Creek Clay isolates the permeable Terrace Gravel from the permeable RGA.

C3.4.2 RECHARGE

Precipitation infiltration recharges the Terrace Gravel at a rate of between 2.64 to 7.64 inches/year. North of the Terrace at PGDP anthropogenic recharge is spatially variable and occurs at rates ranging from 0 to approximately 115 inches/year. For modeling purposes, the anthropogenic recharge is assumed to be 0 inches/year.

C3.4.3 GROUNDWATER DISCHARGE

Groundwater discharges to Bayou Creek and the associated tributaries. Groundwater not captured by Bayou Creek and tributaries flows into the UCRS and then downward into the RGA. The volumes of Terrace Gravel groundwater discharging to the creek and the UCRS have not been measured.

C3.4.4 HYDRAULIC CONDUCTIVITY

Slug tests results used to determine Terrace Gravel hydraulic conductivity range from 1 to 14 ft/d. Because of the limited aquifer volume tested and the likely presence of a smear layer along the walls of the borehole, slug tests typically underestimate aquifer hydraulic conductivity. Thus, it is possible that Terrace hydraulic conductivities are greater than 14 ft/d. Adjacent UCRS hydraulic conductivities are less than 1 ft/d. Porters Creek Clay hydraulic conductivity is much less than the overlying Terrace Gravel hydraulic conductivity (GEO 2009).

C3.5. MODEL CONFIGURATION

Model configuration involves translating the site conceptual hydrogeological model onto a two- or three-dimensional grid and locating boundary conditions and individual aquifer parameter zones within the model domain. Boundary conditions represent hydraulic features such as surface water bodies and groundwater divides. Parameter zones represent areas within the model domain having the same numerical value for a specific input parameter. This section details the process of translating the site conceptual model discussed in Section C3.4 of this attachment into a numerical groundwater flow model.

C3.5.1 MODEL DISCRETIZATION

The model used for this study incorporated the southern portions of the current RGA model with the Terrace Gravel and overlying UCRS. The transformation was accomplished by adding a model layer that included the Terrace Gravel and UCRS above the three RGA model layers. Similar to the current RGA model, the Terrace Gravel model (consisting of 295 rows and 525 columns) utilized uniform 50-ft by 50-ft grid cells. The bottom of Model Layer 4 corresponds to the top of the McNairy Formation.

C3.5.2 MODEL BOUNDARY CONDITIONS

Model boundary conditions contribute, remove, or prevent the movement of water within the model domain. Because recharge adds water to the model domain, recharge is a boundary condition; however, recharge is viewed as a parameter (analogous to hydraulic conductivity) within the modeling community not as a boundary and, as such, will be discussed in Section C3.5.3.

Figure C3.4 shows the boundaries located in Model Layer 1. Bayou Creek and associated tributaries were simulated using river cells and were assigned creek stage elevations 1 ft below the topographic surface. River cells can add or remove water from the model domain depending on the relationship between the river head and adjacent simulated groundwater levels. Where the river cell head is higher than the adjacent simulated groundwater level, water flows from the river cell to the aquifer. When adjacent simulated groundwater levels are higher than the river head, groundwater discharges to the river cell. River cells also contain a conductance term that provides resistance to flow in and out of the river cells.

Little Bayou Creek was not included in the model domain because the creek, when traversing the Terrace, only flows in response to storm runoff. In the absence of storm runoff the creek is dry. West Kentucky Wildlife Management Area (WKWMA) ponds also were simulated using river cells and similarly assigned stage elevations 1 ft below the Terrace topographic surface.

The black areas shown in Figure C3.4 are no-flow cells and, as the name implies, water does not enter or leave these cells. No-flow sections of models can be identical parametrically to active portions of the model. For example, both the eastern and western no-flow areas are hydraulically similar to the active portions of the model. The no-flow portions of the model are on the other side of groundwater divides (which are assumed to correspond to surface water divides) and, as such, are hydraulically isolated from groundwater flow within the model domain.

In Model Layers 2 through 4, representing the RGA, the no-flow boundary cells represent the impermeable Porters Creek Clay (Figure C3.5). Constant head boundary cells are located along the northern edge of the model domain and were assigned groundwater elevations corresponding to the RGA model-predicted groundwater levels at those locations.

C3.5.3 PARAMETER DISTRIBUTIONS

While model boundary conditions contribute, remove, or prevent the movement of water, model parameters, in a general sense, control the water movement within the model domain. An example of a model parameter is hydraulic conductivity. The ease at which water moves through the model domain is directly correlated to hydraulic conductivity. The greater the hydraulic conductivity value, the more transmissive the porous media. Other parameters, such as recharge, while technically a boundary condition, control the location and magnitude of water entering the model domain and, as such, will be discussed in this section.

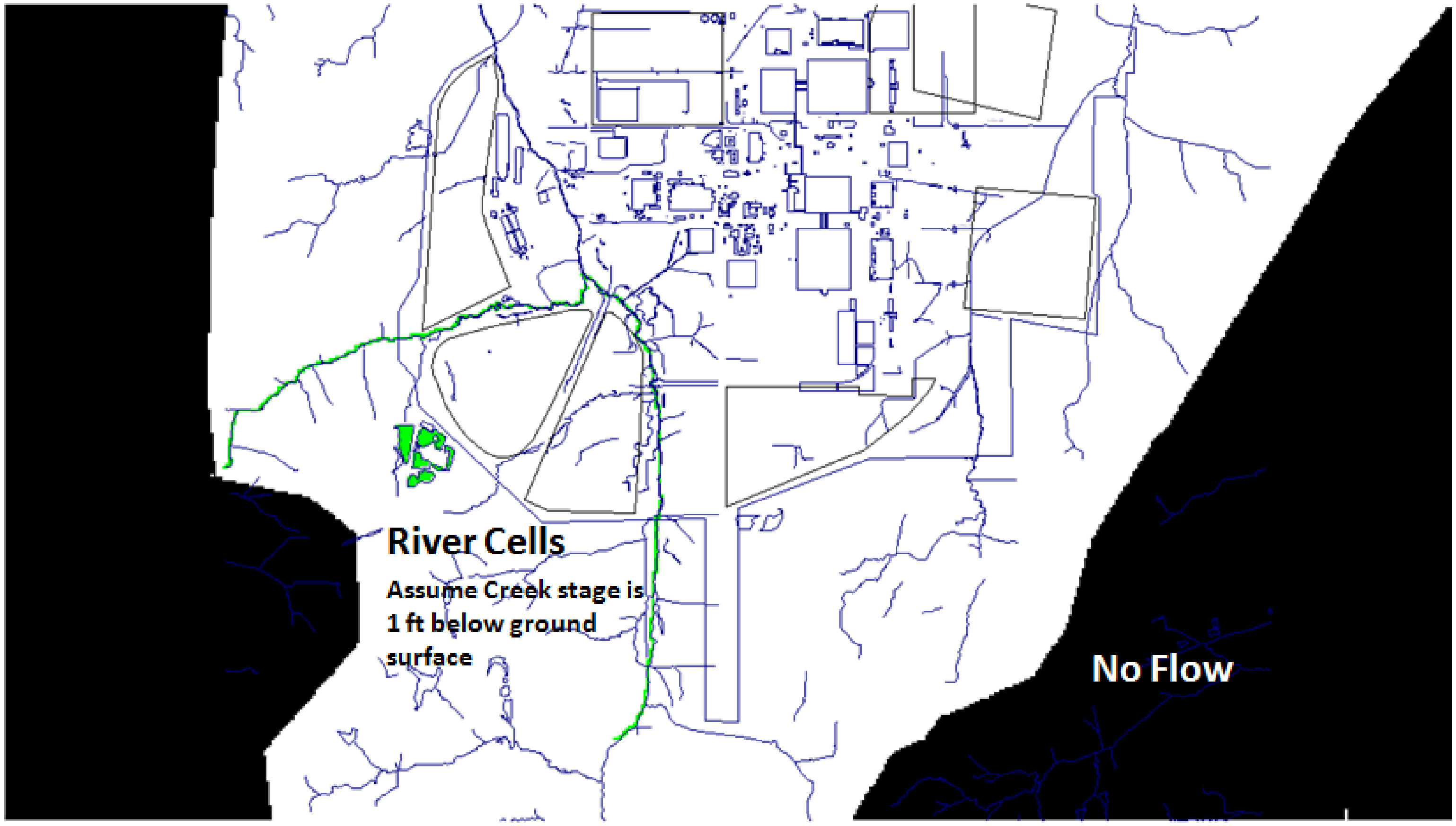


Figure C3.4. Model Layer 1 Boundary Conditions

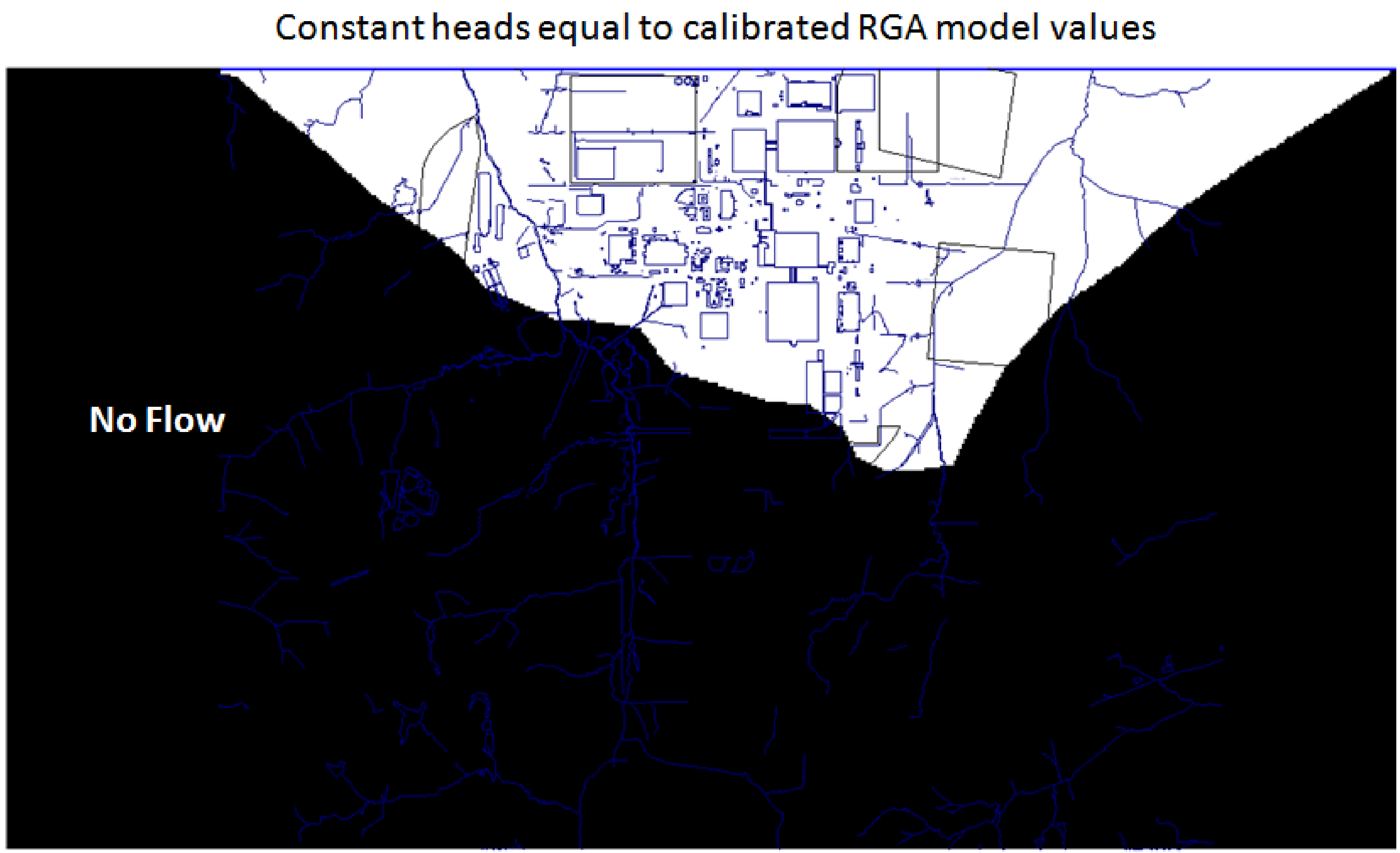


Figure C3.5. Model Layers 2 through 4 Boundary Conditions

C3.5.3.1 Hydraulic Conductivity Zonation

Horizontal hydraulic conductivity in Model Layer 1 was divided into two zones representing the Terrace Gravel and the UCRS (Figure C3.6). Horizontal hydraulic conductivity in Model Layers 2 through 4, representing the RGA, was variable and was assigned values equivalent to the calibrated current RGA model (Figure C3.7). Vertical hydraulic conductivity was assumed to be one-tenth of the horizontal hydraulic conductivity established throughout the modeling domain.

C3.5.3.2 Recharge Zonation

Recharge associated from precipitation was assigned to all cells except those containing anthropogenic features (Figure C3.8). Two recharge precipitation zones are used, one representing the Terrace and the other the UCRS. The discretization is for groundwater mass balance evaluation purposes only, as recharge is assumed to be the same in both areas.

The anthropogenic recharge distribution and rates used in the Terrace model during calibration is identical to that used in the current calibrated RGA model (Figure C3.3). During subsequent modeling, anthropogenic recharge zones were assigned recharge as if no anthropogenic activity were occurring.

C3.5.3.3 Other Parameters

Other input parameters to the flow model included porosity and river conductances. Porosity within the model domain (all layers) was assigned a uniform value of 30%. River conductances were determined during calibration.

C3.6. MODEL CALIBRATION

Model calibration was performed using PEST (Doherty 1999 and 2004). PEST is a parameter estimation code that automatically determines the parameter values that best fit calibration targets for a model as configured. Parameters are the model input values that are adjusted during model calibration. Examples used in this model are hydraulic conductivity and river cell conductance. While the underlying mathematics comprising parameter estimation is formidable and complex, the concept behind the parameter estimation algorithm is rather simple and is identical to the thought process used with traditional manual trial-and-error calibration. That is, find the combination of parameters that results in the smallest difference between observed and model-predicted water levels (and any other calibration targets). While conceptually similar, parameter estimation offers several advantages over trial-and-error model calibration. Parameter estimation results in a nonbiased answer for a given model configuration. The estimated parameters always will be the set of parameter values that results in the lowest calibration error for the model as configured.

For the Terrace Model, only Terrace Gravel and UCRS hydraulic conductivity and river cell conductance were adjusted during calibration. The RGA hydraulic conductivity distribution and values were fixed during calibration corresponding to the calibrated RGA model. Similarly, the RGA model calibrated precipitation and anthropogenic recharge distributions and values were adopted for the Terrace model and were not adjusted during calibration.

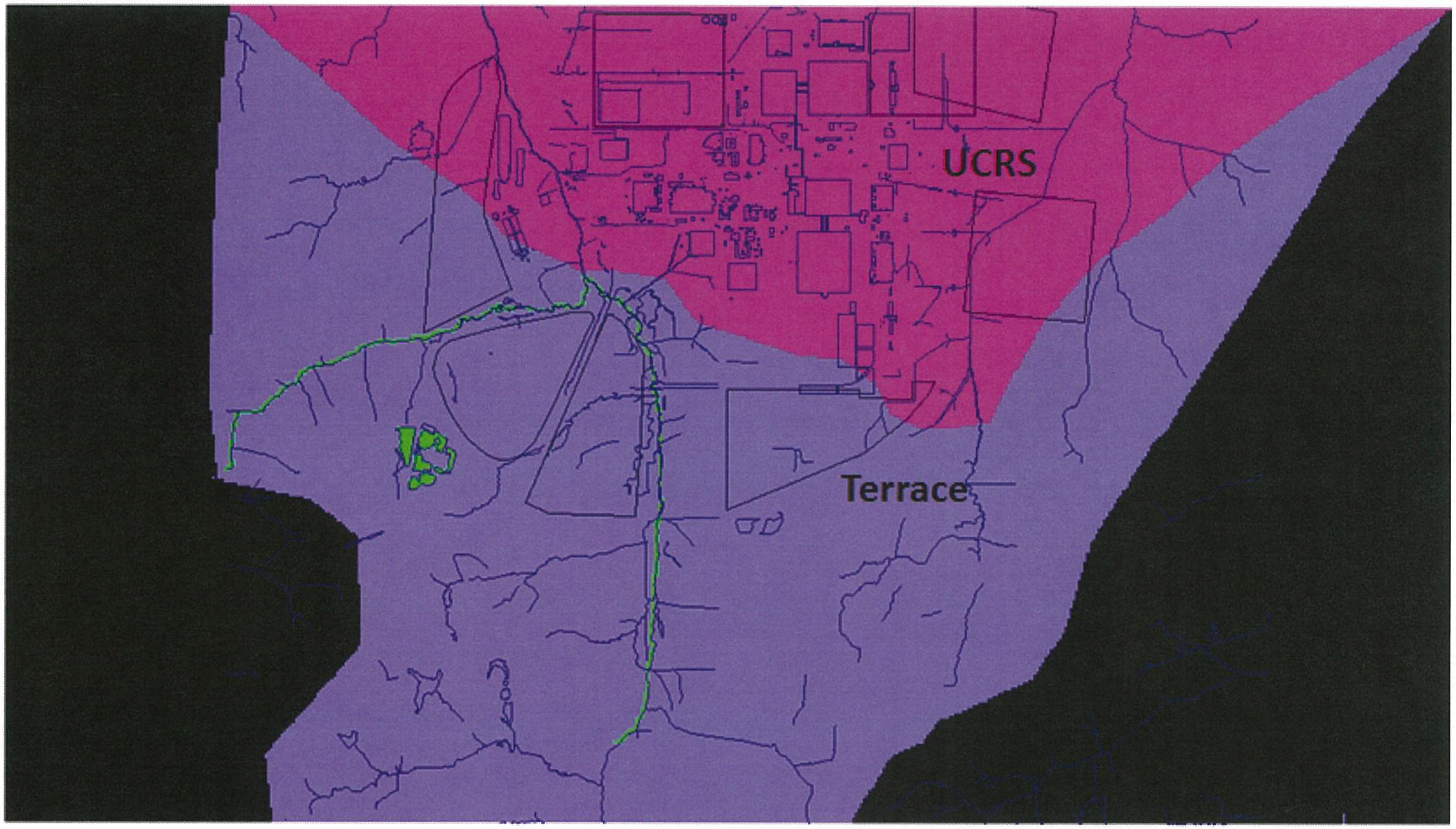


Figure C3.6. Model Layer 1 Hydraulic Conductivity Distribution

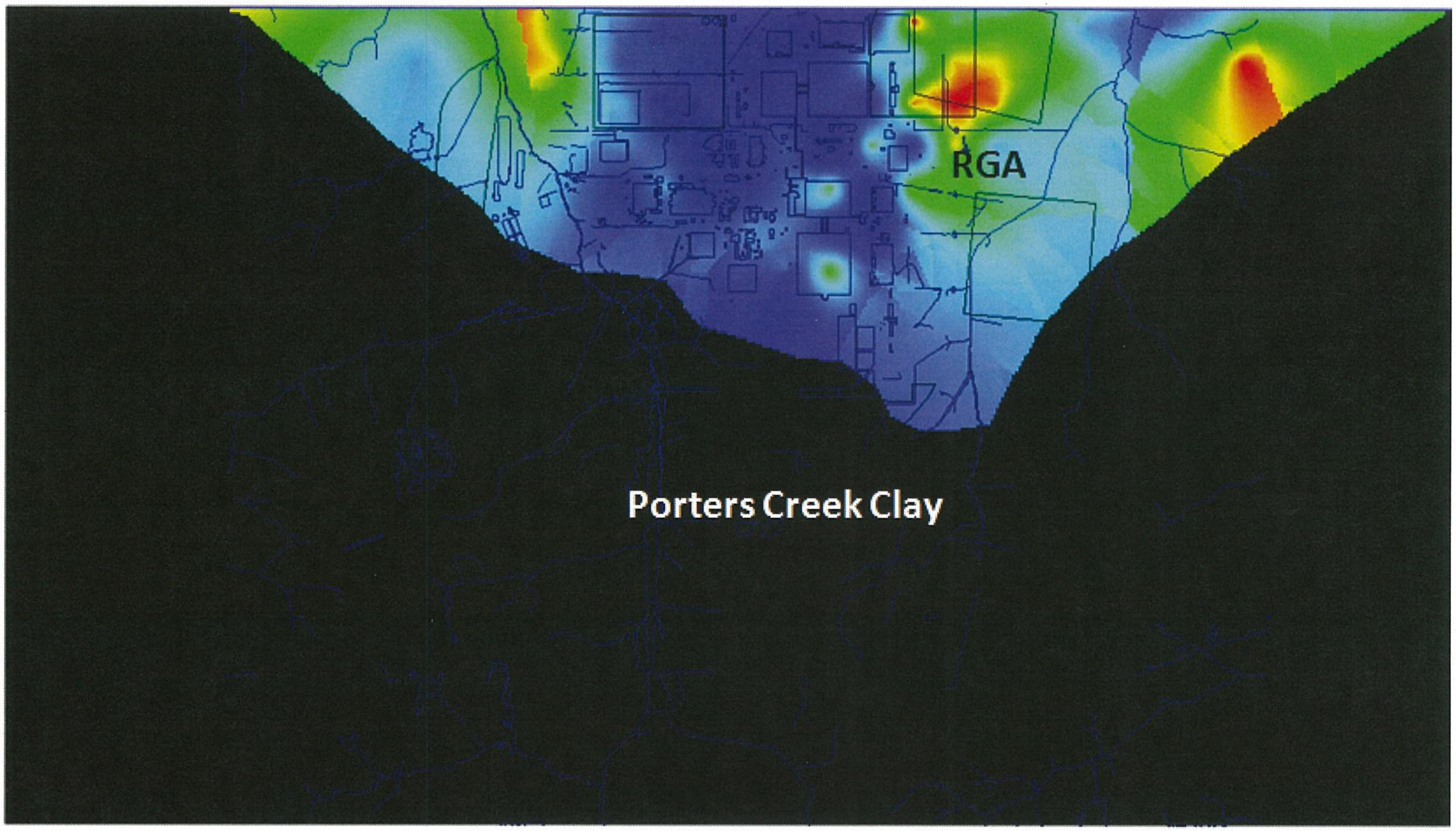


Figure C3.7. Model Layer 2 Hydraulic Conductivity Distribution

Red and Lt. Blue represent recharge from precipitation

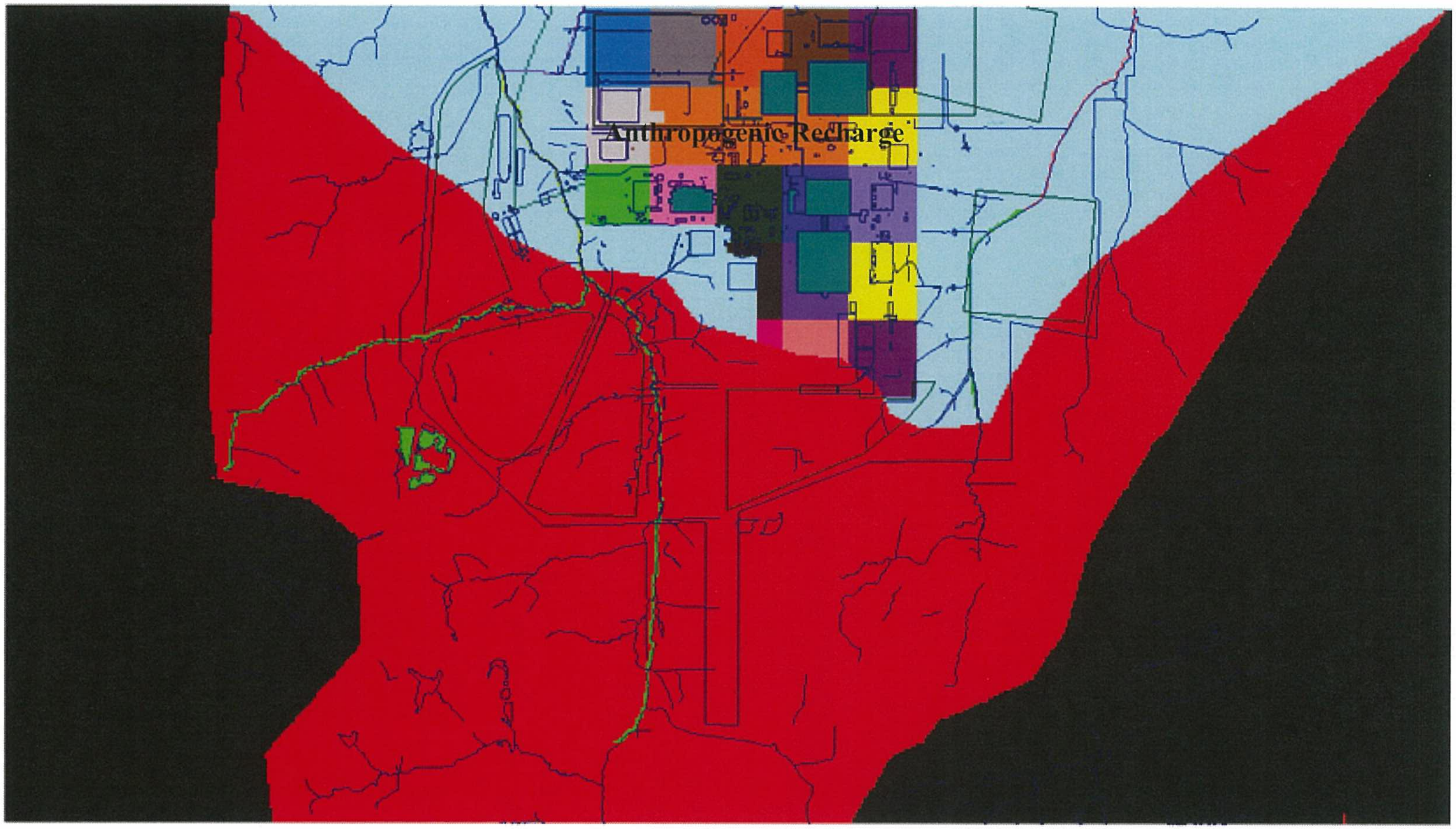


Figure C3.8. Recharge Distribution

C3.6.1 CALIBRATION TARGETS

Model calibration requires calibration targets to be set as benchmarks for evaluating the agreement between the model-generated values and the target values. The easiest calibration targets to obtain and the most common are water-level elevations obtained from groundwater wells. Average groundwater levels from eight Terrace wells were used as Model Layer 1 calibration targets (Figure C3.9 and Table C3.1). Groundwater levels from 50 RGA wells were used to calibrate the RGA model also were used as calibration targets for the Terrace model (Table C3.1).

C3.6.2 CALIBRATION RESULTS

The calibration results with respect to predicted hydraulic conductivity distributions, river conductance, and target agreement are now discussed.

C3.6.2.1 Estimated Hydraulic Conductivity and River Conductance Values

The calibrated model estimated Terrace Gravel and UCRS hydraulic conductivities at 93 ft/d and 0.34 ft/d, respectively. The calibrated Terrace Gravel hydraulic conductivity is greater than the maximum reported value of 14 ft/d. As previously discussed (Section C3.3.4), Terrace Gravel hydraulic conductivity was measured using the slug test method, which typically under predicts aquifer hydraulic conductivity. Additionally, the Terrace Gravel, as the moniker indicates, is comprised of gravel. Gravel typically has hydraulic conductivities of greater than 100 ft/d (Freeze and Cherry 1979). Thus, while higher than the reported hydraulic conductivity, the calibrated Terrace Gravel hydraulic conductivity (93 ft/d) is reasonable. The Terrace model UCRS calibrated hydraulic conductivity of 0.34 ft/d is nearly the same as the characterized UCRS hydraulic conductivity of 0.28 ft/d.

The hydraulic conductivities of the sediment lining the bottom of Bayou Creek and its tributary (represented by the river boundary conductance term) were estimated to be 0.37 ft/d and 0.30 ft/d, respectively. Physically these values make sense, as the sediments collecting along the bottom of surface water bodies typically are fine-grained. The model-predicted bottom sediment hydraulic conductivities are less than the model-predicted Terrace Gravel hydraulic conductivity of 93 ft/d. Thus, as simulated, the bottom sediments provide resistance to flow in and out of the Terrace creeks. The hydraulic conductivity of the sediment lining the bottom of the WKWMA ponds was estimated to be 0.61 ft/d.

C3.6.2.2 Estimated Mass Balance

With respect to the Terrace, the model predicts total Terrace groundwater flow of 2,795 gal/min, with approximately equal portions being contributed by precipitation rainfall and infiltration from the WKWMA ponds. Of the 2,795 gal/min inflow, 1,352 gal/min (48%) discharges to Bayou Creek, 972 gal/min discharges to the tributary (35%) and 470 gal/min (17%) discharges to the UCRS. The combined Bayou Creek and tributary discharge rate of 2,334 gal/min is higher than the originally estimated rate of 410 gal/min (Section 3.3).

C3.6.2.3 Model-Predicted Water Levels

Model calibration is assessed by comparing model-predicted water levels to measured (target) water levels. The closer the agreement between the two, the better calibrated the model is assumed to be. Comparison of eight Terrace model-predicted and target water levels shows that the model over and under-predicts Terrace groundwater levels by approximately 3 ft and 4 ft, respectively (Figure C3.10).

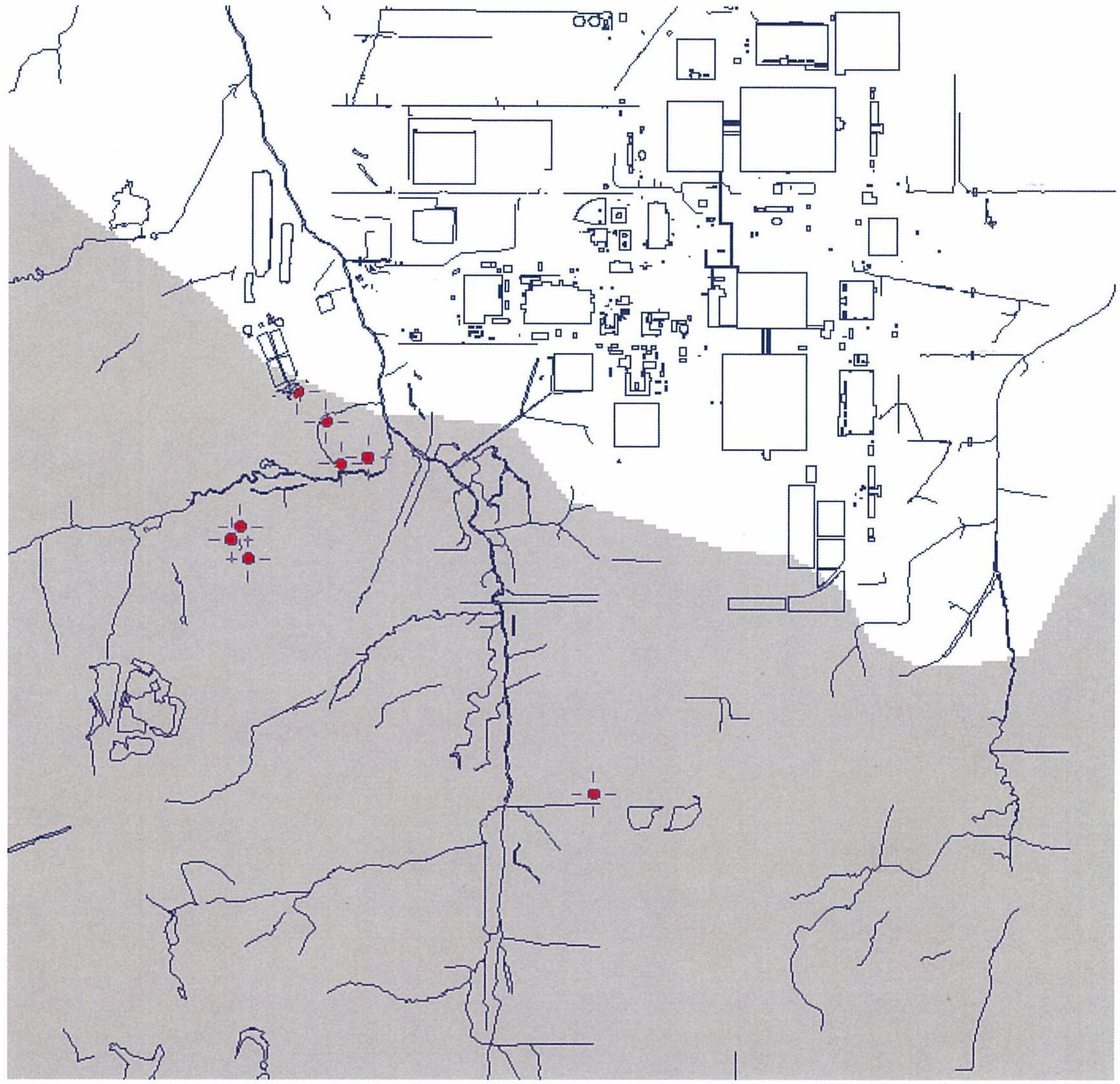


Figure C3.9. Terrace Water-Level Elevation Target Locations (Red)

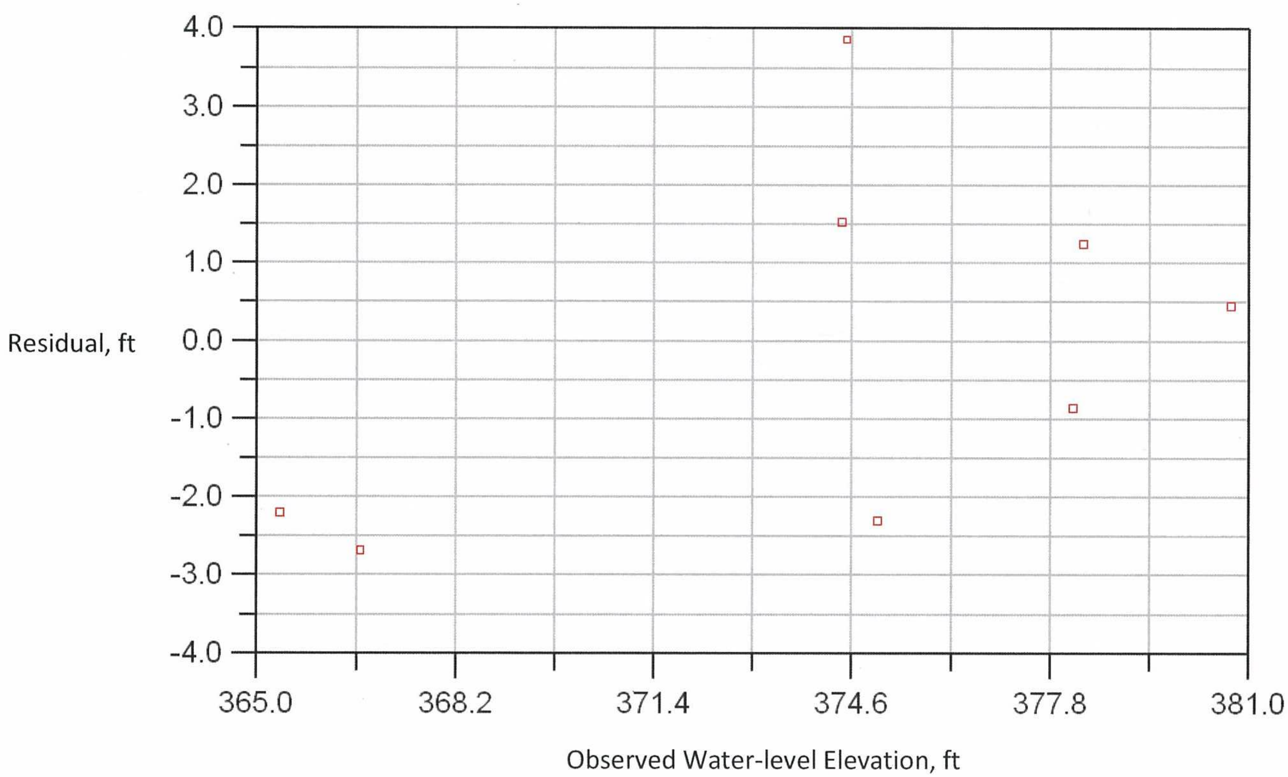


Figure C3.10. Comparison of Model Water-Level Residuals Verses Target Water-Level Elevations

The objective of the calibration was not to obtain exact matches between modeled and measured water levels, rather the objective was to obtain the "best" fit, defined as residuals being spread evenly about the zero line representing a perfect match. Examination of Figure C3.10 shows that the residuals are equally spaced around the zero residual line suggesting that there is no predictive bias. A better match might possibly have been achieved if multiple Terrace hydraulic conductivity zones were utilized; however, there is not sufficient data to justify multiple Terrace hydraulic conductivity zones.

The RGA residuals are not presented in this report because the calibration objective was not to match RGA water levels, indeed none of the RGA parameters were adjusted during calibration, rather the targets were included to minimize the potential for adjustments to Terrace and UCRS hydraulic conductivities and river cell conductance to change RGA flow paths.

The model-predicted Terrace and UCRS potentiometric surface (Figure C3.11) shows mounding around the WKWMA ponds, indicating the ponds are contributing water to the Terrace groundwater flow system, and discharge to the Bayou Creek and the tributary. The close proximity of equipotential lines at the Terrace UCRS interface and within PGDP, which is indicative of rapid declines in the water table over short distances. The purple area shown in the figure represents areas where the model-predicted water table is below the bottom of the UCRS. The light blue areas represent areas where the model predicts groundwater levels above ground surface. This phenomenon likely results from inaccuracies of the simulated topographic surface and numerical issues. While not perfect, the over-prediction of the water table does not hinder the model's ability to predict groundwater flow paths.

Figure C3.12 shows the model-predicted, Model Layer 2 RGA potentiometric surface. The presence of a groundwater mound beneath PGDP due to anthropogenic recharge, which contributes to the trajectories of the Northwest and Northeast Plumes.

C3.6.3 FLOW MODEL CALIBRATION EVALUATION

Model calibration is a function of available data. Up to a point, the more data available, the better the expected calibration. There is minimal Terrace-specific hydrogeologic data available; thus, the "calibrated" Terrace model should not be expected to exactly match target groundwater levels. Essentially, the Terrace model is as good as expected given the available data. The model can be used to predict groundwater flow paths from the potential CERCLA cell locations; however, the predictions should be subjected to uncertainty evaluation (systematically changing parameter values) to determine the potential impact of parameter uncertainty on the model-predicted flow paths.

C3.7. PREDICTED GROUNDWATER FLOW PATHS

To evaluate potential groundwater flow paths from Sites 1 and 3A, particles were placed at the center of the proposed waste sites and allowed to migrate with the model-predicted groundwater flow field. Conceptually, particles are analogous to water molecules and move similarly in the subsurface. In recognition that the Terrace groundwater flow system is not well understood and the Terrace model was calibrated with minimal data, sensitivity analysis was performed to determine how uncertainty in Terrace Gravel and UCRS hydraulic conductivity, creek stage and creek flows impact the model-predicted groundwater flow paths from the proposed waste cells. In addition, in recognition that PGDP is scheduled for demolition, simulations were performed where anthropogenic recharge was replaced with precipitation recharge.

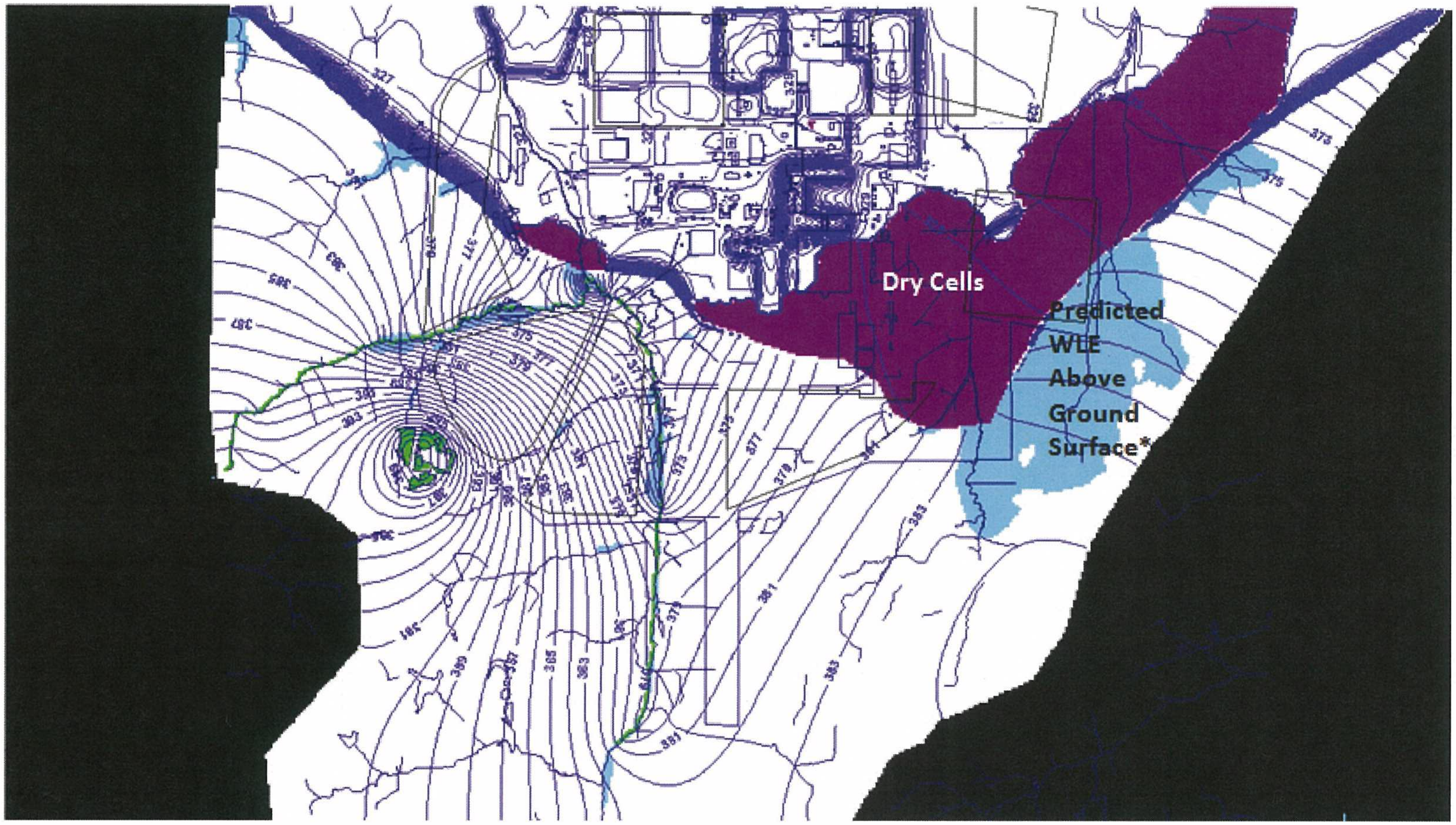


Figure C3.11. Model-Predicted Terrace and UCRS Potentiometric Surface

Figure C3.12. Model-Predicted RGA Potentiometric Surface

C3.7.1 CALIBRATED MODEL

Particles placed in the center of proposed waste cell Sites 1 and 3A discharge to the tributary and Bayou Creek, respectively (Figure C3.13). Travel times to the surface water features are under five years.

C3.7.2 CALIBRATED MODEL, NO ANTHROPOGENIC RECHARGE

It is anticipated that PGDP buildings and infrastructure will be demolished. As a consequence, the current anthropogenic recharge regime will change, possibly reverting back to pre-plant conditions where precipitation recharge is the dominant form of recharge across the site. PGDP decommissioning (where anthropogenic recharge is replaced with precipitation recharge) does not change model-predicted groundwater flow paths from Sites 1 and 3A (Figure C3.14). Particles placed in the center of proposed waste cell Sites 1 and 3A still discharge to the tributary and Bayou Creek, respectively, in under five years.

For the no anthropogenic scenario, the following Site 3A information is available to support preliminary waste acceptance criteria (PWAC) modeling:

- Head at Start of Particle Trace: 376.69 ft
- Head at End of Particle Trace: 369.85 ft
- Average K: 93 ft/day
- Particle Travel Distance: 2,114 ft

C3.7.3 TERRACE GRAVEL HYDRAULIC CONDUCTIVITY UNCERTAINTY

To evaluate the effect of Terrace Gravel hydraulic conductivity uncertainty on model-predicted groundwater flow paths, the model-predicted Terrace Gravel hydraulic conductivity was increased and decreased by a factor of 10. These simulations assumed no anthropogenic recharge, as this condition is most representative of anticipated long-term conditions following PGDP decommissioning. Simulation results show that increases in Terrace Gravel hydraulic conductivity change the groundwater flow path from Site 3A (Figure C3.15) relative to the calibrated, no anthropogenic recharge simulation (Figure C3.14), but groundwater still discharges to Bayou Creek. The groundwater flow path from Site 1 changes minimally relative to the calibrated, no anthropogenic recharge simulation (Figure C3.14). Discharge to the surface water bodies occurs in under five years.

Decreases in Terrace Gravel hydraulic conductivity do not change the groundwater flow paths from Sites 1 and 3A (Figure C3.16), relative to the calibrated, no anthropogenic recharge simulation (Figure C3.14). Particles placed in the center of proposed waste disposal facility Sites 1 and 3A still discharge to the tributary and Bayou Creek, respectively (Figure C3.16); however, travel times to the creek increase due to the decreased hydraulic conductivity and take up to 15 years to reach the surface water bodies.

C3.7.4 UCRS HYDRAULIC CONDUCTIVITY UNCERTAINTY

To evaluate the effect of UCRS hydraulic conductivity uncertainty on model-predicted groundwater flow paths, the model-predicted UCRS gravel hydraulic conductivity was increased and decreased by a factor of 10. Simulation results show that increases in UCRS hydraulic

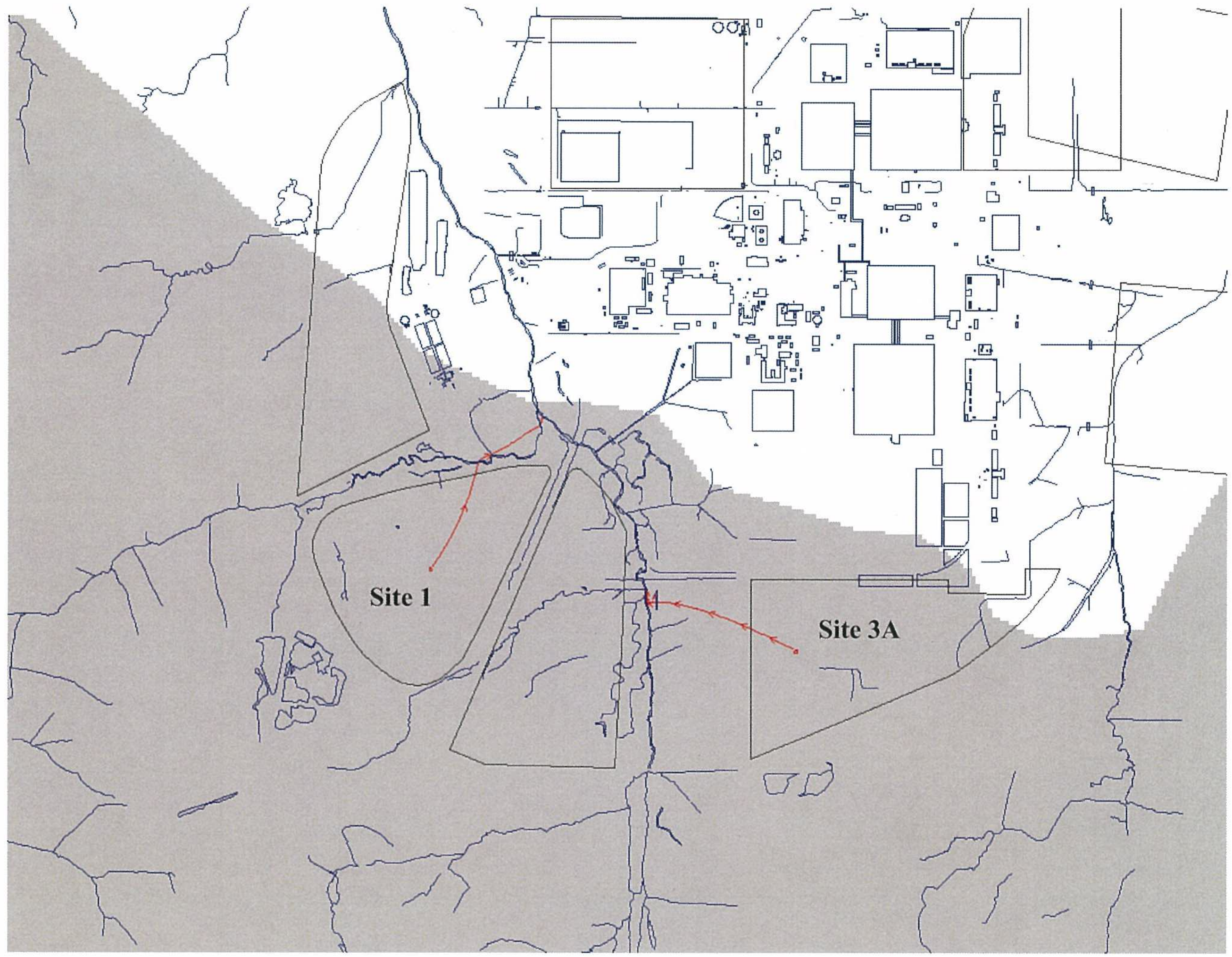


Figure C3.13. Site 1 and 3A Calibrated Model Predicted Groundwater Flow Paths

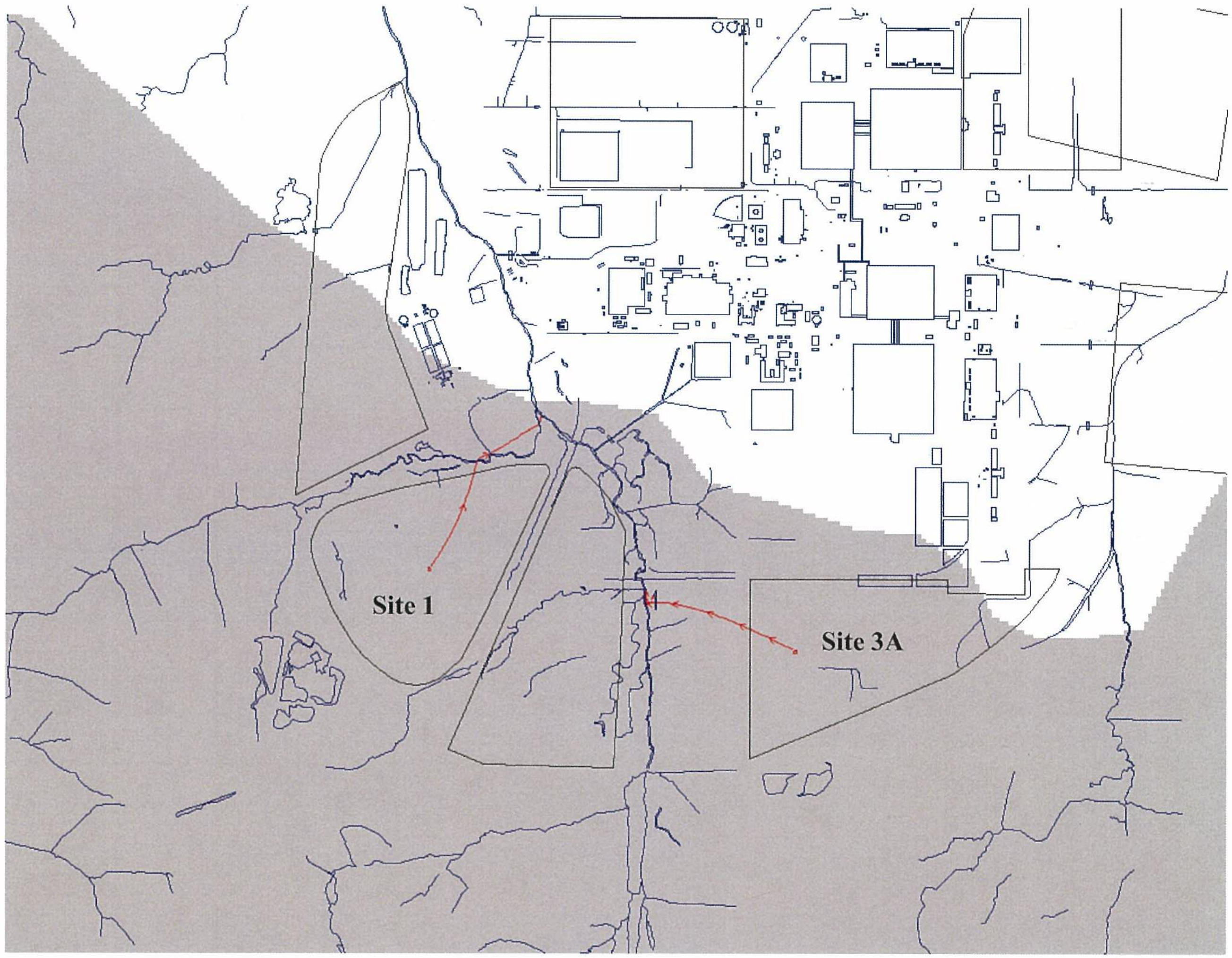


Figure C3.14. Site 1 and 3A Calibrated Model Predicted Groundwater Flow Paths, Without Anthropogenic Recharge

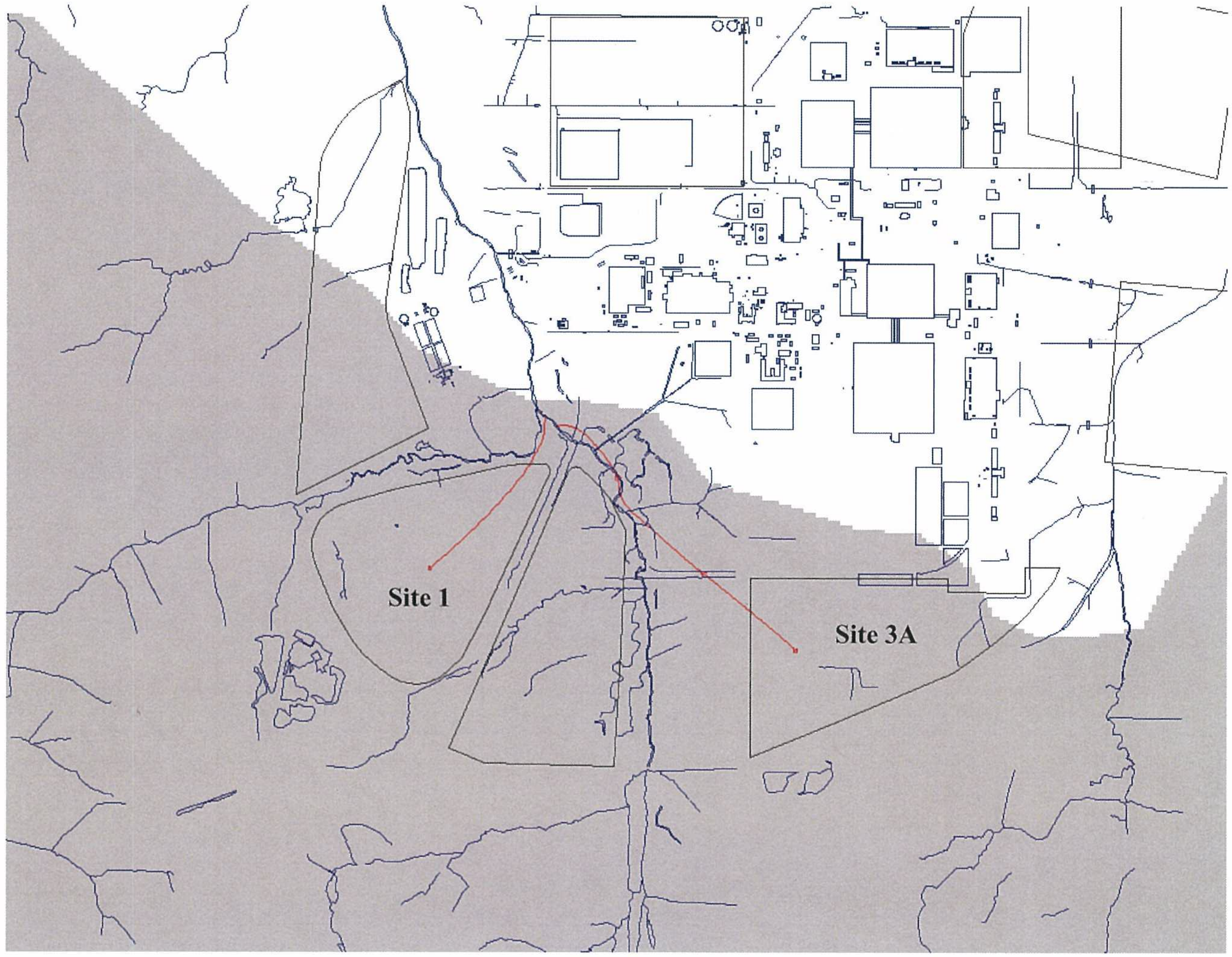


Figure C3.15. Site 1 and 3A Calibrated Model Predicted Groundwater Flow Paths When Terrace Gravel Hydraulic Conductivity is Increased by a Factor of 10

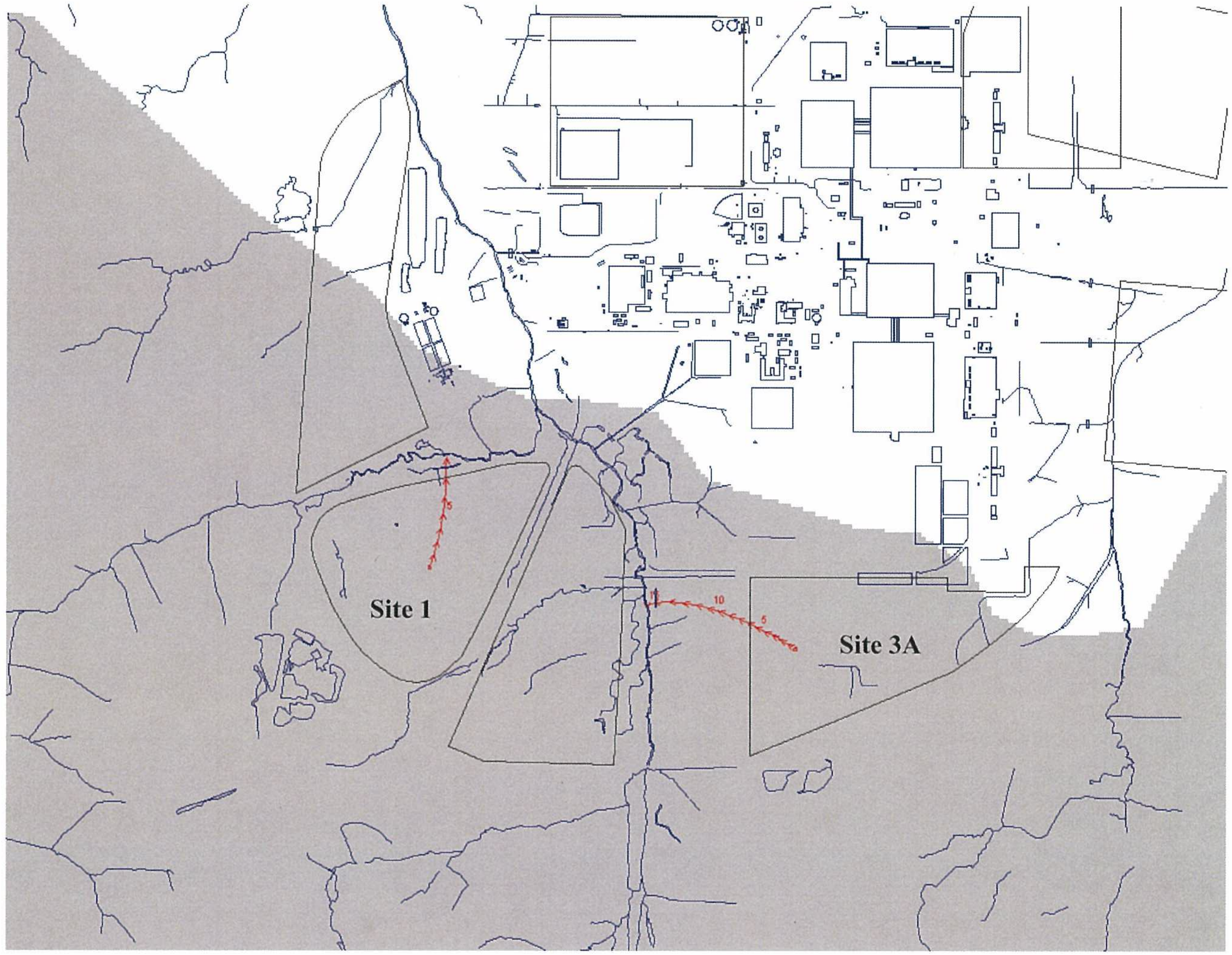


Figure C3.16. Site 1 and 3A Calibrated Model Predicted Groundwater Flow Paths When Terrace Gravel Hydraulic Conductivity is Decreased by a Factor of 10 conductivity cause groundwater from Site 3A to discharge to the UCRS (Figure C3.17) as opposed to Bayou Creek (Figure C3.14). Groundwater beneath Site 1 still flows to the creek (Figures C3.17 and C3.14). Decreases in UCRS hydraulic conductivity do not change the groundwater flow paths from Sites 1 and 3A, discharge is still to the tributary and Bayou Creek, respectively, with travel times under five years (Figures C3.18 and C3.14).

C3.7.5 CREEK STAGE UNCERTAINTY

In the calibrated model, Bayou Creek and the tributary were assumed to have surface water levels (stage) 1 ft below ground surface. To evaluate potential uncertainty associated with this assumption, creek and tributary stage were decreased by 1 ft. Simulation results show that decreasing creek and tributary stage by 1 ft does not change the groundwater flow paths from Sites 1 and 3A; discharge is still to the tributary and Bayou Creek, respectively, with travel times under five years (Figures C3.19 and C3.14).

C3.7.6 CREEK BASEFLOW UNCERTAINTY

Based on measured Bayou Creek flow, base flow in Bayou and the tributary was estimated to be 410 gal/min. The model-calibrated base flow was 2,334 gal/min. To evaluate how creek base flow potentially could impact groundwater flow paths from Sites 1 and 3A, Terrace models were calibrated to combined creek and tributary base flows of 41 gal/min, 410 gal/min and 4,100 gal/min.

Simulation results show that at 41 gal/min groundwater from Sites 1 and 3A discharges to the UCRS (Figure C3.20). Conceptually, this makes sense because with precipitation recharge constant for all simulations, as less groundwater discharges to the creek, more must discharge to the UCRS. In addition, to accommodate the increase in groundwater flow, UCRS hydraulic conductivity increases to 7 ft/d as compared to 0.34 ft/d for the calibrated Terrace model (Section C3.6.2.1).

When creek base flow is 410 gal/min, groundwater beneath Sites 1 and 3A discharges to the creek and UCRS, respectively (Figure C3.21). As with the 41 gal/min creek base flow simulation, to accommodate the additional groundwater flow, UCRS hydraulic conductivity increases to 3 ft/d as compared to 0.34 ft/d for the calibrated Terrace Gravel model (Section C3.6.2.1). With more groundwater discharging to the creek (410 gal/min vs. 41 gal/min), the UCRS hydraulic conductivity does not need to be as high (3 ft/d) as when minimal groundwater discharges to the creek (7 ft/d).

At a base flow of 4,100 gal/min, groundwater from Sites 1 and 3A discharges to the surface water bodies (Figure C3.22). With more groundwater discharge to the creek and less flowing to the UCRS, the calibrated UCRS hydraulic conductivity declines to 0.3 ft/d, a value very similar to the original calibrated value of 0.34 (Section C3.6.2.1).

The simulation results demonstrate that groundwater flow paths from Sites 1 and 3A, as a function of creek base flow, are variable. In the absence of measured Terrace Bayou Creek flow, it is not possible to determine directly which simulation scenario is more representative; however, an indirect measure of representativeness can be obtained by examination of calibration statistics and residual distributions (Figure C3.23.A–C). Sum of the difference squared (SDS), a quantitative measure of model calibration with zero representing ideal, is highest (217 ft^2) for the 41 gal/min creek base flow simulation and lowest (43 ft^2) for the 4,100 gal/min creek base flow simulation. Additionally, the Terrace target residuals for the 4,100 gal/min creek base flow simulation cluster tighter and have less bias, as indicated by even

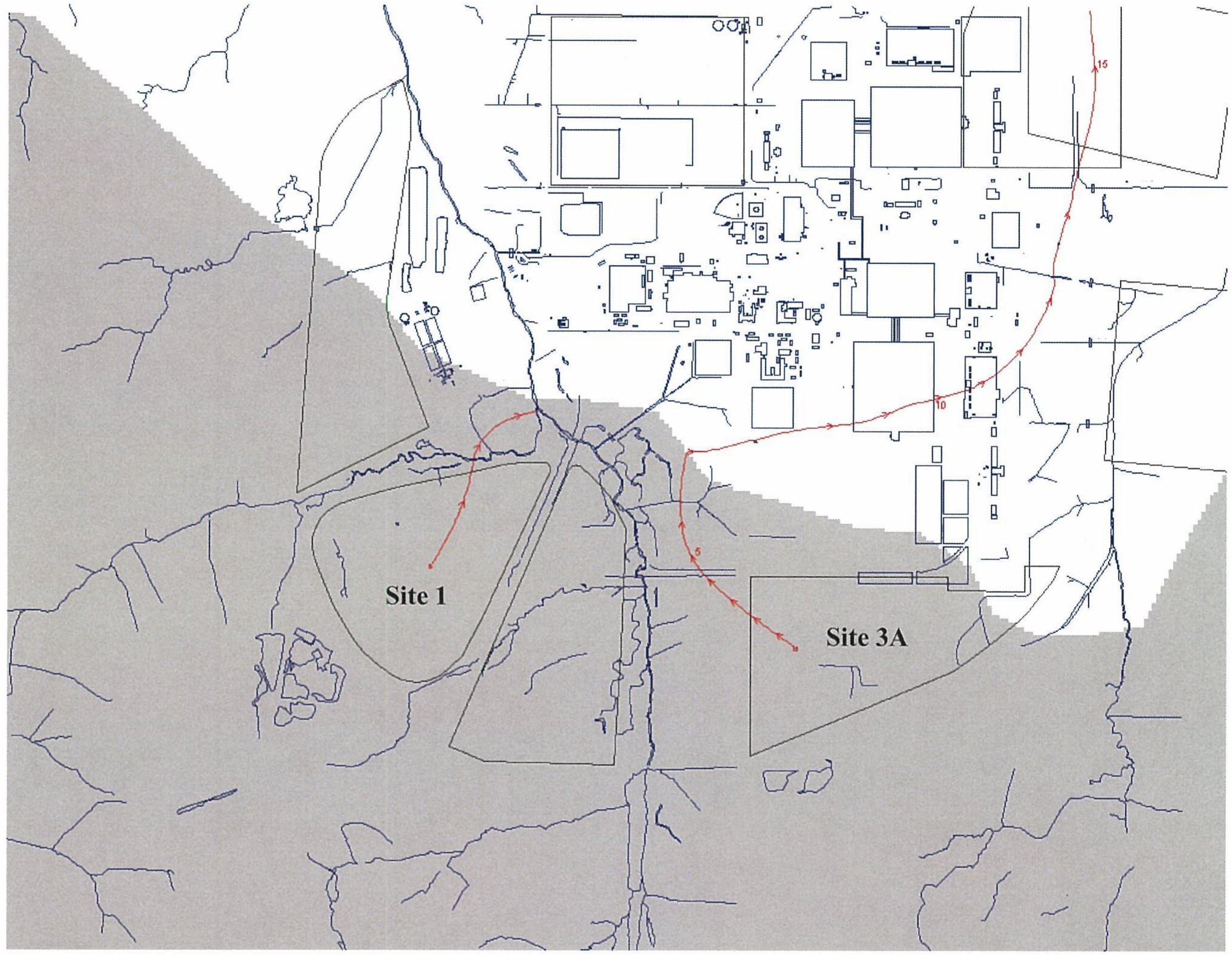


Figure C3.17. Site 1 and 3A Calibrated Model Predicted Groundwater Flow Paths When UCRS Hydraulic Conductivity is Increased by a Factor of 10

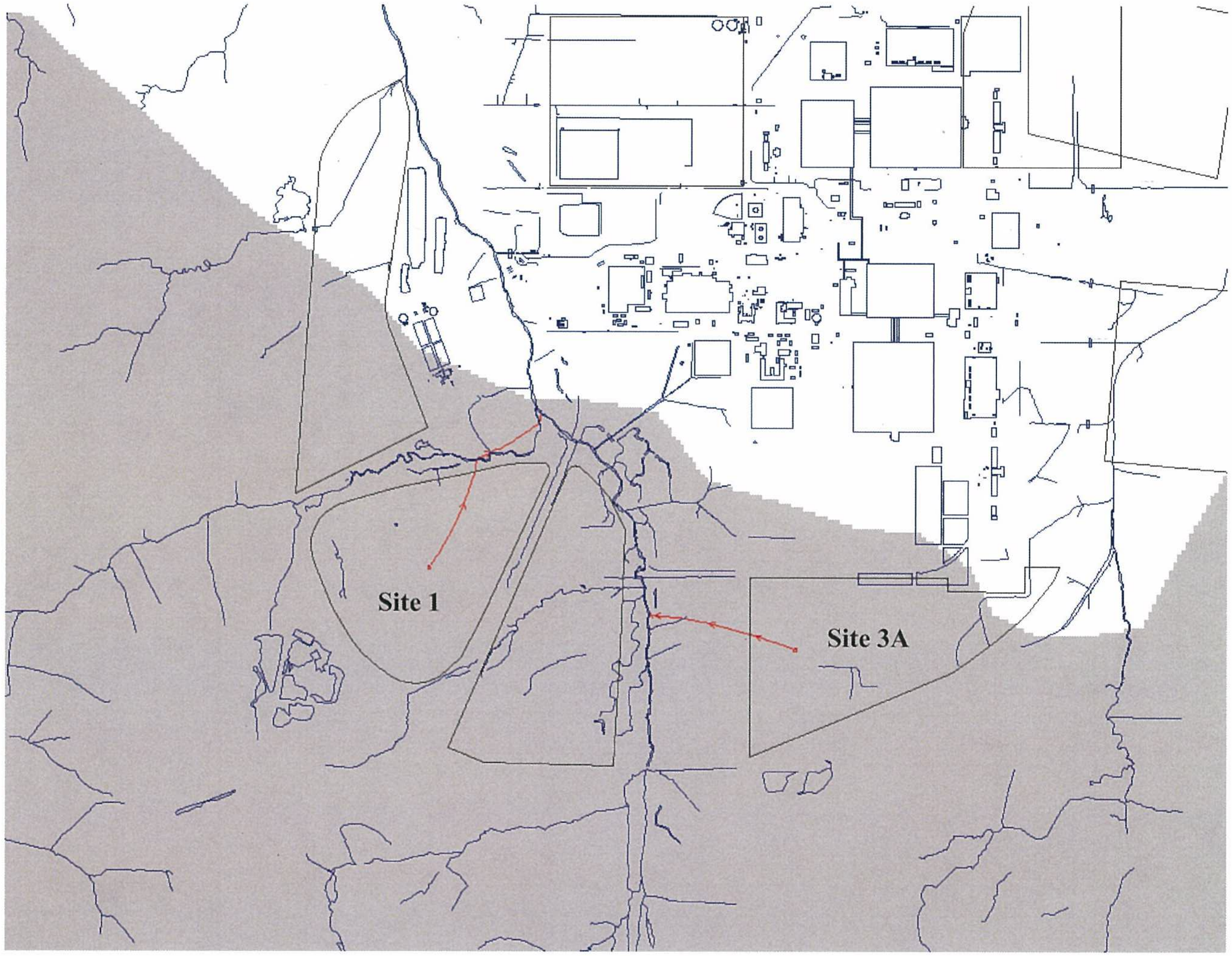


Figure C3.18. Site 1 and 3A Calibrated Model Predicted Groundwater Flow Paths When UCRS Hydraulic Conductivity is Decreased by a Factor of 10

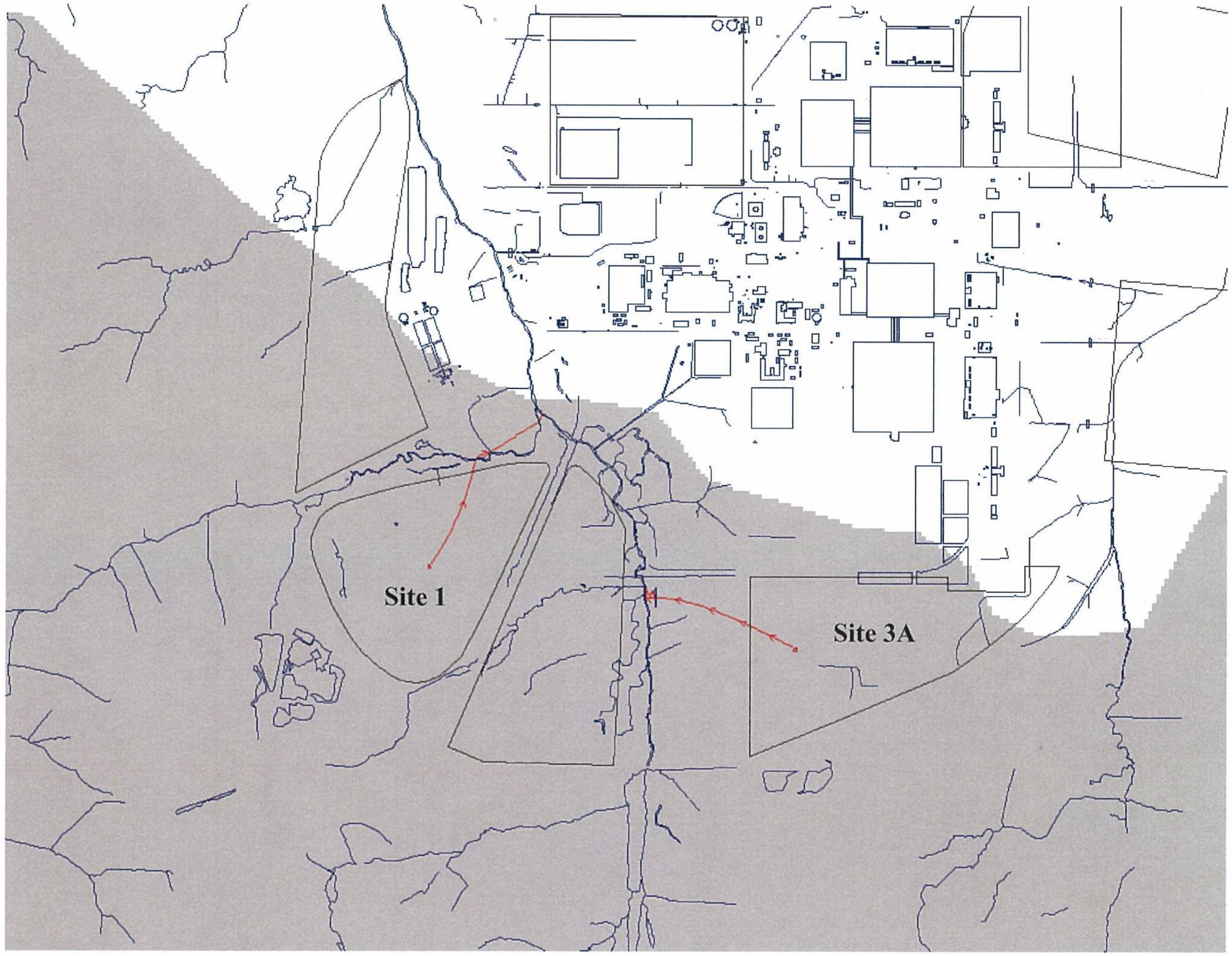


Figure C3.19. Site 1 and 3A Calibrated Model Predicted Groundwater Flow Paths When the Creek Stage is Decreased by One Foot

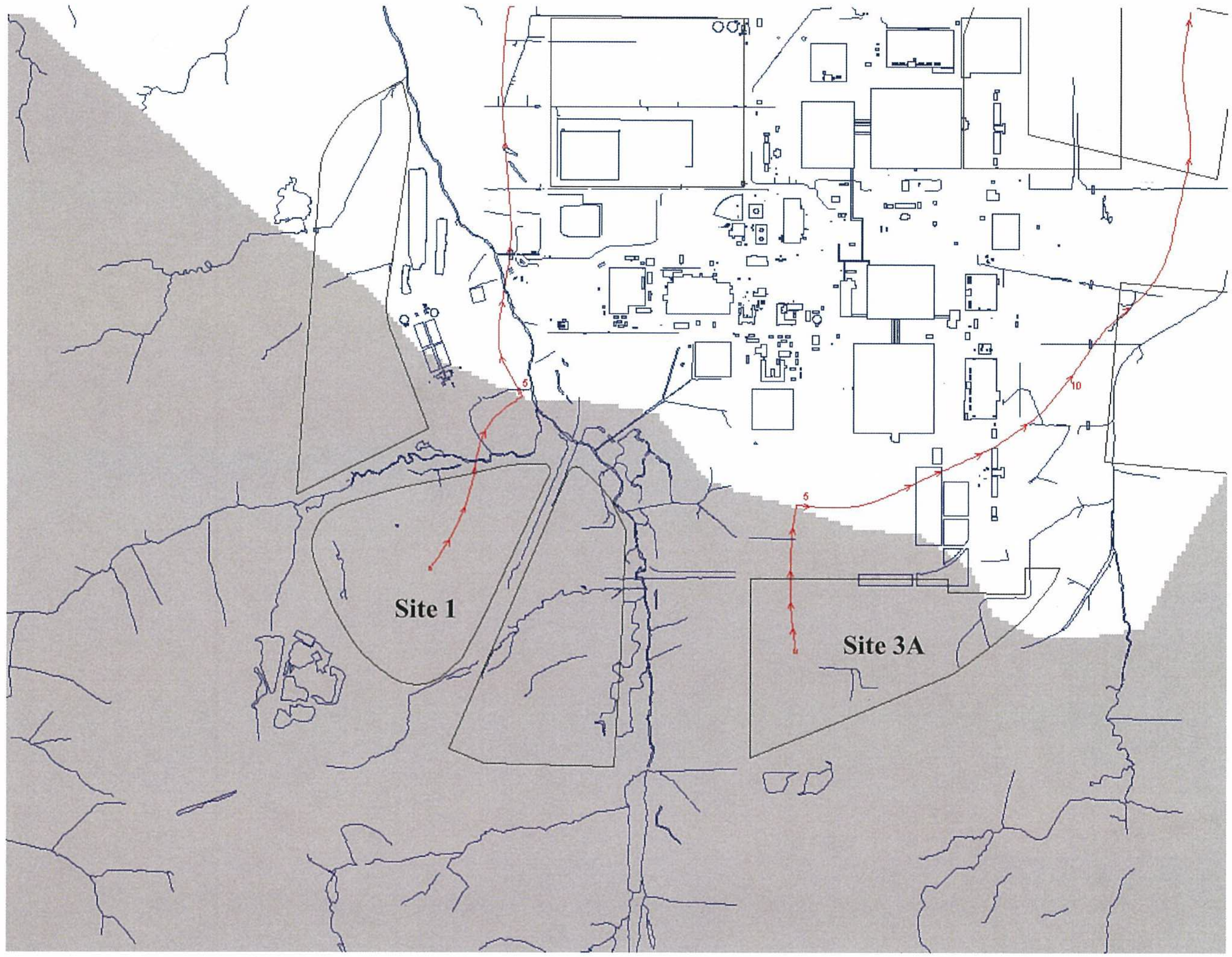


Figure C3.20. Site 1 and 3A Calibrated Model Predicted Groundwater Flow Paths When the Creek Base Flow is 41 Gal/Min

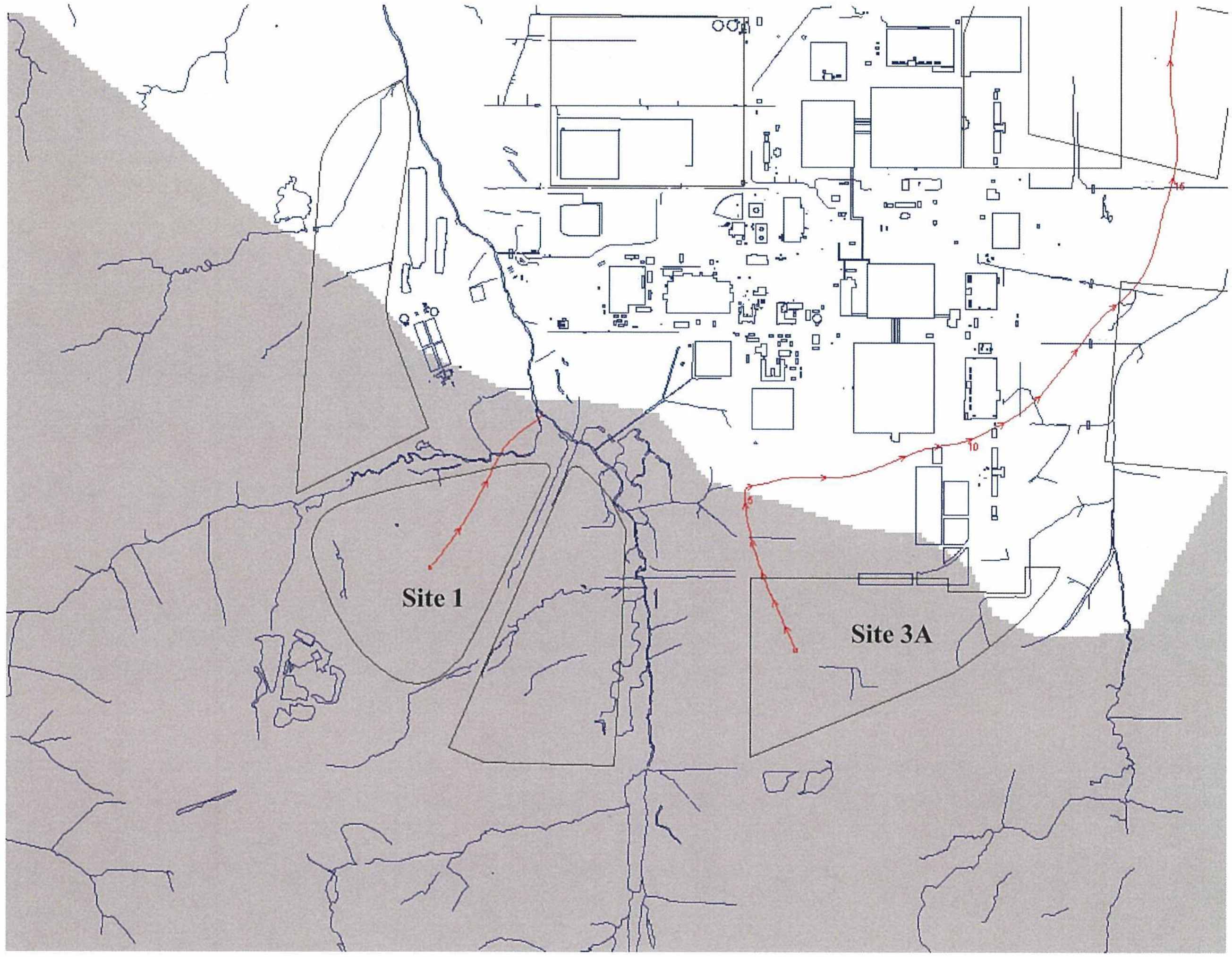


Figure C3.21. Site 1 and 3A Calibrated Model Predicted Groundwater Flow Paths When the Creek Base Flow is 410 Gal/Min

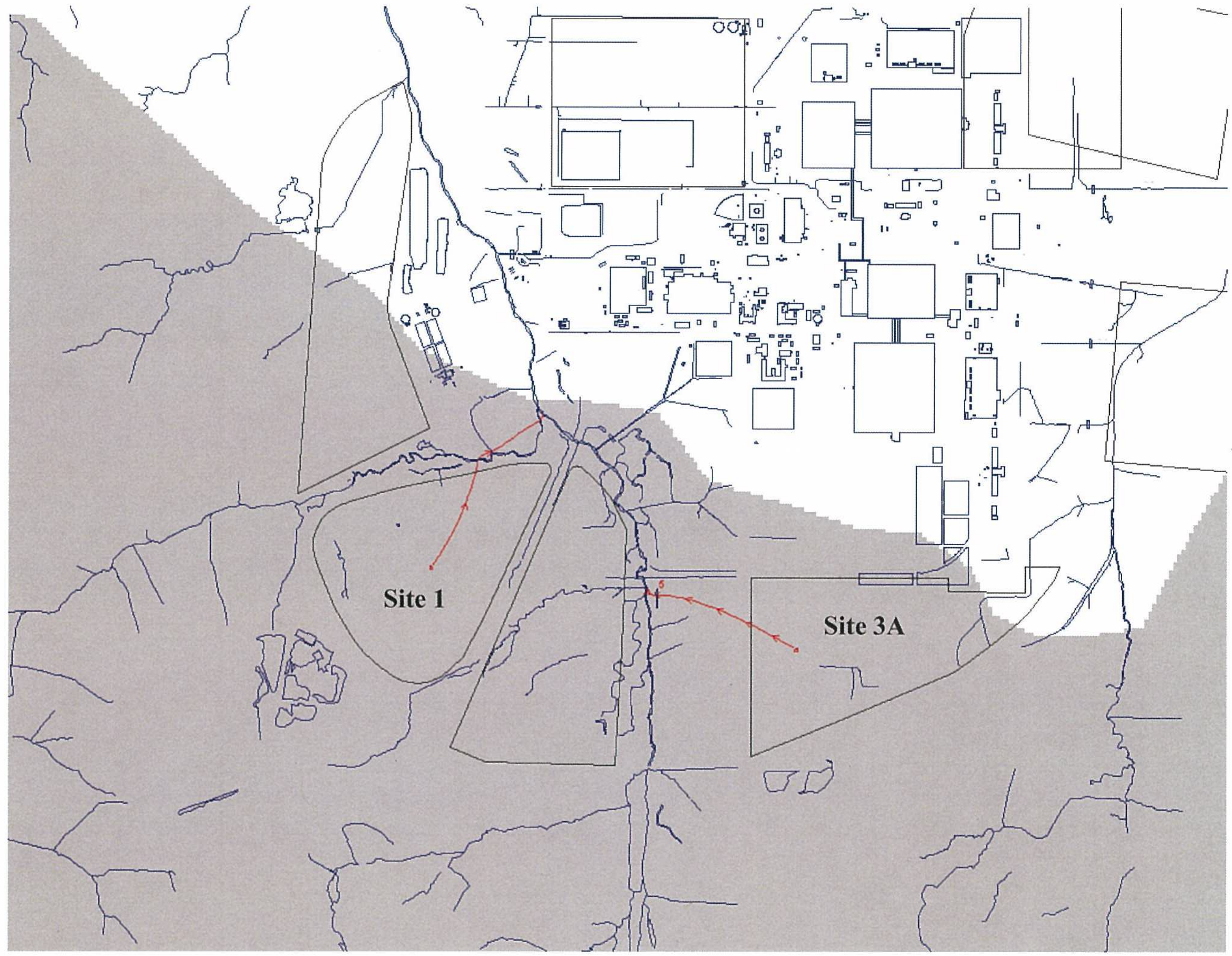


Figure C3.22. Site 1 and 3A Calibrated Model Predicted Groundwater Flow Paths When the Creek Base Flow is 4,100 Gal/Min

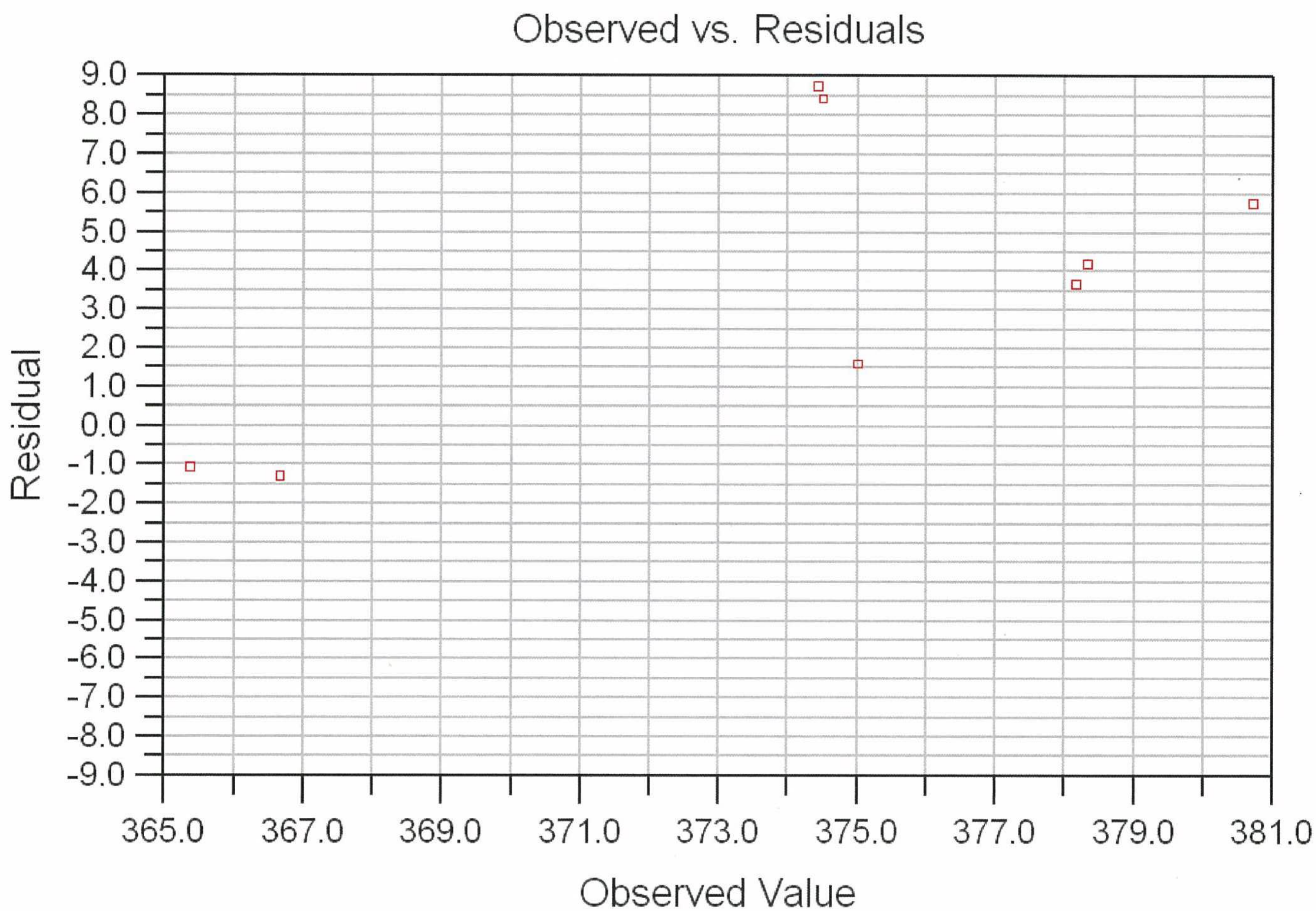


Figure C3.23.A. Comparison of Calibration Statistics and Residual Distributions (41 gpm; SDS = 217 ft^2)

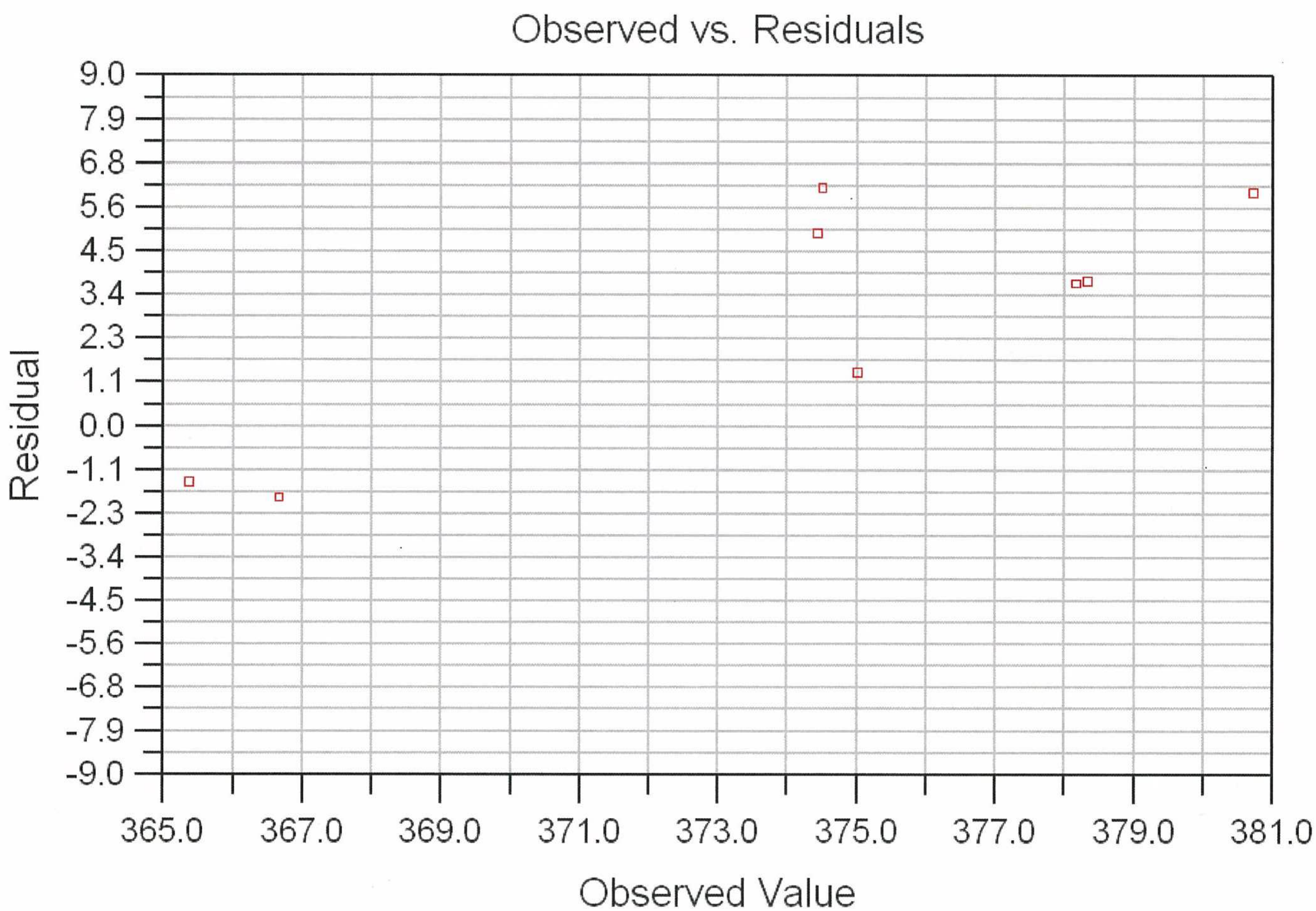


Figure C3.23.B. Comparison of Calibration Statistics and Residual Distributions (410 gpm; SDS = 134 ft^2)

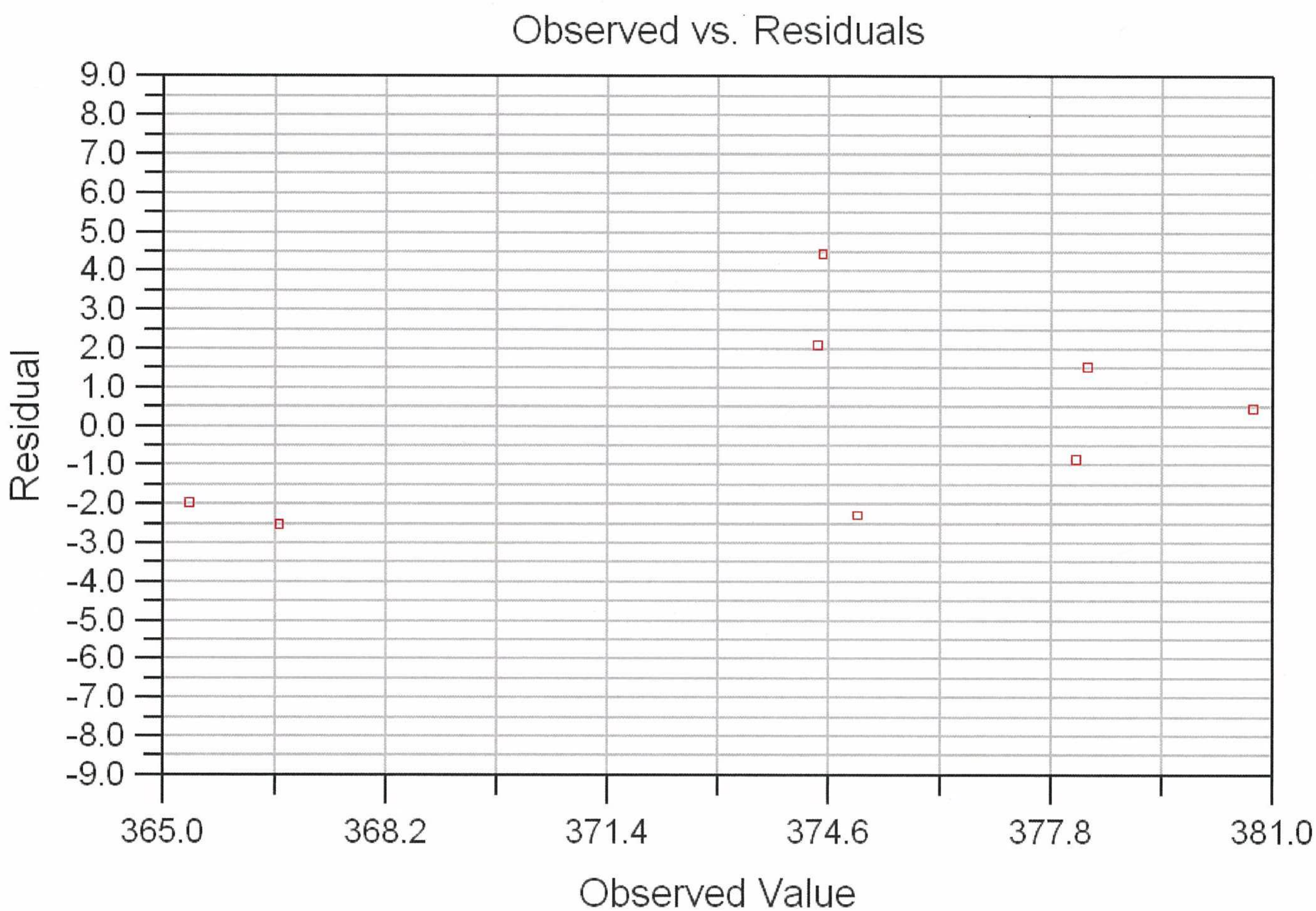


Figure C3.23.C. Comparison of Calibration Statistics and Residual Distributions (4,100 gpm; SDS = 43 ft²)

distribution around the zero line, than either of the 41 gal/min or 410 gal/min creek base flow simulations. Based on model calibration and data from USGS station, 03611800 Bayou Creek (Section C3.3.2), the 4,100 gal/min creek base flow simulation appears more representative of actual conditions.

C3.8. SUMMARY AND RECOMMENDATIONS

This report documents model predicted groundwater flow paths from Sites 1 and 3A, located on the Terrace Gravel, for a variety of hydrogeological conditions. Site 3A predictions used to support PWAC modeling include the following:

- Hydraulic Head at Start of Particle Trace: 376.69 ft
- Hydraulic Head at End of Particle Trace: 369.85 ft
- Average Hydraulic Conductivity: 93 ft/day
- Particle Travel Distance: 2,114 ft

Simulation results suggest the following.

- As calibrated, groundwater originating beneath Sites 1 and 3A is predicted to discharge to the tributary and Bayou Creek, respectively.

- The absence of anthropogenic recharge resulting from PGDP decommissioning does not change the model-predicted groundwater flow paths from Sites 1 and 3A; discharge is still to the tributary and Bayou Creek, respectively.

- Groundwater flow paths from Sites 1 and 3A are minimally sensitive to one order of magnitude increases and decreases in Terrace Gravel hydraulic conductivity relative to the calibrated value; discharge is still to the tributary and Bayou Creek, respectively.

- Groundwater flow paths from Sites 1 and 3A are sensitive to one order of magnitude increases and decreases in UCRS hydraulic conductivity relative to the calibrated value. Unlike the calibrated simulation, when UCRS hydraulic conductivity is increased by a factor of 10, groundwater beneath Site 3A discharges to the UCRS. When UCRS hydraulic conductivity is decreased by a factor of 10, similar to the calibrated model, groundwater beneath Site 3A discharges to Bayou Creek. Site 1 groundwater discharge flow paths do not change with increasing or decreasing UCRS hydraulic conductivity.

- A 1 ft decrease in tributary and Bayou Creek stage does not alter the calibrated model-predicted groundwater flow paths from Sites 1 and 3A. Groundwater discharge from the sites is still to the surface water bodies.

- Simulation results show that model-predicted groundwater flow paths from Sites 1 and 3A are sensitive to base flow in Bayou Creek and the tributary. At creek base flow rates of 41 gal/min, model-predicted groundwater flow paths from Sites 1 and 3A are to the UCRS. When creek base flow rates increase to 410 gal/min, groundwater beneath Sites 1 and 3A discharges to the creek and UCRS, respectively. At base flow rates of 2,334 gal/min (corresponding to the calibrated model) and 4,100 gal/min, model-predicted groundwater flow paths from Sites 1 and 3A are to the surrounding surface water bodies.

Comparison of model calibration statistics and residual distributions suggest that the higher creek base flow rates are likely more representative than the lower creek base flow rates. The specified base flow rate of 4,100 gal/min seems to best match site data and natural conditions.

RECOMMENDATIONS

- Based on simulation results, groundwater flow paths from Sites 1 and 3A are uncertain. For purposes of waste disposal evaluation, the most conservative approach based on the shortest groundwater flow paths is to assume that groundwater discharge from Sites 1 and 3A is to Bayou Creek and the tributary, respectively.

- If preliminary evaluation suggests either Site 1 or 3A is a viable disposal options, then additional data, such as measurements of Terrace Gravel hydraulic conductivity and Terrace Bayou Creek flow rates, would improve model predictions.

C3.9. REFERENCES

Doherty, J. 1999. *PEST Model-Independent Parameter Estimation*, Watermark Numerical Computing, 1st Edition.

Doherty, J. 2004. *PEST Model-Independent Parameter Estimation*, Watermark Numerical Computing, 4th Edition.

Freeze R. A. and Cherry, J. A. 1979. *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, NJ.

GEO (GEO Consultants, LLC) 2009. *Assessment of the Adequacy of Geotechnical and Hydrogeological Data in the Terrace Setting to Support a Remedial Investigation/Feasibility Study (RI/FS) - Level Evaluation of Potential Waste Disposal Sites Paducah, Kentucky*, GEO/09-207, R2, GEO Consultants, LLC, Kevil, KY, August.

Harbaugh, A., E. Banta, C. Hill, and M. McDonald 2000. *MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model–Users Guide to Modularization Concepts and Groundwater Flow Process*.

McDonald, M. G. and A. W. Harbaugh 1988. *MODFLOW: A Modular Three-Dimensional Finite Difference Groundwater Flow Model*, U. S. Geological Survey.

Pollack, D. W. 1994. *User's Guide for MODPATH/MODPATH-PLOT, Version 3: A Particle Tracking Post-Processing Package for MODFLOW, the U. S. Geological Survey Finite-Difference Groundwater Flow Model*, U. S. Geological Survey, Open-File Report 94-464.

PRS (Paducah Remediation Services, LLC) 2010. *2008 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model*, PRS-ENR-0028, Paducah Remediation Services, LLC, Kevil, KY, February.

ATTACHMENT C4

DUSTMS AND AT123D INPUT PARAMETERS

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Attachment C.4
DUST-MS and AT123D Input Parameters
Preliminary Waste Acceptance Criteria Modeling, Paducah Gaseous Diffusion Plant
Paducah, Kentucky

Parameter	Units	Deterministic Value	Justification / Notes	Reference(s)
DUST-MS Model Input Parameters[a]				
Title and General Problem Definition				
Number of Nodes	n/a	298 (Site 11) 266 (Site 3A)	1 node = 0.5 ft so the number of nodes is the height of the model domain x 2.	Conceptual model Figures 5.5 and 5.6 in the RI/FS.
Number of Isotopes	n/a	Varies		
Mass Units	grams	grams		
Decay Chains	n/a	Varies	Decay chains were utilized to account for the ingrowth of radioactive decay products where applicable.	
Time Parameters				
Number of Time Steps	n/a	10000	10000 is the maximum number of time steps allowed by the model.	
Initial Time Interval (yrs)	years	1.6 0.16 0.08	1.6 used for compounds with distribution coefficients (Kd) > 1, 0.16 used for Tc-99 (Kd = 0.282 for non-clay and 1 for clay), and 0.08 used for compounds with Kd less than 1. The time step was reduced for compounds with a low Kd due to instabilities in the AT123D model using a 1.6 year time step.	
Fractional Change in Time Interval		0	not used	
Maximum Time Interval	years	1.6 0.16 0.08	1.6 used for compounds with distribution coefficients (Kd) > 1, 0.16 used for Tc-99 (Kd = 0.282 for non-clay and 1 for clay), and 0.08 used for compounds with Kd less than 1. The time step was reduced for compounds with a low Kd due to mitigate instabilities in the AT123D model.	
Maximum Simulation Time	years	16000 1600 800	Maximum simulation time equal to the time interval multiplied by the number of time steps.	
Number of Time Step Resets	n/a	0	not used	
Material Parameters				
Number of Materials	n/a	6 (Site 11) 5 (Site 3A)	The number of unique materials in the model domain.	Conceptual model Figures 5.5 and 5.6 in this document.
Number of Material Changes	n/a	298 (Site 11) 266 (Site 3A)	The number of model nodes.	
K-d (Distribution Coefficient)	cc/gm	Chemical Specific		See table below for Chemical Specific Model Parameters
Density	gm/cc	Material - Density 1 - 1.34 2- 1.4 3 - 1.8 4 - 3.1 5 - 1.43 (Site 11) 5 - 1.41 (Site 3A) 6 - 1.43 (Site 11)		Material 1 - Cap Soil, DOE (2004) and GEO (2009) Material 2 - Sand, DOE (2003) Table 4.5 Material 3 - Compacted Clay, DOE (2003) Table 4.5 Material 4 - Waste, Table 5.22 in this document Material 5 (Site 11) - Native Soil, DOE (2004) and GEO (2009) Material 5 (Site 3A) - Native Soil, DOE (2004) and GEO (2009) Material 6 (Site 11) - Saturated Soil, DOE (2004) and GEO (2009)

DUST-MS and AT123D Input Parameters
Preliminary Waste Acceptance Criteria Modeling, Paducah Gaseous Diffusion Plant
Paducah, Kentucky

Parameter	Units	Deterministic Value	Justification / Notes	Reference(s)
Dispersion Coefficient	cm	415 (Site 11) 366 (Site 3A)	Equal to 1/10th the distance from the top of the waste to the lower boundary of the model domain.	Conceptual model Figures 5.5 and 5.6 in this document.
Diffusion Coefficient	cm^2/s	Chemical Specific		See table below for Chemical Specific Model Parameters
Changes to Node Material Types	n/a	First Node to Last Node = Material 1 to 10 = 1 11 to 20 = 2 21 to 26 = 3 27 to 196 = 4 197 to 198 = 3 199 to 200 = 2 201 to 206 = 3 207 to 226 = 1 227 to 270 = 5 (Site 11) 227 to 266 = 5 (Site 3A) 271 t0 298 = 6 (Site 11)		Conceptual model Figures 5.5 and 5.6 in this document.
Change in Node Number	n/a	1		
Change in Material Type	n/a	0		
		Output Parameters		
Output for Time Steps	n/a	Print Concentrations at time step = 1 and every 999 time steps		
Number of Concentration Traces	n/a	5 (Site 11) 4 (Site 3A)	Traces were placed at the top of the landfill cap, top of waste, bottom of bottom clay barrier, bottom of LOESS deposit (Site 11), and bottom of Terrace Gravel (Site 3A) or bottom of the Saturated Uppercontinental Deposits (Site 11).	Conceptual model Figures 5.5 and 5.6 in this document.
Node Locations for Concentration Traces	n/a	1, 26, 206, 270, 298 (Site 11) 1, 26, 206, 266 (Site 3A)		
Number of Flux Traces	n/a	5 (Site 11) 4 (Site 3A)		
Node Locations for Flux Traces	n/a	1, 26, 206, 270, 298 (Site 11) 1, 26, 206, 266 (Site 3A)		
		Facility Dimensions		
Area of Facility	cm^2	7.67E+08	Area of the 2.6 MCY landfill.	Appendix F, Conceptual Design, Figure F-9 in this document.
		Node Coordinates		
First Node	n/a	1		
Last Node	n/a	298 (Site 11) 266 (Site 3A)		
Change in Node Number	n/a	1		
Starting Location	cm	0	Top of the model domain = 0.	
Change in Delta X	cm	15.24	Each node is 0.5 ft in height.	
Incremental Change in Delta X	n/a	0		
		Initial Conditions		
First, Last Node, and Initial Concentration	g/cc	First Node to Last Node = Initial Concentration 1 to 26 = 0 27 to 196 = 1 or Chemical Specific 197 to 266 (Site 3A) or 298 (Site 11) = 0	Nodes 27 to 196 represent the waste layer in the model. Waste initial concentration is 0 for radionuclide progeny.	
Change in Node Number	n/a	1		
Fractional Change in Concentration	n/a	0		
		Boundary Conditions		
Upper Boundary	$g/cm^2/s$	Total Flux = 0	Contaminant flux = 0 at the upper boundary of the model domain.	
Lower Boundary	g/cc	Concentration = 0	Contaminant concentration = 0 at the lower boundary of the model domain.	
Number of Data Points	n/a	2	2 data points utilized to set the boundary condition from the beginning to the end of the simulation.	
Use BC File	n/a	No - All	No boundary conditions files used.	
		Water Velocity Parameters		

DUST-MS and AT123D Input Parameters
Preliminary Waste Acceptance Criteria Modeling, Paducah Gaseous Diffusion Plant
Paducah, Kentucky

Parameter	Units	Deterministic Value	Justification / Notes	Reference(s)
Number of Data Points		10 - Gradual Failure (BL) Scenario 4 - Instantaneous Failure (IF) Scenario 2 - No Failure (NF) Scenario		
Time and Water Velocity Parameters	years and cm/s	Time - Water Velocity 0 - 2.458E-14 (BL, IF, NF) 170 - 2.458E-14 (BL, IF, NF) 195 - 1.217E-13 (BL) 220 - 6.030E-13 (BL) 320 - 3.626E-10 (BL) 395 - 3.962E-08 (BL) 470 - 3.636E-07 (BL) 520 - 3.889E-07 (BL) 570 - 3.901E-07 (BL, IF) 16000 - 3.907E-07 (BL, IF)	Linear interpolation is used between the water velocity points to calculate a water velocity at each time step in the simulation.	HELP model results and Lee et al. (1995) equation (Equation 1 this document).
Moisture Content				
First and Last Node - Initial Moisture Content	n/a	First Node to Last Node = Material 1 to 10 = 0.3098 11 to 20 = 0.0452 21 to 26 = 0.4251 27 to 196 = 0.3588 197 to 198 = 0.4112 199 to 200 = 0.1123 201 to 206 = 0.427 207 to 226 = 0.342 227 to 270 = 0.393 (Site 11) 227 to 266 = 0.3025 (Site 3A) 271 t0 298 = 0.445 (Site 11)		Initial Moisture Contents were referenced from the HELP modeling results.
Change in Node Number	n/a	1	not used	
Incremental Change in Moisture Content	n/a	0	not used	
Container Failure Times				
Number of Containers	n/a	0	Initial concentrations were utilized to specify contaminant mass in the waste instead of waste forms, therefore no containers were specified.	
Number of Failure Types	n/a	none		
Failure Times for Containers	n/a	none		
Waste Forms				
Not used				
Sources				
Number of Source/Sink Nodes		0	not used	

AT123D Model Input Parameters

Parameter	Units	Deterministic Value	Justification / Notes	Reference(s)
Aquifer Tab				
Hydraulic Conductivity	m/hr	35.6 (Site 11) 1.18 (Site 3A)		Attachment C-2 to Appendix C in this document.
Hydraulic Gradient	m/m	0.00066 (Site 11) 0.0032 (Site 3A)		Attachment C-2 to Appendix C in this document.
Effective Porosity	n/a	0.3		DOE (2003), Table 4.7, page 4-21
Soil Bulk Density	kg/m^3	1670 (Site 11) 1560 (Site 3A)		Site 11 - DOE (2003), Table 4.7, page 4-21 Site 3A - DOE (2004) and GEO (2009)
Longitudinal Dispersivity	m	15		DOE (2003), Table 4.7, page 4-21
Transverse Dispersivity	m	1.5		DOE (2003), Table 4.7, page 4-21
Vertical Dispersivity	m	0.15		Standard 1/10th of Transverse Dispersivity
Aquifer Width	m	Infinite	Set to infinite to allow uninhibited dilution of chemicals laterally.	
Aquifer Depth	m	10.8 (Site 11) 4.572 (Site 3A)		Site 11 - Geolithic log GB-02D Site 3A - DOE (2004) and GEO (2009)
Number of Eigenvalues	n/a	500	Model Default	
Steady-State Error Tolerance	n/a	0.01	Model Default	

Input Tab

DUST-MS and AT123D Input Parameters
Preliminary Waste Acceptance Criteria Modeling, Paducah Gaseous Diffusion Plant
Paducah, Kentucky

Parameter	Units	Deterministic Value	Justification / Notes	Reference(s)
Release Coordinates	m	Site 11 X - Start = -113.1, End = 113.1 Y - Start = -169.6, End = 169.6 Z - Start = 0, End = 0 Site 3A X - Start = -124.8, End = 124.8 Y - Start = -153.6, End = 153.6 Z - Start = 0, End = 0	The conceptual waste dimensions were utilized to calculate equivalent rectangular areas.	Appendix F, Conceptual Design, Figure F-9 in this document.
Foc - Soil organic carbon content	%	0	not used	
Koc - Organic carbon adsorption coefficient	(ug/g)/(ug/ml)	0	not used	
Kd - Distribution Coefficient	m^3/kg	Chemical Specific		See Chemical Specific Parameters below
Water Diffusion Coefficient	m^2/hr	Chemical Specific		
First-Order Decay Coefficient	1/hr	Chemical Specific	Decay constants were calculated as $(\ln 2/t_{1/2}) \times$ (1 year/8,760 hours).	
Output Tab				
Starting Time Step	n/a	1		
Ending Time Step	n/a	10001		
Time Step	n/a	1		
X-Axis Coordinates	m	Site 11 - 113.1, 213.1, 225.9, 1356.3, 3907.6 Site 3A - 124.8, 224.8, 242.6, 625.7, 1000	The X-Axis coordinates correspond to the distance from the center of the landfill to downstream points of assessment (POA). At Site 11 the POAs are Edge of Waste (EOW), 100m, Waste Disposal Facility (WDF) / DOE Boundary, Surface Water (Little Bayou Creek), and Ohio River respectively. At Site 3A the POAs are EOW, 100 m, WDF boundary, Surface Water (Bayou Creek), and arbitrary 5th POA respectively.	Attachment C-2 to Appendix C in this document. Also, see Figure 5.7 of this document.
Y-Axis Coordinates	m	0	Y = 0 is the center of the aerial source of landfill located at the bottom of the landfill.	
Z-Axis Coordinates	m	0	Z = 0 is the top of the model domain.	
Load Tab				
Initial Concentration	mg/L	0		
Single Mass Load	kg	not used		
Model Time Step	hrs	14025.6 1402.56 701.28	14025.6 used for compounds with distribution coefficients (Kd) > 1E-03 m^3/kg, 1402.56 used for Tc-99 (Kd = 2.82E-04 m^3/kg), and 701.28 used for compounds with Kd less than 1E-03 m^3/kg. The time step was reduced for compounds with a lower relative Kd to mitigate instabilities in the AT123D model.	
Continuous = 0, >1 Varying	n/a	10000	The number of time steps	
Water Density	kg/m3	1000	STP density of water.	
Release Type	n/a	Continuous Release		
Load Release Rate	kg/hr	Varies by Chemical	Data is reference from the DUST-MS mass rate results for each chemical.	

Chemical Specific Parameters

Vinyl Chloride (VC) - Atomic Weight 62.5 g/mol				
Half Life	years	7.90E+00		Howard et al., 1991, Page 138
Solubility Limit	gm/cc	2.76E-03		EPA (1996), Table 36, Pages 134 to 136.

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Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd)	cc/gm	1.49E-02	Kd calculated by multiplying Koc (1.86E+01 l/kg) by foc (8.01E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2011), page E-261 "Likeliest" value.
Saturated Horizontal Flow Distribution Coefficient (Kd)	cc/gm	6.51E-03	Kd calculated by multiplying Koc (1.86E+01 l/kg) by foc (3.5E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2000), Table F.2.8 "Likeliest" value.
Diffusion Coefficient	cm2/sec	1.23E-06		EPA (1996), Table 37, Pages 137 to 139
Trichloroethylene (TCE) - Atomic Weight 131.4 g/mol				
Half Life	years	4.50E+00		Howard et al., 1991, Page 190
Solubility Limit	gm/cc	1.10E-03		EPA (1996), Table 36, Pages 134 to 136
Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd)	cc/gm	7.55E-02	Kd calculated by multiplying Koc (9.43E+01 l/kg) by foc (8.01E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2011), page E-261 "Likeliest" value.
Saturated Horizontal Flow Distribution Coefficient (Kd)	cc/gm	3.30E-02	Kd calculated by multiplying Koc (9.43E+01 l/kg) by foc (3.5E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2000), Table F.2.8 "Likeliest" value.
Diffusion Coefficient	cm2/sec	9.10E-06		EPA (1996), Table 37, Pages 137 to 139
2-Butanone (Methyl Ethyl Ketone) - Atomic Weight 72.1 g/mol				
Half Life	years	3.80E-02		Howard et al., 1991, Page 186
Solubility Limit	gm/cc	7.40E-02		EPA (1996), Table 36, Pages 134 to 136
Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd)	cc/gm	5.54E-03	Kd calculated by multiplying Koc (6.92E+00 l/kg) by foc (8.01E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2011), page E-261 "Likeliest" value.
Saturated Horizontal Flow Distribution Coefficient (Kd)	cc/gm	2.42E-03	Kd calculated by multiplying Koc (6.92E+00 l/kg) by foc (3.5E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2000), Table F.2.8 "Likeliest" value.
Diffusion Coefficient	cm2/sec	9.30E-06		EPA (1996), Table 37, Pages 137 to 139
Chlorobenzene - Atomic Weight 112.6 g/mol				
Half Life	years	1.64E+00		Howard et al., 1991, Page 412
Solubility Limit	gm/cc	4.72E-04		EPA (1996), Table 36, Pages 134 to 136
Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd)	cc/gm	1.79E-01	Kd calculated by multiplying Koc (2.24E+02 l/kg) by foc (8.01E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2011), page E-261 "Likeliest" value.
Saturated Horizontal Flow Distribution Coefficient (Kd)	cc/gm	7.84E-02	Kd calculated by multiplying Koc (2.24E+02 l/kg) by foc (3.5E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2000), Table F.2.8 "Likeliest" value.
Diffusion Coefficient	cm2/sec	8.70E-06		EPA (1996), Table 37, Pages 137 to 139
Benzene - Atomic Weight 78.1 g/mol				
Half Life	years	2.00E+00		Howard et al., 1991, Page 111
Solubility Limit	gm/cc	1.75E-03		EPA (1996), Table 36, Pages 134 to 136
Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd)	cc/gm	4.94E-02	Kd calculated by multiplying Koc (6.17E+01 l/kg) by foc (8.01E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2011), page E-261 "Likeliest" value.

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Saturated Horizontal Flow Distribution Coefficient (Kd)	cc/gm	2.16E-02	Kd calculated by multiplying Koc (6.17E+01 l/kg) by foc (3.5E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2000), Table F.2.8 "Likeliest" value.
Diffusion Coefficient	cm2/sec	9.80E-06		EPA (1996), Table 37, Pages 137 to 139
2-Methylphenol (o-Cresol) - Atomic Weight 108 g/mol				
Half Life	years	7.70E-02		Howard et al., 1991, Page 294
Solubility Limit	gm/cc	2.60E-02		EPA (1996), Table 36, Pages 134 to 136
Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd)	cc/gm	7.31E-02	Kd calculated by multiplying Koc (9.12E+01 l/kg) by foc (8.01E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2011), page E-261 "Likeliest" value.
Saturated Horizontal Flow Distribution Coefficient (Kd)	cc/gm	3.19E-02	Kd calculated by multiplying Koc (9.12E+01 l/kg) by foc (3.5E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2000), Table F.2.8 "Likeliest" value.
Diffusion Coefficient	cm2/sec	8.30E-06		EPA (1996), Table 37, Pages 137 to 139
Pentachlorophenol - Atomic Weight 266.3 g/mol				
Half Life	years	4.20E+00		Howard et al., 1991, Page 242
Solubility Limit	gm/cc	1.95E-03		EPA (1996), Table 36, Pages 134 to 136
Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd)	cc/gm	4.74E-01	Kd calculated by multiplying Koc (5.92E+02 l/kg) by foc (8.01E-4 unitless).	Koc referenced from EPA (1996), Table 42, Pages 150. Fractional organic carbon foc referenced from DOE (2011), page E-261 "Likeliest" value.
Saturated Horizontal Flow Distribution Coefficient (Kd)	cc/gm	2.07E-01	Kd calculated by multiplying Koc (5.92E+02 l/kg) by foc (3.5E-4 unitless).	Koc referenced from EPA (1996), Table 42, Pages 150. Fractional organic carbon foc referenced from DOE (2000), Table F.2.8 "Likeliest" value.
Diffusion Coefficient	cm2/sec	6.10E-06		EPA (1996), Table 37, Pages 137 to 139
Benzo(a)pyrene - Atomic Weight 252.3 g/mol				
Half Life	years	5.80E+00		Howard et al., 1991, Page 12
Solubility Limit	gm/cc	1.62E-09		EPA (1996), Table 36, Pages 134 to 136
Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd)	cc/gm	7.76E+02	Kd calculated by multiplying Koc (9.69E+05 l/kg) by foc (8.01E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2011), page E-261 "Likeliest" value.
Saturated Horizontal Flow Distribution Coefficient (Kd)	cc/gm	3.39E+02	Kd calculated by multiplying Koc (9.69E+05 l/kg) by foc (3.5E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2000), Table F.2.8 "Likeliest" value.
Diffusion Coefficient	cm2/sec	9.00E-06		EPA (1996), Table 37, Pages 137 to 139
PCBs (Total) - Atomic Weight 375.7 g/mol				
Half Life	years	1.00E+02		(DOE 2003), Table 4.5, page 4-12
Solubility Limit	gm/cc	7.00E-07		EPA (2004), Page A-295
Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd)	cc/gm	2.48E+02	Kd calculated by multiplying Koc (3.09E+05 l/kg) by foc (8.01E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2011), page E-261 "Likeliest" value.
Saturated Horizontal Flow Distribution Coefficient (Kd)	cc/gm	1.08E+02	Kd calculated by multiplying Koc (3.09E+05 l/kg) by foc (3.5E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2000), Table F.2.8 "Likeliest" value.
Diffusion Coefficient	cm2/sec	1.00E-06		(DOE 2003), Table 4.5, page 4-12
gamma-Chlordane (Chlordane) - Atomic Weight 409.8 g/mol				

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Half Life	years	7.60E+00		Howard et al., 1991, Page 48
Solubility Limit	gm/cc	5.60E-08		EPA (1996), Table 36, Pages 134 to 136
Unsaturated Soils, Waste, and Saturated Vertical Flow Distribution Coefficient (Kd)	cc/gm	4.11E+01	Kd calculated by multiplying Koc (5.13E+04 l/kg) by foc (8.01E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2011), page E-261 "Likeliest" value.
Saturated Horizontal Flow Distribution Coefficient (Kd)	cc/gm	1.80E+01	Kd calculated by multiplying Koc (5.13E+04 l/kg) by foc (3.5E-4 unitless).	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. Fractional organic carbon foc referenced from DOE (2000), Table F.2.8 "Likeliest" value.
Diffusion Coefficient	cm2/sec	4.37E-06		EPA (1996), Table 37, Pages 137 to 139
Antimony - Atomic Weight 121.7 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	1.70E-01		EPA (2004), Page A-25.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	45 (sand and all other materials) 250 (clay)		Sheppard and Thibault (1990), Table 1, Page 472
Diffusion Coefficient	cm2/sec	1.00E-06		--
Arsenic - Atomic Weight 74.9 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	1.20E-01		EPA (2004), Page A-29.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	2.90E+01		EPA (1996), Table 46, Page 158.
Diffusion Coefficient	cm2/sec	1.00E-06		(DOE 2003), Table 4.5, page 4-12
Barium - Atomic Weight 137.3 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	2.80E-03		EPA (2004), Page A-33.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	4.10E+01		EPA (1996), Table 46, Page 158.
Diffusion Coefficient	cm2/sec	1.00E-06		--
Beryllium - Atomic Weight 9.01 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	8.40E-02		EPA (2004), Page A-49.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	250 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	1,300 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Cadmium - Atomic Weight 112.4 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	1.70E-03		EPA (2004), Page A-59.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	80 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	560 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Chromium - Atomic Weight 51.9 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	6.00E-01		EPA (2004), Page A-83.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	3.21E+01		DOE (2002), Appendix D
Diffusion Coefficient	cm2/sec	1.00E-06		--
Copper - Atomic Weight 63.6 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	5.70E-04		EPA (2004), Page A-97.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	3.1		Dragun (1988), Table 4.2, page 158
Diffusion Coefficient	cm2/sec	1.00E-06		--
Lead - Atomic Weight 207.2 g/mol				
Half Life	years	--		--

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Parameter	Units	Deterministic Value	Justification / Notes	Reference(s)
Solubility Limit	gm/cc	8.70E-04		EPA (2004), Page A-223.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	270 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	550 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Manganese - Atomic Weight 54.9 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	1.10E-03		EPA (2004), Page A-231.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	50 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	180 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Mercury - Atomic Weight 200.6 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	4.50E-04		EPA (2004), Page A-235.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	5.20E+01		EPA (1996), Table 46, Page 158.
Diffusion Coefficient	cm2/sec	1.00E-06		--
Nickel - Atomic Weight 58.7 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	1.50E-03		EPA (2004), Page A-255.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	1.079E+02		DOE (2002), Appendix D
Diffusion Coefficient	cm2/sec	1.00E-06		--
Selenium - Atomic Weight 78.9 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	2.60E+00		EPA (2004), Page A-309.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	150 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	740 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Silver - Atomic Weight 107.9 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	2.50E-04		EPA (2004), Page A-311.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	90 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	180 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Thallium - Atomic Weight 204.4 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	8.60E-03		EPA (2004), Page A-337.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	7.10E+01		EPA (1996), Table 46, Page 158.
Diffusion Coefficient	cm2/sec	1.00E-06		--
Uranium - Atomic Weight 238 g/mol				
Half Life	years	4.50E+09		ANL (2005), Figure N.1
Solubility Limit	gm/cc	1.00E-04		EPA (2004), Page A-389.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution	cc/gm	35 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	1600 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Vanadium - Atomic Weight 50.9 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	7.00E-04		EPA (2004), Page A-391.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	1.00E+03		EPA (1996), Table 46, Page 158.
Diffusion Coefficient	cm2/sec	1.00E-06		--
Zinc - Atomic Weight 65.4 g/mol				
Half Life	years	--		--
Solubility Limit	gm/cc	1.40E-03		EPA (2004), Page A-405.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	200 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	2,400 (clay)		

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Diffusion Coefficient	cm2/sec	1.00E-06		--
Cs-137 - Atomic Weight 137 g/mol				
Half Life	years	3.02E+01		DOE (2011), Appendix D, page D-77
Solubility Limit	gm/cc	3.40E-01		EPA (2004), Page A-71.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	280 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	1,900 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Tc-99 - Atomic Weight 99 g/mol				
Half Life	years	2.13E+05		DOE (2011), Appendix D, page D-77
Solubility limit	gm/cc	7.18E-03		Derived from the geochemical database 'thermo.com.V8.R6.230' which was prepared by the Lawrence Livermore National Laboratory. The exact database used here is 'llnl.dat 4023 2010-02-09 21:02:42Z' which was converted to PHREEQC format by Greg Anderson and David Parkhurst of the U.S. Geological Survey.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	2.82E-01		DOE (2002), Appendix D
Diffusion coefficient	cm2/sec	1.00E-06		--
Ac-227 - Atomic Weight 227 g/mol				
Half Life	years	22		ANL (2005), Figure N.2
Solubility Limit	gm/cc	1.00E+01		No value found. Assume 10 gm/cc to prevent solubility from limiting migration.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	450 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	2,400 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Am-241 - Atomic Weight 241 g/mol				
Half Life	years	4.32E+02		--
Solubility Limit	gm/cc	8.00E-03		Derived from the geochemical database 'thermo.com.V8.R6.230' which was prepared by the Lawrence Livermore National Laboratory. The exact database used here is 'llnl.dat 4023 2010-02-09 21:02:42Z' which was converted to PHREEQC format by Greg Anderson and David Parkhurst of the U.S. Geological Survey.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	1900 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	8400 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Np-237 - Atomic Weight 237 g/mol				
Half Life	years	2.14E+06		DOE (2011), Appendix D, page D-77
Solubility Limit	gm/cc	1.00E+01		No value found. Assume 10 gm/cc to prevent solubility from limiting migration.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	5 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	55 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		DOE (2003), Table 4.5, page 4-12
Pa-231 - Atomic Weight 231 g/mol				
Half Life	years	3.30E+04		ANL (2005), Figure N.2
Solubility Limit	gm/cc	1.00E+01		No value found. Assume 10 gm/cc to prevent solubility from limiting migration.

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Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	550 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	2,700 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Pb-210 - Atomic Weight 210 g/mol				
Half Life	years	2.20E+01		ANL (2005), Figure N.1
Solubility Limit	gm/cc	8.70E-04		EPA (2004), Page A-225.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	270 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	550 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Pu-238 - Atomic Weight 238 g/mol				
Half Life	years	8.78E+01		DOE (2011), Appendix D, page D-77
Solubility Limit	gm/cc	1.00E+01		No value found. Assume 10 gm/cc to prevent solubility from limiting migration.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	550 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	5100 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Pu-239 - Atomic Weight 239 g/mol				
Half Life	years	2.41E+04		DOE (2011), Appendix D, page D-77
Solubility Limit	gm/cc	1.00E+01		No value found. Assume 10 gm/cc to prevent solubility from limiting migration.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	550 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	5100 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Pu-240 - Atomic Weight 240 g/mol				
Half Life	years	6.54E+03		DOE (2011), Appendix D, page D-77
Solubility Limit	gm/cc	1.00E+01		No value found. Assume 10 gm/cc to prevent solubility from limiting migration.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	550 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	5100 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Ra-226 - Atomic Weight 226 g/mol				
Half Life	years	1.60E+03		ANL (2005), Figure N.1
Solubility Limit	gm/cc	3.10E-01		EPA (2004), Page A-301.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	500 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	9,100 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Ra-228 - Atomic Weight 228 g/mol				
Half Life	years	5.80E+00		ANL (2005), Figure N.3
Solubility Limit	gm/cc	3.10E-01		EPA (2004), Page A-303.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	500 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	9,100 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Th-228 - Atomic Weight 228 g/mol				
Half Life	years	1.90E+00		ANL (2005), Figure N.3
Solubility Limit	gm/cc	2.80E-01		EPA (2004), Page A-343.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	3200 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	5800 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Th-229 - Atomic Weight 229 g/mol				

DUST-MS and AT123D Input Parameters
Preliminary Waste Acceptance Criteria Modeling, Paducah Gaseous Diffusion Plant
Paducah, Kentucky

Parameter	Units	Deterministic Value	Justification / Notes	Reference(s)
Half Life	years	7.34E+03		Disposal Unit Source Term (DUST) default library
Solubility Limit	gm/cc	2.80E-01		EPA (2004), Page A-345.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	3200 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	5800 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Th-230 - Atomic Weight 230 g/mol				
Half Life	years	7.70E+04		ANL (2005), Figure N.1
Solubility Limit	gm/cc	2.80E-01		EPA (2004), Page A-347.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	3200 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	5800 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
Th-232 - Atomic Weight 232 g/mol				
Half Life	years	1.40E+10		ANL (2005), N.3
Solubility Limit	gm/cc	2.80E-01		EPA (2004), Page A-351.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	3200 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	5800 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
U-233 - Atomic Weight 233 g/mol				
Half Life	years	1.59E+05		Disposal Unit Source Term (DUST) default library
Solubility Limit	gm/cc	1.00E-04		EPA (2004), Page A-381.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	35 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	1600 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
U-234 - Atomic Weight 234 g/mol				
Half Life	years	2.40E+05		ANL (2005), Figure N.1
Solubility Limit	gm/cc	1.00E-04		EPA (2004), Page A-383.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	35 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	1600 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
U-235 - Atomic Weight 235 g/mol				
Half Life	years	7.00E+08		ANL (2005), Figure N.2
Solubility Limit	gm/cc	1.00E-04		EPA (2004), Page A-385.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	35 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	1600 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
U-236 - Atomic Weight 236 g/mol				
Half Life	years	2.34E+07		Disposal Unit Source Term (DUST) default library
Solubility Limit	gm/cc	1.00E-04		EPA (2004), Page A-387.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	35 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	1600 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--
U-238 - Atomic Weight 238 g/mol				
Half Life	years	4.50E+09		ANL (2005), Figure N.1
Solubility Limit	gm/cc	1.00E-04		EPA (2004), Page A-389.
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Distribution Coefficient (Kd)	cc/gm	35 (sand and all other materials)		Sheppard and Thibault (1990), Table 1, Page 472
	cc/gm	1600 (clay)		
Diffusion Coefficient	cm2/sec	1.00E-06		--

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ATTACHMENT C5

CONCENTRATION TIME SERIES PLOTS

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C5.1. CONCENTRATION TIME SERIES PLOTS

This attachment to Appendix C presents AT123D-predicted contaminant groundwater concentrations at the waste disposal facility (WDF) boundary over time for the sensitivity analysis constituents (Figures C5.1 through C5.10). The waste form source initial concentrations were assigned in DUSTMS based upon the preliminary waste acceptance criteria (PWAC)-edge of waste (EOW) for the gradual failure scenario as presented in Appendix C, Tables C.2 and C.3. Shown on each plot are the chemical-specific maximum contaminant level and background concentrations, where applicable. The sensitivity analysis constituents represent each chemical group and are key compounds regarding evaluation of the on-site waste disposal option. Sensitivity analysis constituents include silver, arsenic, vanadium, copper, technetium (Tc-99), neptunium (Np-237), uranium (U-238, U-235, and U-234), trichloroethene (TCE), benzo(a)pyrene, and polychlorinated biphenyls (PCBs). Plots for vanadium, U-238, U-235, U-234, TCE, benzo(a)pyrene, and PCBs are not included because the predicted AT123D concentrations are less than the minimum presented concentration level of 1E-09 mg/L (or 1E-09 pCi/L). Shown on each plot also are the chemical-specific maximum contaminant level and background concentrations, where applicable.

Simulations were performed for a maximum of 10,000 years unless numerical limitations required shorter duration simulations. For clarity and to align with the 1,600-year duration used to derive PWAC values, the concentration time series plots presented herein are limited to 1,600 years. Whenever predicted groundwater concentrations became less than the minimum presented concentration or activity level, the time axis was truncated to improve readability.

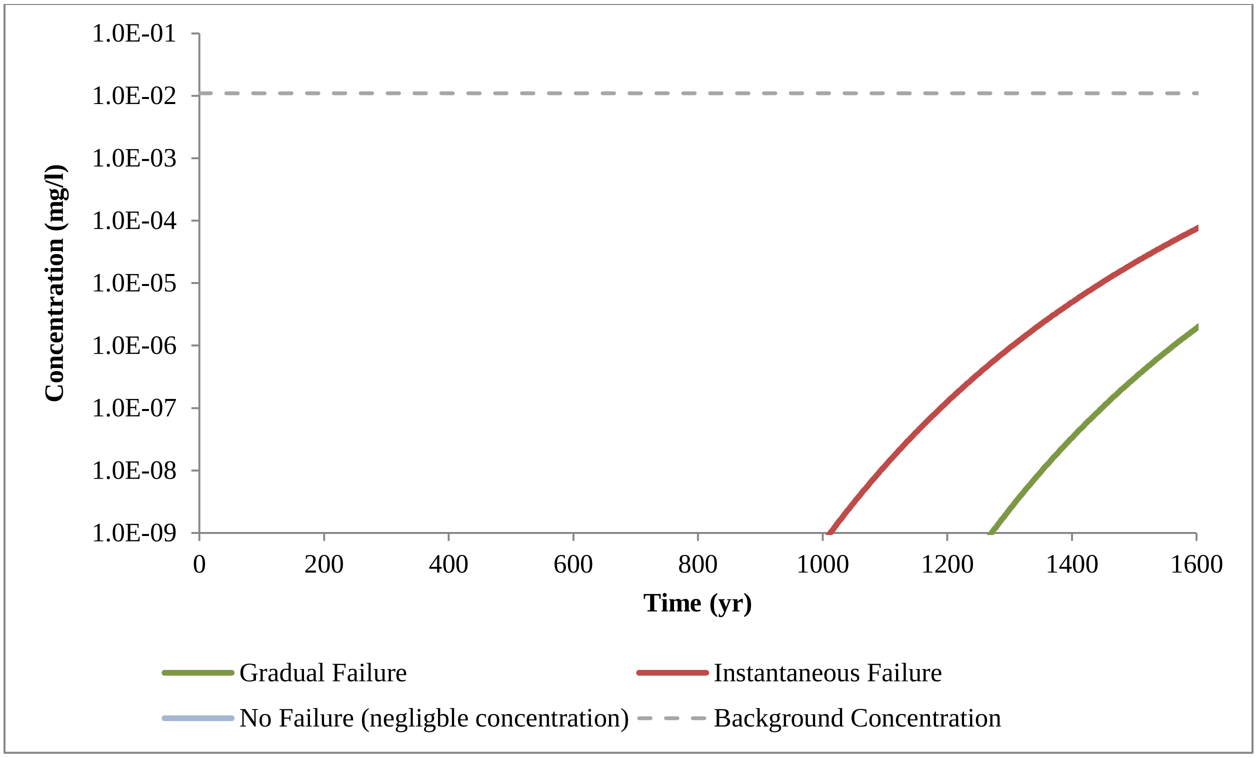

Figure C5.1. Site 3A—Silver Groundwater Concentrations at WDF Boundary
Negligible groundwater concentrations predicted for the No Failure Scenario.

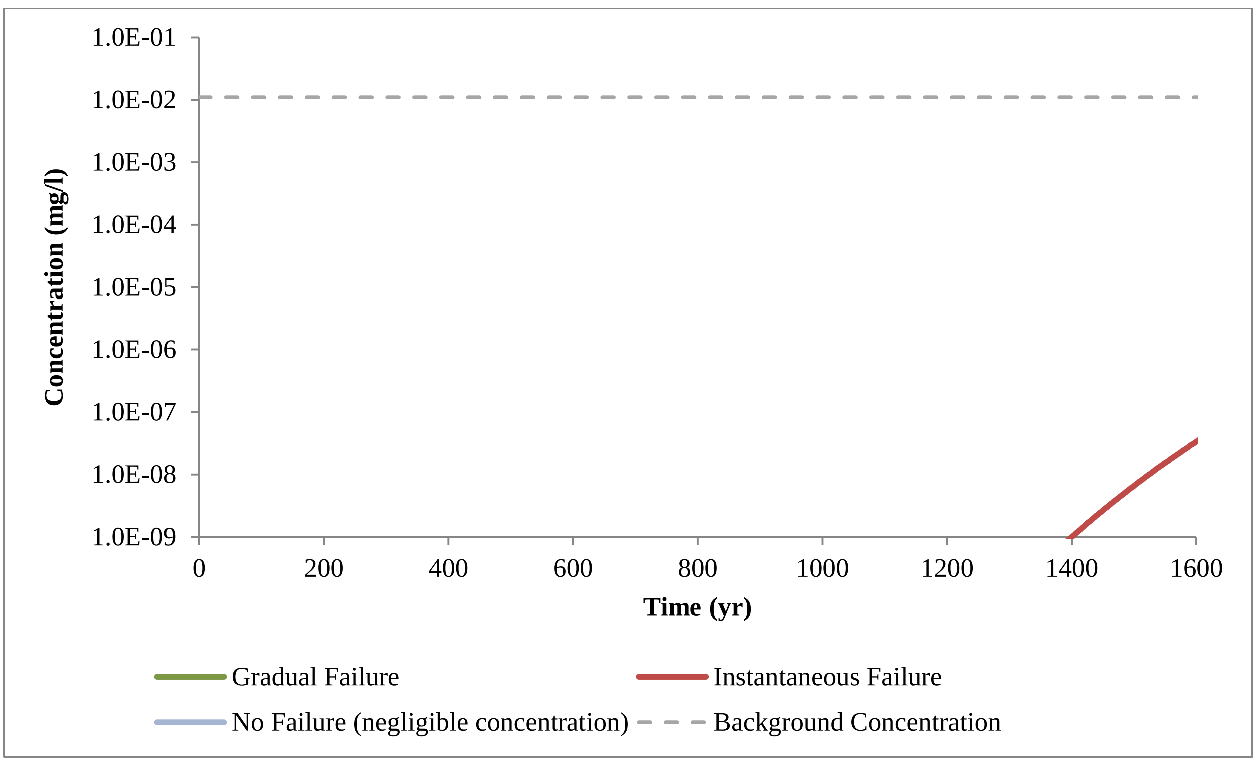

Figure C5.2. Site 11—Silver Groundwater Concentrations at WDF Boundary
Negligible groundwater concentrations predicted for the No Failure Scenario.

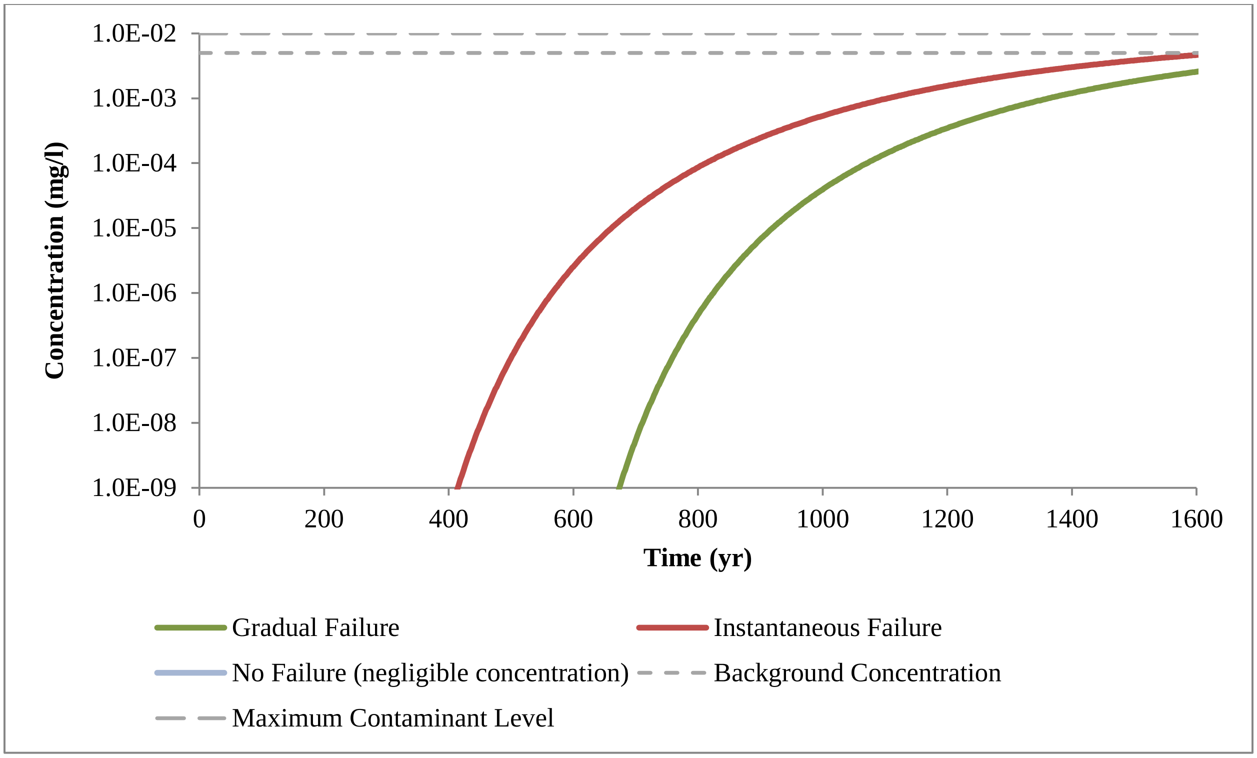

Figure C5.3. Site 3A—Arsenic Groundwater Concentrations at WDF Boundary
Negligible groundwater concentrations predicted for the No Failure Scenario.

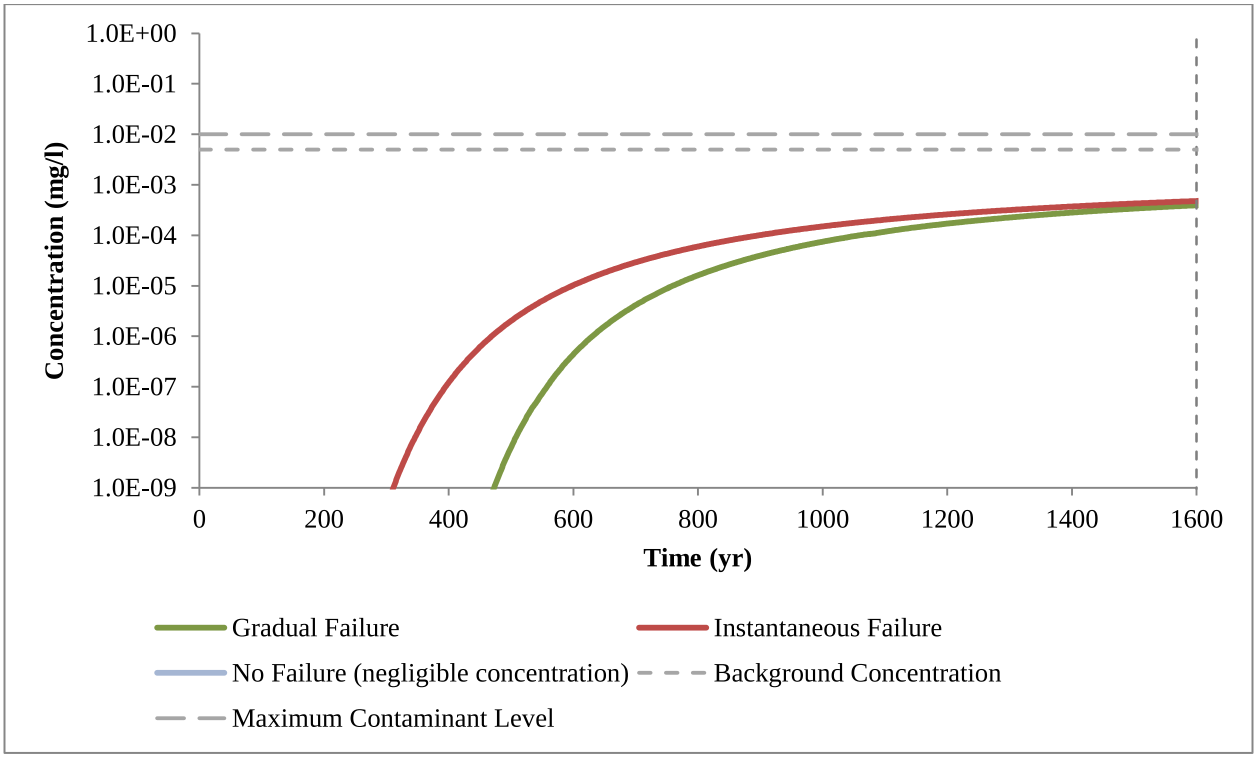

Figure C5.4. Site 11—Arsenic Groundwater Concentrations at WDF Boundary
Negligible groundwater concentrations predicted for the No Failure Scenario.

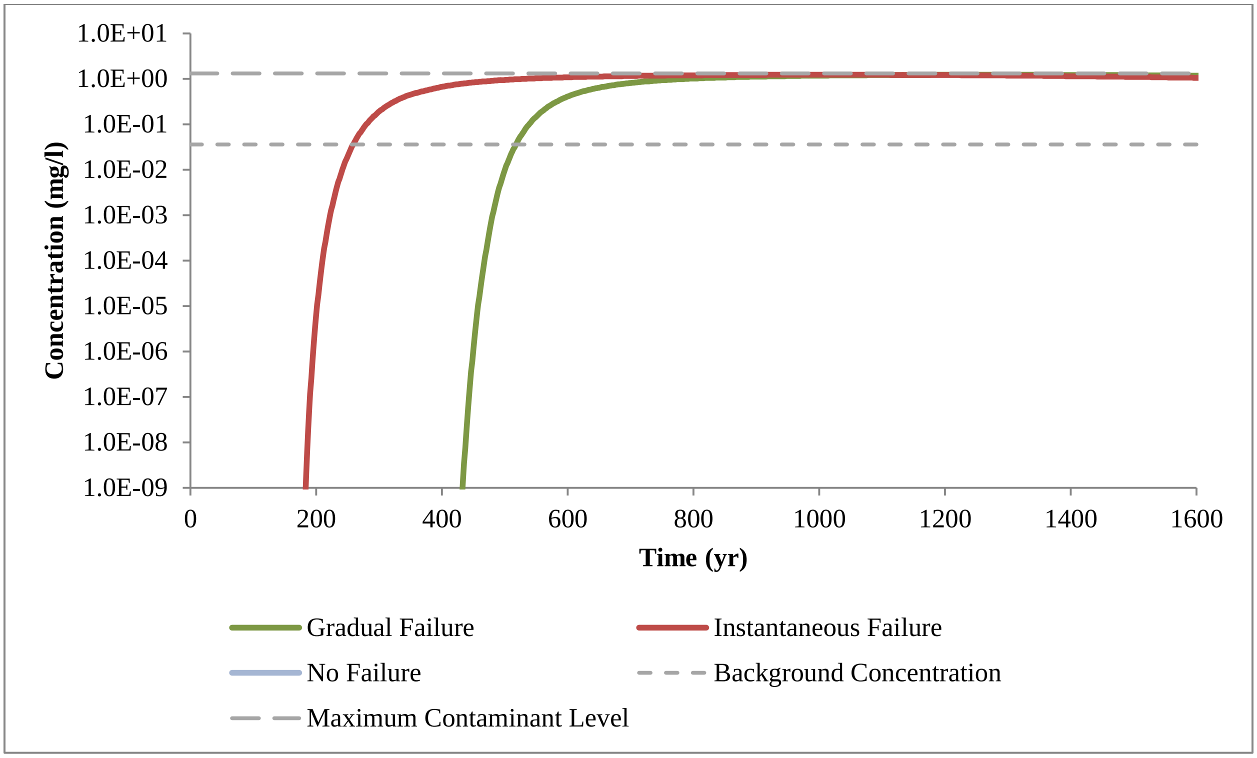

Figure C5.5. Site 3A—Copper Groundwater Concentrations at WDF Boundary
Negligible groundwater concentrations predicted for the No Failure Scenario.

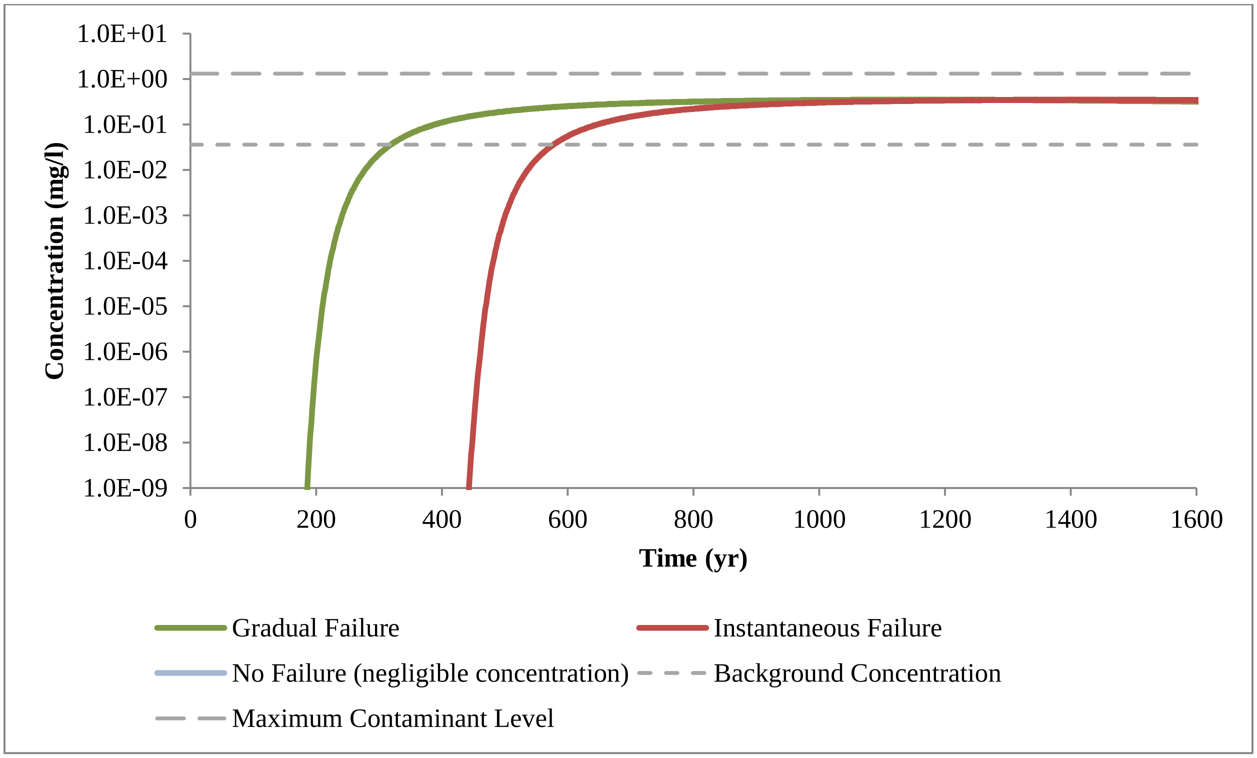

Figure C5.6. Site 11—Copper Groundwater Concentrations at WDF Boundary
Negligible groundwater concentrations predicted for the No Failure Scenario.

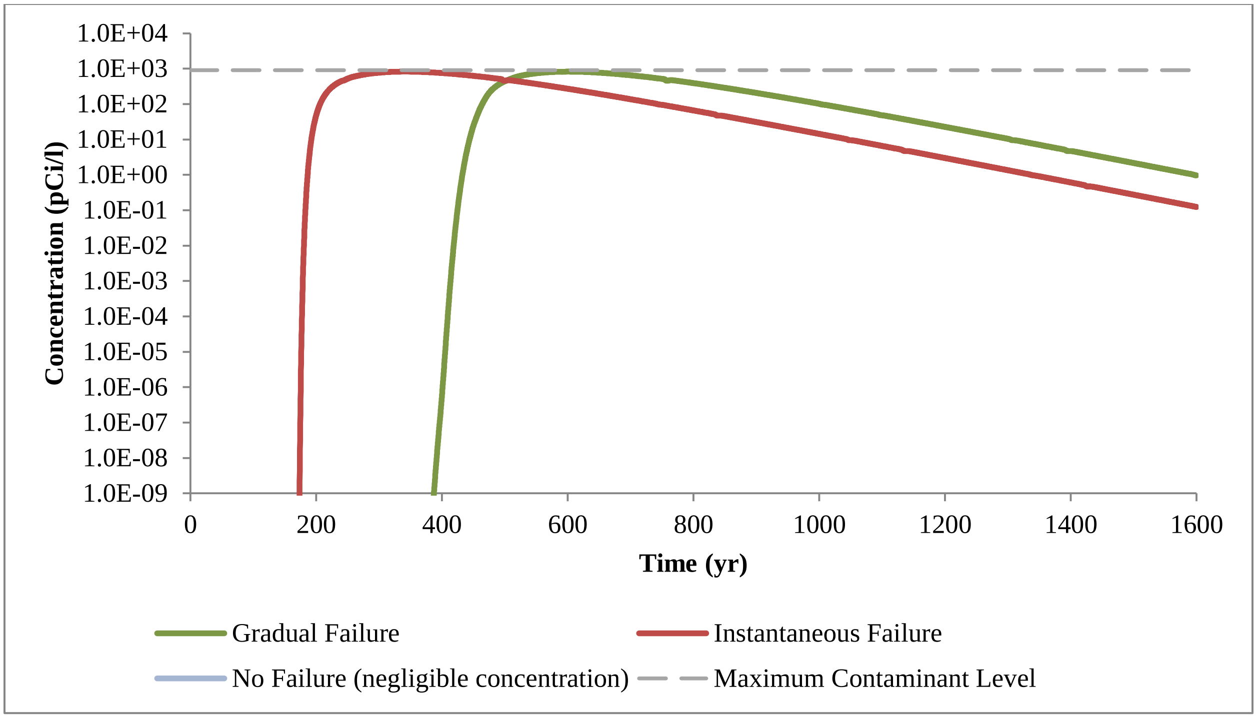

Figure C5.7. Site 3A—Tc-99 Groundwater Concentrations at WDF Boundary
Negligible groundwater concentrations predicted for the No Failure Scenario.

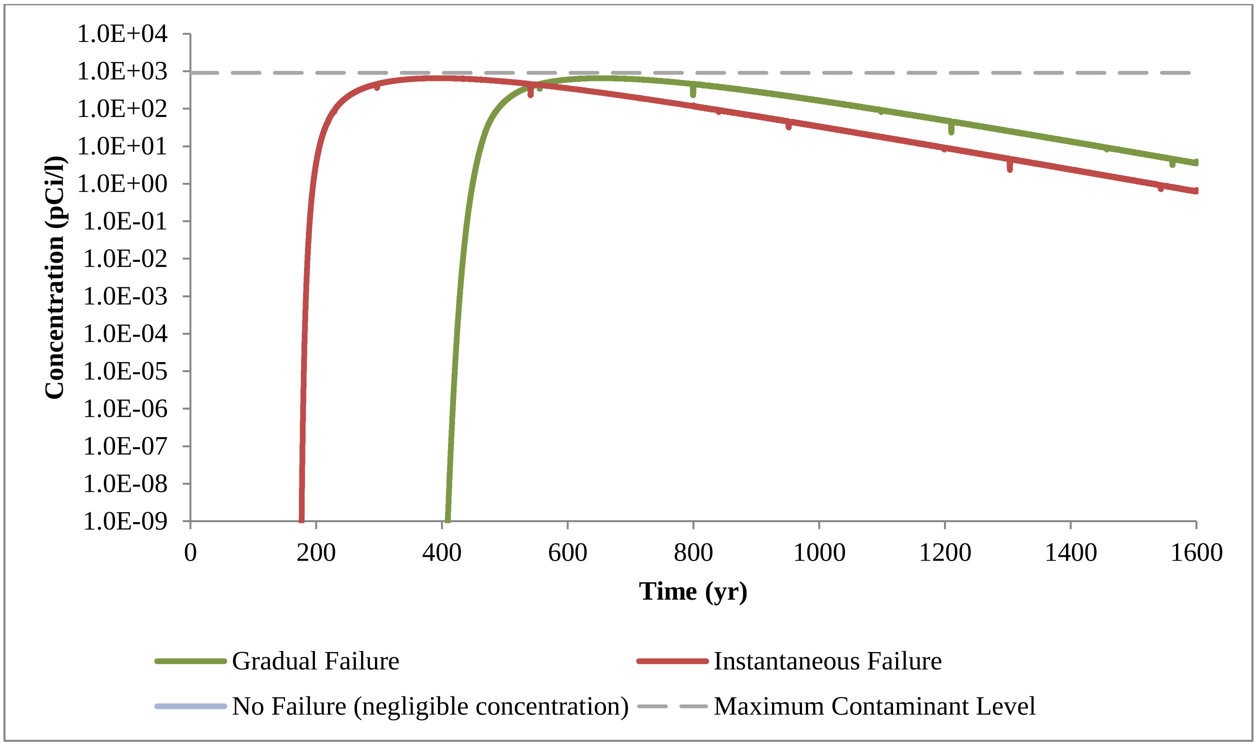

Figure C5.8. Site 11—Tc-99 Groundwater Concentrations at WDF Boundary
Negligible groundwater concentrations predicted for the No Failure Scenario.

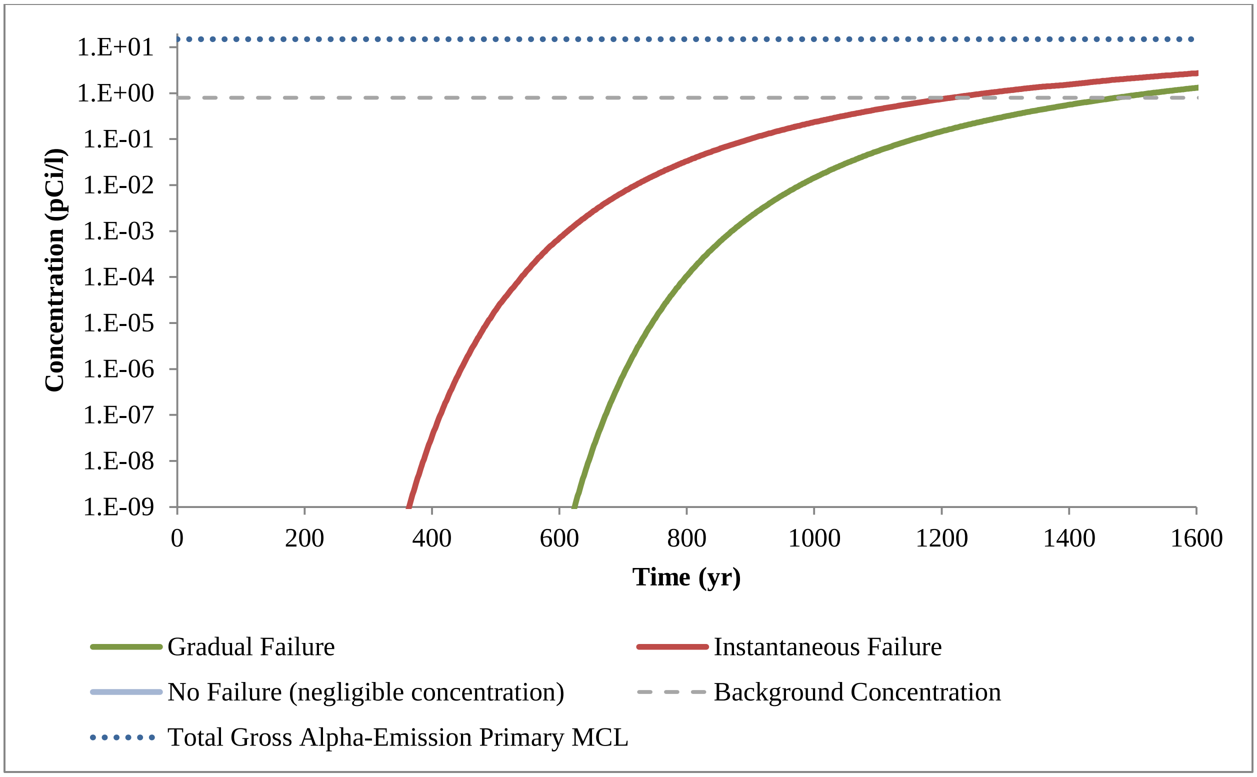

Figure C5.9. Site 3A—Np-237 Groundwater Concentrations at WDF Boundary
Negligible groundwater concentrations predicted for the No Failure Scenario

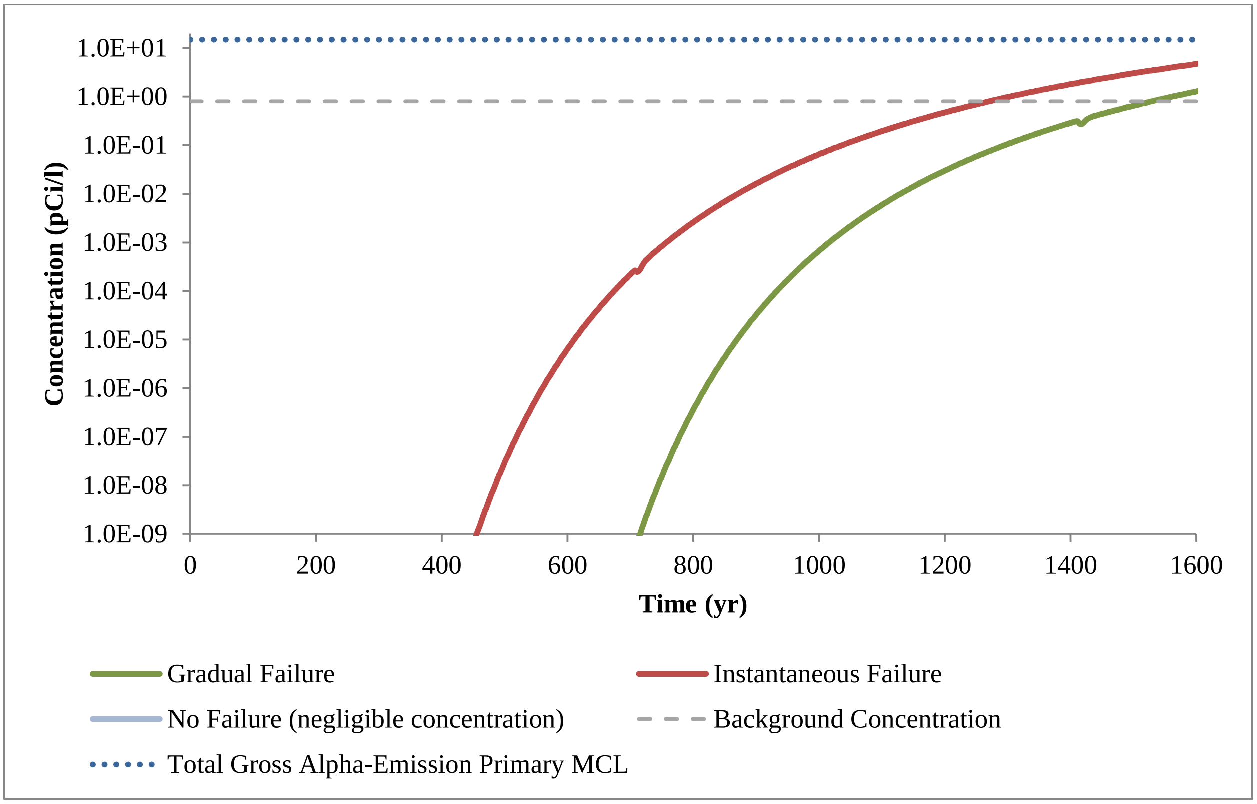

Figure C5.10. Site 11-Np—237 Groundwater Concentrations at WDF Boundary
Negligible groundwater concentrations predicted for the No Failure Scenario

ATTACHMENT C6

POTENTIAL RECEPTORS AND EXPOSURE PATHWAYS

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C6.1. POTENTIAL RECEPTORS AND EXPOSURE PATHWAYS

This section describes the human receptors that may be exposed to contamination in or migrating from wastes placed in a potential on-site waste disposal facility (WDF) and exposure pathways that were considered as part of the development of the preliminary waste acceptance criteria (PWAC). This material was developed to be consistent with guidance contained in *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Volume 1, Human Health* (DOE 2011).

C6.1.1 HUMAN RECEPTORS

Several potential human receptors were considered in support of the development of the PWAC. The purpose of this was to determine which receptor would be the maximum exposed individual to use when preparing the PWAC modeling.

Residential Groundwater User. This potential receptor is assumed to be a resident drawing drinking water from a well completed in the primary aquifer [Regional Gravel Aquifer (RGA)] from Year 200 to 1,600. Water is assumed to be drawn from the Terrace Gravel aquifer at Site 3A and from the RGA at Site 11. This receptor would be exposed to contaminants migrating to groundwater only. The point of exposure considered is the WDF boundary, which is located 100 m from the edge of the waste to account for the size of the cap/liner and berm, as the closest plausible (although unlikely) location for a well. The U.S. Department of Energy (DOE) will provide long-term care of the facility so that a receptor likely would not be at this location. This provides a reasonable bounding scenario for evaluation in this feasibility study (FS) such that the final WAC, which would be developed only if an on-site WDF is the selected remedy, likely would be a higher value than the PWAC and more waste likely would be acceptable for disposal.

Rural Resident. This potential receptor is assumed to be a farmer who lives in a home near the WDF boundary, considered to be at the WDF boundary (i.e., same as the Residential Groundwater User) from Year 200 to 1,600. This potential receptor may be exposed to contaminants remaining in source material and to contaminants that may have migrated from the source material. Direct exposure to source material is unlikely because erosion of the 16-ft thick landfill cap, which includes a biointrusion layer consisting of large boulders and rocks, would be prevented because of continuing surveillance, maintenance, and monitoring (SM&M). Exposure by this receptor is functionally equivalent to that of the residential groundwater user drawing water from a well located at the WDF boundary.

Excavation Worker. This potential receptor is assumed to be a worker who inadvertently digs into source material at the disposal facility from Year 200 to 1,600. This scenario provides the only mechanism through which exposure to disposed waste can be assumed to occur, but would require loss of institutional control of the landfill and disregards the biointrusion layer of the cap. The exposure point for this scenario is at the landfill; this excavation worker scenario is not considered feasible Year 200 to 1,600 because access for industrial purposes will be controlled, and active maintenance of the facility following the long-term monitoring period is not anticipated.

Industrial Worker/Landfill Worker. This potential receptor is assumed to be a worker who is employed at a location that is on or near the site of the disposal facility from Year 200 to 1,600; however, this receptor is not exposed to waste material or to groundwater (as drinking water). Instead, the point of exposure considered is at the first location where groundwater discharges to surface water downgradient of the landfill (i.e., local seeps, gaining streams, and the Ohio River). The industrial worker and landfill worker employed at the landfill during the postclosure period (Year 30 to 200) are not included in the evaluation because that worker is assumed to be protected by regulation and DOE policy.

Recreational User. This potential receptor is assumed to be a local resident who hunts, fishes, or just visits the area near the landfill. This receptor is assumed to be exposed only to contaminants migrating from the source material because erosion of the cap is not being evaluated. The point of exposure is at the first location where groundwater discharges to surface water downgradient of the landfill (i.e., local seeps at Bayou Creek for Site 3A and Little Bayou Creek at Site 11, gaining streams, and the Ohio River).

C6.1.2 EXPOSURE PATHWAYS

This section provides information delineating the potential exposure pathways through which each of the receptors listed previously may be exposed to contamination at or migrating from the waste disposal facility. In addition, the rationale for the selection or exclusion of pathways of exposure for each of the receptors is provided. This material is also depicted in Figure C6.1. Reasons for not selecting a particular potential receptor and/or exposure pathway when deriving the PWAC are discussed in Section C6.3.

Groundwater. Contaminants leaching from waste in an on-site WDF could migrate through the vadose zone and enter the shallow aquifers underlying the WDF where groundwater flow could transport contaminants to the receptor's location (i.e., the receptor's drinking water well). This exposure pathway, which could include exposure routes ingestion, inhalation from vapors emitted from groundwater during showering and household use, and dermal, is evaluated for the receptor as a plausible exposure (DOE 2011). Also, contamination through use of groundwater for irrigation and the use of groundwater for animal and dairy production is considered unlikely because surface water would be used for these purposes (DOE 2003; DOE 2011).

Surface Water. Surface water immediately adjacent to the WDF would not be impacted because erosion of the WDF cap is not considered likely due to continuing SM&M, as necessary. Surface water could be impacted at local seeps (i.e., at Bayou Creek for Site 3A and Little Bayou Creek at Site 11), gaining streams, and the Ohio River from migration of contaminated groundwater. Surface water could be impacted at seeps near the Ohio River, and the Ohio River could be impacted from migration of contaminated groundwater. These exposure pathways were not further evaluated because of the significant additional distance that the groundwater and local seeps (i.e., at Bayou Creek for Site 3A and Little Bayou Creek at Site 11) would have to transport that would result in greater natural attenuation than at 100 m from the waste (i.e., a groundwater user would be the most sensitive receptor).

Direct Contact. Direct contact with waste in the WDF is not considered a viable exposure pathway because of the cap design and continuing SM&M, as necessary.

Air. Volatilization of contaminants and particulates to ambient air is not considered a viable exposure pathway because of the cap design and continuing SM&M as necessary. The generation of gases by organic waste decomposition is expected to be minimal. A methane gas generation analysis will be performed to establish limits on the amount of wood and leafy material that can be placed in the landfill.

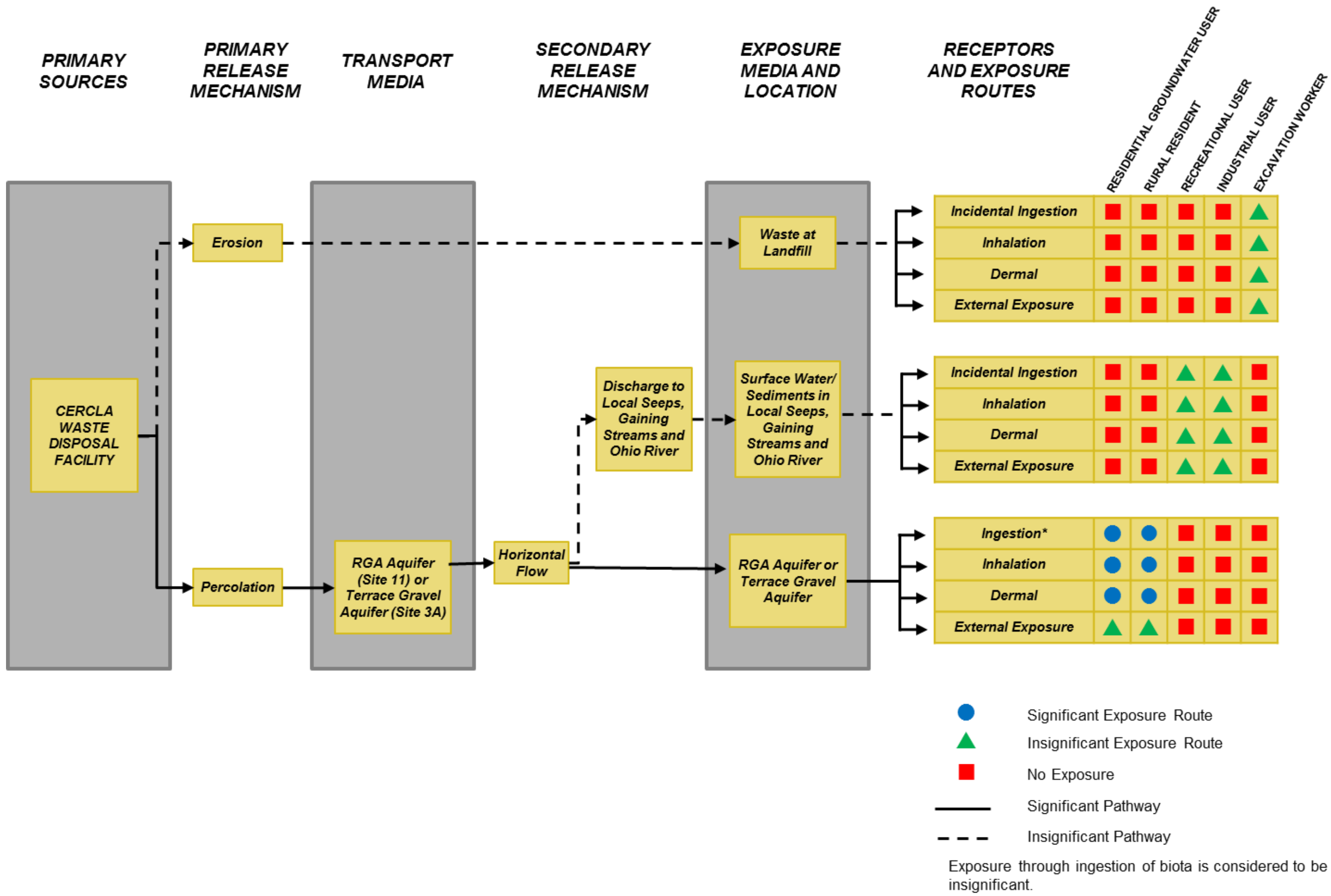

Figure C6.1. Conceptual Site Model for the Human Health Risk Assessment

C6.1.3 SELECTION OF THE HUMAN RECEPTOR

The receptor selected for PWAC development is the residential groundwater user drawing water from a well located at one of three points of assessment (i.e., edge of waste, WDF boundary, property boundary, or surface water outcrop) from Year 200 to 1,600. As discussed in Section C.6.1.1, the point of exposure considered is the WDF boundary, which is located 100 m from the edge of the waste to account for the size of the cap/liner and berm, as the closest plausible (although unlikely) location for a well. This receptor was selected because this individual would reasonably be expected to receive the largest cancer risk, hazard and/or radionuclide dose from most contaminants migrating from the landfill (Table C6.1). The risk-based PWAC are based on a child/adult lifetime exposure, hazard-based PWAC are based on a child exposure, and dose-based PWAC are based on an adult exposure for an beta/gamma maximum contaminant level (MCL) of 4 mrem/yr. DOE will provide long-term care of the facility such that a receptor likely would not be at this location. This provides a reasonable bounding scenario for evaluation in this FS although it is recognized that the final WAC, which would be developed only if an on-site WDF is the selected remedy, may differ from the PWAC.

The exposure routes selected in the analysis for the residential groundwater user are ingestion of groundwater, inhalation of vapors emitted by groundwater during household use and bathing (i.e., showering), and dermal absorption during bathing (i.e., showering). An exposure route not retained is consumption of farm produce contaminated by groundwater through irrigation. The farm produce pathways are not included because this pathway relies on modeling containing a significant level of uncertainty and because water used for irrigation most likely would be surface and not groundwater (DOE 2011). The risk-based PWAC are based on a child/adult lifetime exposure, hazard-based PWAC are based on a child exposure, and dose-based PWAC are based on an adult exposure for a beta/gamma MCL of 4 mrem/yr.

Reasons for not selecting other potential receptors when deriving the PWAC are presented below.

Rural Resident. This receptor was not selected because direct exposure to source material is unlikely since erosion of the landfill cap is not being considered in this evaluation because of continuing SM&M as necessary. The closure cap includes a biointrusion layer consisting of large boulders and rocks to prevent direct intrusion into the waste. Exposure by this receptor is functionally equivalent to that of the residential groundwater user drawing water from a well located at the WDF boundary. The residential groundwater user is considered the maximum exposed individual, and the rural resident scenario is not considered for further analysis.

Excavation Worker. This receptor was not selected because experience at PGDP has shown that the potential risk levels calculated for a groundwater user normally exceed those posed under a direct contact scenario. Direct contact with waste in the WDF is not considered a viable exposure pathway because of the cap design and continuing SM&M as necessary. The closure cap includes a biointrusion layer consisting of large boulders and rocks to prevent direct intrusion into the waste. Additionally, any worker involved in waste excavation would be protected per DOE work rules.

Industrial Worker/Landfill Worker. This receptor was not selected because experience at PGDP has shown that the potential risk levels calculated for a groundwater user normally exceed those posed under a direct contact scenario. This receptor is not exposed to waste material or to groundwater (as drinking water). Instead, the point of exposure considered is at the first location where groundwater discharges to surface water downgradient of the landfill (i.e., local seeps, gaining streams, and the Ohio River). Direct contact with waste in the WDF is not considered a viable exposure pathway because of the cap design and continuing SM&M as necessary. The closure cap includes a biointrusion layer consisting of large boulders and rocks to prevent direct intrusion into the waste. Additionally, continued control of the area

Table C6.1. Exposure Route Summary

Medium	Exposure Medium	Exposure Point	Receptor	Exposure Route	Rationale for Selection or Exclusion of Exposure Pathway
Groundwater	Groundwater	100 m from edge of waste	Resident	Ingestion	**Selected**: Groundwater use is an expected condition. Groundwater is assumed to be drawn from the Terrace Gravel aquifer at Site 3A and from the RGA at Site 11.
				Dermal (shower)	
	Air	100 m from edge of waste	Resident	Inhalation (shower and household use)	**Selected**: Exposure from the air pathway subsequent to groundwater use in the household and during showering is considered.
				Dermal (shower)	
	Surface Water/Sediment	Local seeps, gaining streams, and Ohio River	Recreational User	Incidental Ingestion (swimming)	**Excluded**: The concentrations at the well located 100 m from the waste provides higher concentration than at local seeps (i.e., at Bayou Creek for Site 3A and Little Bayou Creek at Site 11), gaining streams, and Ohio River.
				Dermal (swimming)	
				Dermal (wading)	
	Fish	Local seeps, gaining streams, and Ohio River	Recreational User	Ingestion	**Excluded**: The concentrations at the well located 100 m from the waste provide higher concentration than at local seeps, gaining streams, and Ohio River.
	Game	Local seeps, gaining streams, and Ohio River	Recreational User	Ingestion	**Excluded**: The concentrations at the well located 100 m from the waste provides higher concentration than at local seeps (i.e., at Bayou Creek for Site 3A and Little Bayou Creek at Site 11), gaining streams, and Ohio River. Seeps are unlikely to be a water source for significant numbers of game animals; therefore, the groundwater concentrations at the Bayou and Little Bayou Creek seeps would not constitute a significant contribution to human dose from game animals.

Table C6.1. Exposure Route Summary (Continued)

Medium	Exposure Medium	Exposure Point	Receptor	Exposure Route	Rationale for Selection or Exclusion of Exposure Pathway
Soil	Soil	At facility	Resident	Ingestion Dermal External Exposure	**Excluded**: The final cap will prevent the indirect pathway to source material due to the final cap design, which includes a 3-ft thick biointrusion layer (3-inch to 12-inch diameter rock) and depth of the waste.
			Recreational User	Ingestion Dermal External Exposure	
			Excavation Worker	Ingestion Dermal External Exposure	**Excluded**: Unrestricted excavation is unreasonable due to the final cap design, which includes a 3-ft thick biointrusion layer (3-inch to 12-inch diameter rock) and depth of the waste.
			Industrial Worker	Ingestion Dermal External Exposure	**Excluded**: Direct contact with waste in the WDF is not considered a viable exposure pathway because of the thickness of the cap design and the 3-ft biointrusion layer as well as continuing SM&M (as needed).
	Air (Vapors and Particulates)	At facility	Resident	Inhalation	**Excluded**: The final cap will prevent the indirect pathway to source material due to the cap design and continuing SM&M, as necessary. The forecasted waste is not expected to contain significant amounts of decomposable material that would create significant gas in the WDF. The landfill cap also would prevent the release of particulates from the waste.
			Recreational User	Inhalation	
			Excavation Worker	Inhalation	**Excluded**: The final cap will prevent the indirect pathway to source material due to the cap design and continuing SM&M, as necessary. The forecasted waste is not expected to contain significant amounts of decomposable material that would create significant gas in the WDF. The landfill cap also would prevent the release of particulates from the waste.
			Industrial Worker	Inhalation	**Excluded**: The final cap will prevent the indirect pathway to source material due to the cap design and continuing SM&M, as necessary. The forecasted waste is not expected to contain significant amounts of decomposable material that would create significant gas in the WDF. The landfill cap also would prevent the release of particulates from the waste.

Table C6.1. Exposure Route Summary (Continued)

Medium	Exposure Medium	Exposure Point	Receptor	Exposure Route	Rationale for Selection or Exclusion of Exposure Pathway
	Vegetables	At facility	Resident	Ingestion	**Excluded**: The final cap will prevent the indirect pathway to source material due to the cap design and continuing SM&M, as necessary. The forecasted waste is not expected to contain significant amounts of decomposable material that would create significant gas in the WDF. The landfill cap also would prevent the release of particulates from the waste. Also, contamination through use of groundwater for irrigation is unlikely because surface water would be used for large-scale irrigation and animal watering (DOE 2011).
	Beef	At facility	Resident	Ingestion	
	Milk	At facility	Resident	Ingestion	
	Pork	At facility	Resident	Ingestion	
	Poultry	At facility	Resident	Ingestion	
	Game	At facility	Recreational User	Ingestion	
Source Material	Source Material	At facility	Resident	Ingestion	**Excluded**: Direct contact with waste in the WDF is not considered a viable exposure pathway because of the cap design and continuing SM&M, as necessary. The closure cap includes a biointrusion layer consisting of large boulders and rocks to prevent direct intrusion into the waste.
				Dermal	
				External Exposure	
			Excavation Worker	Ingestion	**Excluded**: Direct contact with waste in the WDF is not considered a viable exposure pathway because of the cap design and continuing SM&M, as necessary. The closure cap includes a biointrusion layer consisting of large boulders and rocks to prevent direct intrusion into the waste.
				Dermal	
				External Exposure	
	Air (Vapors and Particulates)	At facility	Resident	Inhalation	**Excluded**: The forecasted waste is not expected to contain significant amounts of decomposable material that would create significant gas in the WDF.
			Excavation Worker	Inhalation	**Excluded**: The forecasted waste is not expected to contain significant amounts of decomposable material that would create significant gas in the WDF. The landfill cap also would prevent the release of particulates from the waste.

around the landfill can be expected, and any worker involved in waste excavation would be protected per DOE work rules.

Recreational User. This receptor was not selected because experience at PGDP has shown that the potential risk levels calculated for a groundwater user normally exceed those posed under a direct contact scenario, such as exposure to groundwater discharged to the surface. The recreational user also is exposed for less time in comparison to the residential groundwater user. Additionally, the point of exposure for the recreational user is much further from the landfill than that for the groundwater user (i.e., local seeps at Bayou Creek for Site 3A and Little Bayou Creek at Site 11, gaining streams, and the Ohio River), thus making the exposure concentrations lower.

C6.2 REFERENCES

DOE (U.S. Department of Energy) 2003. *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* Volume 1, *Human Health,* DOE/OR/07-2041&D2R1, U.S. Department of Energy, Paducah, KY, September.

DOE 2011. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* Volume 1, *Human Health,* DOE/LX/07-0107&D2/R1/V1, U.S. Department of Energy, Paducah, KY, February.

ATTACHMENT C7

INADVERTENT INTRUDER ANALYSIS

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C7.1. INADVERTENT INTRUDER ANALYSIS

This section describes the intruder scenarios for a potential on-site waste disposal facility (WDF). The U.S. Department of Energy (DOE) will provide long-term care of the facility such that an inadvertent intruder is not a likely exposure scenario; however, the inadvertent intruder scenarios are summarized and screened in this report based on the assumption that long-term care is lost in the future. The intruder scenarios are screened based on the conceptual design of a potential on-site WDF (i.e., depth to the waste, side slope, and biointrusion layers).

Intruder scenarios considered for use were limited to those described previously for low-level radioactive waste performance assessments (Kennedy and Peloquin 1988; DOE 1999). These intruder scenarios include both acute and chronic exposure scenarios. Acute exposure scenarios involve exposures of short duration and include an intruder-construction scenario, a discovery scenario, and a drilling scenario. The intruder scenarios used include the intruder-construction, intruder-discovery, and intruder-agriculture scenarios.

Chronic, longer-duration intruder scenarios include the intruder-agriculture, intruder-resident, and post-drilling scenario. The *Addendum to Radioactive Waste Management Complex Low-Level Waste Radiological Performance Assessment* considered two additional intruder scenarios: chronic intruder-radon and chronic biointrusion (Maheras et al. 1997). All eight of these scenarios were screened for use and are discussed in this section (Maheras et al. 1997).

When waste is disposed of at depths greater than 16 ft, the intruder scenarios for surface excavation may not apply directly if the reasonable anticipated depth of intrusion is less than the depth to the waste. Disposal with special waste forms or at a depth greater than 16 ft resembles the conditions anticipated for "Greater Confinement Disposal" operations for low-level waste at many of the operating DOE burial grounds (Oztunali and Roles 1986). These conditions require the definition of additional intruder scenarios. Kennedy and Peloquin (1988) and Oztunali and Roles (1986) present intruder-drilling and post-drilling scenarios to deal with waste disposed at depths greater than 16 ft.

The remainder of this section explores the intruder scenario definitions and evaluates likely site-specific conditions to determine whether each intruder scenario is a complete exposure pathway for a potential receptor at an on-site disposal facility for the development of a preliminary waste acceptance criteria (PWAC).

C7.1.1 ACUTE INADVERTENT INTRUDER SCENARIO SCREENING

As suggested in the performance assessment guidance (DOE 1999), three potential acute intruder exposure scenarios were considered: (1) intruder-construction; (2) intruder-discovery; and (3) intruder-drilling scenarios. These scenarios are described below and those determined not applicable to a potential on-site WDF were screened out from further consideration, as appropriate. As discussed in the following sections, none of the inadvertent intruder scenarios considered for this remedial investigation/feasibility study is considered applicable; the rationale for this conclusion for each scenario is presented below.

C7.1.1.1 Intruder-Construction Scenario

The intruder-construction scenario involves an inadvertent intruder who chooses to excavate or construct a building on the disposal site. In this scenario, the intruder is assumed to dig a basement excavation to a depth of approximately 10 ft (Oztunali and Roles 1986). It is assumed that the intruder does not recognize the hazardous nature of the material excavated. He or she would be exposed to waste removed during the excavation of a basement. The intruder also would be exposed to the exhumed waste by inhalation of resuspended contaminated soil and external irradiation from contaminated soil.

Based on the conceptual design, the depth to waste of a potential on-site disposal facility (i.e., 16-ft thick cap material) would preclude direct contact with the waste from a 10-ft excavation for a basement. The intruder-construction scenario is not considered applicable to these wastes due to the disposal depth of the waste in a potential on-site disposal facility (i.e., greater than 16 ft).

C7.1.1.2 Intruder-Discovery Scenario

The intruder-discovery scenario is conceptualized as a modification of the intruder-construction scenario presented above. The basis for the intruder-discovery scenario is the same as the intruder-construction scenario except that the exposure time is reduced (Oztunali and Roles 1986). This scenario also involves the intruder excavating a basement to a 10-ft depth, but it is assumed the intruder will recognize that he or she is digging into very unusual soil immediately upon encountering the waste and leave the site. Consequently, the exposure time is reduced. The time typically applied to this scenario is 6 hour.

The depth to the waste in a potential on-site disposal facility (i.e., 16-ft thick cap material) would preclude direct contact with the waste from the 10-ft excavation. As for the intruder-construction scenario, the intruder-discovery scenario was not considered applicable to these waste due to the disposal depth of the waste in a potential on-site waste disposal facility (i.e., greater than 16 ft) and the biointrusion layer, which consists of large boulders and rocks (3- to 12-inch diameter), that likely would stop the intruder prior to excavating to 10 ft.

C7.1.1.3 Intruder-Drilling Scenario

The intruder-drilling scenario assumes the short-term exposure of a hypothetical intruder to drill cuttings from a borehole penetrating the waste disposal site. This scenario involves wastes buried below the depth of typical construction excavations.

Oztunali and Roles (1986) indicate that for waste below 33 ft, the only applicable intrusion scenario, is the intruder-drilling scenario. Because a potential on-site disposal facility is aboveground, it is considered unlikely that an inadvertent intruder would mobilize a drilling rig on top of the disposal facility for this scenario and instead would avoid this area to save the drilling distance of 100 ft required to drill through the disposal cell in an attempt to reach groundwater. Additionally, the closure cap includes a biointrusion layer consisting of large boulders and rocks (3- to 12-inch diameter) that would prove difficult to drill through, with most drilling techniques causing a driller to attempt to repeatedly off-set the location and likely ultimately discouraging the drilling entirely.

C7.1.1.2 CHRONIC INADVERTENT INTRUDER SCENARIO SCREENING

As suggested in the performance assessment guidance (DOE 1999), five potential chronic intruder exposure scenarios were considered: (1) the intruder-agriculture; (2) intruder-resident; (3) intruder-radon; (4) biointrusion; and (5) post-drilling scenarios. These scenarios are described below and those determined not applicable to an on-site WDF were screened out from further consideration, as appropriate.

C7.1.2.1 Intruder Postconstruction Scenario

The chronic intruder postconstruction (i.e., agriculture) scenario is an extension of the acute intruder-construction scenario. It is assumed in this scenario that an intruder would live in the building constructed as part of the intruder-construction scenario and would engage in agricultural activities on the contaminated site. The intruder would be exposed to contamination by inhalation of resuspended contaminated soil, inhalation of gaseous radionuclides released from the waste, external irradiation, ingestion of contaminated soil, ingestion of contaminated beef and milk, and ingestion of contaminated vegetables.

As stated earlier, the intruder-construction scenario was not considered applicable because the depth to waste in a potential on-site disposal facility (i.e., 16 ft of cap material) would preclude direct contact with the waste from the 10-ft excavation and the cap material would provide shielding and isolation from the waste, preventing exposure to radiation or contaminated soil gas. Further, the biointrusion layer likely would preclude construction of a house with a basement and would prevent contamination of any vegetables grown on it; therefore, the intruder postconstruction scenario was not considered applicable to an on-site disposal facility.

C7.1.2.2 Intruder-Resident Scenario

The intruder-resident scenario assumes that the intruder would construct a residence on the disposal cell after an excavation or some natural process exposes it. This scenario was not considered applicable to an on-site disposal facility because of the depth of the waste and the shielding provided by the overlying cap; therefore, the intruder-resident scenario was not considered for further analysis.

C7.1.2.3 Intruder-Radon Scenario

The intruder-radon scenario assumes that the intruder would excavate a 66 ft $\times$ 33 ft $\times$ 10 ft basement over the waste while constructing a home. While residing in the home, the intruder would be exposed to radon-222 and its short-lived progeny emanating from the waste and migrating into the home.

The cap and liner design will include a clay cap and other soil components that will attenuate the radon and will be designed to mitigate radon release. As presented in Appendix F to the this report, the conceptual cap and liner design includes the following components (from top down to waste): 5-ft vegetated soil/rock matrix; 1-ft graded natural filter layer; 3-ft biointrusion layer; two geotextiles encompassing a 1-ft drainage layer; 3-ft compact clay layer; 0.5-ft vegetative soil layer; and 2.5-ft[1] contoured soil. Radon specific modeling was not performed for this effort; however, radon modeling was performed as part of the 2011 C-746-U Landfill authorized limits request (DOE 2011). Because of similarities in cap design, waste profile, and siting, these results are extended to this effort. During the evaluation of radon migration at the C-746-U Landfill, Th-230, U-234, and U-238 isotopes were evaluated for radon emissions using an updated version of the RAECOM program found at *http://www.wise-uranium.org/ctc.html?unit=c*. This analysis indicated that no radon would escape the first layer of the cap. More information, including RAECOM input parameters, can be found in Attachment A in DOE 2011.

[1] The 2.5-ft contoured soil may actually range from 6-inches to 3-ft.

C7.1.2.4 Biointrusion Scenario

The biointrusion scenario assumes that an intruder would move onto the site, but would not excavate into the waste. Rather, radioactivity would be brought to the surface by plants through root uptake (i.e., evapotranspiration) and by diffusion through tunnels made by burrowing animals.

The biointrusion scenario was not considered applicable because the cap contains a biointrusion layer consisting of large boulders and rocks (3- to 12-inch diameter) to prevent biointrusion into the waste. In addition, the depth to waste in an on-site disposal facility (i.e., 16 ft of cap material) would preclude direct contact with the waste from biointruding plants and animals; therefore, the biointrusion scenario was not considered for further analysis. Because (SM&M) activities will continue for as long as the waste disposed of in the facility poses an unacceptable risk to human health and environment, trees would be prevented from growing on the cell cover. Following the period of active maintenance, the biointrusion layer would discourage growth of deep-routed trees. As discussed in Piet et al. (2003), because plants will not grow in coarse materials that drain to low water contents (i.e., below the wilting point), the biointrusion layer can serve as a barrier to root penetration.

C7.1.2.5 Post-Drilling Scenario

The chronic post-drilling scenario is an extension of the acute drilling scenario. It assumes that the intruder would occupy the site after drilling a water well and would grow crops on a mixture of clean soil and contaminated drill cuttings. After exhumation of the waste, the exposure pathways are the same as for the intruder-agriculture scenario.

Due to the side slopes of a potential on-site disposal facility (i.e., 6 to 1) and the fact that the disposal facility is aboveground, it is considered unlikely that an inadvertent intruder would mobilize a drilling rig on top of the disposal facility for this scenario.

C7.2. REFERENCES

DOE (U.S. Department of Energy) 1999. “Implementation Guide for Use with DOE M-435.1-1,” DOE G 435.1-1, U.S. Department of Energy, July 9.

DOE 2001. “Radioactive Waste Management Manual,” DOE M 435.1-1, Change 1, U.S. Department of Energy, June 19.

DOE 2011. “Authorized Limits Request for Solid Waste Disposal at C-746-U LANDFILL at the Paducah Gaseous Diffusion Plan, U.S. Department of Energy, Portsmouth/Paducah Project Office, Lexington, Kentucky, August.

Kennedy, W. E., Jr., and R. A. Peloquin 1988. *Intruder Scenarios for Site-Specific Low-Level Radioactive Waste Classification,* DOE/LLW-71T, U.S. Department of Energy, Idaho Operations Office.

Maheras, S. J., A. S. Rood, S. O. Magnuson, E. M. Sussman, and R. N. Bhatt 1997. *Addendum to Radioactive Waste Management Complex Low-Level Waste Radiological Performance Assessment (EGG-WM-8773),* INEEL/EXT-97-00462, April.

Oztunali, O. I., and G. W. Roles 1986. *Update of Part 61: Impacts Analysis Methodology, Methodology Report,* NUREG/CR-4370, Vol. 1, U.S. Nuclear Regulatory Commission, Washington, DC, January.

Piet, S., Jacobson, J., Martian P., Martineau, R. and Soto, R. 2003. “Modeling and Simulation of Long-Term Performance of Near-Surface Barriers.” Idaho National Engineering and Environmental Laboratory (INEEL). WM ’03 Conference, February 23–27, 2003, Tucson, AZ.

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ATTACHMENT C8

FACILITATED TRANSPORT EVALUATION

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C8.1. FACILITATED TRANSPORT EVALUATION

Any process that can accelerate the pace of contaminant transport, particularly at rates exceeding average groundwater velocities, is considered a facilitated transport process. Facilitated transport may occur at two different size scales: the microscale (corresponding to molecular and atomic diffusion) and the macroscale (such as cracks in the liner). An evaluation of "facilitated transport" of contaminants from the waste cell was conducted during the conceptual cell performance modeling and preliminary waste acceptance criteria (PWAC) development for a potential on-site waste disposal facility. Facilitated transport refers to the enhanced migration of contaminants from the disposal cell into the surrounding environment. Two mechanisms currently are proposed that can account for facilitated transport. First, waste placed in the disposal cell has the potential to create a chemical environment that will accelerate the leaching of contamination from the waste and into water migrating through and exiting the disposal cell. Examples include cosolvent facilitated transport and colloidal facilitated transport. Second, waste has the potential to create a leachate that deteriorates the liner system and exits the cell faster than predicted. Facilitated transport may occur when chelating agents are present in the disposal cell (will enhance the migration of contamination) or a large volume of organic waste is disposed of in the cell. Decomposition of a large volume of organic waste could result in an acidic leachate that may deteriorate the clay portion of the disposal cell liner system.

The evaluation started with an examination of the two reports recommended by the Kentucky regulators [*Assessing the Impacts of Hazardous Constituents on the Mobilization, Transport, and Fate of Radionuclides in RCRA Waste Disposal Units* (ANL 2001) and *Radionuclide-Chelating Agent Complexes in Low-level Radioactive Decontamination Waste: Stability, Adsorption, and Transport Potential* (PNNL 2002)]. *Radionuclide-Chelating Agent Complexes in Low-Level Radioactive Decontamination Waste; Stability, Adsorption and Transport Potential* was examined to determine if any radionuclide chelating agents had been identified at U.S. Department of Energy (DOE) gaseous diffusion plants. Paducah Gaseous Diffusion Plant (PGDP) was not specifically included in this study; however, the gaseous diffusion plant in Piketon, OH, was included. No chelating agents were identified in similar wastes at that site.

Wastes expected in a potential on-site disposal facility would consist of large volumes of soil and debris generated during the remediation activities and from the demolition of the facilities at PGDP. This demolition debris will be comprised primarily of radioactively and/or chemically contaminated concrete, masonry, metal structural components, metal piping, equipment, and metal and transite siding. Smaller volumes of contaminated glass, asbestos, and man-made fiber insulation, plastic materials and piping, personal protective equipment, etc., also are expected. Very little contaminated waste that would typically decompose in aboveground conditions, such as wood, paper, or vegetation, is expected. Solid, nonhazardous wastes also may be expected. These wastes also would be composed of debris, except that they would not be low-level waste/hazardous waste. Wet garbage, such as food and waste from the cafeteria, waste from the medical facility, organic debris from ongoing facilities maintenance activities, "office waste" from active administrative activities, or other putrescent waste, will not be eligible for disposal in a potential on-site facility. (These are not Comprehensive Environmental Response, Compensation, and Liability Act activities.) A comparison of waste predicted to be generated at PGDP with waste profiled for disposal in the Oak Ridge Environmental Management Waste Management Facility (EMWMF) determined that the PGDP waste should be similar to those being disposed of at EMWMF. This was confirmed by personnel characterizing waste for disposal at EMWMF and the manager of the waste acceptance process for EMWMF. The personnel concluded that "insignificant amounts" of organic materials (< 5% of the total waste volume) are being disposed of in EMWMF.

Analytical results on samples of leachate from EMWMF were obtained during this evaluation. The leachate samples were reported as approximately neutral (pH values ranged from 6.74 to 7.67 with an average of 7.13). Because EMWMF does not dispose of nonhazardous solid waste, analytical results of recent sampling of leachate from the C-746-U Landfill at PGDP (that accepts solid, nonhazardous wastes from remediation, construction, and demolition activities on PGDP) were obtained. These leachate samples also were reported approximately neutral (pH values ranged from 6.89 to 7.19 with an average of 7.09).

Chelating agents commonly are used in industrial processes other than the enrichment of uranium (PNNL 2002). Chelating agents are not expected in the waste originating on PGDP. Oak Ridge personnel characterizing waste for disposal at EMWMF and the manager of the waste acceptance process for EMWMF stated that there is no evidence of chelating in the waste being disposed of in EMWMF.

Although very little organic matter is expected to be disposed of in the cell, the evaluation continued to assess the potential impact of the decomposition of organic waste. Most of the organic waste is expected to decompose within a few years after disposal when the materials are exposed to water migrating through the waste during operations. This would occur before the final cover has been installed and while leachate is being removed from the leachate collection system. Decay is expected to substantially subside shortly after the final cover has been installed and substantial amounts of water no longer migrate through the waste. Leachate collection is required to continue for many years after the final cover has been installed. Studies of existing landfill systems show that volumes of leachate rapidly decrease within five to ten years of cover installation (Bonaparte et al. 2002; Bonaparte et al. 2011); therefore, virtually all of the leachate originating when the organic waste is decomposing would be removed from the disposal cell and would not contact the clay portion of the liner system. In the case of the failure of the leachate collection system, the leak detection system below would function as a redundant leachate collection system. The liner system will contain several layers of high-density polyethylene flexible membranes. While these liner components are not considered in the long-term performance modeling of the disposal cell, they are predicted to remain intact for at least several hundred years (Rowe and Islam 2009; Rowe 2010; Rowe et al. 2010) after installation and should prevent leachate generated during the decomposition of organic waste from migrating into the clay portion of the liner system. Detailed disposal cell design is required to include an assessment of liner system membranes to ensure they do not deteriorate when exposed to an expected range of leachate compositions.

Regarding cosolvent facilitated transport, the cosolvent effect may apply in situations where there are two types of organic contaminants present in the waste: one type that is hydrophobic and sparingly soluble, [e.g., polyaromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs)], and another type that may function as a cosolvent for the sparingly soluble contaminant, or moderately to highly soluble in water (Huling 1989). In order for a substance to behave as a cosolvent it must be miscible with water, even to a small degree. The cosolvent effect is such that the solubility of the hydrophobic compounds increases due to co-mixing with the organic cosolvent, particularly if the latter is fully miscible with water (e.g., ethanol or methanol) (Suresh et al. 1990; Li and Andren 1994). Nonspecific hydrophobic partitioning to solid phase materials also is understood to decline in the presence of an organic cosolvent. This is not expected to be an operative transport mechanism in the disposal cell, since very little organic matter is expected to be disposed of in the cell. Although trichloroethene (TCE) is expected to be present as a comingled contaminant in the disposal cell, a large volume (relative to the size of the overall solid waste material in the cell) would need to be present before TCE could behave as a cosolvent and appreciably enhance the solubility of highly insoluble substances such as PCBs or PAHs.

Another microscale process is colloidal facilitated transport, which can be described as a mass of contaminant associated with suspended colloidal-size particles (diameter < 10 micrometers) (Huling 1989). These small suspended particles may be organic or inorganic in composition. Hydrophobic organic contaminants, as well as inorganic metals/metalloids, are known to show affinity for binding to colloids, in part due to the high surface area that is characteristic of small, roughly spherical- to acicular-shaped particles. Colloidal transport at any given site is dependent upon the ability of solid phase substrates to release colloids. Pertaining to the disposal cell, colloids may originate from within the waste materials or within the aquifer media itself (e.g., humic substances). In either case, the contaminants could form noncovalent (physisorbed) associations with colloidal particles; however, the waste material planned for disposal in the disposal cell and the coarse textured/low carbon properties of the Regional Gravel Aquifer are not expected to be abundant sources of colloids.

This evaluation concluded that significant facilitated transport is not expected to occur in the potential disposal cell. It is believed that if facilitated transport did occur in the disposal cell, the cell would continue to perform as predicted by the modeling. Uncertainty in the waste environment was considered during the selection of the solid-to-liquid partitioning coefficients for contaminant leaching (the K_d values) used during the performance modeling and P WAC development. If predicted or actual waste ever is identified with chelating agents or large volumes of organic materials that potentially could result in facilitated transport, the WAC could be revised appropriately at that time to prohibit disposal of the problematic wastes.

C8.2. REFERENCES

ANL (Argonne National Laboratory) 2001. *Assessing the Impacts of Hazardous Constituents on the Mobilization, Transport, and Fate of Radionuclides in RCRA Waste Disposal Units*, ANL/EAD/TM-93, Prepared by Argonne National Laboratory, Environmental Assessment Division for U.S. Department of Energy, Office of Environmental Policy and Guidance, August.

Bonaparte, R., R. M. Koerner, and D. E. Daniel 2002. *Assessment and Recommendations for Improving the Performance of Waste Containment Systems*, research report published by the U.S. Environmental Protection Agency, National Risk Management Research Laboratory, EPA/600/R-02/099, December 2002.

Bonaparte R., J. F. Beech, L. M. Griffin, D. K. Phillips, B. A. Gross, B. Klenzendorf, and L. O'Leary 2011. *Cold War Legacy – Design, Construction, and Performance of a Land-Based Radioactive Waste Disposal Facility*, The Nineteenth Spencer J. Buchanan Lecture, Texas A&M University, Nov 2011.

Huling, S. G. 1989. "Facilitated Transport," Superfund Groundwater Issue, U.S. Environmental Protection Agency, ORD-OSWER, EPA/540/4-89-003.

Li, A. and A. W. Andren 1994. "Solubility of Polychlorinated Biphenyls in Water/Alcohol Mixtures, 1. Experimental Data," *ES&T* 28:47-52.

PNNL (Pacific Northwest National Laboratory) 2002. Radionuclide-Chelating Agent Complexes in Low-Level Radioactive Decontamination Waste; Stability, Adsorption and Transport Potential, NUREG/CR-6758, PNNL-13774, Prepared for Pacific Northwest National Laboratory for Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, February.

Rowe, R. K., and M. Z. Islam 2009. "Impact of Landfill Liner Time-Temperature History on the Service Life of HDPE Geomembranes," *Waste Management* 29, 2689-2699.

Rowe, R. K. 2010. "Degradation Processes and Changes in Performance of Geomembrane," Workshop on Engineered Barrier Performance Related to Low-Level Radioactive Waste, Decommissioning, and Uranium Mill Tailings Facilities, Rockville, MD, August 3-5.

Rowe, R. K., M. Z. Islam, and Y. G. Hsuan 2010a. "Effects of Thickness on the Aging of HDPE Geomembranes," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 136, No. 2, pp. 299-309.

Suresh, P., C. Rao, L.S. Lee, and R. Pinal 1990. "Cosolvency and sorption of hydrophobic organic chemicals," *ES&T* 24:647-654.

ATTACHMENT C9

UNCERTAINTY ANALYSIS

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C9.1. UNCERTAINTY ANALYSIS

C9.1.1 INTRODUCTION

This attachment to Appendix C presents uncertainty analysis constituents, simulations, and results. The uncertainty analysis was performed on the gradual failure model scenario. Both qualitative and quantitative assessments were performed and are documented herein. Qualitative assessments were performed for the following parameters.

- Chemical Environment
- Waste Characterization Uncertainties
- Homogenized Waste
- Receptor Location
- Source Depletion During Operational/Closure Period
- Clay Barrier Environment
- Centerline Groundwater Concentration and Well Dilution
- Ingrowth of Organics
- Ingrowth of Radiological Constituents
- 1,000-Year Rainfall Storm Event Uncertainty
- Flexible Membrane Liner (FML) Installation Quality Uncertainty

The parameters evaluated quantitatively during the uncertainty analysis are summarized below and in Table C9.1.

- FML Instantaneous Failure
- FML No Failure
- Hydraulic Conductivity of Bottom Compacted Clay Liners
- Hydraulic Conductivity of Cap Soil and Clay
- Partitioning Coefficient Variation
- Solubility Uncertainty
- Hydraulic Gradient Uncertainty
- Climate Change (Variation of Precipitation and Temperature)
- Waste Form Bulk Density

A select list of chemical constituents was used for quantitative uncertainty analysis. The uncertainty analysis constituents represent each chemical group and are compounds that are expected to drive evaluation of the on-site waste disposal option. Uncertainty analysis constituents include the following:

- Silver (Ag)
- Arsenic (As)
- Vanadium (V)
- Technetium (Tc-99)
- Neptunium (Np-237)
- Uranium (U-238, U-235, and U-234)
- Americium (Am-241)
- Trichloroethene (TCE)

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Table C9.1 Quantitative Uncertainty Analysis Simulation Comparison Matrix

	Initial Scenario Simulations (Baseline Scenarios)			Uncertainty Simulations[1]										
Simulations	Gradual Failure	FML Instantaneous Failure	FML No Failure	Drainage Layer Duration[2]	Increased Hydraulic Conductivity of Compacted Clay Liners	Constant Hydraulic Conductivity of Compacted Clay Liners	Hydraulic Conductivity of Cap Soil and Clay	Partitioning Coefficient Uncertainty (Maximum)	Partitioning Coefficient Uncertainty (Minimum)	Solubility Uncertainty	Hydraulic Gradient Uncertainty (Double Baseline)	Hydraulic Gradient Uncertainty (Half Baseline)	Climate Change (Variation of Precipitation and Temperature)	Waste Form Bulk Density
Leachate Collection System (years)	0-200	NC	**0-10k**	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Cap Soil 0" to 18" bls k_H, cm/s (years)	2.32×10^{-6} (30-10k)	NC	NC	NC	NC	NC	**2.32×10^{-5} (30-10k)**	NC	NC	NC	NC	NC	NC	NC
Cap Soil 18" to 60" bls k_H, cm/s (years)	5×10^{-7} (30-10k)	NC	NC	NC	NC	NC	**5×10^{-6} (30-10k)**	NC	NC	NC	NC	NC	NC	NC
Cap Clay Layer k_H, cm/s (years)	10^{-7} (30-200) & 10^{-6} (600-10k)	10^{-7} (30-200) & **10^{-6} (200-10k)**	**10^{-7} (30-10k)**	NC	NC	NC	10^{-6} (30-200) & 10^{-5} (600-10k)	NC	NC	NC	NC	NC	NC	NC
Bottom Clay Layer k_H, cm/s (years)	10^{-7} (0-200) & 10^{-6} (600-10k)	10^{-7} (0-200) & **10^{-6} (200-10k)**	**10^{-7} (0-10k)**	NC	10^{-7} (0-200) & **10^{-5} (600-10k)**	10^{-7} (0-200) & **10^{-7} (600-10k)**	NC	NC	NC	NC	NC	NC	NC	NC
Geomembranes Degradation (years)	0-200 FML Fully Competent, 600-10k FML Fully Degraded	**0-200 FML Fully Competent, 200-10k FML Fully Degraded**	**0-10k FML Fully Competent**	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Liner/Geomembrane Degradation Model (years)	Lee et al. Equation (applied to years 200 to 600)	**Step Failure at Year 200**	**No Degradation**	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Other Simulation Information	Initial Base Case Scenario	Complete failure of FML at 200 years.	The FML is fully competent indefinitely.	Cap Drainage Layer Operational for entire simulation duration.	Gradual Failure Scenario, with bottom compacted clay liner (CCL) hydraulic conductivity increased by two orders of magnitude at Year 600	Gradual Failure Scenario, with bottom CCL hydraulic conductivity constant for entire simulation	Gradual Failure Scenario, Increase Cap Soil and Clay hydraulic conductivity by one order of magnitude	Gradual Failure Scenario, Greatest value for each constituent and soil type from ORISE 2011, DOE 2003, DOE 2002, others to be specified	Gradual Failure Scenario, All Constituents have K_d set to 0 L/kg	Gradual Failure Scenario, All Constituents have solubility set to 10 g/cc	Gradual Failure Scenario, Double Hydraulic Gradient Site 3A = 0.0064 m/m Site 11 = 0.00132 m/m	Gradual Failure Scenario, Half Hydraulic Gradient Site 3A = 0.0016 m/m Site 11 = 0.00033 m/m	Gradual Failure Scenario, Predicted future temperature and precipitation changes	Gradual Failure Scenario, Waste Soil bulk density specified in the ORISE 2011 report (1.5 gm/cc)

Notes:

[1] Contaminants included in uncertainty analysis—Ag, V, PCB-1254, Benzo(a)pyrene, Am-241, Np-237, U-234, U-235, U-238, Tc-99, TCE, As (simulated progeny include: U-234, Th-230, Ra-226, Pb-210, Np-237, Pa-231, Ac-227, U-233, Th-229, Ra-225).

[2] Cap Drainage Layer Uncertainty Simulation developed based on information presented during the February 22, 2012, Symposium on Performance Modeling of Low-Level Radioactive Waste Disposal Facilities hosted by the University of Kentucky in Lexington, Kentucky, and attended by representatives from DOE, EPA, Kentucky Department for Environmental Protection, and the Kentucky Radiation Health Branch, as well as literature reviews on performance of cover systems and a subsequent review of the conceptual design with respect to this information.

Bold descriptions indicate the parameter that varies from the Gradual Failure Scenario (baseline).

NC = No change from Gradual Failure Scenario (baseline) input.

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- Benzo(a)pyrene
- Polychlorinated biphenyls (PCBs)

Model input parameters for the gradual failure scenario and uncertainty analysis simulations are presented in Table C9.1, with values varied from the gradual failure scenario identified in bold font. The results for the gradual failure scenario form the baseline for comparison of the uncertainty analysis simulations. Tables C9.2 to C9.9 in this attachment present preliminary waste acceptance criteria (PWAC) values for the gradual failure scenario at the edge of waste (EOW) (PWAC-EOW) and are compared to calculated PWAC-EOW values for the uncertainty scenarios. Figures 5.8 and 5.9 in the main report depict the deviation in the PWAC-EOW for evaluated organic and inorganic compounds by uncertainty scenario for Site 11 and Site 3A, respectively. Site 11 and Site 3A deviations in the PWAC-EOW for evaluated radionuclides are presented in main report Figures 5.10 and 5.11, respectively. Each PWAC-EOW presented in this attachment has been corrected for chemical-specific saturation[1] and total mass limits as discussed in Section 5 of the main report.

C9.1.2 UNCERTAINTY ANALYSIS

Below is a description of each qualitative and quantitative uncertainty scenario.

Chemical Environment. It is understood that landfill waste form, unsaturated zone, and saturated zone chemistry play an important role in the migration and attenuation of contaminants. The assumed general chemical environmental conditions for the simulations performed at Site 3A and Site 11 are summarized below (see also main report Section 5.4.6).

- **Waste form**—Low redox potential with little to no measurable dissolved oxygen (DO) due to full enclosure by a gas-impermeable cover and the presence of ferrous metals (scrap metal) in the waste. Alkaline pH (8–10) is assumed due to hydrated lime in waste concrete. Reduced form of metals and anions [e.g., Am(III), As(III), As(-II), Se(-II), Cr(III), U(IV), Hg(I), Ni(II), Sn(II), Tc(IV), etc.] would be expected to predominate over oxidized forms. Reduced forms of many metals may exhibit dramatically different transport (solubility, adsorption) under reducing conditions. In particular, Tc-99, which is highly conservative (i.e., non-sorptive) under oxic conditions in the +7 oxidation, may attenuate by sorption and/or precipitation upon reduction to the +4 oxidation state.

- **Unsaturated zone**—High DO (4–6 ppm) is anticipated. Oxidizing conditions due to rainwater recharge. Neutral to slightly acidic pH (4.5–7) assumed. Oxidized species expected to predominate over reduced forms. However, once the cap and liners are in place, the vertical recharge from precipitation would diminish. This would have an impact on the overall redox conditions of the unsaturated zone, with the possibility of evolution of sub-oxic conditions due to limited oxygen resupply.

- **Saturated zone—**Low to moderate DO (1–4 ppm) and circumneutral pH (6.5–7.5) is anticipated. Little or no change in redox potential is expected in going from the unsaturated zone into the saturated zone; however, the chemical composition of groundwater in the Regional Gravel Aquifer (RGA) may be quite different than pore water from the leachate, so additional chemically mediated precipitation may take place in the RGA.

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[1] Corrections for soil saturation are performed for those chemicals that in their pure form are liquids at 25°C or above.

Table C9.2. Predominant Speciation of Evaluated Metals

Element	Predominant form at pH (4.5-7), oxidizing conditions	Predominant form at pH 8-10, reducing conditions	Predominant form at sub-oxic, circumneutral pH (6.5-7.5)	Oxidation states commonly encountered
Actinium (227)	cationic (+3)	Mineral hydroxide	Mineral hydroxide	+3
Americium (241)	cationic (+3)	anionic carbonate species (+3)	cationic (+3)	+3
Antimony	anionic (+5)	anionic (+5), neutral (+3)	anionic (+5)	+3, +5
Arsenic	anionic (+5)	neutral and anionic oxyanions (+3)	neutral (+3) and anionic (+5)	+3, +5
Barium	cationic	Barium carbonate or sulfate mineral	Barium sulfate or carbonate mineral	+2
Beryllium	Polynuclear cationic complexes, beryllium hydroxide mineral	Polynuclear cationic complexes, beryllium hydroxide mineral	Polynuclear cationic complexes, beryllium hydroxide mineral	+2
Cadmium	cationic	cationic, or neutral carbonate species, or insoluble carbonate mineral	cationic	+2
Cesium (137)	cationic	cationic	cationic	+1
Chromium	anionic (+6)	Chromium hydroxide mineral (+3)	anionic (+6)	+3, +6
Copper	cationic (+2)	cationic (+2)	cationic (+2)	+1, +2
Lead (210)	cationic (+2)	Lead hydroxide/carbonate mineral	cationic and neutral-carbonate species	0, +2
Manganese	Mineral oxide (+4)	cationic (+2)	cationic (+2), and mineral oxide (+4)	+2, +4
Mercury	cationic (+2)	neutral hydroxide, chloride species (+1, +2)	cationic (+2)	+1, +2

Table C9.2. Predominant Speciation of Evaluated Metals (Continued)

Element	Predominant form at pH (4.5-7), oxidizing conditions	Predominant form at pH 8-10, reducing conditions	Predominant form at sub-oxic, circumneutral pH (6.5-7.5)	Oxidation states commonly encountered
Neptunium (237)	cationic (+5)	neutral hydroxide (+4)	cationic (+5), and neutral hydroxide (+4)	+4, +5
Nickel	cationic (+2)	cationic (+2)	cationic (+2)	+2
Plutonium (238, 239, 240, 241)	cationic (+5)	neutral hydroxide species (+4), Hydroxide/carbonate mineral (+4).	anionic carbonate/hydroxide complex (+4, +5)	+3, +4, +5, +6
Protactinium (231)	cationic (+4) cationic (+5)	Mineral	Mineral	+4, +5
Radium (226, 228)	cationic (+2)	cationic (+2)	cationic (+2)	+2
Selenium	anionic (+6)	neutral/anionic (+4)	anionic (+6)	-2, 0, +4, +6
Silver	cationic (+1)	cationic (+1)	cationic (+1)	+1
Technetium (99)	anionic (+7)	neutral (+4)	anionic (+7)	+4, +7
Thallium	cationic	Thallium oxide mineral	Cationic, thallium oxide mineral	+1
Thorium (228, 229, 230, 232)	cationic (+4)	cationic (+4)	cationic (+4)	+4
Uranium (233, 234, 235, 236, 238)	neutral (oxyhydroxide; (+6)	anionic (+4) and hydroxide mineral (+4)	anionic (+4)	+4, +6
Vanadium	anionic oxyanions (+5)	anionic oxyanion (+4), oxide mineral (+3)	anionic oxyanions (+4, +5)	+3, +4, +5
Zinc	cationic (+2)	cationic (+2)	cationic (+2)	+2

Cation or anionic designation indicates the net charge on the predominant soluble species for the stated geochemical condition.
A mineral phase is indicated if a solid phase is expected to form under the stated geochemical conditions.

Table C9.3. Comparison of Retarded Travel Times to Contaminant Half Lives

Unsaturated Zone Vertical Percolation, Long-Term Modeling Period		Saturated Horizontal Groundwater Migration, Site 11		Saturated Horizontal Groundwater Migration, Site 3A	
Darcy Velocity (cm/s)	3.90E-07	Hydraulic Gradient (m/m)	0.00066	Hydraulic Gradient (m/m)	0.0032
Unsaturated zone length Below FLM (cm)	1067	Hydraulic Conductivity (m/h)	35.6	Hydraulic Conductivity (m/h)	1.18
		DOE POA distance (m)	113	DOE POA distance (m)	501
Length Weighted Density (gm/cm^3)	1.43	Density (g/cm^3)	1.67	Density (g/cm^3)	1.56
Length Weighted Porosity	0.42	Porosity	0.3	Porosity	0.3

	Radionuclide	Distribution Coefficient (L/kg)	Unsaturated Zone: Retarda-tion Factor	Retarded Travel Time to Water Table (yr)	Half-Life (yr)	Number of Half-Life Cycles Before Reaching POA	Site 11: Retarda-tion Factor	Retarded Travel Time to DOE POA	Half-Life (yr)	Number of Half-Life Cycles Before Reaching POA	Site 3A: Retarda-tion Factor	Retarded Travel Time to DOE POA	Half-Life (yr)	Number of Half-Life Cycles Before Reaching POA
Parent Radionuclides	Tc-99	2.82E-01	2	1.70E+02	2.13e+05	0	3	1.41E+00	2.13E+05	0	2	3.73E+01	2.13E+05	0
	Am-241	1.90E+03	6,470	5.61E+05	4.32E+02	1,297	10,578	5.79E+03	4.32E+02	13	9,881	1.50E+05	4.32E+02	346
	Cs-137	2.80E+02	954	8.27E+04	3.02E+01	2,738	1,560	8.54E+02	3.02E+01	28	1,457	2.20E+04	3.02E+01	730
	Np-237	5.00E+00	18	1.56E+03	2.14E+06	0	29	1.58E+01	2.14E+06	0	27	4.09E+02	2.14E+06	0
	Pu-238	5.50E+02	1,874	1.62E+05	8.78E+01	1,849	3,063	1.68E+03	8.78E+01	19	2,861	4.33E+04	8.78E+01	493
	Pu-239	5.50E+02	1,874	1.62E+05	2.41E+04	7	3,063	1.68E+03	2.41E+04	0	2,861	4.33E+04	2.41E+04	2
	Pu-240	5.50E+02	1,874	1.62E+05	6.54E+03	25	3,063	1.68E+03	6.54E+03	0	2,861	4.33E+04	6.54E+03	7
	Th-230	3.20E+03	10,896	9.44E+05	7.70E+04	12	17,814	9.76E+03	7.70E+04	0	16,641	2.52E+05	7.70E+04	3
	U-234	3.50E+01	120	1.04E+04	2.40E+05	0	196	1.07E+02	2.40E+05	0	183	2.77E+03	2.40E+05	0
	U-235	3.50E+01	120	1.04E+04	7.00E+08	0	196	1.07E+02	7.00E+08	0	183	2.77E+03	7.00E+08	0
	U-238	3.50E+01	120	1.04E+04	4.50E+09	0	196	1.07E+02	4.50E+09	0	183	2.77E+03	4.50E+09	0
Progeny Radionuclides	Ac-227	4.50E+02	1,533	1.33E+05	2.20E+01	6,039	2,506	1.37E+03	2.20E+01	62	2,341	3.54E+04	2.20E+01	1,610
	Pa-231	5.50E+02	1,874	1.62E+05	3.28E+04	5	3,063	1.68E+03	3.28E+04	0	2,861	4.33E+04	3.28E+04	1
	Pb-210	2.70E+02	920	7.97E+04	2.20E+01	3,625	1,504	8.24E+02	2.20E+01	37	1,405	2.13E+04	2.20E+01	966
	Ra-226	5.00E+02	1,703	1.48E+05	1.60E+03	92	2,784	1.52E+03	1.60E+03	1	2,601	3.94E+04	1.60E+03	25
	Ra-228	5.00E+02	1,703	1.48E+05	5.80E+00	25,450	2,784	1.52E+03	5.80E+00	263	2,601	3.94E+04	5.80E+00	6,786
	Th-228	3.20E+03	10,896	9.44E+05	1.90E+00	496,965	17,814	9.76E+03	1.90E+00	5,135	16,641	2.52E+05	1.90E+00	132,539
	Th-229	3.20E+03	10,896	9.44E+05	7.34E+03	129	17,814	9.76E+03	7.34E+03	1	16,641	2.52E+05	7.34E+03	34
	Th-232	3.20E+03	10,896	9.44E+05	1.40E+10	0	17,814	9.76E+03	1.40E+10	0	16,641	2.52E+05	1.40E+10	0
	U-233	3.50E+01	120	1.04E+04	1.59E+05	0	196	1.07E+02	1.59E+05	0	183	2.77E+03	1.59E+05	0
	U-236	3.50E+01	120	1.04E+04	2.34E+07	0	196	1.07E+02	2.34E+07	0	183	2.77E+03	2.34E+07	0
	Th-228	3.20E+03	10,896	9.44E+05	1.90E+00	496,965	17,814	9.76E+03	1.90E+00	5,135	16,641	2.52E+05	1.90E+00	132,539

Table C9.4. Uncertainty Analysis Summary—Distribution Coefficient (K_d) Values

Contaminant	Gradual Failure Scenario K_d (cc/gm)	High K_d (cc/gm)	High K_d Source*
Organics			
TCE	0.0755 (Vertical Saturated and Unsaturated Flow) 0.0330 (Horizontal Flow)	0.151 (Vertical Saturated and Unsaturated Flow) 0.0660 (Horizontal Flow)	Doubled Baseline K_d
Benzo(a)pyrene	776 (Vertical Saturated and Unsaturated Flow) 339 (Horizontal Flow)	1552 (Vertical Saturated and Unsaturated Flow) 678 (Horizontal Flow)	Doubled Baseline K_d
PCBs	248 (Vertical Saturated and Unsaturated Flow) 108 (Horizontal Flow)	496 (Vertical Saturated and Unsaturated Flow) 216 (Horizontal Flow)	Doubled Baseline K_d
Metals			
Ag, Silver	90 (Sand and all other materials) 180 (Clay)	180 (Sand and all other materials) 360 (Clay)	Doubled Baseline K_d
As, Arsenic	29	200	DOE 2003, Table 4.5 page 4-12
V, Vanadium	1000	2000	Doubled Baseline K_d
Parent Radionuclides			
Np-237	5 (Sand and all other materials) 55 (Clay)	70 (Sand and all other materials) 144 (Clay)	ORISE 2011, Appendix A, page A-48
Tc-99	0.282 (Sand and all other materials) 1 (Clay)	0.848 (Sand and all other materials) 20 (Clay)	Sand and all other materials - DOE 2002, Appendix D Summary Table, Maximum value. Clay—ORISE 2011.
U-234,-235,-238	35 (Sand and all other materials) 1,600 (Clay)	66.8 (Sand and all other materials) 3640 (Clay)	ORISE 2011, Appendix A, page A-48
Am-241	1,900 (Sand and all other materials) 8,400 (Clay)	3,800 (Sand and all other materials) 16,800 (Clay)	Doubled Baseline K_d
Progeny Radionuclides			
U-233	35 (Sand and all other materials) 1,600 (Clay)	66.8 (Sand and all other materials) 3,640 (Clay)	ORISE 2011, Appendix A, page A-48
Th-229, -230	3,200 (Sand and all other materials) 5,800 (Clay)	6,400 (Sand and all other materials) 11,600 (Clay)	Doubled Baseline K_d
Ra-226	500 (Sand and all other materials) 9,100 (Clay)	1000 (Sand and all other materials) 18,200 (Clay)	Doubled Baseline K_d

Table C9.4. Uncertainty Analysis Summary—Distribution Coefficient (K_d) Values (Continued)

Contaminant	Gradual Failure Scenario Kd (cc/gm)	High K_d (cc/gm)	High K_d Source*
Pb-210	270 (Sand and all other materials) 550 (Clay)	540 (Sand and all other materials) 1,100 (Clay)	Doubled Baseline K_d
Pa-231	550 (Sand and all other materials) 2,700 (Clay)	1,100 (Sand and all other materials) 5,400 (Clay)	Doubled Baseline K_d
Ac-227	450 (Sand and all other materials) 2,400 (Clay)	900 (Sand and all other materials) 4,800 (Clay)	Doubled Baseline K_d

Notes: 1. * Indicates greatest value used of the following: double baseline K_d, DOE 2003, DOE 2002, and ORISE 2011.
2. For "Low" K_d simulations, K_d will be set to 0.0 cc/gm.

References

DOE (U.S. Department of Energy) 2002. *Geochemical Modeling to Assist in Developing Site Wide K_d Values for Metals and Radionuclides for the Upper Continental Recharge System and Regional Gravel Aquifer*, BJC/PAD-451.

DOE 2003. *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-204&D2R1.

Oak Ridge Institute for Science and Education (ORISE) 2011. *Dose Modeling Evaluations and Technical Support Document for the Authorized Limits Request for the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (Final Report)*, DCN 56090-TR-01-5.

Table C9.5. PWAC-EOW Variation Due to Hydraulic Gradient Uncertainty

Contaminant	PWAC-EOW Average Concentration (mg/kg or pCi/g)					
	Site 11 Gradual Failure Scenario	Site 11 Double Hydraulic Gradient Scenario	Site 11 Half Hydraulic Gradient Scenario	Site 3A Gradual Failure Scenario	Site 3A Double Hydraulic Gradient Scenario	Site 3A Half Hydraulic Gradient Scenario
Benzo(a)pyrene	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Total PCBs	1.73E+02	1.73E+02	1.73E+02	1.73E+02	1.73E+02	1.73E+02
TCE	2.32E+02	2.32E+02	2.32E+02	2.32E+02	2.32E+02	2.32E+02
Ag	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
As	2.27E+02	4.52E+02	1.20E+02	6.09E+00	1.01E+01	4.51E+00
V	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Am-241	3.43E+11	3.43E+11	3.43E+11	3.43E+11	3.43E+11	3.43E+11
Np-237	2.58E+02	3.27E+02	7.04E+01	8.91E-01	9.79E-01	2.82E-01
Tc-99	2.67E+01	5.75E+01	1.27E+01	2.08E+00	4.24E+00	1.03E+00
U-235	2.16E+05	2.16E+05	2.16E+05	2.16E+05	2.16E+05	2.16E+05
U-238	3.36E+04	3.36E+04	3.36E+04	3.36E+04	3.36E+04	3.36E+04
U-234	6.25E+08	6.25E+08	6.25E+08	6.25E+08	6.25E+08	6.25E+08

Note: PWAC-EOW values shown are corrected for soil saturation and total mass limits.

Table C9.6. Predicted Landfill Percolation and PWAC-EOW Variation Due to Climate Change Uncertainty

Year	DUSTMS Gradual Failure Scenario (T+400 years) Water Velocity (cm/s)	Year	DUSTMS Water Velocities for Climate Change Scenario (cm/s)
30	2.46E-14	30	2.46E-14
200	2.46E-14	200	2.46E-14
225	1.22E-13	225	1.34E-13
250	6.03E-13	250	7.36E-13
350	3.63E-10	350	6.60E-10
425	3.96E-08	500	3.69E-07
500	3.64E-07	550	3.77E-07
550	3.89E-07	600	3.77E-07
600	3.90E-07	985	3.62E-07
10000	3.90E-07	10000	3.62E-07

Contaminant	PWAC-EOW Average Concentration (mg/kg or pCi/g)			
	Site 11 Gradual Failure Scenario Climate Parameters	Site 11 Precipitation and Temperature Change Scenario	Site 3A Gradual Failure Scenario Hydraulic Gradient	Site 3A Precipitation and Temperature Change Scenario
Benzo(a)pyrene	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Total PCBs	1.73E+02	1.73E+02	1.73E+02	1.73E+02
TCE	2.32E+02	2.32E+02	2.32E+02	2.32E+02
Ag	1.00E+05	1.00E+05	1.00E+05	1.00E+05
As	2.27E+02	2.77E+02	6.09E+00	6.97E+00
V	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Am-241	3.43E+11	3.43E+11	3.43E+11	3.43E+11
Np-237	2.58E+02	2.05E+02	8.91E-01	6.26E-01
Tc-99	2.67E+01	2.79E+01	2.08E+00	2.16E+00
U-235	2.16E+05	2.16E+05	2.16E+05	2.16E+05
U-238	3.36E+04	3.36E+04	3.36E+04	3.36E+04
U-234	6.25E+08	6.25E+08	6.25E+08	6.25E+08

Note: PWAC-EOW values shown are corrected for soil saturation and total mass limits.

Table C9.7. PWAC-EOW Comparison of Gradual Failure Scenario Bulk Density to Decreased Bulk Density

Contaminant	PWAC-EOW Average Concentration (mg/kg or pCi/g)			
	Site 11 Gradual Failure Scenario Bulk Density = 3.1 g/cc	Site 11 Decreased Bulk Density = 1.5 g/cc Scenario	Site 3A Gradual Failure Scenario Bulk Density = 3.1 g/cc	Site 3A Decreased Bulk Density = 1.5 g/cc Scenario
Benzo(a)pyrene	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Total PCBs	1.73E+02	1.73E+02	1.73E+02	1.73E+02
TCE	2.32E+02	3.90E+02	2.32E+02	3.90E+02
Ag	1.00E+05	1.00E+05	1.00E+05	1.00E+05
As	2.27E+02	2.56E+02	6.09E+00	3.30E+00
V	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Am-241	3.43E+11	3.43E+11	3.43E+11	3.43E+11
Np-237	2.58E+02	1.77E+02	8.91E-01	2.88E-01
Tc-99	2.67E+01	4.30E+01	2.08E+00	1.47E+00
U-235	2.16E+05	2.16E+05	2.16E+05	2.16E+05
U-238	3.36E+04	3.36E+04	3.36E+04	3.36E+04
U-234	6.25E+08	6.25E+08	6.25E+08	6.25E+08

Note: PWAC-EOW values shown are corrected for soil saturation and total mass limits.

Gradual Failure Scenario Waste Form Bulk Density Composition

Waste Types	Total Hazardous Waste[7] (yd^3)	Percent (%) of Total	Bulk Density (g/cc)	Volume Weighted Dry Bulk Density (g/cc)
Asbestos[1]	31,400	1.2	1.8	0.02
Concrete[2]	365,700	14.01	2.4	0.34
General Construction Debris[3]	238,200	9.13	0.8	0.07
Other Dry Solids[4]	50,200	1.92	0.8	0.02
Scrap Metal[5]	632,500	24.24	7.85	1.9
Soil[6]	1,291,600	49.49	1.5	0.74
Total	2,609,600	100		**3.1**

Notes:
[1] Density varies greatly depending on form of asbestos. Slate asbestos used in table referenced accessed at http://www.wolframalpha.com/entities/common_materials/asbestos/nj/lk/s6/.
[2] Assumed to be normal strength cement, Density referenced from "The Physics Factbook," accessed at http://hypertextbook.com/facts/1999/KatrinaJones.shtml.
[3] Referenced from the study of density of C&D debris in 171 Florida landfills, accessed at http://www.ees.ufl.edu/homepp/townsend /Research/C&DConv/default.asp. The average value for C&D debris is 484lb/cy (0.3 g/cc). A value of 1,300 lb/cy (0.8 g/cc) was used in the table because the debris from PGDP is likely to be of above average density.
[4] Includes personal protective equipment, plastic, and packing material of unknown density. Assumed to have the same density as general construction debris.
[5] Anticipated to be structural steel. Some other metals may also be present. Density of steel referenced from "The Physics Factbook," accessed at http://hypertextbook.com/facts/2004/KarenSutherland.shtml.
[6] Assumed to be a predominantly sandy soil mixture similar to other soils above and below the waste.
[7] Waste volumes referenced from Table 4.3 of the RI/FS.

Table C9.8 PWAC Comparison for the Gradual Failure Scenario and Cap Soil and Clay High Conductivity Analysis

Contaminant	PWAC-EOW Average Concentration (mg/kg or pCi/g)			
	Site 11 Gradual Failure Scenario	Site 11 Cap Soil and Clay Degradation Scenario	Site 3A Gradual Failure Scenario	Site 3A Cap Soil and Clay Degradation Scenario
Benzo(a)pyrene	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Total PCBs	1.73E+02	1.73E+02	1.73E+02	1.73E+02
TCE	2.32E+02	2.32E+02	2.32E+02	2.32E+02
Ag	1.00E+05	1.00E+05	1.00E+05	1.84E+03
As	2.27E+02	1.74E+01	6.09E+00	1.06E+00
V	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Am-241	3.43E+11	3.43E+11	3.43E+11	3.43E+11
Np-237	2.58E+02	1.62E+00	8.91E-01	3.44E-02
Tc-99	2.67E+01	1.28E+01	2.08E+00	1.03E+00
U-235	2.16E+05	2.16E+05	2.16E+05	2.16E+05
U-238	3.36E+04	3.36E+04	3.36E+04	3.36E+04
U-234	6.25E+08	6.25E+08	6.25E+08	6.25E+08

Note: PWAC-EOW values shown are corrected for soil saturation and total mass limits.

Table C9.9 Soil/Water Partitioning Coefficient Uncertainty Simulation Results

Contaminant	PWAC-EOW Average Concentration (mg/kg or pCi/g)					
	Site 11 Partitioning Coefficient (K_d)			Site 3A Partitioning Coefficient (K_d)		
	Gradual Failure Scenario (K_d)	Minimum (K_d) Scenario	Maximum (K_d) Scenario	Gradual Failure Scenario (K_d)	Minimum (K_d) Scenario	Maximum (K_d) Scenario
Benzo(a)pyrene	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Total PCBs	1.73E+02	9.46E-02	3.47E+02	1.73E+02	8.93E-03	3.47E+02
TCE	2.32E+02	1.49E+02	3.15E+02	2.32E+02	1.49E+02	3.15E+02
Ag	1.00E+05	1.00E-01	1.00E+05	1.00E+05	7.49E-03	1.00E+05
As	2.27E+02	9.11E-02	1.00E+05	6.09E+00	6.81E-03	1.00E+05
V	1.00E+05	1.22E+00	1.00E+05	1.00E+05	9.12E-02	1.00E+05
Am-241	3.43E+11	1.79E-02	3.43E+11	3.43E+11	1.32E-03	3.43E+11
Np-237	2.58E+02	7.29E-03	7.05E+07	8.91E-01	5.45E-04	1.34E+04
Tc-99	2.67E+01	8.19E+00	5.43E+02	2.08E+00	6.12E-01	1.49E+01
U-235	2.16E+05	3.65E-03	2.16E+05	2.16E+05	2.72E-04	2.16E+05
U-238	3.36E+04	8.93E-02	3.36E+04	3.36E+04	6.67E-03	3.36E+04
U-234	6.25E+08	8.93E-02	6.25E+08	6.25E+08	6.67E-03	6.25E+08

Note: PWAC-EOW values shown are corrected for soil saturation and total mass limits.

It is impractical to predict chemical environmental conditions accurately at small scales or hundreds of years into the future therefore, the assumed general conditions described above are assumed to be unchanging. With regard to the behavior of metals, it also is not possible to generalize how solubility and sorption characteristics vary as environmental conditions change; however, one class of metals that are “amphoteric” exhibit a characteristic behavior with respect to changes in pH. This group includes metal hydroxides with the general formula Mx(OH)y(xz-y), where z is the charge of the metal (M) cation and x and y are stoichiometric terms; for charge neutrality of the solid xz-y must equal zero. Metal hydroxide compounds are prevalent in the list of metals of concern, so this group is relevant to the RGA and Terrace Gravel formations. The solubility of such metal hydroxides is usually minimum at some pH (which depends on thermodynamic stability constant for that compound), and increases both at lower pH and higher pH, giving a parabolic solubility profile. The minimum solubility may correspond to the predominance of a hydrolyzed metal ion with neutral charge (or where cationic and anionic hydrolysis species are both at their respective minima). If the neutral species predominates over charged species in a certain pH region, the sorption behavior also will be minimized in that same pH range.

Ultimately, there were 25 different metals evaluated for solubility and sorptive partitioning in order to estimate potential leaching from the proposed landfill to the saturated zones. The list of metals is provided in Table C9.2. The purpose of this evaluation is to provide a general description of the valence state, net ionic charge, and mineral phase (if applicable) for the 25 different metals under three different geochemical conditions. For this exercise, electrostatic adsorption is assumed as the principle mechanism driving the formation of surface complexes, leading to greater partitioning to the solid phase (i.e., higher sorption). As such, cations have a greater propensity to adsorb at higher pH (above the pHpzc where the solid phase will bear a net negative charge) and anions will adsorb at lower pH (below the pHpzc where the solid phase will bear a net positive charge). A stoichiometric abundance of the relevant counter ion is requisite for the formation of the indicated solid phase.

An evaluation of the effect of chemical environment for Technetium (Tc-99) follows. The Eh-pH diagram (Figure C9.1) for Tc-99 indicates that the dominant aqueous Tc(VII) species under oxidizing conditions is the oxyanion TcO_4^-. This oxyanion is highly soluble and does not form discrete mineral phases in soil systems. Technetium(VII) can be reduced to Tc(IV) by both biotic and abiotic processes. This reduction usually results in the immobilization of technetium under reducing conditions via the formation of the sparingly soluble solid $TcO_2 \cdot nH_2O$. Technetium(IV) is essentially immobile, because it readily precipitates as sparingly soluble hydrous oxides and forms strong complexes with surface sites on iron and aluminum oxides and clays.

Due to electrostatic attraction, as an anion, the adsorption of TcO_4^- would be expected to increase with decreasing pH at pH values less than 5 (not expected at the disposal cell). Values of K_d measured by Kaplan et al. (2000a) for a wetland sediment ranged from approximately 0 mL/g at pH 4.6 to 0.29 mL/g at pH 3.2. The maximum K_d value (for pH values less than 5) that they determined for an upland sediment was 0.11 mL/g at pH 3. One of the major recommendations of this report is that for site-specific calculations, partition coefficient values measured at site-specific conditions are preferred. The sorption of TcO_4^- has been found positively to be correlated to the organic carbon content of soils; however, studies of the effect that organic material has on the sorption of Tc (VII) in soils are limited. Measurable adsorption of Tc(VII) observed in benchscale studies conducted with organic material as well as with Fe(II)- containing minerals has been attributed to the reduction of Tc(VII) to Tc(IV). Reduction of Tc(VII) to Tc(IV) is known to increase the partition coefficient by approximately three orders of magnitude (Hu et al., 2008). Thus, if reducing conditions are not properly accounted for, the transport potential of Tc is likely to be greatly overestimated.

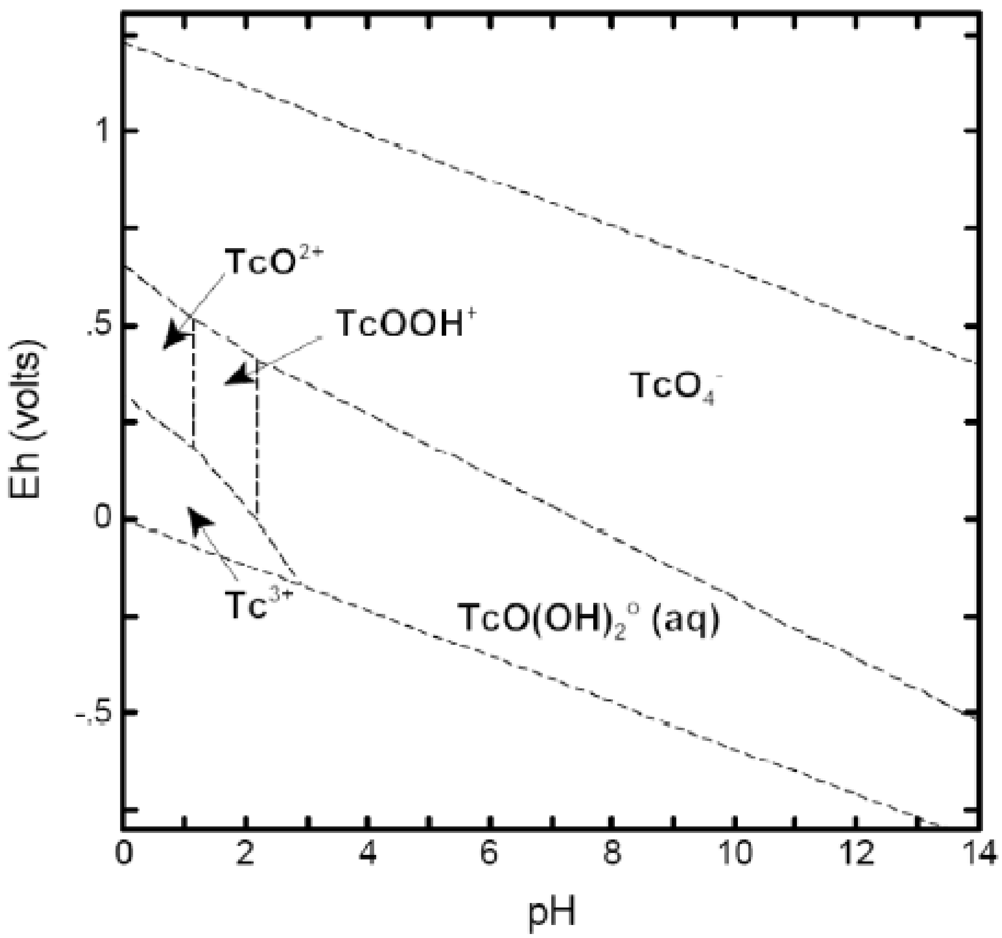

Figure C9.1 Eh-pH Stability Diagram for the Dominant Technetium Aqueous Species at 25°C (Diagram Based on Total Tc Concentration of 10^{-8} M)
(Diagram taken from EPA 402-R-04-002C, 2004)

Waste Characterization Uncertainty. The modeling effort depends heavily on the information provided for the waste characterization and the list of potential contaminants. Site-specific data were used where available. Where site-specific data were not available, the contaminants comprising the waste profiles are assumed to be consistent with the Oak Ridge Gaseous Diffusion Plant on the U.S. Department of Energy (DOE)-Oak Ridge Reservation (ORR), and are representative of the most mobile, recalcitrant, and toxic contaminants. If additional contaminants are added to the inventory list or assumptions used for the waste characterization change significantly, then additional modeling may be required.

Homogenized Waste. A primary uncertainty of the modeling approach supporting development of the PWAC is the simplifying assumptions associated with the hydrogeology, soil properties, and distribution coefficients of contaminants in various media within the waste disposal facility. For example, a major assumption in the modeling is that the waste in the disposal facility is a homogenized mass consisting of soil, whereas the actual waste disposal will include various physical waste forms that will have less surface area and likely have less propensity to leach, such as metal. Consequently, the assumption of a homogenized soil likely results in an overestimation of the contaminant leached from the waste zone and an underestimation of the PWAC.

Receptor Location. The groundwater receptor was assumed to be located at one of three locations at each site for the development of the PWAC: edge of waste (EOW), waste disposal facility (WDF) boundary, DOE property line (Site 11), or Bayou Creek (Site 3A). Appendix C (Tables C.2 and C.3) presents predicted PWAC values for each receptor location (i.e., point of assessment) for Site 11 and Site 3A.

As the receptor location moves farther away from the contaminant source, the PWAC values can be expected to increase because of increased attenuation. This increased attenuation would be due to increased dilution over the longer travel path and increased degradation due to the increased travel time. Additionally, the receptor location was assumed to be along the centerline of the flow path. Location of the receptor to the side of the centerline would result in a lower concentration at the receptor location.

Source Depletion During Operational/Closure Period. Reduction of the contaminant mass in the waste during the operational/closure period was not considered in the PWAC analysis; however, modeling was performed to predict source depletion due to leachate collection during the operational/closure period (Table C1.2 in Attachment C1 of Appendix C). Overall, each of the four disposal cells within the WDF would have waste open to the environment (under a temporary cover) during the operational/closure period as a disposal cell is being filled with waste. Results show that contaminants with low K_d values would leach from the waste during this period and be captured in the leachate collection system for treatment. The impact of this assumption is that for contaminants with low sorption coefficients (i.e., low K_d values), the predicted groundwater concentrations would decrease due to less remaining source mass, and the PWAC likely would increase. Therefore, if source depletion was accounted for in the modeling and applied to the calculated PWAC, the PWAC would increase, particularly for the low K_d compounds.

Clay Barrier Environment. Key performance issues for compacted clay liners (CCLs) include potential increases in hydraulic conductivity with time caused by desiccation, shrink/swell, freeze/thaw, root penetration, thermal stresses, differential settlement, chemical incompatibility, erosion of protective soil layers, development of secondary structures from cracking, subsidence and waste and slope stability (National Academy of Sciences 2007). These processes are most significant in cover systems because bottom barrier performance generally is enhanced by increases in the confining pressure from waste disposal. As noted further by the National Academy of Sciences (2007), documented observations of the hydraulic performance of compacted clay liners (CCLs) for more than about 15 years do not exist.

At PGDP, there would be waste and soil/debris placement requirements that would minimize the potential for subsidence. In addition, the conceptual design assumes no excavation for construction of the on-site disposal cell. The disposal cell would be built above the ground surface, thus avoiding the long-term need to pump liquids form the leachate collection system and leak detection system. General subsidence throughout the cell would be less destructive than differential settlement, which involves settlement of areas adjacent to each other that are significantly different.

Clay barriers near the upper surface have the potential to degrade due to erosion of overlying soil layers and desiccation; however, several design features of the cover system for an on-site disposal cell minimize clay barrier degradation and prolong the service life. These features include the use of 10 ft of overlying soil layers (including a 3 ft biointrusion layer that would prevent root penetration), a geomembrane liner that also would prevent root penetration, and a clay barrier with near constant water content due to the 10 ft of material and the geomembrane layer overlying the clay barrier in the cover system. Additionally, it is anticipated that DOE would perform as-needed surveillance and maintenance for as long as the material disposed of in the facility presents an unacceptable risk to human health and the environment.

The CCL barriers in the PGDP engineered conceptual cover design may last much longer than the 570 years assumed in the modeling (Year 30 to 600). The impact of a longer CCL service life on the modeling results would be longer contaminant arrival times to the receptor, reduced groundwater concentrations, and increased PWAC values.

Centerline Groundwater Concentration and Well Dilution. The groundwater receptor location was assumed to be along the predicted steady-state centerline (as predicted using MODFLOW and MODPATH) of the contaminant plume. Vertically, the groundwater receptor was assumed to withdraw water at the top portion of the aquifer that corresponds to the maximum AT123D-predicted groundwater concentration (because that is the depth nearest the source). These are worst-case scenario assumptions because the potential receptor would receive the maximum contaminant concentration possible because the receptor would have to place a well exactly at this location at the appropriate depth to intercept the predicted groundwater concentrations.

Also, the assumption of a steady-state groundwater flow field over predicts the groundwater concentration at the centerline because it neglects dilution (from dispersion) resultant of likely changing groundwater flow direction.

In addition, a well screen spanning a larger interval of the aquifer than the interval represented by the calculated maximum downgradient concentration (i.e., including water from the aquifer with lower concentrations) was not considered in the PWAC modeling. Simulated PWAC average concentrations are based on model-predicted output concentrations from the top of aquifer (i.e., maximum concentration over the simulated depth). A "real" well screen would draw groundwater with lower contaminant concentrations from lower depths, which would decrease (dilute) the top of the aquifer concentration. In general, consideration of well screen integration (or unsteady flow direction) would reduce groundwater concentrations and increase PWAC values.

Ingrowth of Organics. The modeling did not consider the ingrowth of degradation products of organic contaminants. This would primarily involve production of vinyl chloride, a degradation product of TCE. The effect of this uncertainty may be an underestimation of the groundwater concentrations of some organic contaminants. Since organic contaminants such as TCE are not limited by the PWAC compared to the waste characterization, and because low level waste (LLW), not organic waste, makes up the majority of the waste volume, ingrowth of organics is not expected to impact the findings of this RI/FS.

Ingrowth of Radiological Constituents. The DUSTMS model accounts for the ingrowth of radionuclide decay products (i.e., progeny); AT123D does not consider this phenomenon. DUSTMS, however, was not used for saturated zone simulations primarily because it is limited to 1,000 times steps for saturated zone simulations (10,000 time steps are possible in the unsaturated zone). To complete the 10,000-year simulations, the 1,000 time step limitation would have required 10-year time steps, which would have enacted unsatisfactory numerical instabilities (e.g., oscillations and excessive numerical dispersion) for some simulated contaminants. Even though AT123D does not simulate progeny formation, it does simulate progeny (generated in the unsaturated zone using DUSTMS) fate and transport in the saturated zone.

To evaluate the impact of using AT123D without progeny formation for saturated zone contaminant fate and transport simulations, comparisons were made for radionuclides between the following:

- Unsaturated zone vertical travel times and radionuclide half lives, and
- Saturated zone travel times and radionuclide half lives.

Table C9.3 presents the results of this analysis. Two radionuclides of particular interest are used as examples for this evaluation. Americium (Am-241) is not very mobile and has a relatively short half-life; however, it can degrade to neptunium (Np-237), which is much more mobile. The calculated retarded travel time for Am-241 to migrate in the unsaturated zone from beneath the FML to the groundwater table is $5.61x10^5$ years. This is a conservative estimate in that the travel distance is limited to solely below the FML and percolation is assumed to be at the magnitude with FML failure occurring (i.e., maximum percolation). The half-life for Am-241 is 432 years; therefore, an estimated 1,297 half-life cycles would occur while Am-241 travels to the groundwater table. In the saturated zone, Am-241 would undergo only 13 and 346 half-life cycles while traveling to the DOE boundary for Site 11 and Site 3A, respectively. This is conservative because the distance analyzed to the DOE boundary is at the exposure point farthest from the release point. By comparing the number of half-life cycles for Am-241 in the unsaturated zone (i.e., 1,297) to that in the saturated zone (13 and 346), it is evident that most of the progeny formation (i.e., generation of Np-237) would be expected to occur in the unsaturated zone, which is simulated using DUSTMS (the code that predicts progeny formation).

Considering the U-234 isotope at Site 11, the saturated zone retarded travel time is estimated to be 107 years. The U-234 half-life is 2.4×10^5 years; therefore, U-234 will have only enough time in the aquifer as it migrates to the DOE boundary for 0.004% of its half-life. Performing the same analysis at Site 3A, U-234 will have only enough time in the aquifer for approximately 1.2% of its half life. Therefore, Site 11 and Site 3A exhibit limited travel times that would not allow for significant progeny generation.

Overall, results presented in Table C9.3 indicate that employing AT123D and not accounting for progeny ingrowth in the saturated zone gives satisfactory results and is appropriate because the travel times in the unsaturated zone (simulated using DUSTMS) are significantly larger than in the saturated zone (simulated using AT123D) such that ingrowth in the aquifer is insignificant by comparison. Also, radionuclide half lives generally are much longer than travel times in the aquifer, which limits progeny generation in the saturated zone (see Table C9.3).

1,000-Year Rainfall Storm Event Uncertainty. The HELP-predicted percolation was evaluated assuming a 1,000-year rainfall storm event occurring during one year. For Paducah, Kentucky, the 1,000-year rainfall storm event equals 10.2 inches falling over 24 hours (Bonnin et al. 2006). Over the 10,000 year simulation, the 1,000-year rainfall storm event comprises 0.002% of the total precipitation.

HELP model results indicate that during the postclosure period (Year 30–200), percolation would be expected to increase by 0.00001 inches during the year incorporating the 1,000-year rainfall event. During the Long-term Modeling Period (Years 600 to 10,000) subsequent to liner failure, the 1,000-year rainfall storm event would be expected to increase percolation by about 7 inches solely during the year containing the extreme event.

Overall, a 1,000-year rainfall storm event is a relatively minor magnitude event over the 10,000 year simulation. Therefore, the model is not sensitive to the occurrence of a 1,000-year rainfall storm event and the PWAC would not be expected to be affected by the increased rainfall.

Regarding surface erosion and other landfill cover system performance during the 1,000-year rainfall storm event, this is outside of the scope of the modeling analysis; however, this will be taken into account during final landfill design.

FML Installation Quality Uncertainty. The HELP model has an input specification for FML installation quality. Inputs are defined by the HELP model as shown below (Schroeder et al. 1994).

- **Perfect—**Assumes perfect contact between geomembrane and adjacent soil that limits drainage rate (no gap, "sprayed-on" seal between membrane and soil formed in place).

- **Excellent—**Assumes exceptional contact between geomembrane and adjacent soil that limits drainage rate.

- **Good**—Assumes good field installation with well-prepared, smooth soil surface and geomembrane wrinkle control to ensure good contact between geomembrane and adjacent soil that limits soil surface and geomembrane wrinkle control to ensure good contact between geomembrane and adjacent soil that limits drainage rate.

- **Poor—**Assumes poor field installation with a less well-prepared soil surface and/or geomembrane wrinkling providing poor contact between geomembrane and adjacent soil that limits drainage rate, resulting in a larger gap for spreading and greater leakage.

For the simulations included herein, the FML installation quality was assigned as Excellent. Compared to the Excellent specification, Perfect quality would enact less percolation and Good or Poor quality would result in more percolation. Design specifications are expected to be such that the Excellent or Perfect specifications in HELP are appropriate.

FML Instantaneous Failure and FML No Failure. Geomembrane liners have been shown to be very effective in limiting the leakage of leachate to groundwater when the geomembrane is intact. As noted by Koerner et al. (2005), geomembrane liners are formulated materials consisting of (at a minimum) (1) the resin from which the geomembrane name derives, (2) carbon black or colorants, (3) short-term processing stabilizers, and (4) long-term antioxidants. If the formulation changes (particularly the additives); the predicted lifetime may also change.

The purposes of stabilizer antioxidants are to prevent polymer degradation during processing and prevent oxidation reactions from taking place during the service life. The rate of antioxidant depletion is related to the type and amount of antioxidants, the service temperature, and the nature of the site-specific environment (Hsuan and Koerner 1988).

Studies on the lifetime of geomembrane liners have been conducted that indicate a large range of possible service lives. For example, Rowe and Islam (2009) found geomembrane liner service lives ranging from 20 to 3,300 years. The higher end of this range corresponds to data from geomembranes aged in simulated landfill liner tests and a maximum liner temperature of 37ºC. The lower end of the range corresponds to a maximum liner temperature of 60ºC, which is not anticipated in the proposed on-site landfill because a heat source will not be available. For this reason, the service lives towards the upper end of the range are expected.

Based on these studies, the FMLs in the PGDP engineered cover design may have the potential to last longer than the 600 years assumed in the modeling. The impact of a longer geomembrane service life on the modeling would be longer contaminant arrival times to the receptor, reduced groundwater concentrations, and increased PWAC values.

The no failure, gradual failure, and instantaneous failure scenarios were evaluated and compared. The lateral gravel drainage layer (part of the leachate collection system) beneath the waste was assumed to degrade for the gradual and instantaneous failure scenarios. To account for degradation, the man-made FML layers no longer acted as barrier layers, and the two drainage layers below the waste no longer functioned (i.e., they effectively became vertical percolation layers). The difference between the three scenarios involves the timing of the degradation. The instantaneous failure occurs at the end of the postclosure period (Year 200). The gradual failure begins at the end of the postclosure period and gradually increases to the maximum degradation water flux around 570 years after closure (Year 600). The no-failure scenario assumes that all components of the waste disposal cell would be in place and the water flux would be equal to the postclosure period value until Year 10,000.

The results indicate, as expected, that the PWAC for some COCs decreases for the instantaneous failure scenario in relation to the PWAC for the gradual failure scenario. This is due to the increased groundwater concentrations predicted for the instantaneous failure scenario. The results of this analysis are provided in Appendix C Tables C.4 and C.5 for Site 11 and Site 3A, respectively. In several instances, the PWAC did not change with location due to the requirement to meet the soil saturation limit[2] or the mass concentration limit of the facility.

Simulation results indicate that the PWAC for some COCs increases dramatically for the no failure scenario in relation to the PWAC for the gradual failure scenario. This is because several contaminants do not reach the groundwater receptor under this scenario, and the PWAC is set to the limits established using the soil saturation limit for chemicals that in their pure form are liquids at 25°C or the mass concentration limit of the facility.

Cap Drainage Layer Duration. For the gradual failure scenario, the sand drainage layer in the cover system was assumed to fail in a manner similar to the geosynthetic components and is modeled as a vertical flow layer during the long-term modeling period. Information presented during the February 22, 2012, Symposium on Performance Modeling of Low-Level Radioactive Waste Disposal Facilities,[3] as well literature reviews on the performance of cover systems, and a subsequent review of the conceptual design with respect to this information, indicate that the sand drainage layer in the cover system potentially can be modeled as a drainage layer as opposed to a vertical percolation layer during the Long-Term Modeling Period. For the gradual failure scenario, percolation of landfill leachate as a function of time is shown in Figure C9.2. The steady-state value of shown in Figure C9.2 does not account for evapotranspiration and should be considered a high-end or maximum value.

The incorporation of a biointrusion layer comprised of rocks and boulders, overlain by a filter of sand and underlain by a drainage sand in the conceptual cover system design, has the added advantage of providing a secondary layer within the cover system to facilitate drainage from the cap system and thereby reduce infiltration.

The model used for gradual failure due to degradation of the FML, cover, and liner from Year 200 to 600 is represented by the following equation (Lee et al. 1995).

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[2] Corrections for soil saturation are performed for those chemicals that in their pure form are liquids at 25°C or above.

[3] The February 22, 2012, Symposium on Performance Modeling of Low-Level Radioactive Waste Disposal Facilities was hosted by the University of Kentucky in Lexington, Kentucky, and was attended by representatives from DOE, EPA, Kentucky Department for Environmental Protection, and Kentucky Radiation Health Branch.

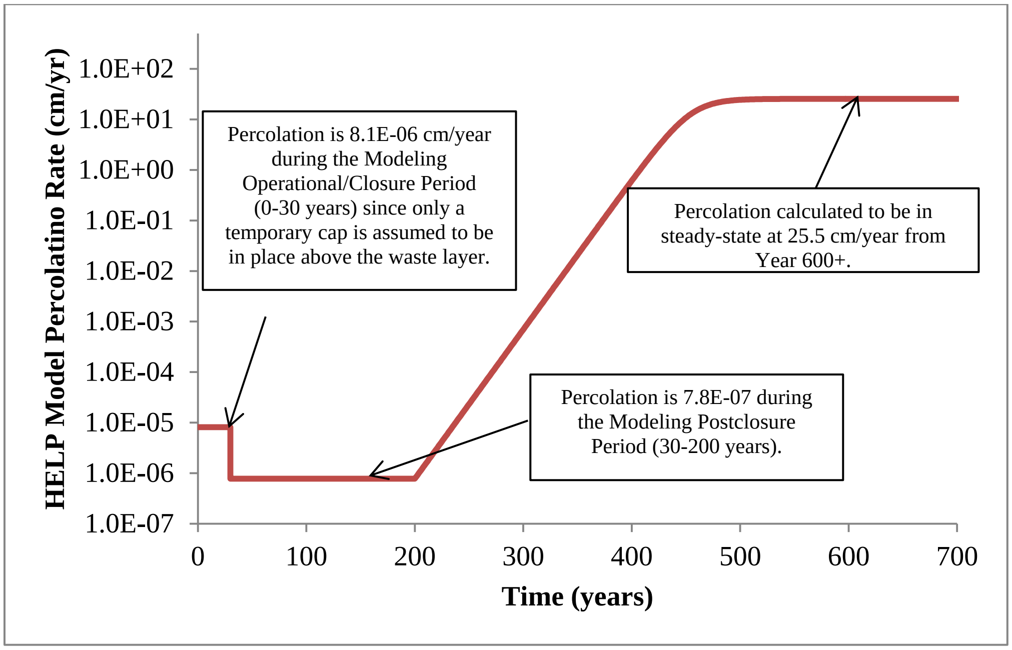

Figure C9.2. Percolation of Landfill Leachate as a Function of Time for the Gradual Failure Scenario with Increased Cap Hydraulic Conductivity

$$F(t) = \frac{f_2 \times f_3}{f_2 + (f_3 - f_2) \times e^{-\alpha(t-t_1)}} \qquad \text{(main text Eq. 1)}$$

$F(t)$ = groundwater recharge rate at time of interest (t), cm/yr
f_2 = average groundwater recharge in the postclosure period based on HELP run, cm/year
f_3 = the final groundwater recharge based on HELP run for the long-term modeling period after cover and liner failure, cm/year
t = the time (years) at which F(t) is measured
t_1 = the time (years) at the end of the postclosure period (i.e., Year 200)
α = the decay constant (0.051 year^{-1}), specifically developed for this time frame and differential magnitude in recharge rates

For this uncertainty gradual failure scenario, the value of the decay constant, α, was assumed to be 0.051 year^{-1}, which resulted in the water flux reaching the fully degraded recharge rate of 0.321 cm/yr (see Figure C9.3 and Table C9.10) approximately 400 years after initiation of gradual failure (i.e. Year 600). The value of the decay constant determined the time at which the peak water flux was attained (i.e., failure of the liner components was complete). For the gradual failure scenario (which assumes failure of the sand drainage layer in the cover system such that it is modeled in HELP as a vertical drainage layer), the value of the decay constant was assumed to be 0.064 year^{-1}, which resulted in the water flux reaching the fully degraded recharge rate of 12.3 cm/yr approximately 400 years after initiation of gradual failure (i.e., Year 600).

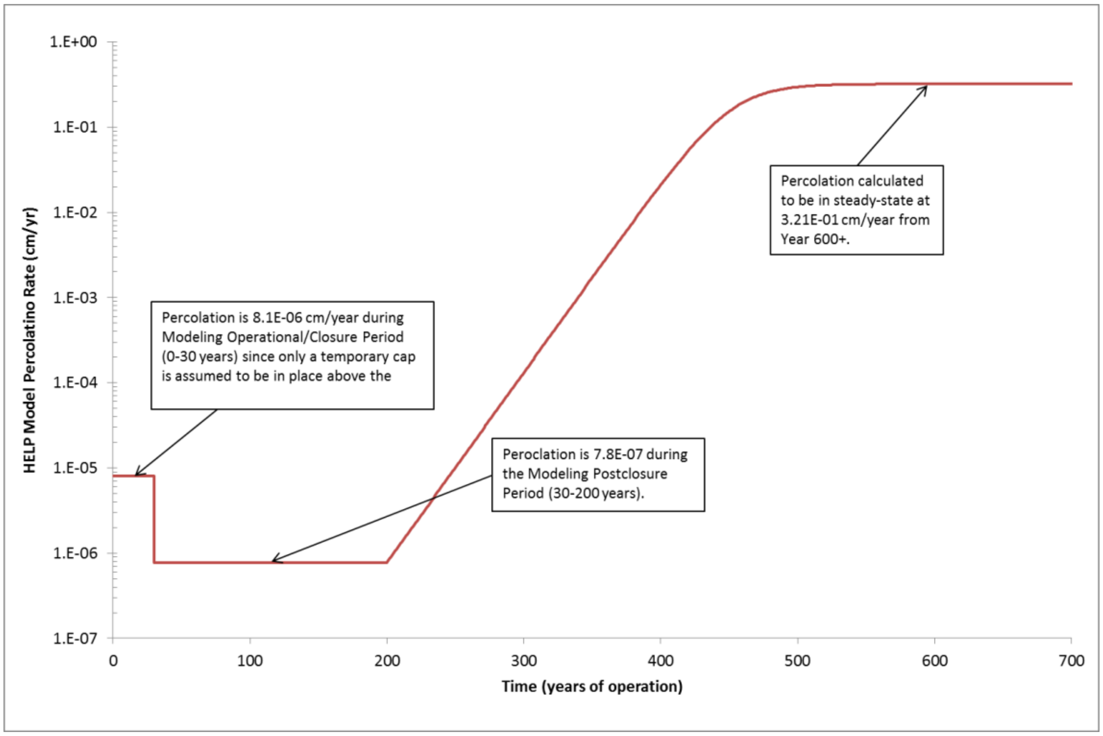

Figure C9.3. Percolation of Landfill Leachate as a Function of Time for the Final Gradual Failure Scenario (Cap Drainage Layer Uncertainty Alternate Drainage Scenario)

To better understand the effects of potential clogging on the sand drainage layer within the cover system, an uncertainty assessment was performed whereby the hydraulic conductivities of the cap drainage sand and biointrusion layers were decreased by one order of magnitude to understand the effect of deposition or precipitation of fines into these layers[4] (clogging scenario), or for the case where the drainage sand layer was assumed to become completely clogged and no longer function as a drainage layer (this layer was incorporated into the underlying soil layer and modeled as a barrier layer) and where the biointrusion layer was modeled as a drainage layer (biointrusion drainage). This sensitivity assessment revealed little change in infiltration when the drainage layer is operable for the simulation duration for either case. Specifically, for the aforementioned clogging and biointrusion drainage scenarios, the HELP-predicted infiltration rates were 0.310 cm/yr and 0.314 cm/yr, respectively.

One difference between modeling the long-term performance of the sand drainage layer as a vertical flow layer versus a drainage layer in HELP is that vertical flow layers in HELP do not allow for evapotranspiration, thereby increasing the infiltration rate. In other words, once water enters a vertical flow layer, it can move downward only and cannot move upward due to evapotranspiration. Ignoring evapotranspiration from the sand drainage layer maximizes the amount of water available for infiltration in the model, but is not necessarily physically realistic. Based on this limitation within the HELP model, it may be more appropriate to model the sand drainage layer as a drainage layer or use other models that account for evapotranspiration. In either case, to account for long-term performance, a sensitivity of the infiltration rate to the hydraulic conductivity of the sand drainage layer should be performed.

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[4] Note that as part of the long-term modeling period, the hydraulic conductivity of the clay portion of the cover system have been increased one order of magnitude from 10^{-7} cm/sec (Year 30-200) to 10^{-6} cm/sec (starting at Year 600) (DOE 2011).

Table C9.10. Predicted Landfill Percolation and PWAC-EOW Variation Due to Cap Drainage Layer Uncertainty

HELP Predicted Percolation Rate			
DUSTMS Gradual Failure Scenario (T+400 years) Year	**DUSTMS Gradual Failure Scenario (T+400 years) Percolation Rate (cm/s)**	**DUSTMS Alternate Drainage Scenario Year**	**DUSTMS Alternate Drainage Scenario Percolation Rate (cm/s)**
30	2.46E-14	30	2.46E-14
200	2.46E-14	200	2.46E-14
225	1.22E-13	225	8.88E-14
250	6.03E-13	250	3.21E-13
350	3.63E-10	350	5.45E-11
425	3.96E-08	425	2.06E-09
500	3.64E-07	500	9.40E-09
550	3.89E-07	550	1.01E-08
600	3.90E-07	600	1.02E-08
10000	3.90E-07	10000	1.02E-08

Contaminant	**PWAC-EOW Average Concentrations (mg/kg or pCi/g)**			
	Site 11 Gradual Failure Scenario	**Site 11 Cap Drainage Layer Scenario (Alternate Drainage Scenario)**	**Site 3A Gradual Failure Scenario**	**Site 3A Cap Drainage Layer Scenario (Alternate Drainage Scenario)**
Benzo(a)pyrene	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Total PCBs	1.73E+02	1.73E+02	1.73E+02	1.73E+02
TCE	2.32E+02	2.32E+02	2.32E+02	2.32E+02
Ag	1.00E+05	1.00E+05	1.00E+05	1.00E+05
As	2.27E+02	1.00E+05	6.09E+00	1.00E+05
V	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Am-241	3.43E+11	3.43E+11	3.43E+11	3.43E+11
Np-237	2.58E+02	7.05E+07	8.91E-01	7.05E+07
Tc-99	2.67E+01	7.85E+04	2.08E+00	5.16E+02
U-235	2.16E+05	2.16E+05	2.16E+05	2.16E+05
U-238	3.36E+04	3.36E+04	3.36E+04	3.36E+04
U-234	6.25E+08	6.25E+08	6.25E+08	6.25E+08

Note: PWAC-EOW values shown are corrected for soil saturation and total mass limits.

As shown in Table C9.10, compared to the predictions using the Gradual Failure Scenario, the PWAC-EOW values are equal to or greater in magnitude for the simulated contaminants when the drainage layer is operational for the entire simulation duration (including the long-term modeling period). Tables C9.11 and C9.12 include the PWAC values derived using the alternate drainage scenario for Sites 11 and 3A, respectively.

Partitioning Coefficient Variation. The soil/water distribution coefficient, K_d, is a potentially important parameter regarding contaminant migration. Dissolved compounds with lesser magnitude K_d values tend to adsorb less to nearby soil particles and migrate more readily. Conversely, compounds with greater magnitude K_d values tend to adsorb to soil particles, inhibiting contaminant migration.

Under certain circumstances, a phenomenon referred to as facilitated transport can affect contaminant migration by varying contaminant soil/water distribution. Facilitated transport refers to the enhanced migration of contaminants from the disposal cell into the surrounding environment. This primarily can occur in two ways. First, waste placed in the disposal cell can create a chemical environment (co-solvent transport or colloidal facilitative transport) that will accelerate the leaching of contamination from the waste and into water migrating through and exiting the disposal cell, or the waste can create a leachate that deteriorates the liner system and exits the cell faster than predicted. Second, facilitated transport can occur when chelating agents are present in the disposal cell (which would potentially enhance the migration of contamination) or if a large volume of organic waste is disposed of in the cell. It is not expected that either of these conditions will be present at PGDP and liner compatibility with anticipated wastes will be assessed as part of the design process. More detail on facilitated transport (including potential co-solvent effects) is presented in Attachment C.8 to Appendix C.

Uncertainty simulations were performed by varying the K_d value of the soil/water distribution coefficient from a minimum value (K_d equal to 0 L/kg for all compounds) to the greatest magnitude expected for a given compound. For the high K_d simulation, the greater of the values shown below was selected for the uncertainty compounds (see Table C9.4).

- Double the gradual failure scenario K_d
- K_d values presented in DOE 2002
- K_d values presented in DOE 2003
- K_d values presented in ORISE 2011

Uncertainty simulation results presented in Table C9.5 and main text Figures 5.8 through 5.11 show that with increasing K_d, indicating more chemical affinity for the solid phase, the PWAC-EOW for the simulated chemical constituents increases or stays the same compared to the PWAC-EOW calculated for the gradual failure scenario. Conversely, with the K_d set to the extreme low level of 0 L/kg, indicative of no contaminant adsorption to the solid phase, the PWAC-EOW for the simulated chemical constituents decreases compared to the PWAC-EOW calculated for the gradual failure scenario.

Solubility Uncertainty. Contaminant solubility specifies the amount of contaminant (expressed as a concentration) that can be dissolved in water (such as leachate). Contaminants with a larger solubility would exhibit larger leachate concentrations which would likely enhance contaminant release and migration, increase groundwater concentrations, and decrease the contaminant PWAC. Contaminants with a lower solubility would have delayed contaminant release; therefore, groundwater concentrations would decrease and the PWAC would be increased. Solubility also affects the amount of contaminant that can be in the waste (dissolved in the leachate and adsorbed to the solid matrix), since no liquid waste is allowed by regulation. DUSTMS accounts for solubility limitations when calculating mass release from containers (not applied for simulations presented herein). DUSTMS does not account for solubility limitations in its calculation of contaminant fate and transport (Sullivan 2011). Not accounting for

Table C9.11. Site 11 PWAC for the Alternate Drainage Scenario

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Nonaromatic, Straight-Chain Halogenated Hydrocarbons						
Chloroform	1.40E+03	8.65E+06	1.40E+03	8.65E+06	1.40E+03	8.65E+06
cis-1,2-DCE	5.73E+02	3.53E+06	5.73E+02	3.53E+06	5.73E+02	3.53E+06
Methylene chloride	1.86E+03	1.15E+07	1.86E+03	1.15E+07	1.86E+03	1.15E+07
Vinyl Chloride	4.14E+02	2.55E+06	4.14E+02	2.55E+06	4.14E+02	2.55E+06
TCE	2.32E+02	1.43E+06	2.32E+02	1.43E+06	2.32E+02	1.43E+06
PCE	6.95E+01	4.28E+05	6.95E+01	4.28E+05	6.95E+01	4.28E+05
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons						
Acetone	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
2-Butanone	1.04E+04	6.42E+07	1.04E+04	6.42E+07	1.04E+04	6.42E+07
Butanal	4.82E+03	2.97E+07	4.82E+03	2.97E+07	4.82E+03	2.97E+07
Hexanone (2-)	2.53E+03	1.56E+07	2.53E+03	1.56E+07	2.53E+03	1.56E+07
Methyl-2-pentanone (4-)	2.76E+03	1.70E+07	2.76E+03	1.70E+07	2.76E+03	1.70E+07
Aromatic, Ring-Structured Halogenated Hydrocarbons						
Chlorobenzene	1.48E+02	9.15E+05	1.48E+02	9.15E+05	1.48E+02	9.15E+05
Dimethylbenzene (1,2-)	7.87E+01	4.85E+05	7.87E+01	4.85E+05	7.87E+01	4.85E+05
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons						
Benzene	3.23E+02	1.99E+06	3.23E+02	1.99E+06	3.23E+02	1.99E+06
Cumene	4.25E+01	2.62E+05	4.25E+01	2.62E+05	4.25E+01	2.62E+05
Ethylbenzene	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.05E+01	3.11E+05
Toluene	1.30E+02	8.02E+05	1.30E+02	8.02E+05	1.30E+02	8.02E+05
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)						
Acenaphthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Acetophenone	1.08E+03	6.68E+06	1.08E+03	6.68E+06	1.08E+03	6.68E+06
Benzoic Acid	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Carbazole	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Chloro-3-methylphenol (4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
o-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
p-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzofuran(s)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methyl Naphthalene (2-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methylphenol (3&4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group						
Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(a)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Butyl benzyl phthalate	2.99E+01	1.84E+05	2.99E+01	1.84E+05	2.99E+01	1.84E+05
Chrysene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Diethyl phthalate	2.17E+02	1.34E+06	2.17E+02	1.34E+06	2.17E+02	1.34E+06
Di-n-butyl phthalate	1.56E+01	9.61E+04	1.56E+01	9.61E+04	1.56E+01	9.61E+04
Di-n-octyl phthalate	1.33E+03	8.21E+06	1.33E+03	8.21E+06	1.33E+03	8.21E+06
Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08

Table C9.11. Site 11 PWAC for the Alternate Drainage Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Fluorene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Naphthalene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pentachlorophenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenanthrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tetrachlorophenol (2,3,4,6-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group						
BEHP	3.03E+01	1.87E+05	3.03E+01	1.87E+05	3.03E+01	1.87E+05
Benzo(a)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(b)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(k)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(g,h,i)perylene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzo(a,h)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Indeno(1,2,3-cd)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
PCBs						
Aroclor-1016	1.61E+01	9.92E+04	1.61E+01	9.92E+04	1.61E+01	9.92E+04
Aroclor-1221	1.03E+02	6.34E+05	1.03E+02	6.34E+05	1.03E+02	6.34E+05
Aroclor-1232	9.77E+01	6.02E+05	9.77E+01	6.02E+05	9.77E+01	6.02E+05
Aroclor-1242	1.74E+01	1.07E+05	1.74E+01	1.07E+05	1.74E+01	1.07E+05
Aroclor-1248	6.13E+00	3.78E+04	6.13E+00	3.78E+04	6.13E+00	3.78E+04
Aroclor-1254	4.50E+00	2.77E+04	4.50E+00	2.77E+04	4.50E+00	2.77E+04
Aroclor-1260	4.04E+00	2.49E+04	4.04E+00	2.49E+04	4.04E+00	2.49E+04
Total PCBs	1.73E+02	1.07E+06	1.73E+02	1.07E+06	1.73E+02	1.07E+06
Pesticides						
beta-BHC	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDD (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDE (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDT (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dieldrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan II	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan sulfate	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin Aldehyde	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
gamma-chlordane	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heptachlor epoxide	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Metals						
Sb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
As	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Ba	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Be	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cd	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08

Table C9.11. Site 11 PWAC for the Alternate Drainage Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Cr	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cu	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Mn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Hg	2.35E+04	1.45E+08	2.35E+04	1.45E+08	2.35E+04	1.45E+08
Ni	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Se	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Ag	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tl	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
V	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Zn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
U[b]	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Radionuclides						
Pu-238	1.71E+12	1.05E+13	1.71E+12	1.05E+13	1.71E+12	1.05E+13
U-238	3.36E+04	2.07E+05	3.36E+04	2.07E+05	3.36E+04	2.07E+05
U-234	6.25E+08	3.85E+09	6.25E+08	3.85E+09	6.25E+08	3.85E+09
Pu-239	6.20E+09	3.82E+10	6.20E+09	3.82E+10	6.20E+09	3.82E+10
U-235	2.16E+05	1.33E+06	2.16E+05	1.33E+06	2.16E+05	1.33E+06
Pu-240	2.27E+10	1.40E+11	2.27E+10	1.40E+11	2.27E+10	1.40E+11
Np-237	7.05E+07	4.34E+08	7.05E+07	4.34E+08	7.05E+07	4.34E+08
Cs-137	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.65E+12	5.33E+13
Tc-99	7.85E+04	4.84E+05	1.16E+05	7.16E+05	1.16E+05	7.16E+05
Am-241	3.43E+11	2.12E+12	3.43E+11	2.12E+12	3.43E+11	2.12E+12
Th-230	2.02E+09	1.24E+10	2.02E+09	1.24E+10	2.02E+09	1.24E+10

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.

[b] Applying natural abundance mass ratios to elemental uranium PWAC would result in the following uranium isotope PWAC: 3.34E+04 of U-238, 1.56E+03 pCi/g of U-235, and 3.44E+04 pCi/g of U-234.

PWAC - Preliminary Waste Acceptance Criteria

EOW - Edge of Waste

WDF - Waste Disposal Facility boundary

DOE/SW - DOE property (Site 11)/surface water outcrop (Site 3A)

Table C9.12. Site 3A PWAC for the Alternate Drainage Scenario

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Nonaromatic, Straight-Chain Halogenated Hydrocarbons						
Chloroform	1.40E+03	8.64E+06	1.40E+03	8.64E+06	1.40E+03	8.64E+06
cis-1,2-DCE	5.73E+02	3.53E+06	5.73E+02	3.53E+06	5.73E+02	3.53E+06
Methylene chloride	1.86E+03	1.15E+07	1.86E+03	1.15E+07	1.86E+03	1.15E+07
Vinyl Chloride	4.14E+02	2.55E+06	4.14E+02	2.55E+06	4.14E+02	2.55E+06
TCE	2.32E+02	1.43E+06	2.32E+02	1.43E+06	2.32E+02	1.43E+06
PCE	6.95E+01	4.28E+05	6.95E+01	4.28E+05	6.95E+01	4.28E+05
Nonaromatic, Straight-Chain Nonhalogenated Hydrocarbons						
Acetone	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
2-Butanone	1.04E+04	6.41E+07	1.04E+04	6.41E+07	1.04E+04	6.41E+07
Butanal	4.82E+03	2.97E+07	4.82E+03	2.97E+07	4.82E+03	2.97E+07
Hexanone (2-)	2.53E+03	1.56E+07	2.53E+03	1.56E+07	2.53E+03	1.56E+07
Methyl-2-pentanone (4-)	2.76E+03	1.70E+07	2.76E+03	1.70E+07	2.76E+03	1.70E+07
Aromatic, Ring-Structured Halogenated Hydrocarbons						
Chlorobenzene	1.48E+02	9.14E+05	1.48E+02	9.14E+05	1.48E+02	9.14E+05
Dimethylbenzene (1,2-)	7.87E+01	4.84E+05	7.87E+01	4.84E+05	7.87E+01	4.84E+05
Aromatic, Ring-Structured Nonhalogenated Hydrocarbons						
Benzene	3.23E+02	1.99E+06	3.23E+02	1.99E+06	3.23E+02	1.99E+06
Cumene	4.25E+01	2.62E+05	4.25E+01	2.62E+05	4.25E+01	2.62E+05
Ethylbenzene	5.05E+01	3.11E+05	5.05E+01	3.11E+05	5.05E+01	3.11E+05
Toluene	1.30E+02	8.01E+05	1.30E+02	8.01E+05	1.30E+02	8.01E+05
Light Semivolatile Organic Compounds (molecular weight < 200 g/mole)						
Acenaphthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Acetophenone	1.08E+03	6.67E+06	1.08E+03	6.67E+06	1.08E+03	6.67E+06
Benzoic Acid	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Carbazole	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Chloro-3-methylphenol (4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
o-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
p-Cresol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzofuran(s)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methyl Naphthalene (2-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Methylphenol (3&4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Mobile Group						
Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(a)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Butyl benzyl phthalate	2.99E+01	1.84E+05	2.99E+01	1.84E+05	2.99E+01	1.84E+05
Chrysene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Diethyl phthalate	2.17E+02	1.34E+06	2.17E+02	1.34E+06	2.17E+02	1.34E+06
Di-n-butyl phthalate	1.56E+01	9.61E+04	1.56E+01	9.61E+04	1.56E+01	9.61E+04

Table C9.12. Site 3A PWAC for the Alternate Drainage Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Di-n-octyl phthalate	1.33E+03	8.21E+06	1.33E+03	8.21E+06	1.33E+03	8.21E+06
Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Fluorene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Naphthalene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pentachlorophenol	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Phenanthrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tetrachlorophenol (2,3,4,6-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heavy Semivolatile Organic Compounds (molecular weight > 200 g/mole) Less Mobile Group						
BEHP	3.03E+01	1.86E+05	3.03E+01	1.86E+05	3.03E+01	1.86E+05
Benzo(a)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(b)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(k)Fluoranthene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Benzo(g,h,i)perylene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dibenzo(a,h)Anthracene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Indeno(1,2,3-cd)pyrene	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
PCBs						
Aroclor-1016	1.61E+01	9.92E+04	1.61E+01	9.92E+04	1.61E+01	9.92E+04
Aroclor-1221	1.03E+02	6.34E+05	1.03E+02	6.34E+05	1.03E+02	6.34E+05
Aroclor-1232	9.77E+01	6.02E+05	9.77E+01	6.02E+05	9.77E+01	6.02E+05
Aroclor-1242	1.74E+01	1.07E+05	1.74E+01	1.07E+05	1.74E+01	1.07E+05
Aroclor-1248	6.13E+00	3.77E+04	6.13E+00	3.77E+04	6.13E+00	3.77E+04
Aroclor-1254	4.50E+00	2.77E+04	4.50E+00	2.77E+04	4.50E+00	2.77E+04
Aroclor-1260	4.04E+00	2.49E+04	4.04E+00	2.49E+04	4.04E+00	2.49E+04
Total PCBs	1.73E+02	1.07E+06	1.73E+02	1.07E+06	1.73E+02	1.07E+06
Pesticides	0.00E+00		0.00E+00		0.00E+00	
beta-BHC	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDD (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDE (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
DDT (4,4-)	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Dieldrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan II	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endosulfan sulfate	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Endrin Aldehyde	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
gamma-Chlordane	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Heptachlor epoxide	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Metals						
Sb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
As	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Ba	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08

Table C9.12. Site 3A PWAC for the Alternate Drainage Scenario (Continued)

Chemical Groups[a]	PWAC-EOW Average Concentration (mg/kg or pCi/g)	PWAC-EOW Inventory Limit (kg or Ci)	PWAC-WDF Average Concentration (mg/kg or pCi/g)	PWAC-WDF Inventory Limit (kg or Ci)	PWAC-DOE/SW Average Concentration (mg/kg or pCi/g)	PWAC-DOE/SW Inventory Limit (kg or Ci)
Be	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cd	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cr	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Cu	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Pb	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Mn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Hg	2.35E+04	1.44E+08	2.35E+04	1.44E+08	2.35E+04	1.44E+08
Ni	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Se	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Ag	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Tl	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
V	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Zn	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
U[b]	1.00E+05	6.16E+08	1.00E+05	6.16E+08	1.00E+05	6.16E+08
Radionuclides						
Pu-238	1.71E+12	1.05E+13	1.71E+12	1.05E+13	1.71E+12	1.05E+13
U-238	3.36E+04	2.07E+05	3.36E+04	2.07E+05	3.36E+04	2.07E+05
U-234	6.25E+08	3.85E+09	6.25E+08	3.85E+09	6.25E+08	3.85E+09
Pu-239	6.20E+09	3.82E+10	6.20E+09	3.82E+10	6.20E+09	3.82E+10
U-235	2.16E+05	1.33E+06	2.16E+05	1.33E+06	2.16E+05	1.33E+06
Pu-240	2.27E+10	1.40E+11	2.27E+10	1.40E+11	2.27E+10	1.40E+11
Np-237	7.05E+07	4.34E+08	7.05E+07	4.34E+08	7.05E+07	4.34E+08
Cs-137	8.65E+12	5.33E+13	8.65E+12	5.33E+13	8.65E+12	5.33E+13
Tc-99	5.16E+02	3.18E+03	5.95E+02	3.66E+03	6.08E+02	3.74E+03
C9-3Am-241	3.43E+11	2.11E+12	3.43E+11	2.11E+12	3.43E+11	2.11E+12
Th-230	2.02E+09	1.24E+10	2.02E+09	1.24E+10	2.02E+09	1.24E+10

[a] Contaminants noted in bold are indicator chemicals for the surrogate chemical group.

[b] Applying natural abundance mass ratios to elemental uranium PWAC would result in the following uranium isotope PWAC: 3.34E+04 of U-238, 1.56E+03 pCi/g of U-235, and 3.44E+04 pCi/g of U-234.

PWAC - Preliminary Waste Acceptance Criteria

EOW - Edge of Waste

WDF - Waste Disposal Facility boundary

DOE/SW - DOE property (Site 11)/surface water outcrop (Site 3A)

solubility limitations enables the model to dissolve all available contaminant mass in the leachate which is conservative regarding the calculation of contaminant-specific PWAC values (e.g., higher leachate concentrations results in higher predicted groundwater concentrations which results in a conservatively low PWAC).

Because waste containers are not employed for the presented simulations and DUSTMS does not incorporate solubility limitations during contaminant fate and transport simulations, the model results are not sensitive to assignment of solubility. For contaminants with predicted groundwater concentrations at or near zero within the 1,600-year evaluation period at the relevant point of assessment (i.e., instances where PWAC values are not limited except for solubility or mass/activity limitations), the specification of a greater solubility can increase the PWAC since the leachate can dissolve more contaminant.

The solubility of a chemical constituent may be modified because of the presence of large amounts of solvents (e.g., TCE). Because DUSTMS does not account for solubility considerations, and because of the likely lack of solvents in the waste, co-solvent affects are not an important consideration related to the simulations presented herein. See Attachment C.8 to Appendix C for more details on facilitated transport, including co-solvent enhanced migration.

A solubility-related uncertainty analysis was performed on the chemical constituent indeno(1,2,3-cd)pyrene, which is not predicted to impact groundwater concentrations. For the gradual failure scenario, the PWAC-EOW average concentration was calculated as 6.12E-02 mg/kg, which is less than both the high-volume disposal cell (1.76E-01 mg/kg) and low-volume disposal cell (1.81E-01 mg/kg) concentrations. The specified solubility for the gradual failure scenario for indeno(1,2,3-cd)pyrene is conservatively low (2.2E-5 g/cc). Indeno(1,2,3-cd)pyrene is a surrogate of benzo(a)pyrene in the Heavy Semivolatile Organic Compound (molecular weight > 200 g/mole) Less Mobile Group, which had a model-predicted maximum groundwater concentration of 0 mg/L at the EOW. Since benzo(a)pyrene presence in the disposal cell did not result in groundwater impacts, it is expected that the PWAC values for benzo(a)pyrene and the surrogate compounds in the Heavy Semivolatile Organic Compound (molecular weight > 200 g/mole) Less Mobile Group would have relatively high PWAC values that are only limited by solubility (liquids are not permitted to be disposed of in the landfill) and total mass limits, and this is the case. Additionally, toxicity data for indeno(1,2,3-cd)pyrene is usually lower than that of benzo(a)pyrene, further indicating that the PWAC for indeno(1,2,3-cd)pyrene should be at least equal to or greater than the PWAC for benzo(a)pyrene. The low indeno(1,2,3-cd)pyrene solubility value (2.2E-5 g/cc) limits the calculated PWAC-EOW to a low value not consistent with the benzo(a)pyrene findings. The solubility limit of indeno(1,2,3-cd)pyrene of 2.2E-05 mg/L used for the PWAC calculation was referenced from the U.S. Environmental Protection Agency (EPA) soil screening guidance document (EPA 1996). Alternatively, the solubility limit of indeno(1,2,3-cd)pyrene from EPA in a document (more recent EPA document than EPA 1996) containing solubility values derived from EPI WATERNT is 1.9E-4 mg/L (EPA 2010). Using the solubility limit from EPA 2010, instead of EPA 1996, increases the PWAC-EOW for indeno(1,2,3-cd)pyrene from 6.12E-02 mg/kg to 5.28E-01 mg/kg. Applying the more appropriate EPA 2010 value of solubility for indeno(1,2,3-cd)pyrene increases the PWAC-EOW average concentration to more than both the high-volume disposal cell (1.76E-01 mg/kg) and low-volume disposal cell (1.81E-01 mg/kg) concentrations.

Hydraulic Gradient Uncertainty. The hydraulic gradient at Site 3A and 11 is prone to change in magnitude both seasonally and temporally. This could potentially result in a change in groundwater flow direction. The gradual failure scenario simulation assumed a hydraulic gradient of 3.2E-03 ft/ft and 6.6E-04 ft/ft for Site 3A and Site 11, respectively.

Quantitative uncertainty simulations were performed by varying the gradual failure scenario hydraulic gradient by a factor of 0.5 (low gradient) and 2 (high gradient). Therefore, the hydraulic gradient was varied at Site 3A from 1.6E-03 ft/ft to 6.4E-03 ft/ft. At Site 11, the hydraulic gradient was varied from 3.3E-04 ft/ft to 1.3E-03 ft/ft

PWAC-EOW simulation results for baseline and variable hydraulic gradient scenarios are presented in Table C9.6. Uncertainty simulation results show that the model is relatively insensitive to changes in aquifer hydraulic gradient.

Climate Change. Simulations were performed to evaluate the effect of anticipated long-term climate change at PGDP. It was assumed that climate change would consist of precipitation and temperature changes. Based on the 2007 Climate Change Report (IPCC 2007) by the Intergovernmental Panel on Climate Change (IPCC), the following trends were projected for the approximate location of Paducah, Kentucky:

- The average yearly temperature will increase 3.75°C compared to the gradual failure scenario data within 100 years. The predicted average winter temperature increase (December, January, and February months) is 3.5°C and the average summer temperature increase (June, July, and August months) is 4°C.

- The yearly average precipitation will increase by 3% compared to the precipitation data used for the gradual failure scenario data within 100 years. The predicted winter precipitation increase is 6% and the summer precipitation decrease is 5%.

No regional data was provided for a time period longer than 100 years, and only a global average yearly temperature was presented for 1,000 years into the future. The predicted yearly global average temperature increase ranges from 1.9°C to 5.6°C, while the 100-year global average temperature increase range was 1.2°C to 4.1°C. In the uncertainty analysis simulation to represent the physical impacts of climate change, the average yearly temperature was increased 5.15°C (+4.81°C in winter and +5.49°C during the summer) compared to gradual failure scenario data from Year 1,000 to Year 10,000.

The yearly average precipitation was maintained at an increased value by 3% compared to the precipitation data used for the gradual failure scenario from Year 100 to 10,000.

With these values input into the HELP model, the resulting water velocity distribution is as shown in Table C9.7. Over the 10,000-year period, about 6.7% less water percolates through the landfill during the climate change scenario compared to the gradual failure scenario. The predicted decrease in percolation indicates that the specified increase in temperature (increases evapotranspiration and other water depleting processes) had more of an impact on percolation than the specified increase in precipitation. Table C9.7 also presents the variation in the PWAC-EOW given the above-mentioned climate change scenario. Model results show that the IPCC anticipated climate change would have little impact on the PWAC because the change in percolation is minimal. Because the climate change uncertainty assessment predicts that less water will percolate through the landfill, some contaminants have a greater calculated PWAC-EOW value (e.g., arsenic, Np-237, and Tc-99) under the climate change scenario.

Waste Form Bulk Density. Gradual failure scenario simulations were performed assuming a waste bulk density of 3.1 g/cm^3. This value for bulk density was computed as a volume weighted average assuming the waste composition shown in Table C9.8. Uncertainty simulations were performed assuming a decreased waste bulk density of 1.5 g/cm^3 (all other specified bulk density values were unchanged from gradual failure scenario values), which assumes that the waste form has the same bulk density as presented in ORISE 2011 for the C-746-U Landfill. This scenario allows for evaluating the impact of the potential deviation from the assumed waste form bulk density.

The predicted groundwater concentration profiles (normalized to initial contaminant mass input into the model) for Tc-99 at Site 11 are shown in Figure C9.4. As expected, inspection of Figure C.9.4 indicates that decreasing the waste form bulk density results in a predicted faster peak arrival time and greater peak concentration magnitude.

The impact on the PWAC-EOW of decreasing the waste form dry bulk density from 3.1 g/cm^3 to 1.5 g/cm^3 is shown in Table C9.8 and main report Figures 5.9 through 5.12. Overall, the model is relatively insensitive to changes in waste form bulk density with changes to the PWAC-EOW for any evaluated compound being less than one order of magnitude. When a change in PWAC-EOW is calculated for this uncertainty scenario, decreasing waste bulk density decreased the PWAC-EOW.

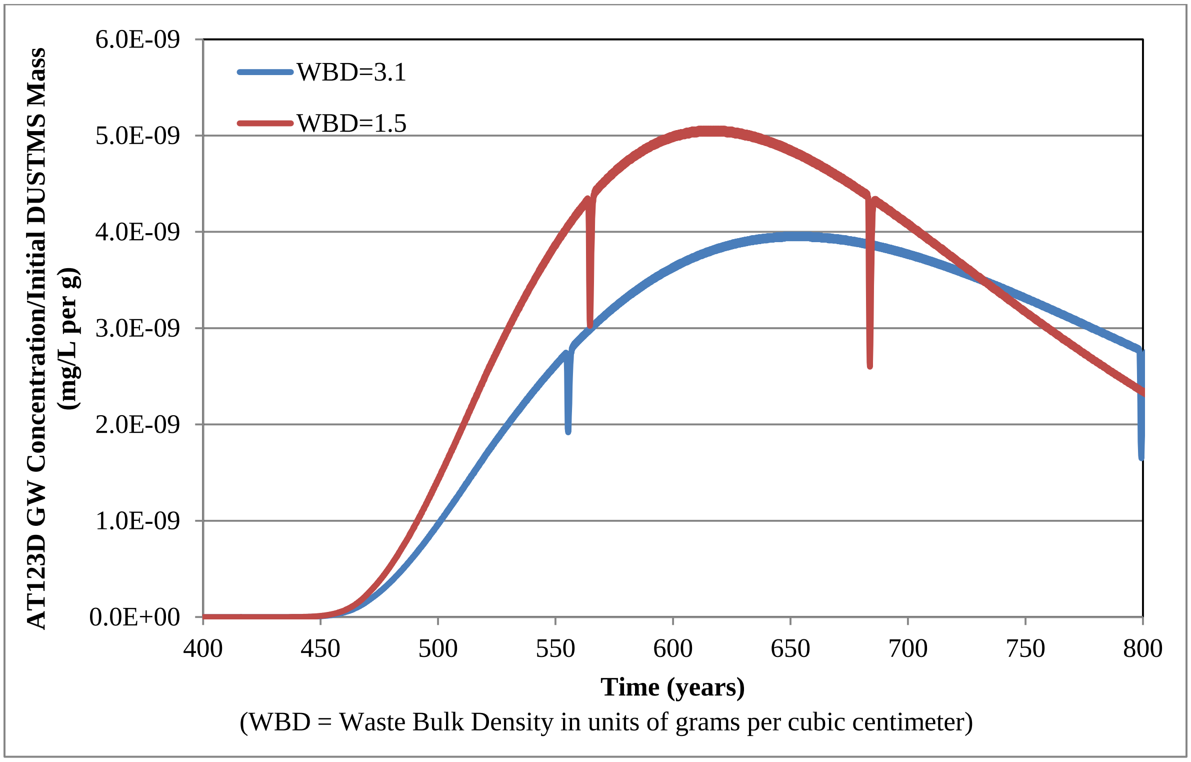

Figure C9.4. Site 11 Tc-99 Model Groundwater Concentration at DOE Boundary Normalized to Source Mass

Hydraulic Conductivity of Compacted Clay Liners. Hydraulic conductivities of the different layers comprising the disposal cell are the most important parameters that control contaminant flux to the groundwater table. Since the HELP model was used to estimate percolation (which affects contaminant flux), an uncertainty analysis was completed by performing multiple simulations using the HELP model with varying hydraulic conductivity values.

The uncertainty analysis was performed only for the long-term modeling period, since during the operational and the postclosure period the groundwater recharge is controlled predominately by the FML layers and the leachate collection system. The combination of the FML layers and leachate collection systems prevent significant contaminant migration vertically through the facility.

The results of the analysis indicated that neither increasing nor decreasing the bottom CCL hydraulic conductivity resulted in a significant change in water flux, since these layers do not control the flow into the landfill system. However, the hydraulic conductivity of the bottom CCL will control the flow out of the disposal cell if sufficient flow occurs above the bottom CCL. The flow into the disposal cell is controlled by the hydraulic conductivity of the cap soil and cap clay.

Hydraulic Conductivity of Cap Soil and Cap Clay. As mentioned above, assigned hydraulic conductivity values specified for the different layers comprising the disposal cell are important parameters controlling contaminant flux to the groundwater table. As for the bottom CCL, the uncertainty analysis on cap materials was performed only for the long-term modeling period. Varying the hydraulic conductivity of the upper most two soil layers in the landfill cap from 2.3E-06 cm/s and 5.0E-07 cm/s to 2.3E-05 cm/s and 5.0E-06 cm/s, respectively, and decreasing the cap CCL hydraulic conductivity by one order of magnitude resulted in a change in the predicted water flux from 12.3 cm/yr to 25.5 cm/yr, respectively (Figure C9.4). As expected, the increase in hydraulic conductivity resulted in increased water flux through the landfill.

Overall, simulations show (Table C9.9 and Figure C9.3) that the predicted PWAC-EOW decreases for the following contaminants when the cap soil and cap CCL hydraulic conductivity values are increased by approximately one order of magnitude: arsenic, Np-237, and Tc-99.

Derivation of Tc-99 PWAC Using Dose-based Concentration. The PWAC values for Tc-99 are sensitive to the concentration in water used as the MCL equivalent. The MCL for Tc-99 is 4 mrem/yr. The PWAC values for Tc-99 were derived using the EPA published value of 900 pCi/L; however, this result differs with the derivation of a 4 mrem/yr dose-based value of 3,910 pCi/L included in Risk Methods Document (DOE 2011b). As can be shown using the dose conversion factors included in the Risk Methods Document, the dose to an adult from ingesting water containing Tc-99 at a concentration of 900 pCi/L at the rate of 2 L/day at the frequency of 350 days/yr would be approximately 0.9 mrem/yr. Use of the dose-based value of 3,910 pCi/L would result in roughly a factor of 4 increase for all Tc-99 PWAC values.

C9.1.3 UNCERTAINTY ANALYSIS RESULTS SUMMARY

Overall, model results indicate that the PWAC is relatively sensitive to the following parameters: landfill cap drainage layer duration (as discussed below), soil/water partitioning coefficient (K_d) (as discussed below), chemical solubility (increased solubility generally increases the PWAC), and cap soil and clay hydraulic conductivity (K) (increased K generally decreases PWAC) (see Table C9.13).

Table C9.13. Uncertainty Analysis Results Summary

Corresponding Table	Scenario	Tc-99 PWAC-EOW Average Concentrations (pCi/g)			
		Site 11		Site 3A	
		Dose-Based Value (3,910 pCi/L)	EPA-Published Value (900 pCi/L)	Dose-Based Value (3,910 pCi/L)	EPA-Published Value (900 pCi/L)
5.17, 5.18	Gradual Failure	1.16E+02	2.67E+01	9.04E+00	2.08E+00
C9.5	Half Hydraulic Gradient	5.53E+01	1.27E+01	4.49E+00	1.03E+00
	Double Hydraulic Gradient	2.50E+02	5.75E+01	1.84E+01	4.24E+00
C9.6	Precipitation and Temperature Change	1.21E+02	2.79E+01	9.37E+00	2.16E+00
C9.7	Decreased Bulk Density	1.87E+02	4.30E+01	6.40E+00	1.47E+00
C9.8	Cap Soil and Clay Degradation	5.57 E+01	1.28E+01	4.46E+00	1.03E+00
C9.9	Soil/Water Partitioning Coefficient (Minimum)	3.56E+01	8.19E+00	2.66E+00	6.12E-01
	Soil/Water Partitioning Coefficient (Maximum)	2.36E+03	5.43E+02	6.49E+01	1.49E+01
C9.10	Alternate Drainage	3.41E+05	7.85E+04	2.24E+03	5.16E+02

Simulation results show that predicted PWAC values are most sensitive to specification of landfill cap drainage layer duration. If the assumption is made that the drainage layer can be expected to last for an extended period of time and that the biointrusion layer is permanent and also may serve as an effective drainage layer, the PWACs predicted under this uncertainty scenario would be more indicative of contaminant-specific PWAC values.

Results show that the value of the PWAC is next most sensitive to assignment of the chemical-specific K_d. With increasing K_d, indicating more chemical affinity for the solid phase, the PWAC-EOW for the simulated chemical constituents increases or stays the same compared to the PWAC-EOW calculated for the gradual failure scenario. Conversely, with the K_d set to the minimum level of 0 L/kg, indicative of no contaminant adsorption to the solid phase, the PWAC-EOW for the simulated chemical constituents decreases compared to the PWAC-EOW calculated for the gradual failure scenario. Also, inspection of Figures 5.9 through 5.12 reveals that PWAC-EOW values calculated using K_d equal to zero (K_d = 0 L/kg) are near or less than high-volume and low-volume inventory limits.

C9.2. REFERENCES

Bonnin, G. M., Martin, D., Lin, B., Parzybok, T., Yekta, M., and Riley, D. 2006. *Precipitation-Frequency Atlas of the United States*. NOAA Atlas 14, Volume 2, Version 3.0, NOAA, National Weather Service, Silver Spring, MD.

DOE (U.S. Department of Energy) 2002. *Geochemical Modeling to Assist in Developing Site Wide K_d Values for Metals and Radionuclides for the Upper Continental Recharge System and Regional Gravel Aquifer*, BJC/PAD-451.

DOE 2003. *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-204&D2R1.

DOE 2011. *Work Plan for CERCLA Waste Disposal Alternative Evaluation Remedial Investigation/ Feasibility Study at the Paducah Gaseous Plant, Paducah, Kentucky,* DOE/LX/07-0099&D2/R1, September.

EPA (U.S. Environmental Protection Agency) 1996. Soil Screening Guidance: Technical Background Document, Office of Solid Waste and Emergency Response, EPA/540/R-95/128.

EPA 2002. *EPA Facts About Technetium-99,* http://www.epa.gov/superfund/health/contaminants/radiation/ pdfs/technetium.pdf, October 31, 2012.

EPA 2010. *Regional Screening Levels for Chemical Contaminants at Superfund Sites*, accessed November 2011 at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.,

Hsuan, Y. G., and Koerner, R. M. 1988. "Antioxidant Depletion Lifetime in High Density Polyethylene Geomembranes," *ASCE J. Geotech. Geoenviron. Engineering* 124, No. 6, 532-5441.

Hu, Q. H.; M. Zavarin; T. P. Rose 2008 "Effect of reducing groundwater on the retardation of redox-sensitive radionuclides" *Geochemical Transactions* Vol. 9, No 12.

IPCC (Intergovernmental Panel on Climate Change) 2007. *Climate Change 2007 - The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the IPCC (ISBN 978 0521 88009-1 Hardback; 978 0521 70596-7 Paperback).

Koerner, R. M., Hsuan, Y. G., and Koerner, G. R. 2005. *Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions*. GRI White Paper #6. Geosynthetic Institute, Folsom, PA.

National Academy of Sciences 2007. *Assessment of the Performance of Engineered Waste Containment Barriers*, Committee to Assess the Performance of Engineered Barriers, National Research Council of the National Academies, The National Academies Press, Washington, DC.

ORISE (Oak Ridge Institute for Science and Education) 2011. *Dose Modeling Evaluations and Technical Support Document for the Authorized Limits Request for the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (Final Report),* DCN 56090-TR-01-5.

Rowe, R. K., and Islam, M. Z. 2009. "Impact of Landfill Liner Time-Temperature History on the Service Life of HDPE Geomembranes," *Waste Management* 29, 2689-2699.

Schroeder, P. R., Aziz, N. M., Lloyd, C. M. and Zappi, P. A. 1994. *The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3*, EPA/600/R-94/168a, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC, September.

Sullivan 2011. Terrence M. Sullivan, Brookhaven National Laboratory, e-mail correspondence with Jason Christopherson, Geosyntec Consultants, "DUSTMS Solubility," August 30 to September 6.

ATTACHMENT C10

LONG-TERM URANIUM MODELING UNCERTAINTY ANALYSIS

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C10.1 LONG-TERM URANIUM MODELING UNCERTAINTY ANALYSIS

The modeling results indicated that some of the radionuclide contaminants (and decay products from ingrowth) would not reach their peak concentration prior to 10,000-years. As a result, the Remedial Investigation/Feasibility Study Work Plan required an extension of the uncertainty analysis to examine growth and risk beyond 10,000 years for uranium-238 (U-238) as a parent compound and thorium-230 (Th-230) as its progeny (DOE 2011). This analysis used a forward run of the transport model for the gradual failure scenario to the predicted peak groundwater concentrations for U-238 and Th-230. These sensitivity simulations for Site 3A and Site 11 were executed using the parameter values as specified for the gradual failure analysis,[1] except with regard to initial source mass. One simulation included, as initial concentration, the U-238 source mass based upon the PWAC (as specified in Table 5.17 for Site 11 and Table 5.18 for Site 3A), while the other simulation included as the initial concentration the U-238 mass equivalent to the maximum U-238 expected disposal cell concentration (low-volume scenario, as specified in Table 4.10). No source term mass was assigned for Th-230 since it was simulated as a decay product (i.e., progeny) of U-238.

A simulation time of 300,000 years was performed to simulate to the peak predicted groundwater concentrations of both U-238 and Th-230; therefore, due to the 10,000 time step limitation of the DUST-MS model, a time step of 30 years was used to simulate groundwater concentrations to 300,000 years. The predicted groundwater concentrations and dose at 100 meters (m) from the edge of waste (EOW) resulting from the AT123D simulations at Site 11 are shown in Figures C.10.1 to C.10.4. The maximum predicted groundwater concentrations and dose compared to the exposure exceedance criteria at Site 11 are included in Table C.10.1.

It should be noted that “the scientific basis for dose and risk assessments at very long times into the future is questionable, and the strict application of numerical criteria may be inappropriate” (ICRP 2011). Therefore, modeling results that predict contaminant migration tens of thousands of years into the future are uncertain because of numerical restrictions and the increasing amount of uncertainty well into the future. Additionally, “dose or risk estimates derived from these exposure assessments should not be regarded as direct measures of health effects beyond timescales of around several hundred years into the future. Rather, they represent indicators of the protection afforded....” (ICRP 2011).

The groundwater concentrations and dose located at 100 m downgradient of the EOW predicted using AT123D simulations at Site 3A are shown in Figures C.10.5 to C.10.8. The maximum groundwater concentrations and dose compared to the exposure exceedance criteria at Site 3A are included in Table C.10.2.

[1] This modeling was performed using the gradual failure scenario where the cover system drainage layers were modeled as vertical flow layers (infiltration of 12.3 cm/year) during the long-term modeling period and for the duration of the modeling discussed in this attachment.

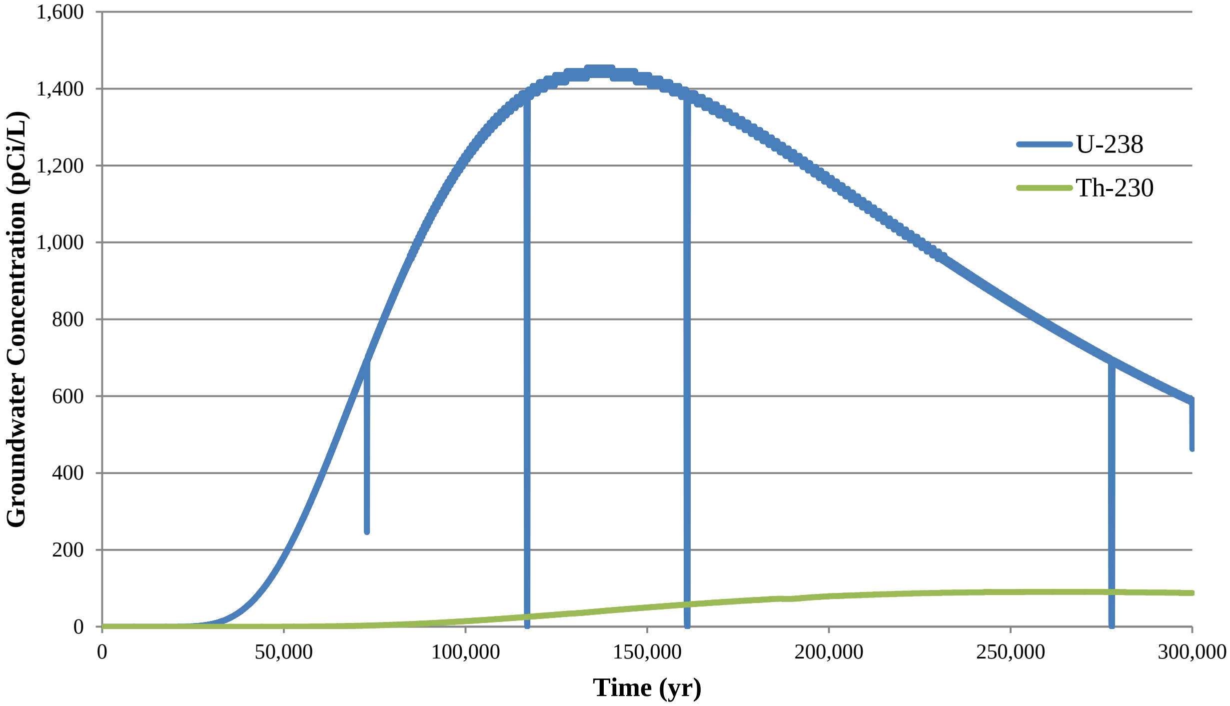

Figure C.10.1. Predicted Site 11 U-238 and Th-230 Groundwater Concentration at 100m from EOW (Gradual Failure Scenario): Source Concetraiton Equal to U-238 PWAC-WDF (33,600 pCi/g)

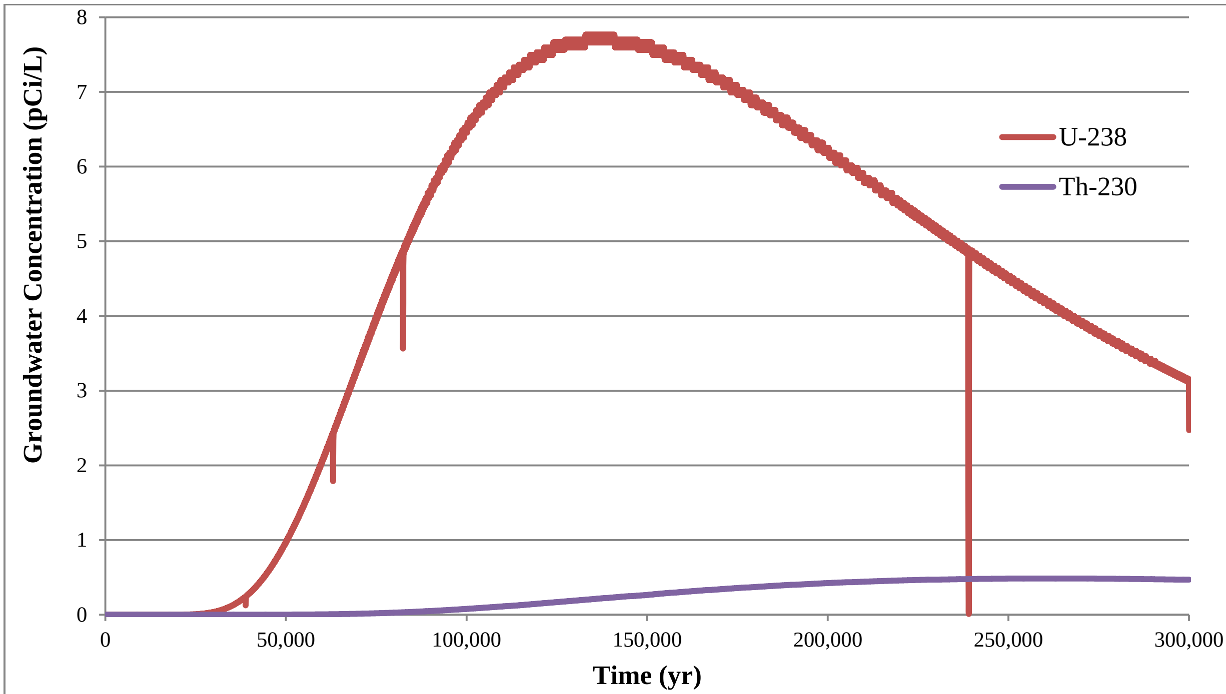

Figure C.10.2. Predicted Site 11 U-238 and Th-230 Groundwater Concentration 100m from EOW (Gradual Failure Scenario): Source Concentration Equal to Expected U-238 Low-Volume Disposal Cell Concentration (180 pCi/g)

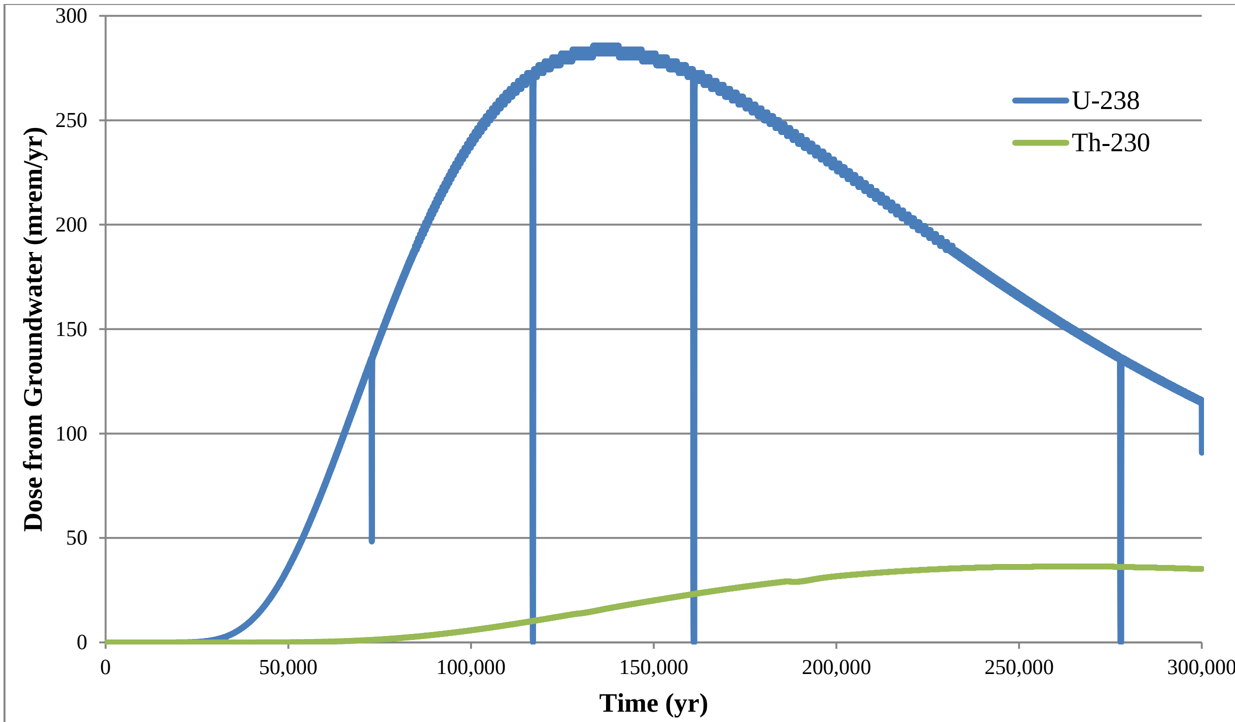

Figure C.10.3. Predicted Site 11 U-238 and Th-230 Groundwater Dose 100m from EOW (Gradual Failure Scenario): Source Concentration Equal to U-238 PWAC-WDF (33,600 pCi/g)

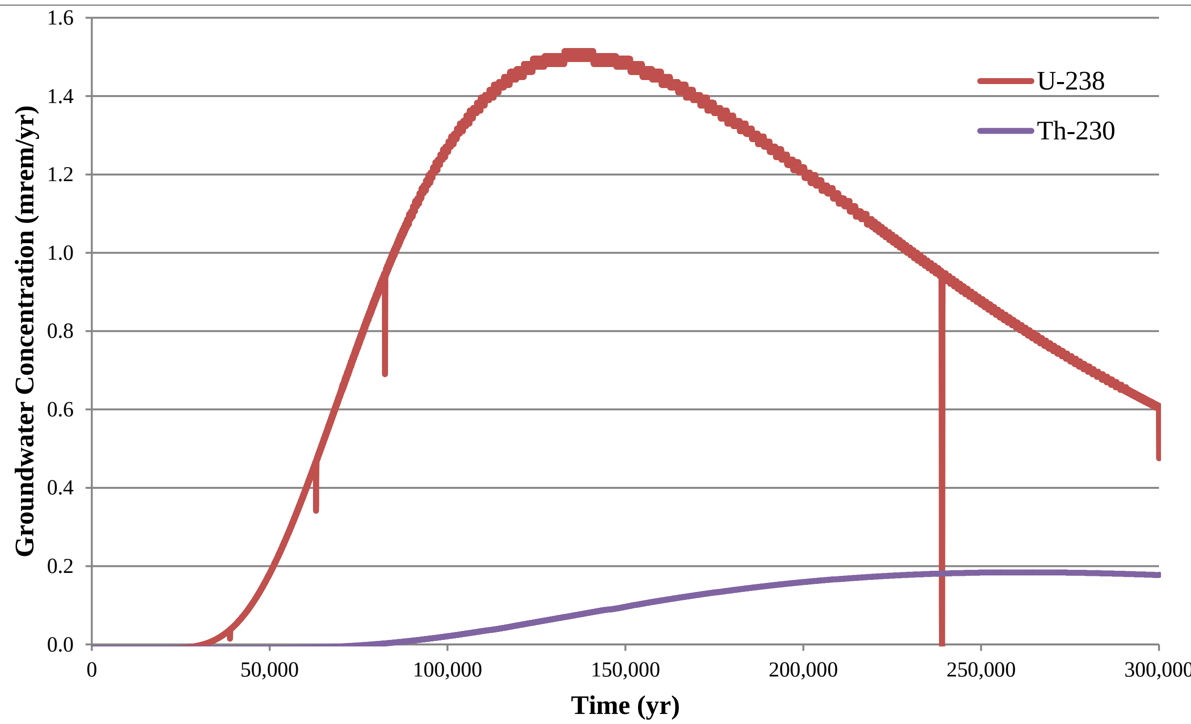

Figure C.10.4. Predicted Site 11 U-238 and Th-230 Groundwater Dose 100m from EOW (Gradual Failure Scenario): Source Concentration Equal to Expected U-238 Low-Volume Disposal Cell Concentration (180 pCi/g)

Table C.10.1. Site 11 Comparison of U-238 and Th-230 Maximum Groundwater Concentrations and Dose at 100m

Isotope Model Source Term	Maximum Groundwater Concentration (pCi/L)	Maximum Groundwater Dose (mrem/year)[1]	Time of Maximum Groundwater Concentration and Dose (year)
U-238 FPWAC-WDF	1,440	282	133,440
U-238 Expected Disposal Cell Concentration	7.77	1.52	132,900
Th-230 PWAC-WDF	90.2	36.1	253,740
Th-230 Expected Disposal Cell Concentration	0.484	0.194	249,450

[1]Dose conversion factor for isotopes referenced from DOE 2011. Assumed drinking water dose of 730 L/yr.

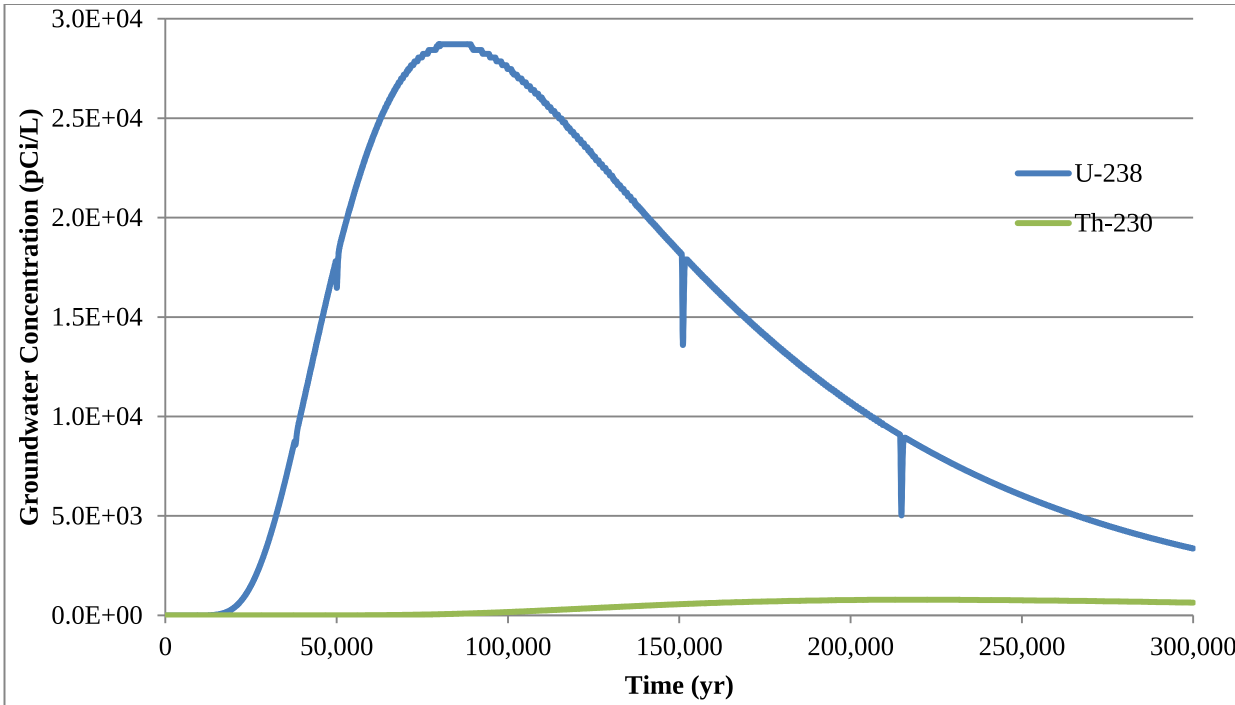

Figure C.10.5. Predicted Site 3A U-238 and Th-230 Groundwater Concentrations 100m from EOW (Gradual Failure Scenario): Source Concentration Equal to U-238 PWAC-WDF (33,600 pCi/g)

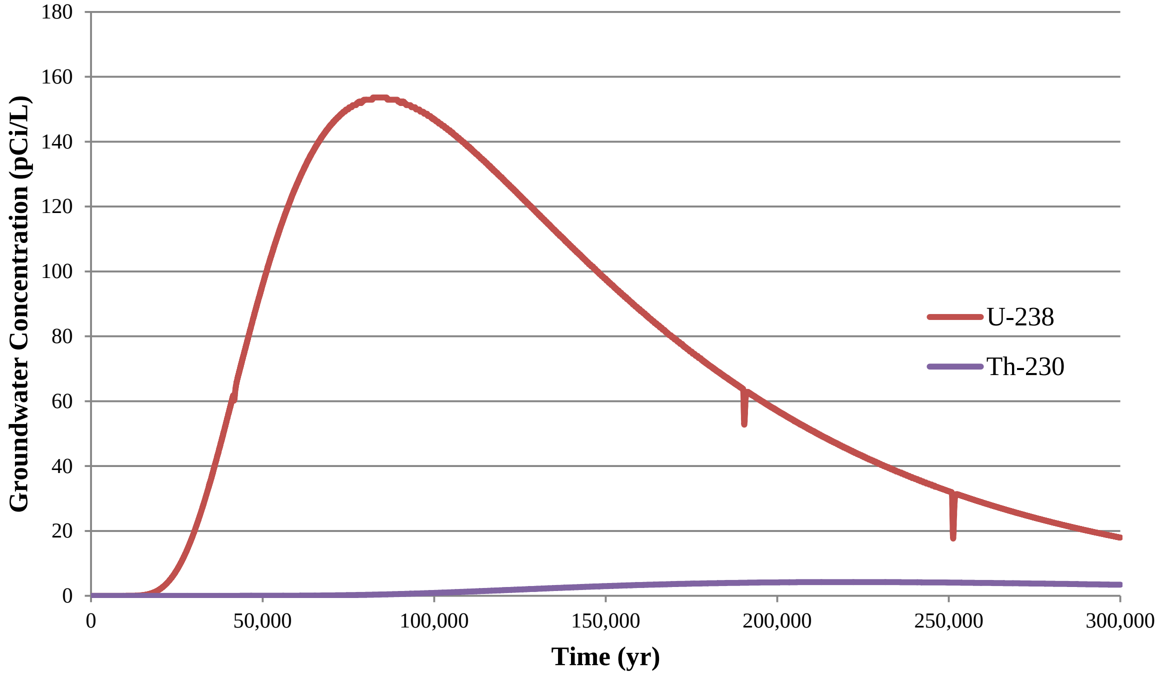

Figure C.10.6. Predicted Site 3A U-238 and Th-230 Groundwater Concentrations 100m from EOW (Gradual Failure Scenario): Source Concentraton Equal to Expected U-238 Low-Volume Disposal Cell Concentration (180 pCi/g)

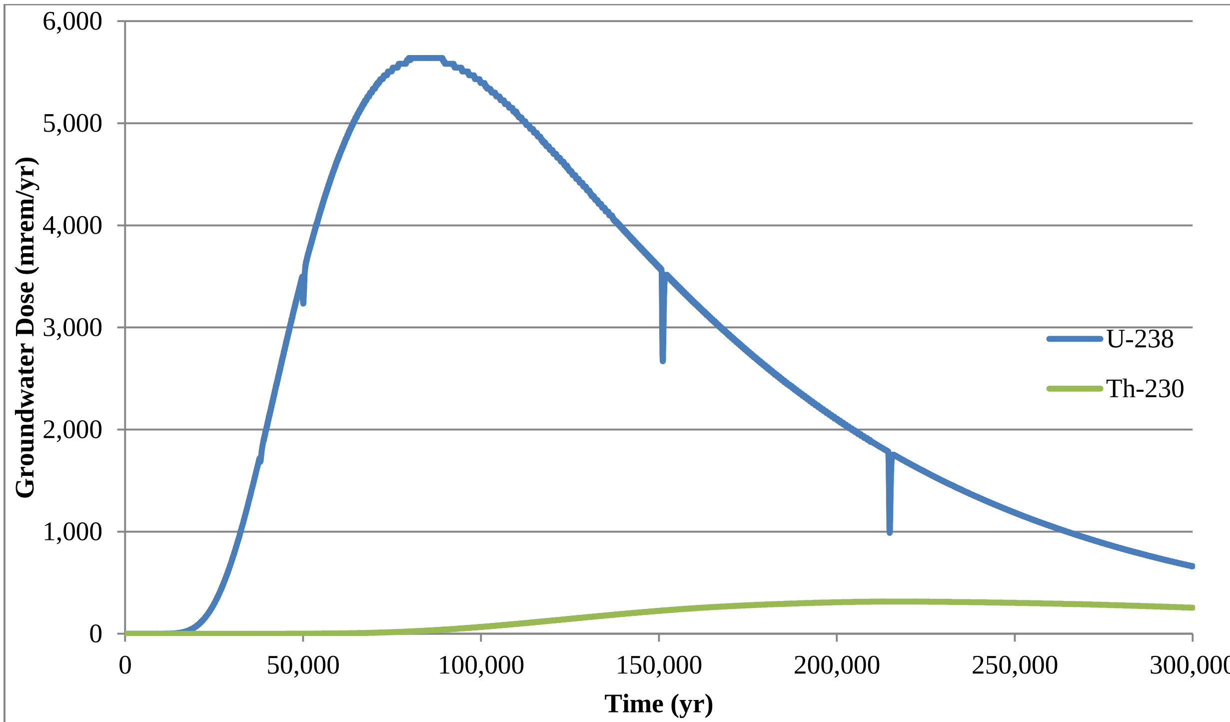

Figure C.10.7. Predicted Site 3A U-238 and Th-230 Groundwater Dose at 100m from EOW (Gradual Failure Scenario): Source Concetraiton Equal to U-238 PWAC-WDF (33,600 pCi/g)

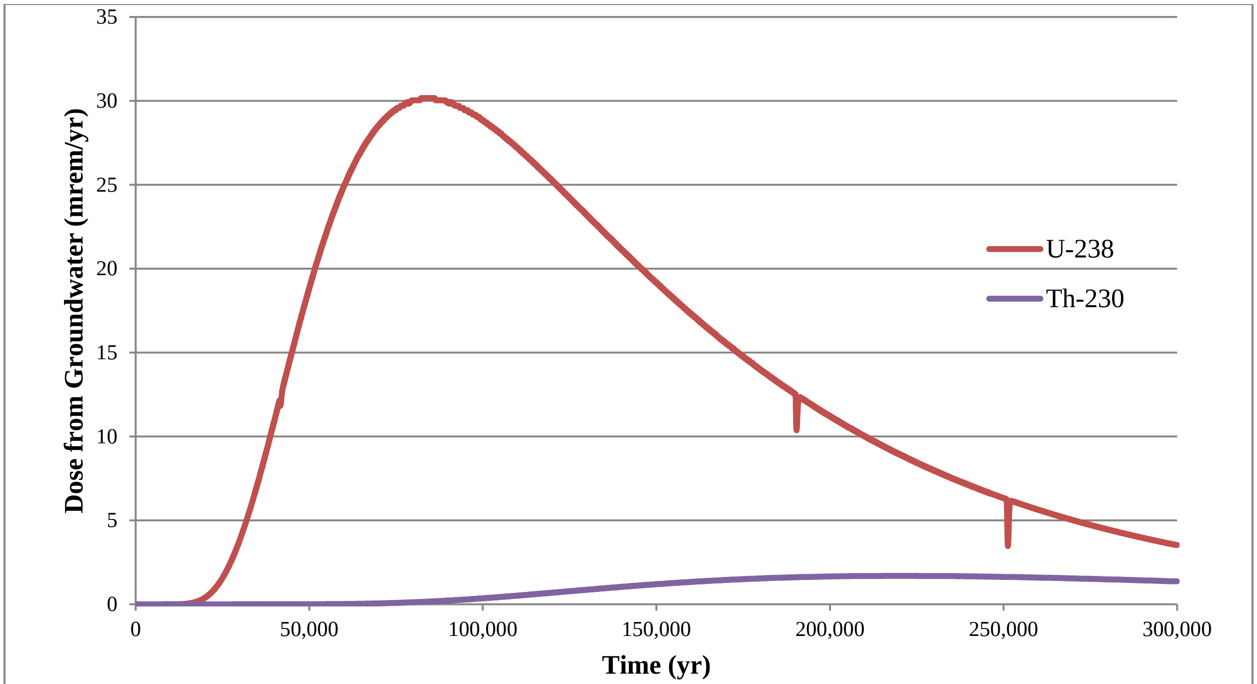

Figure C.10.8. Predicted Site 3A U-238 and Th-230 Groundwater Dose 100m from EOW (Gradual Failure Scenario): Source Concentration Equal to Expected U-238 Low-Volume Disposal Cell Concentration (180 pCi/g)

Table C.10.2 Site 3A Comparison of U-238 and Th-230 Maximum Predicted Groundwater Concentrations and Dose at 100 m

Isotope Model Source Term	Maximum Groundwater Concentration (pCi/L)	Maximum Groundwater Dose (mrem/year)[a]	Time of Maximum Groundwater Concentration and Dose (year)
U-238 PWAC-WDF	28,700	5,600	79,200
U-238 Expected Disposal Cell Concentration	153.6	30.2	82,200
Th-230 PWAC-WDF	787	315	209,430
Th-230 Expected Disposal Cell Concentration	4.24	1.70	215,580

[a]Dose conversion factor for isotopes referenced from DOE 2011. Assumed drinking water dose of 730 L/yr.

C10.2. CONCLUSION

The U-238 and Th-230 long-term modeling uncertainty analysis was based on the PWAC-WDF concentration and the maximum predicted disposal cell concentration for U-238.

Future groundwater concentration and dose estimates must be considered in relation to the time frame of the analysis and the increased uncertainty in predicting future hydrologic and receptor conditions tens of thousands of years into the future. Figures C.10.1 through C.10.8 show the presence of some numerical instability (shown as steep decreases in concentration or dose followed by a rapid increase in concentration or dose back to expected values). This instability likely is a result of the relatively large time step (30 years) necessary to perform the 300,000-year simulation; therefore, numerical results are likely approximations of concentration magnitude and timing of peak concentration. Predicting system behavior tens of thousands of years into the future is fraught with difficulties, and simulations indicate that the maximum predicted waste profile concentrations for U-238 are expected to be protective regarding human health and the environment for significantly longer than the modeling compliance period. These conclusions are based on the gradual failure scenario with 12.3 cm/year of infiltration during the long-term modeling period and beyond. Incorporation of the information from the February 22, 2012, Symposium (i.e., an infiltration rate of 0.321 cm/year for the long-term modeling period and beyond would result in lower groundwater concentrations and doses throughout the 300,000 year simulation period.

C10.3. REFERENCES

DOE (U.S. Department of Energy) 2011. *Work Plan for CERCLA Waste Disposal Alternative Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Plant, Paducah, Kentucky*, DOE/LX/07-0099&D2/R1, U.S. Department of Energy, Paducah, KY, September.

ICRP (International Commission on Radiological Protection) 2011. Annals of the ICRP, ICRP Publication XXX, "Radiological Protection in Geological Disposal of Long-Lived Solid Radioactive Waste," ICRP 4838-8963-9177, International Commission on Radiological Protection, 280 Slater Street, Ottawa, Ontario, Canada, July.

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ATTACHMENT C11

FACTORS AFFECTING CALCULATED PWAC VALUES

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C11.1. FACTORS AFFECTING CALCULATED PWAC VALUES

The preliminary waste acceptance criteria (PWAC) values were developed using the methodology presented in the Remedial Investigation/Feasibility Study (RI/FS) Work Plan (DOE/LX/07-099&D2/R1, September 2011) and are based on groundwater transport and exposure to a residential groundwater user drawing water from a well from Year 200 to 1,600. Three locations are considered for the point of assessment: the edge of waste (EOW), the waste disposal facility boundary (WDF), the U.S. Department of Energy (DOE) property boundary (Site 11), or nearer surface water outcrop (Site 3A) (DOE/SW). As discussed in Appendix C, Attachment C6, this receptor was selected because this individual would reasonably be expected to receive the largest cancer risk, hazard and/or radionuclide dose from most contaminants migrating from the landfill. The risk-based PWAC are based on a child/adult lifetime exposure, hazard-based PWAC are based on a child exposure, and dose-based PWAC are based on an adult exposure for a beta/gamma maximum contaminant level (MCL) of 4 mrem/yr. DOE will provide long-term care of the facility such that a receptor likely would not be at the points of assessment within the DOE property boundary. This receptor was identified in the RI/FS Work Plan (DOE/LX/07-099&D2/R1, September 2011) as providing a reasonable bounding scenario for evaluation in this FS. Other factors will be considered in establishing the waste acceptance criteria (WAC) for the project if the On-Site Alternative is selected. The purpose of this attachment is to provide examples of how the PWAC presented in this report may change during the development of the WAC.

If the On-Site Alternative is selected, the final design may differ from the conceptual design to accommodate the configuration of the selected site and site features, to reflect potential waste volumes, to incorporate standard practice or new technologies, or to improve the design performance of the facility. For example, an amendment could be added to the bottom layer of the waste placed in the WDF or the natural subgrade soils underlying the WDF could be removed and replaced with a higher K_d or lower hydraulic conductivity soil; both of these would have the effect of retarding contaminant transport. These design element changes could result in differing (i.e., higher or lower) WAC mass limits compared to calculated PWAC mass limits presented in this report. In some cases, the alternate drainage scenario calculated PWAC average concentrations presented within this RI/FS are higher than anticipated for WAC values due to the PWAC methodology considering only groundwater exposures. As stated in Section 1 of the main text of this report, high-level, transuranic, and spent nuclear fuel, as defined in DOE Order 435.1, are not expected to be generated and are not included in the Comprehensive Environmental Response, Compensation, and Liability Act waste volume. These waste types, if generated during cleanup, will be disposed of off-site regardless of which alternative is chosen because regulations prescribe disposal in special repositories. Table C11.1 provides a comparison of the calculated PWAC average concentrations from the alternate drainage scenario to the concentrations that define transuranic waste.

From Table C11.1, the alternate drainage scenario Calculated PWAC values for the transuranic radionuclides exceed the concentration definition of transuranic waste and therefore would need to be reduced below that threshold.

To be eligible for near-surface disposal, such as the On-Site Alternative evaluated in this RI/FS, wastes also must meet the definition of Class C wastes, as referenced in DOE Order 435.1. As such, in developing the WAC, the Calculated PWAC average concentrations would need to be considered in conjunction with the sum of fractions rule for the six project radionuclides of concern that are transuranic isotopes and for technetium-99 (Tc-99) and cesium-137 (Cs-137). The concentrations to be used to assess the sum of fractions for Class C waste evaluation are included in Table C11.2. Note that additional operational criteria may apply if Class B or C wastes are proposed for placement in an on-site WDF.

Table C11.1. Alternate Drainage PWAC Average Concentrations Compared to Transuranic Waste Concentration Definitions

Radionuclide	Decay Mode	Half-Life (yr)	Site 11 Calculated PWAC Average Concentration (pCi/g)	Site 3A Calculated PWAC Average Concentration (pCi/g)	Transuranic Waste Criteria[a] (pCi/g)
Am-241	α	4.32E+02	3.43E+11	3.43E+11	1.00E+05
Cs-137	β	3.02E+01	8.65E+12	8.65E+12	NA
Np-237	α	2.14E+06	7.05E+07	7.05E+07	1.00E+05
Pu-238	α	8.78E+01	1.71E+12	1.71E+12	1.00E+05
Pu-239	α	2.41E+04	6.20E+09	6.20E+09	1.00E+05
Pu-240	α	6.54E+03	2.27E+10	2.27E+10	1.00E+05
Tc-99	β	2.13E+05	7.85E+04	5.16E+02	NA
Th-230	α	7.70E+04	2.02E+09	2.02E+09	1.00E+05
U-234	α	2.40E+05	6.25E+08	6.25E+08	NA
U-235	α	7.00E+08	2.16E+05	2.16E+05	NA
U-238	α	4.50E+09	3.36E+04	3.36E+04	NA

[a] Per DOE Order 435.1, radioactive waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste with half-lives greater than 20 years, except for (1) high-level radioactive waste; (2) waste that the Secretary of Energy has determined with the administrator of U.S. Environmental Protection Agency does not need the degree of isolation required by the 40 *CFR* § 191 disposal regulations; or (3) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 *CFR* § 61. [Source: Waste Isolation Pilot Plant Land Withdrawal Act of 1992, as amended (Public Law 102-579)].
[b] NA = Not applicable; the radionuclide is not a transuranic isotope.

Table C11.2. Alternate Drainage Calculated PWAC Average Concentrations Compared to Class C Evaluation Criteria

Radionuclide	Site 11 Calculated PWAC Average Concentration (pCi/g)	Site 3A Calculated PWAC Average Concentration (pCi/g)	Class C Evaluation Criteria (pCi/g)
Am-241	3.43E+11	3.43E+11	1.00E+05
Cs-137*	8.65E+12	8.65E+12	1.48E+09
Np-237	7.05E+07	7.05E+07	1.00E+05
Pu-238	1.71E+12	1.71E+12	1.00E+05
Pu-239	6.20E+09	6.20E+09	1.00E+05
Pu-240	2.27E+10	2.27E+10	1.00E+05
Tc-99[a]	7.85E+04	5.16E+02	9.68E+05
Th-230	2.02E+09	2.02E+09	1.00E+05

*Class C Evaluation Criteria for Tc-99 and Cs-137, respectively, are converted from Ci/m^3 to pCi/g using a waste density of 3.1 g/cm^3 (3.1E+06 g/m^3).

From Table C11.2, the alternate drainage scenario Calculated PWAC values when compared to Class C Evaluation Criteria, with the exception of Tc-99, exceed the Class C Evaluation Criteria and, therefore, would need to be reduced below that threshold.

Limits for fissionable materials also will need to be considered and incorporated into the WAC. This typically is done by developing limits in terms of plutonium- 239 (Pu-239) fissionable gram equivalents. The methodology for limiting fissionable material masses within a waste volume is expected to be developed as part of the final WDF design and operation and maintenance (O&M) plan.

Similarly, landfill worker safety requirements for the handling and placement of waste will need to be developed and may result in lower WAC average concentrations or, in specific operational requirements, to mitigate exposure and risk. A worker health and safety plan will be developed in conjunction with the O&M plan.

The factors described herein are not meant to be all encompassing, but rather are to outline the types of adjustments that are anticipated will be made as part of the development of the WAC, in the event an on-site WDF is selected as the preferred remedy.

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APPENDIX D

WASTE CHARACTERIZATION

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D. WASTE CHARACTERIZATION

The waste characterization/analytical profile presented in Section 4.2 provides the rationale for how the soil and non-soil wastes have been characterized, develops a list of contaminants of concern (COCs) as a subset of the comprehensive Paducah Gaseous Diffusion Plant (PGDP)-wide contaminants of potential concern based on the waste inventory in Section 4.1, and then estimates the concentration or activity for each COC.

The tables on the CD included in this appendix provide the supporting cross references of assigning East Tennessee Technology Park buildings to similar PGDP buildings and the related waste characterization data.

- Table D.1: PGDP Building Waste Profile Assignment
- Table D.2: PGDP Building Waste Profile Association
- Table D.3: PGDP Building and Burial Grounds Operable Unit Data Summary
- Table D.4: Environmental Restoration Soil Summary Statistics
- Table D.5: Surface Water Operable Unit Off-site Summary Statistics
- Table D.6: Groundwater Operable Unit Summary Statistics
- Table D.7: Groundwater Operable Unit Off-site Summary Statistics

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APPENDIX D

ANALYTICAL PROFILE, TABLES D.1–D.7

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APPENDIX E

SITING STUDY FOR THE ON-SITE CERCLA WASTE DISPOSAL ALTERNATIVE AT PGDP

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
CAB	Citizens Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
EEI	Electric Energy, Inc.
EPA	U.S. Environment Protection Agency
FFA	Federal Facility Agreement
FS	feasibility study
KOW	Kentucky Ordnance Works
KPDES	Kentucky Pollutant Discharge Elimination System
PGDP	Paducah Gaseous Diffusion Plant
RGA	Regional Gravel Aquifer
RI	remedial investigation
ROD	record of decision
SSG	site screening group
SWMU	solid waste management unit
TSCA	Toxic Substances Control Act
TVA	Tennessee Valley Authority
WKWMA	West Kentucky Wildlife Management Area

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E.1. INTRODUCTION AND OVERVIEW

This appendix describes the process used to identify candidate locations for the on-site disposal alternative, develops the Threshold and Secondary Screening Criteria, and conducts the site screening; presents the results of the screening process; addresses input from the regulatory agencies and opportunities for public input; and summarizes post-record of decision (ROD) activities.

The U.S. Department of Energy (DOE) began evaluation of waste disposal options for Paducah Gaseous Diffusion Plant (PGDP) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) waste in 2000. Although that effort was discontinued before a remedial investigation (RI)/feasibility study (FS) report was completed, a siting study for on-site disposal locations was conducted. The preliminary evaluation for on-site disposal, *Initial Assessment of Consideration of On-Site Disposal of CERCLA Waste Facility as a Potential Disposal Option at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (DOE 2000) was prepared to determine (1) if the evaluation of an on-site disposal strategy for the forecasted CERCLA-derived wastes was warranted; and (2) if an evaluation was warranted, to propose a method. The initial assessment was modeled after a similar evaluation of disposal alternatives by DOE in Oak Ridge, Tennessee (DOE 1996).

The initial PGDP assessment concluded that the evaluation of an on-site disposal strategy was warranted and proposed the CERCLA process for decision making and documentation. Because it was concluded that on-site disposal could be a potential alternative, a subsequent document was prepared to determine if there were viable locations to site an on-site waste disposal facility. This report, *Identification and Screening of Candidate Sites for a Potential Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (DOE 2001) was prepared to document the process used to identify candidate sites at PGDP for a potential on-site waste disposal facility and to screen those candidate sites for further evaluation in an RI/FS. A transportation risk calculation package is provided as an attachment to this appendix.

Based on the 2001 waste forecast of 3.1 million cubic yards (mcy), a conceptual design determined that a minimum area of 110 acres would be needed for the waste disposal footprint, surrounding dike, and operations support facilities. The 2001 Siting Study considered land space constraints and identified 10 sites on DOE-owned property that could meet the 110-acre footprint requirement. One of the 10 sites, Site 3 later was eliminated because a portion of that site was designated for the construction of the depleted uranium hexafluoride (DUF_6) facility; however, because Site 3 was considered a favorable location by the regulators and the Citizens Advisory Board (CAB), its footprint was reconfigured and renamed Site 3A. Additionally, it was recognized that the area immediately north of the C-746-U Landfill generally met the landspace requirements identified in the 2001 Siting Study. This location was included in the list of potentially viable locations and is identified as Site 11. These 11 sites were used as the starting point for the evaluation to define the best location(s) to represent the on-site disposal alternative in the RI/FS.

Subsequent to the site screening of the 11 candidate sites, the configuration of sites was reevaluated to determine if sites that failed threshold criteria could be reconfigured to pass threshold criteria. This effort included reviewing the criteria that constrained definition of candidate site areas and boundaries. Notably, the assumption that Tennessee Valley Authority (TVA) overhead transmission lines could not be relocated as an absolute condition was revisited, and it was determined that there may be cases where TVA power lines could be relocated. Based on this revised assumption, Site 5A was identified as a viable location assuming that a single north-south oriented overhead TVA transmission line could be relocated. The site then was scored in the same fashion and by the same site screening group (SSG) members as the original 11 sites. The 12 candidate sites evaluated are shown on Figure E.1 and Figure E.2 shows topography in the vicinity of PGDP.

The site screening process is outlined below.

(1) Develop facility conceptual design
(2) Develop Threshold, Secondary, and Final Criteria
(3) Develop weighting and scoring system for Secondary Criteria
(4) Present the criteria and process to the regulatory agencies and incorporate comments
(5) Screen the candidate sites against the Threshold Criteria
(6) Evaluate the sites that pass the Threshold screening against Secondary Criteria
(7) Present the screening results to the regulatory agencies and incorporate comments
(8) Present the screening results at a public meeting to solicit input
(9) Consider public input to the screening process/results

E.2. DEVELOPMENT OF SCREENING CRITERIA AND WEIGHTING

This section describes the process used to develop the Threshold Criteria, Secondary Criteria, and weighting factors for the Secondary Criteria and defines the Final Criteria. Criteria to evaluate candidate on-site disposal locations were developed based on technical requirements and ability to comply with applicable or relevant and appropriate requirements (ARARs). Criteria were defined in sufficient detail to allow individuals scoring the sites to understand the meaning and significance of each criterion and what parameters represent a low or high score.

A requirement applied in developing the criteria was that they must provide discrimination among sites. Factors that failed to discriminate among sites, regardless of their importance, were not included as screening criteria. Eliminating factors common to the candidate sites from the screening process were designed to reduce the potential for masking the distinguishing site features in the overall scoring process.

The screening criteria and supporting rationale are presented in Table E.1.

E.2.1 FACTORS COMMON TO CANDIDATE SITES

Factors potentially relevant to the siting process that do not discriminate among sites were not used as screening criteria. This approach was taken to avoid dilution of the scoring differential in comparing site suitability. Several factors considered for Threshold or Secondary Criteria were not used in the screening process either because they were the same across PGDP or because there was insufficient data available to allow discrimination. Most of these factors are equivalent based on the proximity of the candidate sites in comparison with the geographic range over which such factors would reflect significant variation. The common nondiscriminating factors are described in Sections E.2.1.1 to E.2.1.7.

E.2.1.1 Depth to Groundwater

An ARAR under Toxic Substances Control Act (TSCA) requires 50 ft of separation between the bottom of the liner and the top of the groundwater table. The depth to groundwater across PGDP ranges from approximately 15 to 35 ft bgs, so none of the sites can meet this ARAR; however, the TSCA waste volume is a small portion of the overall waste volume (less than 1%) and an ARAR waiver to this TSCA requirement would need to be requested. An “equivalent protectiveness” CERCLA waiver of this 50-ft

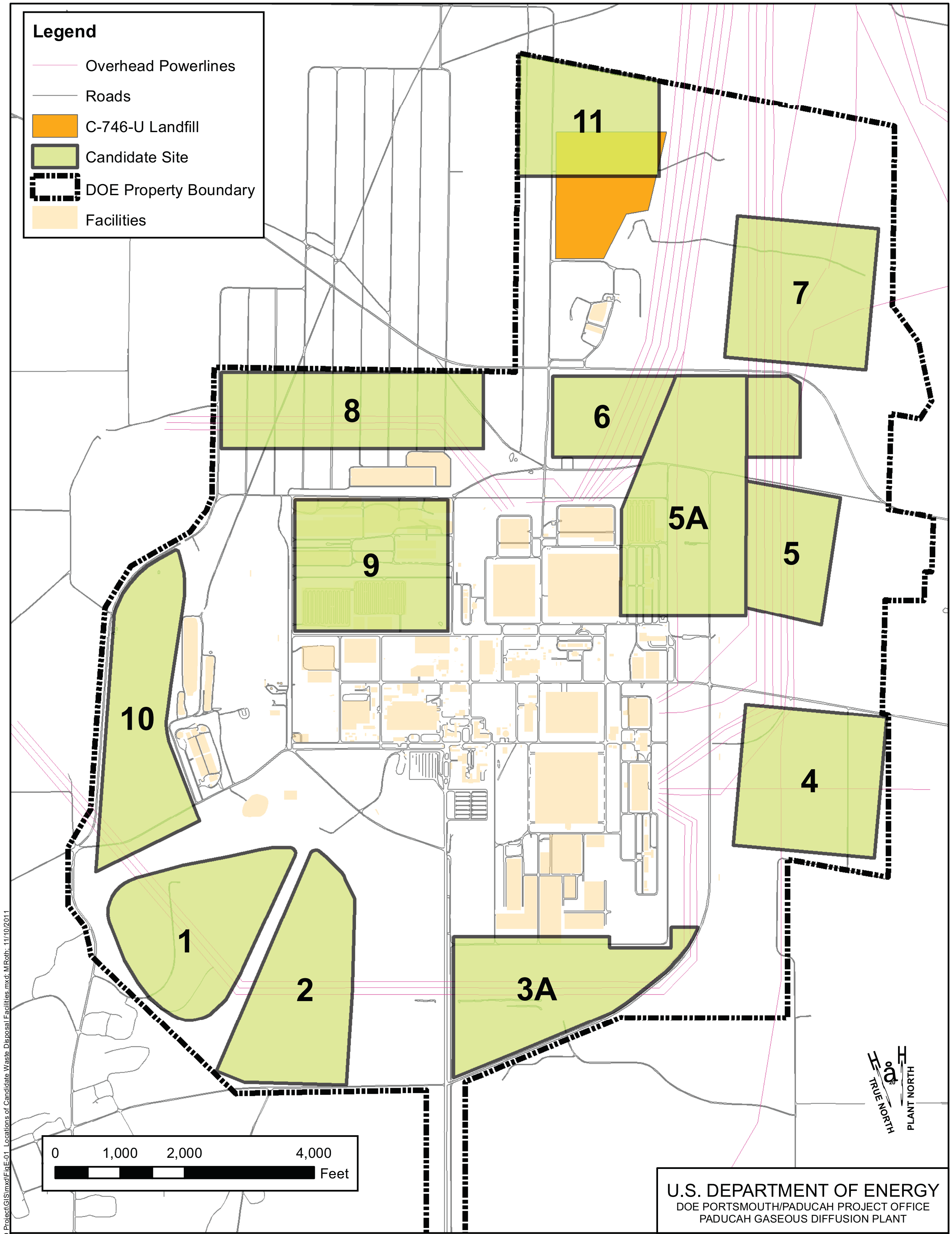

Figure E.1. Locations of Candidate Waste Disposal Facility Sites

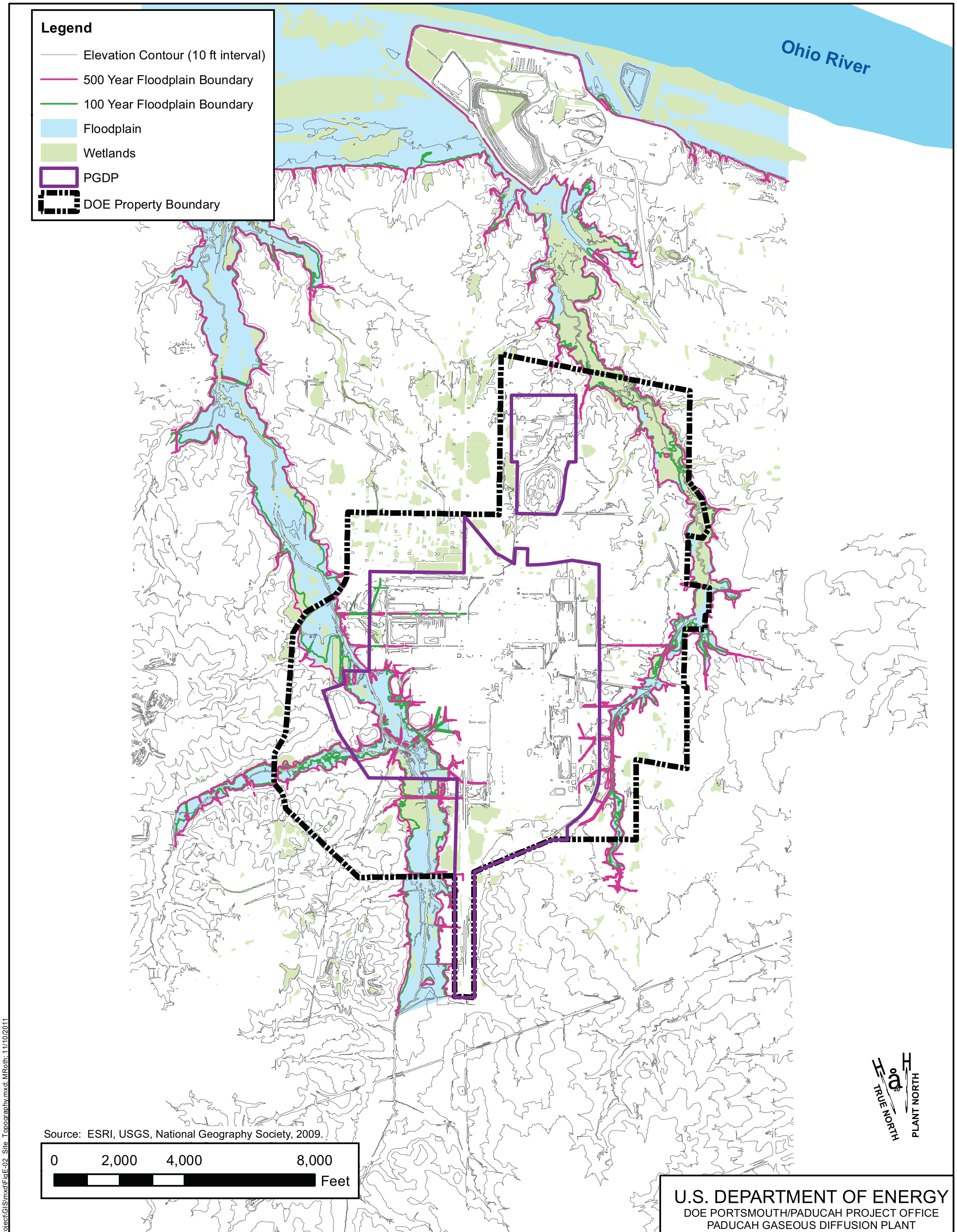

Figure E.2. Site Topography in Vicinity of PGDP

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Table E.1. Screening Criteria Definitions and Weighting

Threshold Criteria		Requirements	Threshold Determination
Available Area	Adequate area	• A 110-acre site is available.	The site must be suitable for the intended objective of constructing a CERCLA waste disposal cell, associated facilities, and construction support areas. Any site with more than 20% of its area within the 100-year or 500-year floodplain or otherwise unavailable for use fails to meet this Threshold Criterion.
	DOE-owned property	• The 110-acre site is located entirely within DOE-owned property.	A 110-acre site is considered available only if it is on DOE-owned property.
Floodplains	Predominately located outside of the 100-year and 500-year floodplains	• The 110-acre site will not restrict flow of the 100-year or 500-year flood or reduce temporary water storage capacity of a 100-year or 500-year flood event posing a hazard to human life or the environment.	Avoid long- and short-term adverse effects associated with occupancy and modification of floodplains. NOTE: A disposal cell and support facility design can be modified to mitigate marginal encroachment on floodplains and is included as a Secondary Criterion below.
Seismic Considerations	> 200 ft of Holocene faults and lineaments	• The waste footprint must have a separation of at least 200 ft from a fault with displacement in Holocene time.	This criterion is included because it is a regulatory requirement for siting facilities that treat, store, or dispose of hazardous waste. Based on two site-specific studies, the current working assumption for the screening process is that there are no faults with Holocene displacement at PGDP.

Secondary Criteria		Rationale and Objective	Scoring Factors	Weight
Hydrologic Considerations	Proximity to the 100-year and 500-year floodplains • site area within floodplains	**Objective:** Identify those sites with the least area within 100- and 500-year floodplains that are critical to a disposal cell design in order to minimize design and control requirements. **Rationale:** Additional disposal cell and support facility design and engineering controls are required to mitigate potential damage from flooding during 100- and 500-year storm events.	**Scoring Basis**: • Score lower those sites with more area within the 100-year and 500-year floodplain. NOTE: While this is also a Threshold Criterion, scoring as a Secondary Criterion is used to distinguish those sites that have the least area of the site within a floodplain that would be critical to the design.	**2**
	Distance to streams • proximity to streams	**Objective:** Identify those sites with the least potential for contaminating streams. **Rationale:** Storm-water runoff and erosion from the site could contaminate area streams.	**Scoring Basis**: • Score higher those sites with a greater distance to any stream. • Score higher those sites with level topography that would minimize potential for impact to streams.	**2**
	Distance to water wells • distance to private land where drinking or agricultural water wells exist or could be drilled • groundwater flow direction	**Objective:** Identify those sites with the least potential for exposure of the public to potential groundwater contamination. **Rationale:** A potential release to groundwater could contaminate drinking water supply or agricultural wells. Sites with no downgradient water supply wells, or that are more distant from such wells, have a lower potential for public exposure to any groundwater contaminants.	**Scoring Basis**: • Score higher those sites that are the farthest from downgradient drinking water or agricultural wells, or private land where such wells could be drilled. NOTE: Residences within the DOE Water Policy Affected Area are provided municipal water.	**2**
	Hydrogeologic setting • Site underlain by Porters Creek Clay vs. the RGA	**Objective:** Identify those sites with hydrogeologic conditions that present the least potential for groundwater contaminant migration and public exposure. **Rationale:** Sites underlain by lower permeable subsurface material are preferable to minimize the potential for contaminant migration and enhance the ability to control groundwater flow in case of a release.	**Scoring Basis**: • Score higher those sites underlain by the Porters Creek Clay. • Score lower those sites underlain by the RGA.	**3**
Terrain Stability	Surface geologic processes and topography • amount of topographic relief	**Objective:** Identify those sites with the most desirable topography to provide optimal conditions for construction and long-term maintenance and operation of a disposal cell. **Rationale:** Greater topographic relief can create constructability issues and increase design and engineering control costs.	**Scoring Basis**: • Score higher those sites with the least topographic relief that would minimize the need for preparatory earthwork or engineering controls and reduce rapid stormflow and erosion.	**1**

Table E.1. Screening Criteria Definitions and Weighting (Continued)

Secondary Criteria		Rationale and Objective	Scoring Factors	Weight
Information Availability	Seismic Data • availability of seismic data	**Objective:** Identify suitable sites with adequate seismic data to proceed directly to design. **Rationale:** Schedule impacts and increased cost will result if additional investigation is required to collect data and evaluate any seismic issues.	**Scoring Basis**: • Score higher suitable sites with adequate seismic data.	**3**
	Geotechnical Data • availability of geotechnical data	**Objective:** Identify suitable sites with adequate geotechnical data and the least need to make design assumptions. **Rationale:** Designs proceed with less delay, more certainty, and fewer assumptions when adequate geotechnical data are readily available to minimize the need for further investigation or additional costs through over-engineering.	**Scoring Basis**: • Score higher suitable sites with adequate geotechnical data.	**2**
	Hydrologic Data • availability of hydrologic data	**Objective:** Identify those sites with adequate hydrologic data and the least need to make design assumptions. **Rationale:** Designs proceed with less delay, more certainty, and fewer assumptions when adequate hydrologic data are readily available to minimize the need for further investigation or additional costs through over-engineering.	**Scoring Basis**: • Score higher those sites with adequate hydrologic data. NOTE: Suitability is not an issue for hydrologic data. It is assumed that such data would not disqualify a site from being a viable location for potential waste disposal facility. Engineered equivalency and a waiver will be required for the for the TSCA 50-ft buffer requirement between the bottom of the landfill liner and top of the water table for all sites.	**2**
Site Contamination	Soil contamination • presence of existing sources of contamination	**Objective:** Identify the presence or absence and extent of any soil contamination. **Rationale:** A site with no existing soil contamination or with contamination that is well defined so that cost/schedule impacts can be quantified allows evaluation of the site's viability. A site requiring cleanup prior to cell construction could result in considerable cost and schedule impacts.	**Scoring Basis**: • Score higher those sites with no SWMUs or other likely sources of existing site contamination. Consider whether historical operations/process knowledge is available to help determine the potential for site contamination.	**2**
	Groundwater contamination • presence of existing sources of contamination	**Objective:** Identify those sites with no upgradient, underlying or immediately downgradient groundwater contamination, or the presence of potential sources of contamination (e.g., UCRS soil contaminants). **Rationale:** A site without existing groundwater contamination can be more easily monitored to identify a release from a disposal cell.	**Scoring Basis**: • Score higher those sites with no with no upgradient, underlying, or immediately downgradient groundwater contamination or the presence of potential sources of contamination. • Score lower those sites with existing groundwater contamination or potential sources of contamination.	**3**
Land Use	Industrial vs. recreational land use • present use and reasonably projected future use	**Objective:** Identify those sites presently used for industrial purposes or similar use. **Rationale:** Using a site that is already dedicated to industrial use minimizes impact on areas currently used for recreation and areas with potential future recreational use.	**Scoring Basis**: • Score higher those sites that are not located within or likely to negatively impact wildlife/recreational areas wildlife/recreational areas. • Score lower if the site is in or adjacent to wildlife or recreational areas that are being used or could be used for purposes such as hunting, hiking, and bird-watching.	**3**
	Existing facilities requiring demolition • presence of existing facilities or operations • schedule for demolition	**Objective:** Identify existing facilities requiring demolition. **Rationale:** A site vacant of structures upon initiation of construction reduces the risk of potential delay associated with facility demolition.	**Scoring Basis**: • Score higher those sites without existing facilities or operations.	**2**
	Expandability • adjacent site conditions allow expandability	**Objective:** Identify the potential for a site to expand the area available for a disposal cell and supporting structures/operations. **Rationale:** If project scope increases, such as from increased waste disposal volumes, delays are minimized if expansion can occur on adjacent areas owned by DOE.	**Scoring Basis**: • Score higher those sites that could be expanded without infrastructure removal/relocation or natural resource impacts/mitigation.	**2**
Transportation Access	Site access • additional improvements • existing access road improvements • new access road construction	**Objective:** Identify the level of existing site access. **Rationale:** Construction of new or modified site access roads, bridges, or overpasses would increase design and construction costs.	**Scoring Basis**: • Score higher those sites with adequate access roads that do not require additional improvement.	**1**
	Impacts to roads • transportation on or across roads and associated risk to members of the public or plant workers • damage to roads	**Objective:** Identify the use of public and plant roads. **Rationale:** Use of roads increases necessary road maintenance, traffic density, and risks to members of the public and/or plant workers.	**Scoring Basis**: • Score higher those sites that do not require transportation across public roads or that potentially impact plant workers.	**2**

Table E.1. Screening Criteria Definitions and Weighting (Continued)

Secondary Criteria		Rationale and Objective	Scoring Factors	Weight
Utilities	Relocation of existing utilities • Relative cost to relocate existing utilities	**Objective:** Identify the extent to which sites will require relocation of existing utilities. **Rationale:** Relocation of existing infrastructure, such as power lines, increases costs, design, and administrative requirements that can increase cost and time required for implementation.	**Scoring Basis**: • Score higher those sites with less existing infrastructure requiring relocation.	**2**
	Existing support infrastructure • availability of necessary utilities	**Objective:** Identify the extent to which sites have available existing site utilities proximate to support construction activities and O&M of a disposal cell. **Rationale:** Construction of new infrastructure for utilities would increase design and construction costs, impact additional areas, and increase the time for construction/implementation.	**Scoring Basis**: • Score higher those sites with existing utilities.	**1**
Buffers	Distance to sensitive environmental areas	See NEPA Considerations below.		
	Physical buffer space • distance to DOE boundary	**Objective:** Identify the extent of the buffer area between the edge of the site and non-DOE owned property. **Rationale:** Additional buffer area will provide additional security and general benefits, such as capture area for any washout or surface release from the site.	**Scoring Basis**: • Score higher those sites that are farthest from the DOE boundary.	**1**
	Distance to streams	See Hydrologic Considerations above.		
NEPA Considerations	Wetlands • area of designated wetlands • area or conditions conducive to development of wetland habitat	**Objective:** Identify the extent of jurisdictional wetlands or conditions conducive to wetland habitat. **Rationale:** Disturbance (dredge and fill) of wetlands is a regulated activity and minimization of disturbance to designated wetlands preserves wildlife habitat. Delays and costs can result from wetland mitigation.	**Scoring Basis**: • Score higher those sites with less jurisdictional wetlands and less area with conditions conducive to wetland habitat.	**2**
	Threatened & endangered species and sensitive habitats • area of sensitive habitat	**Objective:** Identify the extent to which sites contain critical sensitive and T&E habitats. **Rationale:** Impacts to T&E habitat is a regulated activity and minimization of disturbance preserves wildlife habitat. Delays and costs can result from habitat impact and reconstruction.	**Scoring Basis**: • Score higher those sites that have less T&E habitats and less potential for impacting such habitats.	**3**
	Aesthetics • visual impacts • noise impacts	**Objective:** Identify the extent to which a disposal cell would be visible from public areas and construction noise would impact public areas. **Rationale:** Minimization of negative aesthetic impacts is preferable and would have a lower impact to public/residential areas.	**Scoring Basis**: • Score higher those sites where a disposal cell and support facilities would have the least impact on aesthetics, such as visual or noise, from public areas including as recreational areas, private residences, and public roads.	**2**
Final Criteria				
Programmatic Considerations	Availability/time frame of site vs. other actions			
	Cost			
	Regulatory Acceptance			
	Public Acceptance			

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requirement is being invoked for the On-Site Alternative in accordance with CERCLA § 121 (d)(4)(D), allowing waiver of the requirement if protectiveness can be demonstrated. Geologic Features

No karst geology or geologic processes such as mass wasting or other geologic features or processes that could present stability concerns for a disposal cell are present across PGDP or within a distance of any site that could present stability concerns. Liquefaction has been identified as a possible concern at PGDP; however, based on the Seismic Investigation Report (DOE 2004), no evidence of paleoliquefaction was found at the PGDP, and no significant differentiation among the potential sites seems likely based on the available data.

E.2.1.2 Groundwater Discharge/Recharge

Only losing portions of Bayou and Little Bayou Creeks are located within PGDP. Stream flow at PGDP is affected by storm water and effluent, with impacts varying locally and temporally. There is currently insufficient data for groundwater discharge and recharge to distinguish among the sites, and additional data likely would not indicate a significant difference among any of the sites. Even if discernable differences were identified among sites, any potential negative impacts from groundwater discharge likely could be overcome by appropriate design features.

E.2.1.3 Distance to Natural Resource Areas

The Tupelo Swamp is more than a mile from PGDP and reasonably would not be anticipated to be impacted by activities at any of the candidate sites. (Potential wetlands, threatened and endangered species, and wildlife management areas are included in the Secondary Criteria.)

E.2.1.4 Weather

The rate of precipitation and wind velocity would be the most important weather factors potentially impacting disposal facility site selection; however, the average rate of precipitation and wind velocities are the same across the site. No surface features at the PGDP are anticipated to create difference in wind velocity or direction at the sites.

E.2.1.5 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations, requires agencies to identify and address disproportionately high and adverse human health or environmental effects their activities may have on minority and low-income populations. Although a disproportionately high percentage of minority and low-income populations is located within 50 miles of the PGDP site (DOE 2004), the census tracts closest to PGDP do not report a higher proportion of minorities or low-income populations than the national average. Consequently, there would be no disproportionately high and adverse human health or environmental effects on minority populations and low-income populations in the long-term triggering serious consideration of alternatives and mitigation in coordination with community outreach efforts.

E.2.1.6 Cultural Resources

There have been 11 cultural resource sites identified at 12 localities near PGDP, including four prehistoric sites, four homestead sites, and three Archaic open habitation sites. The homestead and prehistoric sites are identified as all being relatively small and/or of poor quality. Additionally, sites of cultural interest near PGDP include the Kentucky Ordnance Works (KOW), located primarily southwest of the DOE-owned property, and Harmony Cemetery, located just north of the PGDP security fence.

As discussed in Section 2.2.2 in the main text, the two historic sites located near Site 11 were recommended for no further archeological work based on the reconnaissance survey by Archeology Resources Consultant Services in 1993.

E.2.2 THRESHOLD CRITERIA

Threshold criteria were established to define minimum technical requirements and threshold ARARs that the candidate sites must meet. Preliminary design efforts for the current waste disposal evaluation, based on the high-end waste volume estimates presented in this RI/FS, indicate that a waste footprint of 40 acres would be needed for the high-end waste volume estimate, compared to a projected 30 acres in the 2001 study (DOE 2001), but that the overall facility still could be accommodated by 110 acres. The Threshold Criteria are listed below and in Table E.1.

- **Available Area.** Comprised of the subcriteria “adequate area” and “DOE-owned property.” A site was considered to have sufficient available area only if it is a 110-acre site completely within DOE-owned property with no more than 20% its total acreage within the 100- or 500-year floodplain or otherwise unavailable for use.[1] Overhead power lines that could not be relocated were considered if more than 20% of a site was affected. TVA overhead power lines generally cannot be relocated, whereas power lines owned by Electric Energy, Inc. (EEI) can. For the reevaluation of site configuration, it was deemed viable to relocate a single TVA power line, but not a bank of multiple lines.

- **Floodplains.** Use of the site cannot restrict flow of the 100-year or 500-year flood or reduce temporary water storage capacity of a 100-year or 500-year flood event posing a hazard to human life or the environment.

- **Seismic Conditions.** The waste footprint must have a separation of at least 200 ft from a fault with displacement in Holocene time.

These criteria were designed to be applied on a strictly pass-fail basis, with the intent that a site would be screened against the Secondary Criteria only if it met all of the Threshold Criteria.e-

E.2.3 SECONDARY CRITERIA

The Secondary Criteria were designed to evaluate and differentiate among the sites passing the Threshold screening. The Secondary Criteria consist of the following:

- Hydrologic Considerations
- Terrain Stability
- Information Availability
- Site Contamination
- Land Use
- Transportation Access

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[1] The 20% threshold for a candidate site’s total acreage within the 100-year or 500-year floodplain or otherwise unavailable for use is based on engineering judgment and is considered to be the maximum decrease of acreage where the high-end waste volume could be located within a candidate site [this includes support facilities as well as the waste disposal facility (WDF) footprint]. The reduction of acreage due to presence of floodplains would be managed through optimized placement of the WDF and support facilities.

- Utilities
- Buffers
- National Environmental Policy Act Considerations

Unlike the Threshold Criteria, which were designed to be applied on a pass-fail basis, the Secondary Criteria were designed to be scored on a relative scale according to a site's ability to meet the criteria. Each of these criteria is comprised of subcriteria. Each of the subcriteria was assigned a weight according to its relative importance. The assigned weights were limited to a range of 1 to 3, and the scoring scale of 0 to 3. This approach was implemented to minimize the potential for subjectivity in the scoring process. The use of weighting factors between 1 and 3 and scores between 0 and 3, as compared to a scale of 1 to 10 often used for siting studies, was designed to prevent very high or low scores for only one or two criteria from biasing the overall results.

Table E.1 provides the definitions of the Secondary Screening criteria, the associated rationale and objective, scoring factors to be considered when screening the sites, and the weighting factors for each of the subcriteria.

E.2.4 FINAL CRITERIA

The Final Criteria are programmatic considerations consisting of the following factors:

- Availability/time frame of site vs. other site activities
- Cost
- Regulatory acceptance
- Public acceptance

The Final Criteria were designed to be applied after the Threshold and Secondary screening as part of the CERCLA evaluation process.

E.3. CANDIDATE SITES

This section provides descriptions for each of the candidate sites. The candidate sites are shown in Figure E.1. Figures E.3 through E.9 support the site descriptions.

E.3.1 SITE 1

Site 1 is located outside the secured area of PGDP in the southwest corner of the DOE-owned property. The majority of the land in this area is designated as DOE-owned property licensed to West Kentucky Wildlife Management Area (WKWMA). A small portion of the northeast tip of the site is DOE-owned industrial land use.

Site 1 is bordered by a Bayou Creek tributary to the north, Water Works Road to the west, railroad tracks to the east (and Site 2 east of the railroad tracks), and the DOE property boundary to the south. The site is relatively flat, with an area of higher elevation in the western portion of the site and minor slope toward a Bayou Creek tributary in the northwest portion of the site. There is approximately 55 ft of topographic relief across Site 1. The site is covered with grasses, underbrush, and trees, with isolated potential wetland

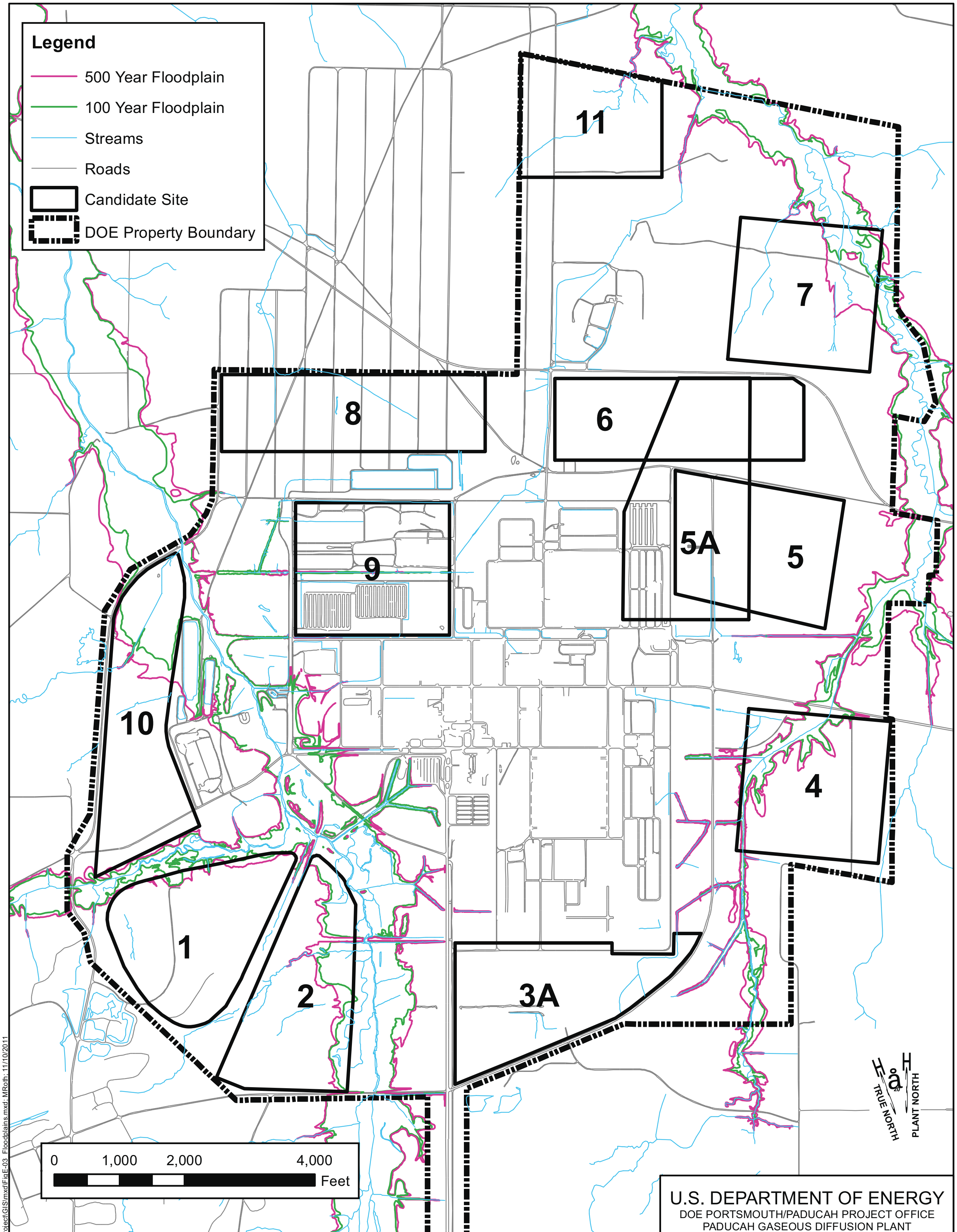

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Figure E.3. Floodplains

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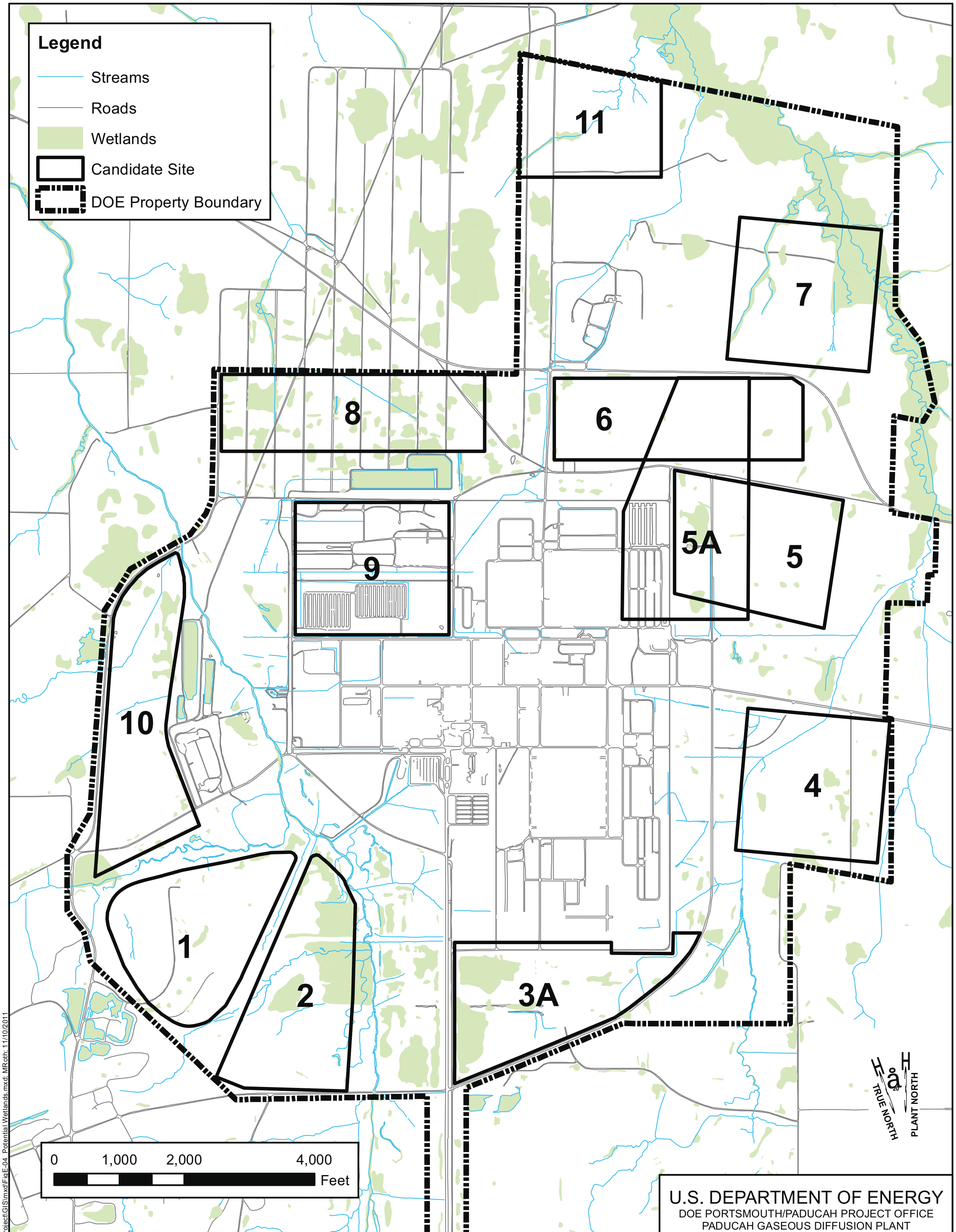

Figure E.4. Potential Wetlands

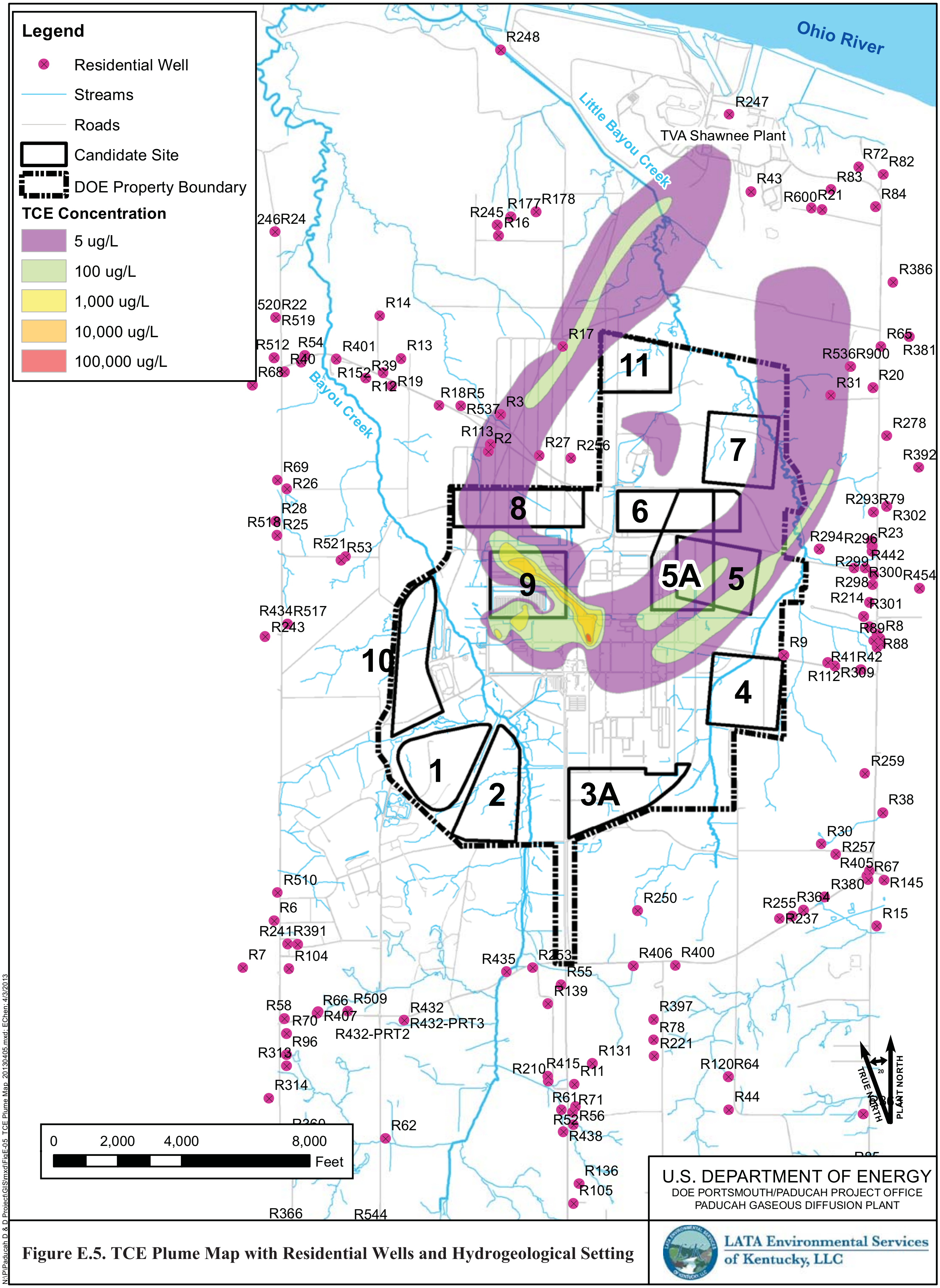

Figure E.5. TCE Plume Map with Residential Wells and Hydrogeological Setting

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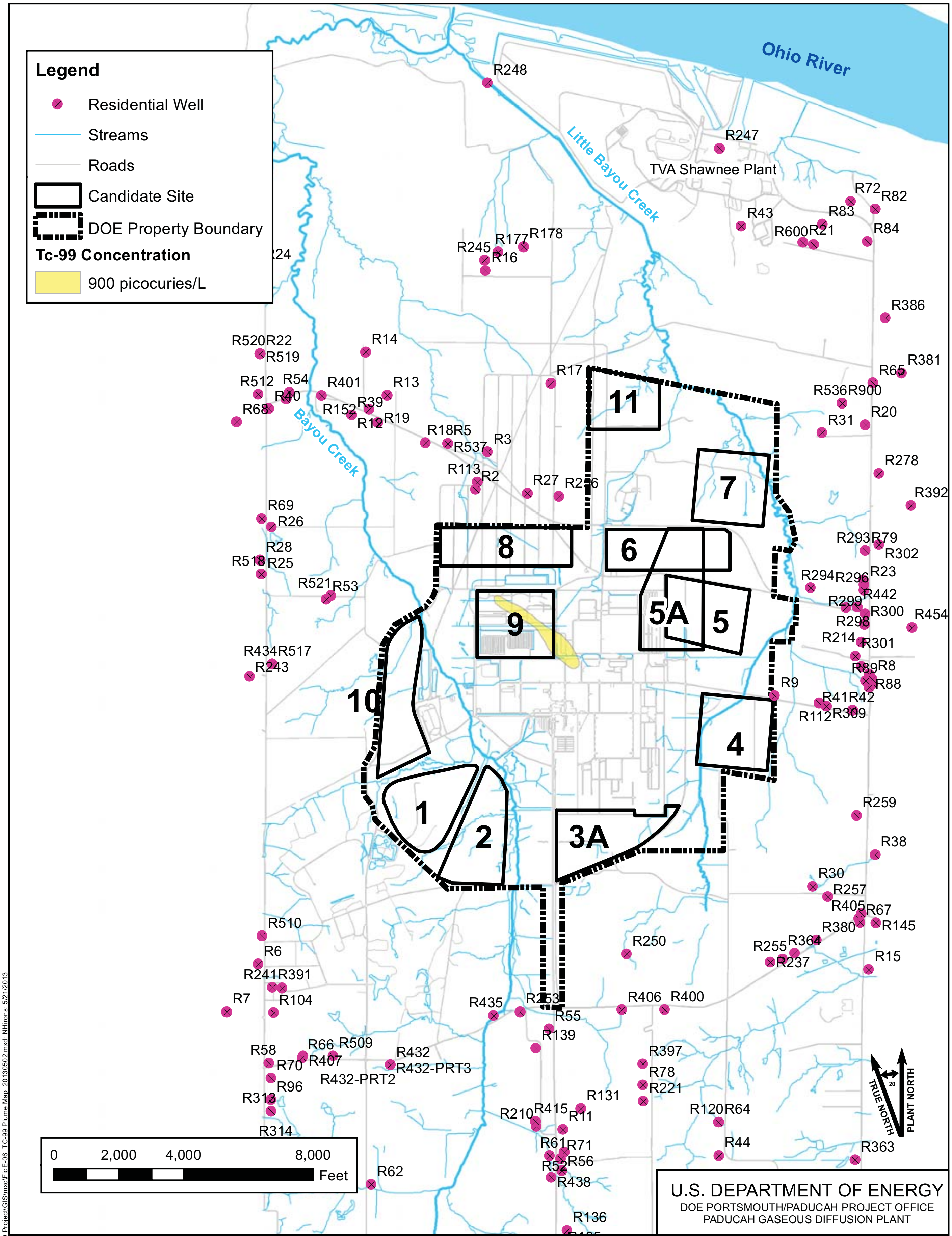

Figure E.6. Tc-99 Plume Map with Residential Wels and Hydrogeologic Setting

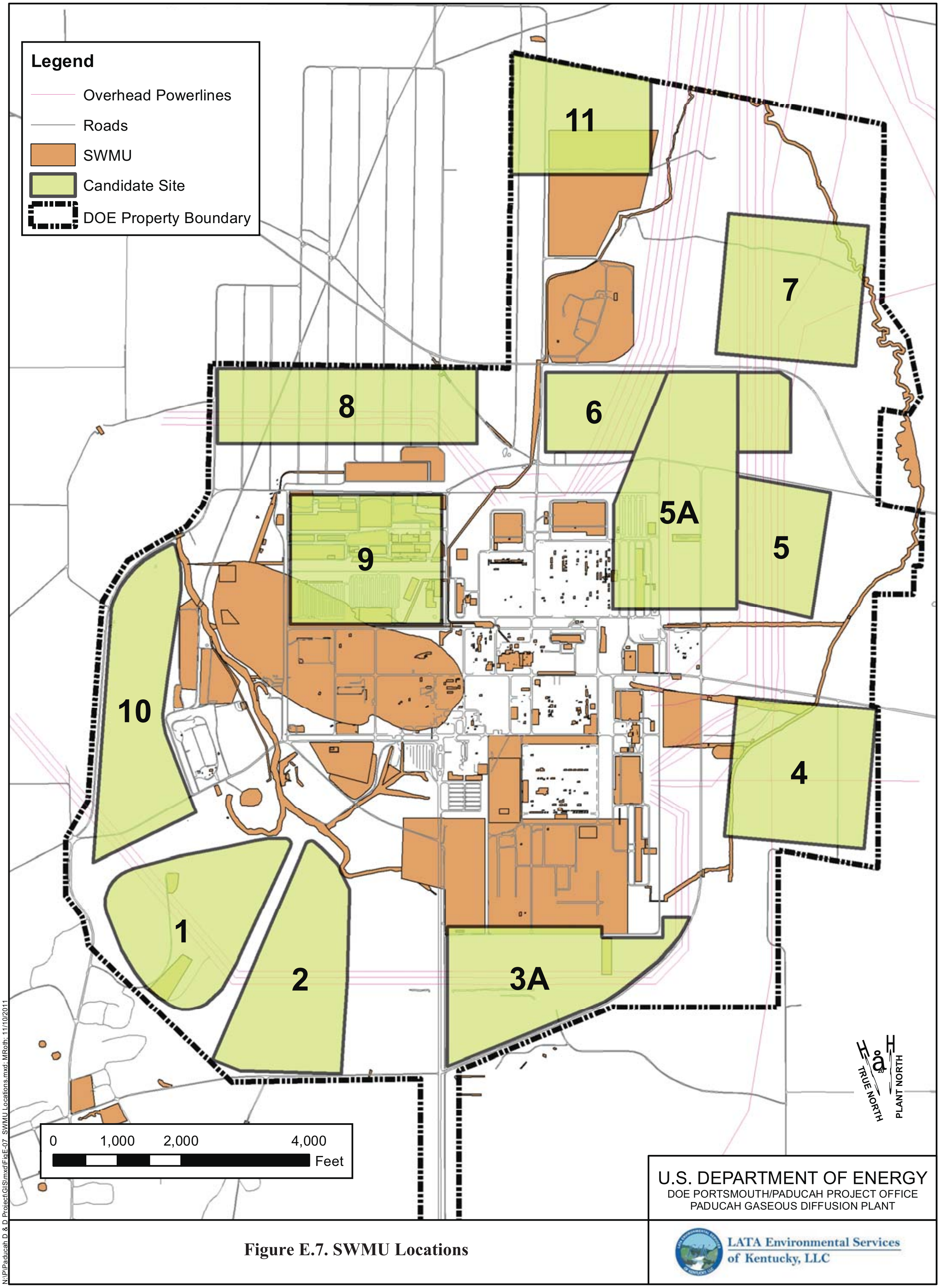

Figure E.7. SWMU Locations

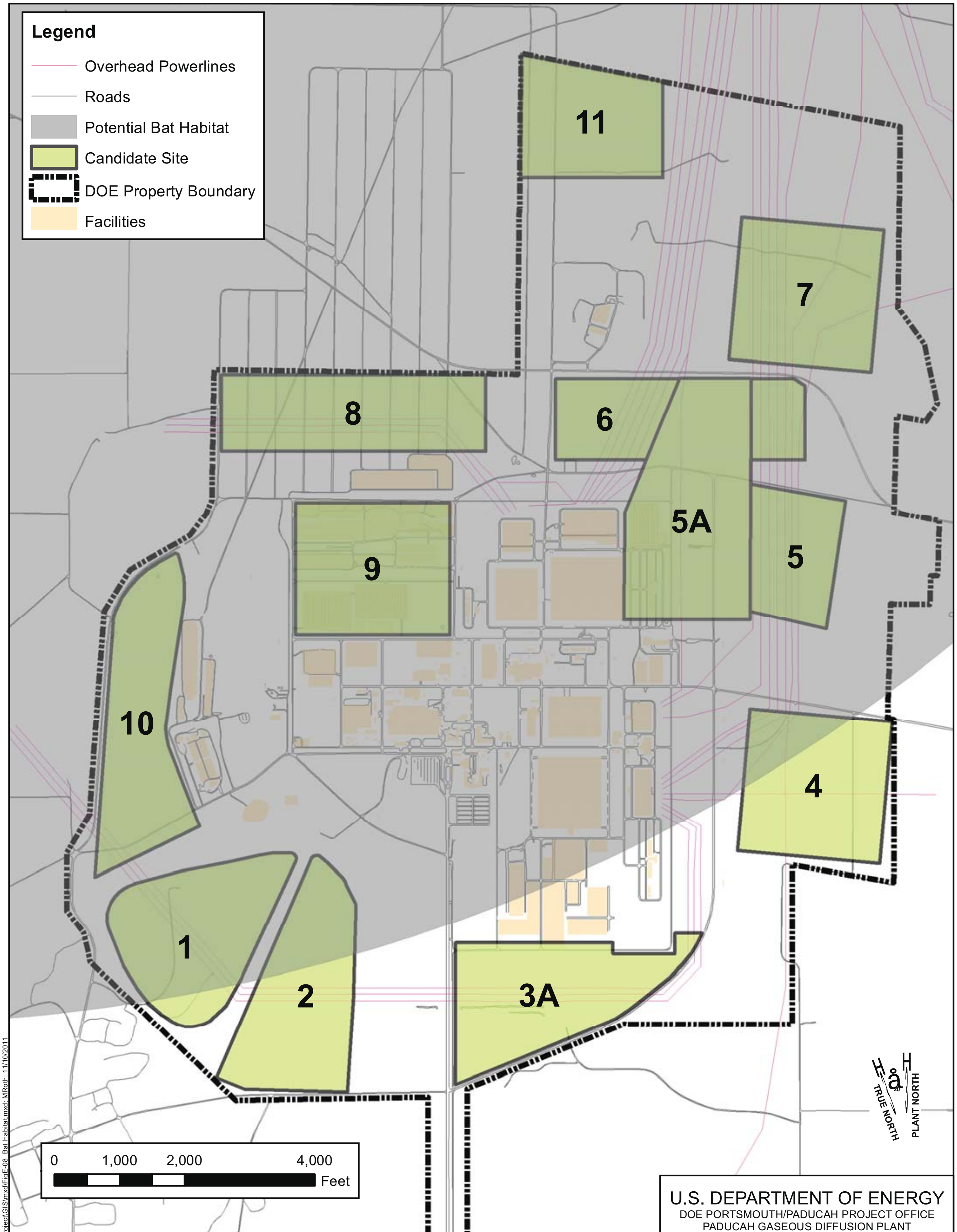

Figure E.8. Potential Indiana Bat Habitat

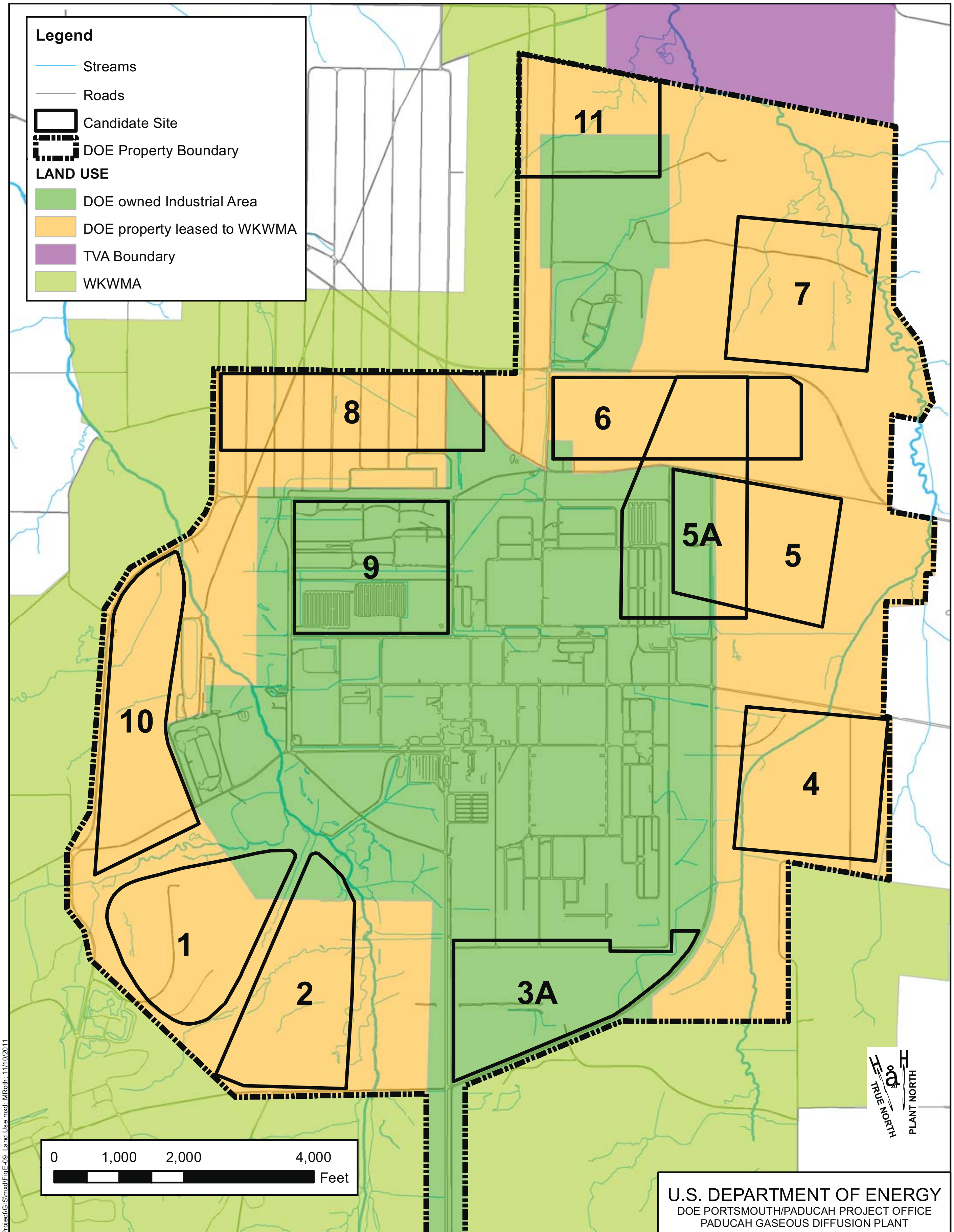

Figure E.9. Land Use

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areas (approximately 2% of site area). Site 1 is used extensively for recreational purposes. The site area may be expandable to the east-southeast, potentially requiring the rerouting of small Bayou Creek tributaries and a railroad line.

This site is located on top of the Terrace Gravel that consists of Pliocene-aged gravel deposits above the Porters Creek Clay. Limited groundwater data are available, but previous studies from 1997 and 1999 indicate the general flow direction across the site is northerly or northeasterly, becoming more northeasterly in the northeast portion of the site. This site is located in the south hydrogeologic setting and, based on conclusions found in a report prepared by GEO Consultants, LLC, would have sufficient hydrologic and geotechnical data for the purpose of evaluation in the RI/FS (GEO 2009). Additional data would need to be collected to support completion of design and groundwater modeling, if Site 1 is selected as the final recommended site.

The distance to the nearest downgradient residential well is approximately 5,200 ft measured from the nearest border of the site. The distance to the nearest DOE boundary is approximately 150 ft. The distance to the nearest segment of Bayou Creek or its tributary is about 100 ft along the east and north boundaries of the site.

The site includes the former KOW sewage treatment facility [solid waste management unit (SWMU) 157] and former toluene storage facility (SWMU 94). There is no known chemical data to determine the presence of any contamination at the site associated with former KOW operations. Selection of this site would require rerouting of at least 2,200 ft of overhead transmission lines. EEI owns these overhead lines and they could be relocated, as confirmed through an engineering study conducted by Commonwealth Associates, Inc. In addition, this site encompasses an unnamed stream, and a road within its borders.

The area of 100-year floodplain at this site is approximately 4% of the total site area, and the area of 500-year floodplain at this site is also approximately 4%. This site has not had a site-specific seismic investigation, but the working assumption of no Holocene age faults is applicable for the screening process. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

E.3.2 SITE 2

Site 2 is located outside the secured area of PGDP in the southwest corner of the DOE-owned property. The majority of the land in this area is designated as DOE-owned property leased to WKWMA. A small portion of the northern tip of the site is designated as DOE-owned industrial land use.

The site is bounded by Bayou Creek to the north and to the east, railroad tracks to the west (and Site 1 west of the tracks), and an unnamed gravel road to the south. The site is moderately flat, with increasing elevation in the southwest portion of the site. There is approximately 50 ft of topographic relief across Site 2. The site is covered with grasses, underbrush, and trees, and with potential wetlands and floodplains present. The site would not be expandable due to railroad tracks on the western boundary, a stream and potential wetlands to the east, and the DOE boundary to the south.

This site is located on top of the Terrace Gravel above the Porters Creek Clay. Similar to Site 1, limited groundwater data is available, but the general groundwater flow would be to the north-northeast. This site is located in the south hydrologic setting and, based on conclusions found in GEO 2009, would have sufficient hydrogeologic and geotechnical data for the purpose of evaluation in the RI/FS. Additional data would need to be collected to support completion of design and groundwater modeling, if Site 2 is selected as the final recommended site.

The distance to the nearest residential well is approximately 5,300 ft measured from the nearest border of the site. The southern boundary is very near the DOE boundary, and the northern and eastern boundaries are near Bayou Creek. Site 2 has EEI-owned overhead transmission lines that run east and west through the center of the site. Selection of this site would require rerouting approximately 1,600 ft of overhead transmission lines. These lines could be relocated as confirmed through an engineering study conducted by Commonwealth Associates, Inc. This site also has unnamed Bayou Creek tributaries within its borders. The site is located just upgradient of existing contaminated areas.

Approximately 30% of the site is unavailable, because it is located within the 100-year or 500-year floodplain. This site has not had a site-specific seismic investigation, but the working assumption of no Holocene age faults is applicable for the screening process. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

E.3.3 SITE 3A

Site 3A is located on the southern perimeter outside of the secured area of PGDP, in the south-central portion of the DOE-owned industrial land use area. The land in the secured area (cylinder yard) is classified as industrial, and the area outside the secured area is designated as recreational use-DOE property.

The site is bounded on the north by the C-745-T cylinder yard; on the south and east by Dyke Road; and on the west by the main entrance road into PGDP, Hobbs Road. The site is relatively flat, with an area of higher elevation in the southern portion of the site and minor slope toward a Little Bayou Creek tributary in the northeast portion of the site. There is a total of about 30 ft relief across the site. The site is covered with grasses, underbrush, and trees, with potential wetland areas. The proposed location is adjacent to and south of the UF_6 cylinder yards and south of the newly constructed DUF_6 facility. The site area may be expandable to the north, potentially requiring moving of the cylinder yards and associated investigation for potential contamination.

This site is located on top of the Terrace Gravel and above the Porters Creek Clay. The site is located in the south hydrologic setting and, based on conclusions found in the GEO 2009 report, there would be sufficient hydrogeologic and geotechnical data for the purpose of evaluation in the RI/FS. Additional data would need to be collected to support completion of design and groundwater modeling, if Site 3A is selected as the final recommended site.

Groundwater elevation data is limited and is based largely on data from two monitoring well locations, and findings from a previous study indicating that Bayou Creek is a gaining stream in the Terrace Gravel region. Based on this data, it has been inferred that lateral flow from (at least) the western part of the site is to the northwest and is a source of recharge to Bayou Creek. In general, flow directions show a slight radial pattern at the site, being northerly from the middle of the site, northwesterly from the western part of the site, and northeasterly from the eastern part of the site.

The distance to the nearest downgradient residential well is approximately 4,500 ft. The distance to the nearest DOE boundary is approximately 110 ft. A segment of a Little Bayou Creek tributary transects the eastern portion of the site.

The site is located just upgradient of existing contaminated areas. There is no known soil or groundwater contamination at Site 3A; however, the Management Assessment Report (July 2008; PRS-2008-0056) recommended that Area of Interest 13, which is in the southwestern-most portion of Site 3A and is indicated to consist of a dirt pile, be further evaluated as a potential area of concern or SWMU.

This site is bisected by east-west running EEI-owned overhead transmission lines and right-of-way near the center of the site. Selection of this site would require rerouting of at least 3,200 ft of overhead transmission lines. These lines could be relocated as confirmed through an engineering study conducted by Commonwealth Associates, Inc.

There are no areas of the 100-year or 500-year floodplains at this site; however, portions of the Little Bayou Creek floodplain are present at a maximum of about 200 ft from the southwest, northwest, and northeast corners of the site. Site 3A has had a comprehensive seismic investigation that concluded there are no Holocene age faults present at the site (DOE 2004).

E.3.4 SITE 4

Site 4 is located outside the secured area of PGDP in the southeastern portion of the DOE-owned property. The land in this area is designated as DOE-owned property licensed to WKWMA. This site is bounded by McCaw Road to the north, Dyke Road to the west, the DOE boundary to the east and south, and a gravel patrol road to the south. There would be little potential to expand the site due to the floodplains that transect the northwest portion of the site, and the proximity to DOE boundaries to the south. There is relatively narrow north-south strip of land south of the site between Little Bayou Creek and floodplains to the west and the DOE boundary to the east that possibly could be used for support facilities.

Site 4 is located on top of the Terrace Gravel above the Porters Creek Clay. This site is located in the south hydrogeologic setting and, based on conclusions found in GEO 2009, would have sufficient hydrologic and geotechnical data for the purpose of evaluation in the RI/FS. Additional data would need to be collected to support completion of design and groundwater modeling, if Site 4 is selected as the final recommended site.

The site is relatively flat and approximately 15 ft of topographic relief across the site. Site 4 is covered with grasses, underbrush, trees, with isolated potential wetland areas. Approximately 24% of the site is unavailable due to the presence of floodplains.

A residential well is located on the northeast corner of the site, and the site boundary coincides with the DOE boundary at the same location. Little Bayou Creek runs southwest to north through Site 4. There also are two gravel roads, one in the northwestern portion and one that runs north to south in the eastern portion. Approximately 2,200 ft of a TVA overhead transmission line that cannot be relocated runs north-south through the western portion of this site.

Site 4 has not had a site-specific seismic investigation, but the working assumption of no Holocene age faults is applicable for the screening process. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

E.3.5 SITE 5

Site 5 is outside the secured area of PGDP in the eastern portion of the DOE-owned property. The majority of the land in this area is designated as DOE-owned property licensed to WKWMA. The western quarter is designated DOE-owned industrial land use. This site is bounded by an unnamed gravel road to the north, Dyke Road to the west, Little Bayou Creek to the east, and McCaw Road to the south.

The site area may be expandable to the north, requiring the rerouting of a minor road; to the east, limited by the DOE boundary and Little Bayou Creek, impacting residential areas just east of the DOE boundary; and to the south, potentially requiring the rerouting of an east-west running ditch that leads to a Kentucky Pollutant Discharge Elimination System (KPDES)-permitted outfall.

The site is flat, with minor slope to the northeast due to a Little Bayou Creek tributary. There is only about 12 ft of relief across Site 5. The site is covered with grasses, underbrush, and trees, with isolated potential wetland areas.

This site is located on top of the Regional Gravel Aquifer (RGA). There is a pond in the southwestern portion of Site 5. If the footprint of the WDF impacts the pond, then those impacts will be addressed in accordance with ARARs. This site is located in the north hydrologic setting in the RGA and would have sufficient information with respect to hydrogeologic data and groundwater flow direction for the purpose of evaluation in the RI/FS. Additional data likely would need to be collected to support completion of design and groundwater modeling, if Site 5 is selected as the final recommended site.

Site 5 overlies the Northeast Plume [part of the Groundwater Operable Unit (GWOU)], which shows flow to the east-northeast. Triangular element analysis provided in the PGDP Sitewide Groundwater Modeling Report also shows a consistent pattern of northeast flow direction at the site.

The distance to the nearest downgradient residential well is approximately 1,800 ft. The distance to the nearest DOE boundary is about 800 ft. A segment of a Little Bayou Creek tributary bisects the southwestern portion of the site. Approximately 2,000 ft of overhead TVA transmission lines that cannot be relocated run north and south through this site.

There are no areas of the 100-year or 500-year floodplains at this site; however, a portion of the Little Bayou Creek floodplain is present at a maximum of about 100 ft from the southeast corner of the site. This site has not had a site-specific seismic investigation, but the working assumption of no Holocene age faults is applicable for the screening process. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

E.3.6 SITE 5A

Site 5A is located on an interior portion of DOE-owned property, located primarily outside of the secured area of PGDP in the eastern and northeastern portions of the DOE-owned property, with approximately 24% of the site within the secured portion of the PGDP plant. This site is approximately 135 acres. The majority of Site 5A land is designated as DOE-owned property licensed to WKWMA. The western portion is designated DOE-owned industrial land use.

This site is located in the north hydrologic setting over the RGA and would have sufficient information with respect to hydrogeologic data and groundwater flow direction for the purpose of the RI/FS evaluation. There is a pond in the southern portion of Site 5A. If the footprint of the WDF impacts the pond, then those impacts will be addressed in accordance with ARARs. Additional data likely would be needed to support completion of design and groundwater modeling if Site 5A is selected as the final recommended site.

Site 5A is bounded by Ogden Landing Road to the north, overhead transmission lines to the east, the eastern extent of the C-337 Process Building to the southwest, and overhead transmission lines to the northwest. There are north-south oriented drainage ditches near the center of the site. There are several SWMUs south of the site. The east-west trending C-375-E5 Effluent Ditch (Outfall 013) (SWMU 61) is located approximately 250 ft to the south, and McCaw Road is located approximately 1,100 ft to the south. The site is flat, with minor slope to the northeast due to the presence of a Little Bayou Creek tributary. There is only about 15 ft of relief across Site 5A. The site is covered with grasses, underbrush, and trees, with isolated wetland areas (approximately 4.8% of site area).

The site overlies a portion of the Northeast Plume (part of the GWOU), which flows to the east-northeast. The distance to the nearest downgradient residential well is approximately 2,600 ft, although that well is essentially southeast of and perpendicular to the existing flow direction. The residential well closest to the current flow path is 3,400 ft (due east), and the nearest residential well along the plume flow path is approximately 4,800 ft downgradient. The distance to the nearest DOE boundary is about 2,250 ft.

TVA overhead transmission lines run north-south along the eastern border of this site and north-northeast and south-southwest adjacent to the northwest border of this site. Selection of this site would require rerouting of at least 3,800 ft of a single overhead TVA transmission line. The estimated area for Site 5A assumes that this transmission line would be rerouted just west of the bank of overhead transmission lines on the eastern border of the site and spaced equidistant to the existing lines.

There are no areas of the 100-year or 500-year floodplains at Site 5A; however, a portion of the Little Bayou Creek floodplain is present at a maximum of about 230 ft from the southeast corner of the site. In addition, portions of the Little Bayou Creek floodplain are present about 1,340 ft from the southeast corner of the site to the natural floodplain and about 1,770 ft from the northeast corner of the site to the natural floodplain.

A site-specific seismic investigation has not been conducted, but the working assumption of no Holocene age faults is assumed to be applicable for the screening process. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

Site 5A extends roughly to the eastern and southern extent of the C-337 Process Building, and incorporates the portion of Site 6 to the north between the two banks of TVA power lines. Conceptually, if the site is selected, construction of the cell would start in the southeast corner of the site and progress to the north and west as environmental remediation waste is generated. Assuming that the northern extent of the cell would coincide roughly with the northern extent of C-337 Process Building, it is estimated that construction of the cell could progress for approximately 10 years before the area currently occupied by the C-745-H Safeguard Cylinder Storage Yard and C-637 Water Cooling Complex would be needed. If these facilities were to remain longer than 10 years, then the cell could be extended further to the north as a contingency. The area to the north could accommodate support facilities and the storm water pond. Area south of the southern boundary of Site 5A also may be available, although investigation and remediation of some SWMUs may be required depending upon the area of expansion.

E.3.7 SITE 6

Site 6 is located outside the secured area of PGDP in the northern portion of the DOE-owned property. The majority of the land in this area is designated as DOE-owned property licensed to WKWMA. Site 6 is bounded by Ogden Landing Road to the north and to the east and an unnamed road to the west and to the south. The site area would be expandable to the south and east to extend permanent roads bounding the site. Approximately 35% of the site is unavailable due to the presence of permanent TVA overhead power lines that cannot be relocated.

This site is located on top of the RGA and over a portion of the Northeast Plume (part of the GWOU). The site is located in the north hydrologic setting and, as such, would have sufficient information with respect to hydrogeologic data and groundwater flow direction for the purpose of evaluation in the RI/FS. Additional data likely would need to be collected to support completion of design and groundwater modeling, if Site 6 is selected as the final recommended site.

The distance to the nearest residential well is approximately 2,500 ft measured from the nearest border of the site. The distance to the nearest DOE boundary is approximately 1,370 ft. The nearest distance to Little Bayou Creek is approximately 1,370 ft to the east, coinciding with the DOE boundary.

There are no areas of the 100-year or 500-year floodplains at this site. The site has not had a site-specific seismic investigation, but the working assumption of no Holocene age faults is applicable for the screening process. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

E.3.8 SITE 7

Site 7 is located outside the secured area of PGDP in the northeastern portion of the DOE-owned property. The majority of the land in this area is designated as DOE-owned property licensed to WKWMA. This site is bounded to the north, west, and east by the Little Bayou Creek tributaries and by Ogden Landing Road to the south. The site is relatively flat, and is covered with grasses, underbrush, trees, and potential wetland areas (approximately 23% of site area). Approximately 47% of the site is unavailable for use, approximately 25% due to the presence of floodplains, and 22% due to permanent TVA overhead power lines that cannot be relocated. The site area may be expandable to the west, to the eastern extent of permanent TVA power lines extending north-south.

This site is located on top of the RGA and partially over the Northeast Plume (part of the GWOU). The site is located in the north hydrologic setting and, as such, would have sufficient information with respect to hydrogeologic data and groundwater flow direction for the purpose of evaluation in the RI/FS. Additional data likely would need to be collected to support completion of design and groundwater modeling, if Site 7 is selected as the final recommended site.

The distance to the nearest residential well is approximately 1,800 ft measured from the nearest border of the site. The distance to the nearest DOE boundary is approximately 250 ft to the east. Little Bayou Creek transects the northeastern portion of the site, and several Little Bayou Creek tributaries are located within the boundary of this site.

This site has not had a site-specific seismic investigation, but the working assumption of no Holocene age faults is applicable for the screening process. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

E.3.9 SITE 8

Site 8 is located outside the secured area of PGDP in the northeastern portion of the DOE-owned property. The majority of the land in this area is designated as DOE-owned property licensed to WKWMA. A small section in the southeast portion of this site is designated as DOE-owned industrial land use. The site is bounded by the DOE border to the north, an unnamed road to the west and to the east, and the C-616 Lagoons and the northern PGDP fence line to the south. The site is relatively flat, and is inundated with potential wetlands covering a minimum of 25% of the total site area. The site may be expandable somewhat to the east and south.

This site is located on top of the RGA and partially overlies the Northwest Plume (part of the GWOU). The site is located in the north hydrologic setting and, as such, would have sufficient information with respect to hydrogeologic data and groundwater flow direction for the purpose of evaluation in the RI/FS. However, additional data likely would need to be collected to support completion of design and groundwater modeling, if Site 8 is selected as the final recommended site.

The distance to the nearest downgradient residential well is approximately 940 ft measured from the nearest border of the site. The northern and western site boundaries coincide with the DOE property boundary. The distance to the nearest segment of Bayou Creek is approximately 900 ft. Site 8 encompasses small tributaries, former KOW facilities, and unnamed gravel roads within the site. EEI-owned transmission lines run east and west through the middle of the site.

There are no areas of the 100-year or 500-year floodplains at this site. The site has not had a site-specific seismic investigation, but the working assumption of no Holocene age faults is applicable for the screening process. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

E.3.10 SITE 9

Site 9 is located within the secured industrialized area of PGDP in the northwestern portion of the DOE-owned industrial land use area. The site is bounded by the PGDP fence line to the north and to the west and plant roads to the east and to the south. The site is flat, with variation in elevation due to SWMUs and industrial operations, with only about 8 ft in relief across the site. The site is covered with grasses, underbrush, and trees (with approximately 10% potential wetlands located within drainage ditches). The site area may be expandable to the south and east, possibly requiring the removal of buildings and rerouting of railroad lines and ditches that lead to KPDES-permitted outfalls.

This site is located on top of the RGA. This site is located in the north hydrologic setting and would have sufficient information with respect to hydrogeologic data and groundwater flow direction for the purpose of evaluation in the RI/FS. Additional data likely would need to be collected to support completion of design and groundwater modeling, if Site 9 is selected as the final recommended site.

Flow directions at Site 9, which generally overlies the core of the Northwest Plume and a portion of the Tc-99 Plume (both part of the GWOU), are to the northwest, based on plume trajectories. Hydraulic gradients are highly variable (likely due to anthropogenic recharge) based on triangular element analysis, but generally show northerly or northwesterly directions. It is noted that the South Well Field extraction system, located just north of Site 9, currently is being optimized and expanded, which will force the hydraulic gradient northward generally in the vicinity of Site 9.

The distance to the nearest downgradient residential well is about 2,900 ft. The distance to the nearest DOE boundary is about 1,300 ft. The distance to the nearest segment of a Little Bayou Creek tributary is about 90 ft along the eastern boundary.

This candidate site is located within a “brownfield” type area. There are at least 19 SWMUs contained within the designated boundaries of this site. The site contains contaminated soils, buried waste, pads, and facilities that must be investigated and remediated prior to any landfill development. Additionally, there are rail spurs within this candidate site’s boundary. Another noted feature is the location of a raw water line. The site would require extensive actions to address these features, possibly including demolition, removal of soil and waste, and/or rerouting of the raw water line.

Because this site is located within the industrial operations area, there are electrical, phone, communications, lighting, potable water, and septic systems in close proximity to this site. A large east-west drainage ditch that discharges to KPDES Outfall 001 bisects this site. This ditch would need to be rerouted to accommodate landfill operations.

The area of the 100-year floodplain at this site is approximately 1%, and the area of 500-year floodplain is approximately 2%. This site has not had a site-specific seismic investigation, but the working assumption of no Holocene age faults is applicable for the screening process. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

E.3.11 SITE 10

Site 10 is located outside the secured area of PGDP in the western portion of the DOE-owned property. The land in this area is designated as DOE-owned property licensed to WKWMA. This site is bounded by Transport Road to the north and to the west, C-611 facilities and lagoons to the east, and a Bayou Creek tributary. The site is relatively flat and is covered with grasses, underbrush, and trees, with isolated potential wetland areas (approximately 8% of the site area). Approximately 29% of the site is unavailable due to the presence of floodplains. The potential to expand the site is very limited due to natural and manmade features, and the DOE property boundary.

This site is primarily located on top of the Terrace Gravel above the Porters Creek Clay, with the northernmost tip over the RGA. The site is located predominately in the south hydrologic setting and, based on conclusions found in GEO 2009, would have sufficient hydrogeologic and geotechnical data for the purpose of evaluation in the RI/FS. Additional data would need to be collected to support completion of design and groundwater modeling, if Site 10 is selected as the final recommended site.

The distance to the nearest residential well is approximately 2,200 ft measured from the nearest border of the site. The western boundary of the site coincides with the DOE property boundary. A tributary of Bayou Creek transects the northern portion of the site, and converges with the creek at the northeastern extent of the site. Transmission lines cut across the southern tip of this site.

This site has not had a site-specific seismic investigation, but the working assumption of no Holocene age faults is applicable for the screening process. Site-specific seismic investigation would not be required if the results of site-specific fault rupture propagation numerical modeling indicate that the impact of a postulated fault on the landfill composite liner and cover systems is small and can be accommodated as designed.

E.3.12 SITE 11

Site 11 is located outside the secured area of PGDP in the northern-most portion of the DOE-owned property. The land in this area is designated as recreational use-DOE property, licensed to WKWMA. This site is bounded to the north and west by the DOE property boundary, to the south by the operating C-746-U Landfill, and to the east by overhead power lines just outside of the site boundary. The site area may be expandable to the south, potentially reducing the current and future operation/expandability of the C-746-U Landfill.

The site is relatively flat, with slope attributable to the Little Bayou Creek tributary in the northeast portion of the site. There is about 30 ft of relief across the site. The site is covered with grasses, underbrush, and trees, with isolated potential wetland areas (approximately 4% of the site area).

This site is located on top of the RGA. The site is located in the north hydrologic setting and would have sufficient information with respect to hydrogeologic data and groundwater flow direction for the purpose of evaluation in the RI/FS. Additional data likely would need to be collected to support completion of design and groundwater modeling, if Site 11 is selected as the final recommended site.

Site 11 partially overlies the downgradient lobe of a portion of the Northwest Plume (part of the GWOU), showing a north-northeast flow direction. This is confirmed by triangular element data, which generally show northerly or north-northeasterly flow directions. Flow in this area is dominated by northward regional gradients toward Little Bayou Creek and the Ohio River.

Distance to the nearest downgradient residential well is 1,200 ft. The DOE boundary essentially defines the west and north boundaries of the site. The central portion of the site is fully bisected by a segment of a Little Bayou Creek tributary.

There are several closed landfills (P, S, and T) south of the C-746-U Landfill. The “P” landfill was a construction and demolition debris landfill, the “S” landfill was a residential permitted landfill, and the “T” landfill was a permitted inert landfill. In order to use Site 11, Phases 12 through 23 of future expansion areas of the C-746-U Landfill would need to be utilized and would prohibit placement of the design capacity of 1.5 mcy of waste.

A tributary of Little Bayou Creek crosses the site from the southwest to the northeast. This tributary would need to be rerouted to accommodate use of the site for a new on-site disposal facility.

There are no areas of the 100-year floodplain at this site, and the area of 500-year floodplain at this site is less than 1%. This site has had a seismic investigation (KRCEE 2006) that concluded there are no Holocene age faults present at the site. Due to the presence of the C-746-U Landfill, there are electrical, phone, communications, lighting, potable water, waste water/leachate treatment, and septic systems in close proximity to this site. Utilization of existing facilities at the C-746-U Landfill would reduce capital expenditures and result in a smaller area footprint of 84, rather than 110 acres.

E.4. SITE SCREENING PROCESS

A site screening lead was identified and a SSG formed to conduct the screening effort. The SSG consisted of engineers and scientists from Paducah and Oak Ridge experienced in DOE site operations. The site screening lead and the SSG defined the screening process, established the siting criteria, developed scoring ranges and weighting factors for the Secondary Criteria, and conducted the Threshold Criteria screening and Secondary Criteria scoring.

To support informed decision making, the members of the SSG were provided site descriptions; data including calculations of the areas covered by potential wetlands, floodplains, and overhead power lines; and access to a GIS Web site that provided various layers relevant to the Secondary Screening criteria. The site screening lead and SSG focused on deriving results that were tangible, defensible, and as objective as possible. The results of the screening process are summarized below.

E.4.1 THRESHOLD SCREENING

The threshold screening was conducted for the 12 candidate sites using the Threshold Criteria described in Section E.2.2, above, and described in Table E.1. The members of the SSG conducted the threshold screening independently to encourage evaluation from various perspectives (i.e., disciplines and backgrounds), with minimal influence from other group members to limit the potential for predecisional conclusions. The Threshold Criteria were applied on a strictly pass-fail basis. Only sites that passed all of the Threshold Criteria were carried forward for the secondary screening. After compilation of the Threshold screening, the SSG convened to review the conclusions and unanimously agreed on the results.

Based on conclusions from two previous site-specific seismic studies conducted on PGDP that no faults with Holocene age displacement are present, all 12 sites were considered to pass the seismic criterion of being greater than 200 ft from a Holocene fault. The Threshold Criteria included a requirement that no more than 20% of a site’s total area could be within the 100-year or 500-year floodplain or otherwise not available for use. In addition to floodplains, the presence of potential wetlands and permanent TVA overhead power lines was considered in determining the percentage of a site’s total area availability for an on-site disposal cell and supporting facilities. Overhead power lines are significant because the height of the landfill in conceptual designs would require that the transmission lines either be raised or relocated. Overhead power lines owned by EEI can be relocated if needed.

The results of the threshold screening are presented in Table E.2. Seven of the 12 sites, Sites 2, 4, 5, 6, 7, 8, and 10 failed the Threshold screening because 20% or more of their area is unavailable for use. In addition to floodplains, the presence of potential wetlands and permanent TVA overhead power lines resulted in the elimination of sites. More than 20% of each of Sites 2, 4, 7 and 10 is located within the 100-year or 500-year floodplains. Permanent TVA overhead power lines also cover approximately 22% of the total area of Site 7. A minimum of 36% of Site 5 and approximately 35% of Site 6 is unavailable due to the presence of permanent TVA overhead power lines. Site 8 is inundated with potential wetlands, which cover a minimum of the 25% of the total area. Site 5A passed the Threshold Criteria with the assumption that the single TVA overhead transmission line could be relocated.

E.4.2 SECONDARY SCREENING

Sites 1, 3A, 5A, 9, and 11 were carried forward from the Threshold Screening as qualified for evaluation against the Secondary Criteria. All of these sites are considered technically adequate for construction of

Table E.2. Threshold Screening Results

Site	Adequate Area	DOE-Owned Property	Predominantly Outside Floodplains	Greater than 200 ft from Holocene Faults or Lineaments	Comments
1	✓	✓	✓	✓	This site passes the Threshold Criteria screening.
2	X	✓	X	✓	Approximately 30% of the site is unavailable due to presence of floodplains.
3A	✓	✓	✓	✓	This site passes the Threshold Criteria screening.
4	X	✓	X	✓	Approximately 24% of the site is unavailable due to presence of floodplains.
5	X	✓	✓	✓	A minimum of 36% of the site is unavailable due to permanent TVA power lines.
5A	✓	✓	✓	✓	This site passes the Threshold Criteria screening
6	X	✓	✓	✓	Approximately 35% of the site is unavailable due to permanent TVA power lines.
7	X	✓	X	✓	Approximately 47% of the site is unavailable for use--approximately 25% due to the presence of floodplains and 22% due to permanent TVA overhead power lines that cannot be relocated.
8	X	✓	✓	✓	There site is inundated with potential wetlands, which cover a minimum of 25% of the total area, not including buffer zones.
9	✓	✓	✓	✓	This site passes the Threshold Criteria screening.
10	✓	✓	X	✓	Approximately 29% of the area is unavailable due to presence of floodplains.
11	✓	✓	✓	✓	This site passes the Threshold Criteria screening.

✓—Meets Threshold Criterion
X—Fails Threshold Criterion

an on-site waste disposal facility. The secondary screening was conducted to identify the most viable location(s) to represent the on-site disposal alternative for the RI/FS evaluation. Unlike the Threshold Criteria, which were designed to be applied on a pass-fail basis, the Secondary Criteria were designed to be scored on a relative scale according to a site's ability to meet the criteria.

After preliminary discussion among all members of the SSG, the weights for the Secondary Criteria were developed by the site screening lead and two SSG members. Additionally, input was received from the Regulators and incorporated into the final screening table. The site scoring matrix that was issued to the SSG for the Secondary Screening did not contain the weighting factors. This approach was implemented, in addition to the use of a relatively low scale for scores (0 to 3) and weighting factors (1 to 3), to minimize the potential for subjectivity in the scoring process. The site screening lead also facilitated a site screening orientation meeting with the SSG to describe the materials and provide additional insights to the process. Subsequent to the independent scoring by the SSG members, the scores were compiled and provided to the SSG for review. A follow-up meeting then was held to discuss the results of the Secondary Screening and determine if the process had achieved its purpose of clearly defining one or more sites to represent the on-site disposal alternative for the RI/FS. The SSG was of the unanimous opinion that the process had successfully served its purpose. In addition to deriving the total site scores, subtotals were summed individually for what were designated as "inherent" vs. "logistical" criteria. Inherent criteria are intrinsic site characteristics such as geology, hydrogeology, and natural site hydrology. Logistical criteria are factors such as information availability, location of power lines, existing infrastructure, and site access that represent more short-term, constructability considerations compared to the long-term inherent factors. These factors are temporary when compared to the long-term considerations for a permanent disposal facility. Kentucky regulators requested this approach in an August 13, 2009, teleconference to help ensure that the best site is selected to represent on-site disposal based on intrinsic site characteristics rather than factors of relative short-term constructability convenience.

E.4.3 SECONDARY SCREENING RESULTS

Table E.3 presents the summary results of the Secondary Screening, including the list of secondary criteria, weighting factors, scoring, and designation of criteria as inherent or external. Table E.4 provides a summary of site scores along with site rankings by each SSG member.

Site 3A scored the highest of the four sites in both total scoring and the inherent criteria subtotal scoring reflected in Table E.3. Notably, Table E.4 shows that Site 3A was ranked highest by all seven SSG members. The consistent ranking of Site 3A, in spite of occasionally divergent scores among the SSG for several criteria, indicates that the screening process, in particular the scoring and weighting structure, was successful in limiting subjectivity by dampening undue bias from an extremely high or low score for one or two criteria.

Based on the scoring and ranking results, the SSG deemed Site 3A as the recommended choice to represent the on-site disposal alternative. Recommending Site 3A, however, does not indicate that Sites 1, 5A, 9, or 11 are not adequate for construction of a potential waste disposal facility. The RI/FS presented conceptual designs and preliminary waste acceptance criteria for two "prototype" sites, one from each of the hydrologic settings at PGDP. The prototype sites were Site 3A and Site 11.

Table E.3. Secondary Site Screening Scores

SECONDARY CRITERIA	Weight Factor	WEIGHTED SITE SCORES 1	3A	5A	9	11	Inherent
Hydrologic Considerations							
Proximity to the 100-year and 500-year floodplains	2	22	40	42	30	32	Y
Distance to streams	2	24	34	34	24	20	Y
Distance to water wells	2	38	40	28	24	16	Y
Hydrogeologic setting	3	57	57	33	12	15	Y
Terrain Stability							
Surface geologic processes and topography	1	12	16	19	19	13	Y
Information Availability							
Seismic Data	3	24	60	24	27	57	N
Geotechnical Data	2	14	34	20	22	34	N
Hydrologic Data	2	22	20	30	34	32	N
Site Contamination							
Soil contamination	2	24	36	20	6	30	Y
Groundwater contamination	3	60	63	18	6	24	Y
Land Use							
Industrial vs. recreational land use	3	12	54	42	63	36	N
Existing facilities requiring demolition	2	40	28	16	6	34	N
Expandability	2	30	22	26	24	12	Y
Transportation Access							
Site access	1	10	18	20	18	17	N
Impacts to roads	2	26	24	32	30	16	N
Utilities							
Relocation of existing utilities	2	16	16	20	30	42	N
Existing support infrastructure	1	5	9	13	16	19	N
Buffers							
Physical buffer space	1	7	7	15	20	5	Y
NEPA Considerations							
Wetlands	2	32	14	30	32	30	Y
Threatened & endangered species and sensitive habitats	3	18	60	36	12	9	Y
Aesthetics	2	26	22	34	42	26	Y
WEIGHTED SCORES PER SITE:	Inherent	350	411	335	251	232	
	External	169	263	217	246	287	
	TOTAL	519	674	552	497	519	

Weighting Range: 1-3

Table E.4. SSG Summary Site Screening Scores

SECONDARY CRITERIA WEIGHTED SCORES BY SCORING MEMBER	TOTAL WEIGHTED SITE SCORES					SITE SCORE RANKINGS				
	1	3A	5A	9	11	1	3A	5A	9	11
1	75	93	81	73	76	4	1	2	5	3
2	75	95	77	68	67	3	1	2	4	5
3	70	94	70	73	81	4	1	4	3	2
4	88	104	83	82	83	2	1	3	4	3
5	62	97	78	64	66	5	1	2	4	3
6	71	94	82	75	72	5	1	2	3	4
7	78	97	81	62	74	3	1	2	5	4
TOTAL Weighted Scores and Rankings Per Site:	519	674	552	497	519	26	7	17	28	24

E.5. REGULATORY INTERFACE

DOE solicited input from the U.S. Environmental Protection Agency (EPA) Region 4 and Kentucky regulatory agencies on development of the screening methodology, the siting criteria and weighting factors, and results of the screening process. A teleconference was held August 5, 2009, to discuss the proposed siting methodology, and on August 13 to discuss development of the siting criteria and weighting for the Secondary Criteria. Regulator comments from the two teleconferences were incorporated into the process before the site screening and scoring was finalized.

As part of the CERCLA process, and as defined in the Federal Facility Agreement (FFA) for PGDP, EPA and the Kentucky regulators will continue to provide input to DOE on the CERCLA waste disposal alternatives, including the recommended site to represent the on-site disposal alternative. This input will include comments on the RI/FS report, proposed plan, ROD, and any post-ROD documentation if the on-site alternative is selected.

E.6. PUBLIC PARTICIPATION

Public participation is integral to the CERCLA process. Soliciting public preference on the location of a potential on-site waste disposal facility is critical to the current evaluation of CERCLA waste disposal alternatives for PGDP. The general siting study approach and siting considerations were discussed at the March 24, 2009, public meeting. Additionally, the RI/FS work plan was made available to CAB members upon its release and the CAB has provided comments to DOE for consideration (DOE 2011). A special public meeting will be held to present the details of the candidate sites, screening criteria and methodology, and results.

The public will have additional opportunity for input to the site selection process including review of CERCLA documentation. The proposed plan will present the alternatives evaluated, including the recommended location for a disposal facility if the on-site alternative is selected. The public will have the opportunity to comment formally on the proposed plan. Public comments could result in modification of the preferred alternative, including a change in on-site vs. off-site disposal or the recommended location of an on-site disposal facility. The recommended location for the Environmental Management Waste Management Facility at the DOE Oak Ridge Reservation was changed based on public comment, demonstrating a precedent for flexibility in the siting process in response to public preference.

E.7. POST-ROD ACTIVITIES

If on-site disposal is selected as the preferred alternative, additional data collection will be required to support facility design. Definition of data needs would be agreed upon by DOE and the regulators and would be presented in a Remedial Action Work Plan, subject to comment-review cycles consistent with the FFA.

E.8. REFERENCES

DOE (U.S. Department of Energy) 1996. *Identification and Screening of Candidate Sites for the Environmental Management Waste Management Facility, Oak Ridge, Tennessee*, DOE/OR/02-1508&D1, U.S. Department of Energy, Oak Ridge, TN, September.

DOE 2000. *Initial Assessment of Consideration of On-Site Disposal of CERCLA Waste Facility as a Potential Disposal Option at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1893&D1, U.S. Department of Energy, Paducah, KY, July.

DOE 2001. *Identification and Screening of Candidate Sites for a Potential Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1939&D1, U.S. Department of Energy, Paducah, KY, March.

DOE 2004. *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2038&D2, U.S. Department of Energy, Paducah, KY, March.

DOE 2011. *Work Plan for CERCLA Waste Disposal Alternative Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Plant, Paducah, Kentucky,* DOE/LX/07-0099&D2/R2, October.

GEO (GEO Consultants, LLC) 2009. *Assessment of the Adequacy of Geotechnical and Hydrogeological Data in the Terrace Setting to Support a Remedial Investigation/Feasibility Study (RI/FS)-Level Evaluation of Potential Waste Disposal Sites, Paducah, Kentucky*, GEO/09-207, R2, August.

KRCEE (Kentucky Research Consortium for Energy and Environment) 2006. *Investigation of Holocene Faulting, Proposed C-746-U Landfill Expansion, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, William Lettis and Associates, Inc. (author) UK/KRCEE Doc # 17.6, July, (Available electronically at http://www.uky.edu/krcee/Reports.html).

ATTACHMENT E1

TRANSPORTATION RISK CALCULATION PACKAGE

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E1.1 TRANSPORTATION RISK CALCULATION PACKAGE

ASSUMPTIONS

1. High-End Waste Volume (3,952,110 yd^3) is used for upper bounds of estimated transportation risks for the On-Site and Off-Site Alternatives

2. Waste volume breakdown

   - LLW: 3,871,220 yd^3 (from Appendix H Table H2.9)
   - TSCA: 7,050 yd^3 (from Appendix H Table H2.10)
   - MLLW: 73,840 yd^3 (requires disposal by truck) (from Appendix H Table H2.11)
   - Classified Waste: 215,700 yd^3 (from Appendix H Table H2.12)

3. Railroad miles from Paducah Gaseous Diffusion Plant (PGDP) to Energy*Solutions* (Clive, UT)

   - 2,092 miles one-way
   - 4,184 miles round trip

4. Highway miles from PGDP to Energy*Solutions* (obtained from MapQuest)[1]

   - 1,670 miles one-way
   - 3,340 miles round trip

5. Highway miles from PGDP to Nevada National Security Site (NNSS) (obtained from MapQuest)[1]

   - 1,828 miles one-way
   - 3,656 miles round trip

6. Amount of waste/dump truck: 12 yd^3 (based on Oak Ridge/Environmental Management Waste Management Facility experience)

7. Highway injury and fatality rates are adequate for estimating transportation risk for dump trucks transporting waste for on-site disposal

8. Average distance from waste generation sites to on-site disposal facility and on-site rail loading facility is one mile (two miles round trip by truck)

9. Off-Site Alternative: Total number of railcars (gondolas) required—29,915 railcars

   - 29,874 for LLW (from Appendix H Table H2.9)
   - 41 for TSCA (from Appendix H Table H2.10)

[1] U.S. Department of Transportation (DOT) routing of shipments was not assessed fully; however, routes around large downtowns were considered. Differences in route distances resulting from DOT routing are expected to be small compared to the overall distance.

10. Off-Site Alternative: Total number of truckloads of waste—9,546 loads

- 2,462 for MLLW
- 7,084 for Classified Waste

11. Off-Site Alternative: Waste volume breakdown for yd^3/railcar (from Appendix H)

- High-sided gondola volume = 232 $yd^3$with 75% packing efficiency = 174 yd^3
- Low-sided gondola volume = 102 $yd^3$with 90% packing efficiency = 91 yd^3
- Average gondola volume = 3,871,220 yd^3/29,874 railcars = 130 yd^3/railcar

12. On-Site Alternative: Amount of waste not meeting waste acceptance criteria (WAC) for on-site disposal facility: 5% of 3,952,110 yd^3 or 197,606 yd^3 (assumed to be LLW for costing and risk assessment purposes) (See Section 6.4.5.1)

13. On-Site Alternative: Number of railcars required for off-site disposal of LLW not meeting WAC for on-site disposal facility: 197,606 yd^3/130 yd^3/railcar = 1,521 railcars

E1.2 INJURY AND FATALITY RATES

E1.2.1 RAIL

Injury and fatality rates were calculated by computing average rates from the state-specific injury and fatality rates (DOE 2002; Table 6.40) for states that railcars pass through en route from PGDP to Energy*Solutions.*

- Injury Rates:

State	Injury Rate (injuries per railcar-mile)
Kentucky	6.86E-08
Illinois	7.00E-08
Missouri	3.38E-08
Kansas	3.48E-08
Iowa	6.87E-08
Nebraska	2.00E-08
Wyoming	2.17E-09
Utah	3.78E-08
Weighted Average	**4.20E-08**

- Fatality Rates:

State	Fatality Rate (fatalities per railcar-mile)
Kentucky	2.37E-08
Illinois	4.15E-08
Missouri	1.85E-08

State	Fatality Rate (fatalities per railcar-mile)
Kansas	1.60E-08
Iowa	1.98E-08
Nebraska	1.19E-08
Wyoming	3.80E-09
Utah	4.09E-08
Weighted Average	**2.20E-08**

E1.2.2 HIGHWAY

Injury and fatality rates for combination trucks (heavy tractor-trailer combinations) were calculated by computing average rates from the state-specific injury and fatality rates (DOE 2002; Tables 6.38 and 6.39) for states that trucks pass through en route from PGDP to Energy*Solutions* and en route from PGDP to NNSS.

- Injury Rates:

State	PGDP to Energy*Solutions* (injuries per mile)	State	PGDP to NNSS (injuries per mile)
Kentucky	5.81E-07	Kentucky	5.81E-07
Illinois	2.64E-07	Missouri	5.87E-07
Missouri	5.87E-07	Arkansas	2.00E-07
Kansas	5.55E-07	Oklahoma	4.59E-07
Iowa	1.82E-07	Texas	8.64E-07
Nebraska	4.17E-07	New Mexico	1.74E-07
Wyoming	5.20E-07	Arizona	1.48E-07
Utah	4.57E-07	Nevada	2.61E-07
Weighted Average	**4.45E-07**	**Weighted Average**	**4.09E-07**

- Fatality Rates:

State	PGDP to Energy*Solutions* (fatalities per mile)	State	PGDP to NNSS (fatalities per mile)
Kentucky	3.69E-08	Kentucky	3.69E-08
Illinois	1.77E-08	Missouri	3.17E-08
Missouri	3.17E-08	Arkansas	3.57E-08
Kansas	3.69E-08	Oklahoma	2.37E-08
Iowa	2.16E-08	Texas	4.35E-08
Nebraska	3.01E-08	New Mexico	1.77E-08
Wyoming	2.00E-08	Arizona	1.51E-08
Utah	2.24E-08	Nevada	1.43E-08
Weighted Average	**2.71E-08**	**Weighted Average**	**2.73E-08**

E1.3 TRANSPORTATION RISK FOR OFF-SITE ALTERNATIVE DISPOSAL OF WASTE

- Evaluated transportation of 3,952,110 yd^3 by truck to on-site facility for loading rail cars and release of trucks for off-site disposal
- Evaluated waste disposal by rail from PGDP to Energy*Solutions* (see Appendix H for a breakdown of volume by material type [soil, concrete, debris, etc.])
- LLW (3,871,220 yd^3)
- TSCA (7,050 yd^3)
- MLLW (73,840 yd^3)
- Evaluated waste disposal by truck from PGDP to NNSS for Classified waste (215,700 yd^3)

E1.3.1 RISK FOR TRUCK TRANSPORTATION ON-SITE FROM GENERATION AREA TO LOADING AREA

- 3,952,110 yd^3/12 yd^3/truck = 329,343 (total truckloads) x 2 (round trip miles to truck/rail staging/loading facility) = 658,686 miles
- Injury rate for Kentucky = 5.81E-07 injuries per mile
- Fatality rate for Kentucky = 3.69E-08 fatalities per mile
- 5.81E-07(injuries/mile) x 658,686 (miles) = 0.38 injuries
- 3.69E-08 (fatalities/mile) x 658,686 (miles) = 0.024 fatalities

E1.3.2 RISK FOR TRANSPORTATION BY RAIL

- 29,915 (total railcars) x 4,184 (round trip miles from PGDP to Energy*Solutions*) = 125,164,360 railcar miles
- 4.20E-08 (injuries/railcar mile) x 125,164,360 (railcar miles) = 5.3 injuries
- 2.20E-08 (fatalities/railcar mile) x 125,164,360 (railcar miles) = 2.8 fatalities

E1.3.3 RISK FOR TRANSPORTATION BY HIGHWAY

- **PGDP to Energy*Solutions***
  - — Highway miles round trip from PGDP to Energy*Solutions* = 3,340 miles x 2,462 (truck shipments to Energy*Solutions*) = 8,223,080 miles (PGDP to Energy*Solutions*)

- 4.45E-07 (injuries/mile) x 8,223,080 (miles) = 3.7 injuries

- 2.71E-08 (fatalities/mile) x 8,223,080 (miles) = 0.22 fatalities

- **PGDP to NNSS**

  - Highway miles round trip from PGDP to NNSS = 3,656 miles x 7,084 (truck shipments to NNSS) = 25,899,365 miles (PGDP to NNSS)

  - 4.09E-07 (injuries/mile) x 25,899,365 (miles) = 10.6 injuries

  - 2.73E-08 (fatalities/mile) x 25,899,365 (miles) = 0.71 fatalities

- **Totals**

  - Total highway injuries = 3.7 (injuries from PGDP to Energy*Solutions*) + 10.6 (injuries from PGDP to NNSS) = 14.3 injuries

  - Total highway fatalities = 0.22 (fatalities from PGDP to Energy*Solutions*) + 0.71 (fatalities from PGDP to NNSS) = 0.93 fatalities

E1.3.4 TOTAL RISK FOR OFF-SITE WASTE DISPOSAL

- 0.38 (on-site injuries) + 5.3 (injuries by rail) + 14.3 (highway injuries) = 20 injuries
- 0.024 (on-site fatalities) + 2.8 (fatalities by rail) + 0.93 (highway fatalities) = 3.7 fatalities

E1.4 TRANSPORTATION RISK FOR ON-SITE ALTERNATIVE DISPOSAL OF WASTE

- Evaluated transportation of 5% of waste by truck to on-site facility for loading rail cars for off-site disposal;

- Evaluated waste disposal by rail from PGDP to Energy*Solutions* for 5% of waste not meeting WAC for on-site disposal facility; and

- Evaluated transportation of 95% of waste volume by truck to on-site disposal facility.

E1.4.1 RISK FOR TRUCK TRANSPORTATION ON-SITE FROM GENERATION AREA TO LOADING AREA (FOR 5% OF WASTE NOT MEETING THE ON-SITE FACILITY WAC)

- 197,606 yd^3/12 yd^3/truck = 16,468 (total truckloads) x 2 (round trip miles to rail staging/loading facility) = 32,936 miles

- Injury rate for Kentucky = 5.81E-07 injuries/mile

- Fatality rate for Kentucky = 3.69E-08 fatalities/mile

- 5.81E-07 (injuries/mile) x 32,936 (miles) = 0.019 injuries
- 3.69E-08 (fatalities/mile) x 32,936 (miles) = 0.0012 fatalities

E1.4.2 RISK FOR TRANSPORTATION BY RAIL (FOR 5% OF WASTE NOT MEETING THE ON-SITE FACILITY WAC)

- 1,521 (total railcars) x 4,184 (round trip miles from PGDP to Energy*Solutions*) = 6,363,864 railcar miles
- 4.20E-08 (injuries/railcar mile) x 6,363,864 (railcar miles) = 0.27 injuries
- 2.20E-08 (fatalities/railcar mile) x 6,363,864 (railcar miles) = 0.14 fatalities

E1.4.3 RISK FOR TRANSPORTATION BY TRUCK TO ON-SITE DISPOSAL FACILITY

- Total highway miles = 2 miles (round trip from waste generation sites to on-site disposal facility) x [3,754,505 (total yd^3 of waste)/12 (yd^3 of waste per dump truck) = 2 miles x 312,876 (dump trucks) = 625,752 miles
- Injury rate for Kentucky = 5.81E-07 injuries/mile
- Fatality rate for Kentucky = 3.69E-08 fatalities/mile
- 5.81E-07 (injuries/mile) x 625,752 (miles) = 0.36 injuries
- 3.69E-08 (fatalities/mile) x 625,752 (miles) = 0.023 fatalities

E1.4.4 TOTAL RISK FOR ON-SITE WASTE DISPOSAL

- 0.019 (on-site transportation injuries) + 0.27 (injuries by rail) + 0.36 (injuries by truck, transporting waste from the loading area to disposal facility) = 0.65 (total injuries)
- 0.0012 (on-site transportation fatalities) + 0.14 (fatalities by rail) + 0.023 (fatalities by truck, transporting waste from the loading area to disposal facility) = 0.16 (total fatalities)

E1.5 SUMMARY OF TRANSPORTATION RISKS

Transportation risks for both injury and fatality for the high-end volume scenarios of the Off-Site Alternative and the On-Site Alternative are summarized in Tables E1.1 and E1.2, respectively. A comparison of the risks shows the Off-Site Alternative transportation risks for both injury and fatality to be higher than those for the On-Site Alternative.

Table E1.1. Off-Site Alternative Transportation Risks

	On-Site Transportation*	Off-Site Transportation		
	Truck	Rail	Truck	Total
Injuries	0.38	5.3	14.3	20
Fatalities	0.024	2.8	0.93	3.8

*Truck Transportation On-Site from Generation Area to Loading Area (for 5% of waste not meeting the on-site facility WAC)

Table E1.2. On-Site Alternative Transportation Risks

	On-Site Transportation		Off-Site Transportation*	
	To On-Site Disposal Facility	To Rail Loading Facility*	Rail	Total
Injuries	0.36	0.019	0.27	0.65
Fatalities	0.023	0.0012	0.14	0.16

*Transportation for 5% of waste not meeting the on-site facility WAC; this volume is assumed to be LLW with Energy*Solutions* as the destination.

E1.6 REFERENCE

DOE 2002. *A Resource Handbook on DOE Transportation Risk Assessment*, DOE/EM/NTP/HB-01, Office of Environmental Management, National Transportation Program, July.

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APPENDIX F

CONCEPTUAL DESIGN FIGURES FOR PROTOTYPE SITES 3A AND 11

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F. CONCEPTUAL DESIGN FIGURES

The On-Site Alternative consists of constructing an aboveground waste disposal facility designed to accept the waste that has been forecasted to be generated. The conceptual designs presented in this appendix are based on low-end and high-end waste capacities [1.5 million cubic yards (mcy) and 4.0 mcy] and include two "prototype" disposal locations. The two prototype locations are Site 3A, located at the southern end of the U.S. Department of Energy (DOE) property boundary; and Site 11, located north of the current 746-U Landfill facility near the northern extent of the DOE property boundary. Each of these sites can be designed to reasonably accommodate a landfill footprint (including an earthfill dike); storm water ditches and ponds; leachate and contact water storage tanks; a security road and fence; services roads and parking; and other supporting structures/facilities. The land surface area impacted by operations for both the 1.5 mcy and 4.0 mcy waste volumes is approximately 110 acres.

The figures include a cross section of a conceptual Comprehensive Environmental Response, Compensation, and Liability Act waste disposal facility with details of the liner and cap, a conceptual schematic site plan, a conceptual site design waste management summary, and conceptual site layouts for the low-end and high-end volume for each prototype site (Figures F.1–F.9).

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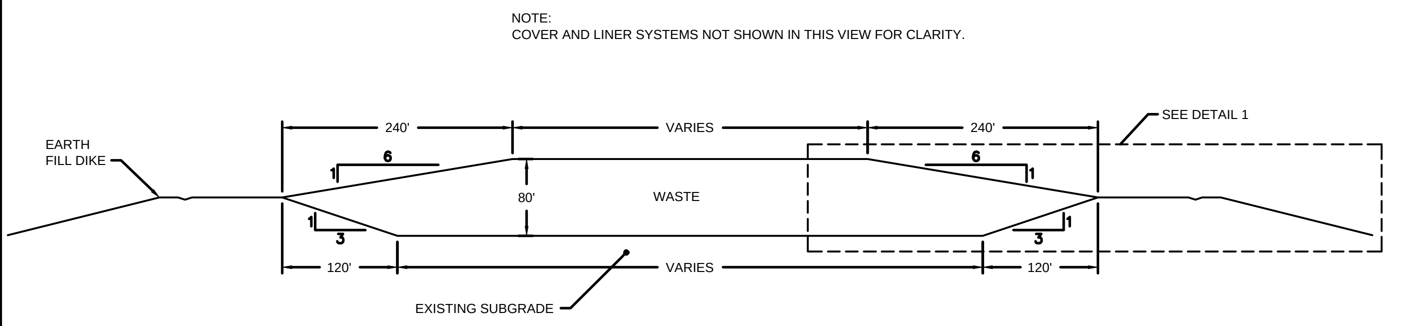
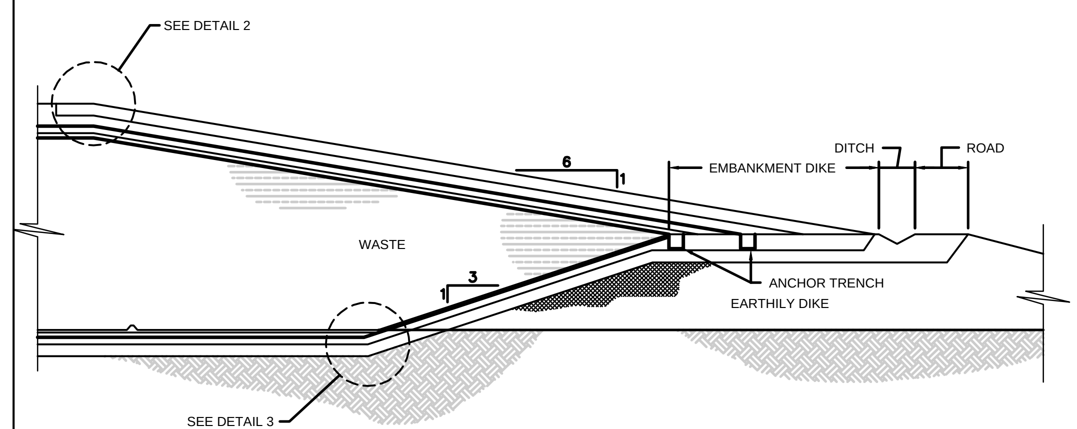
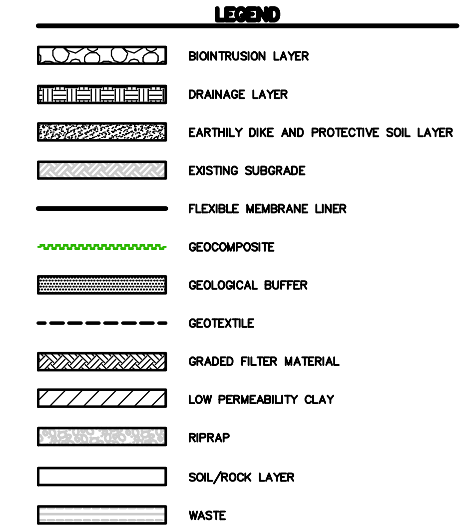


CONCEPTUAL DISPOSAL CELL CROSS SECTION



DETAIL 1

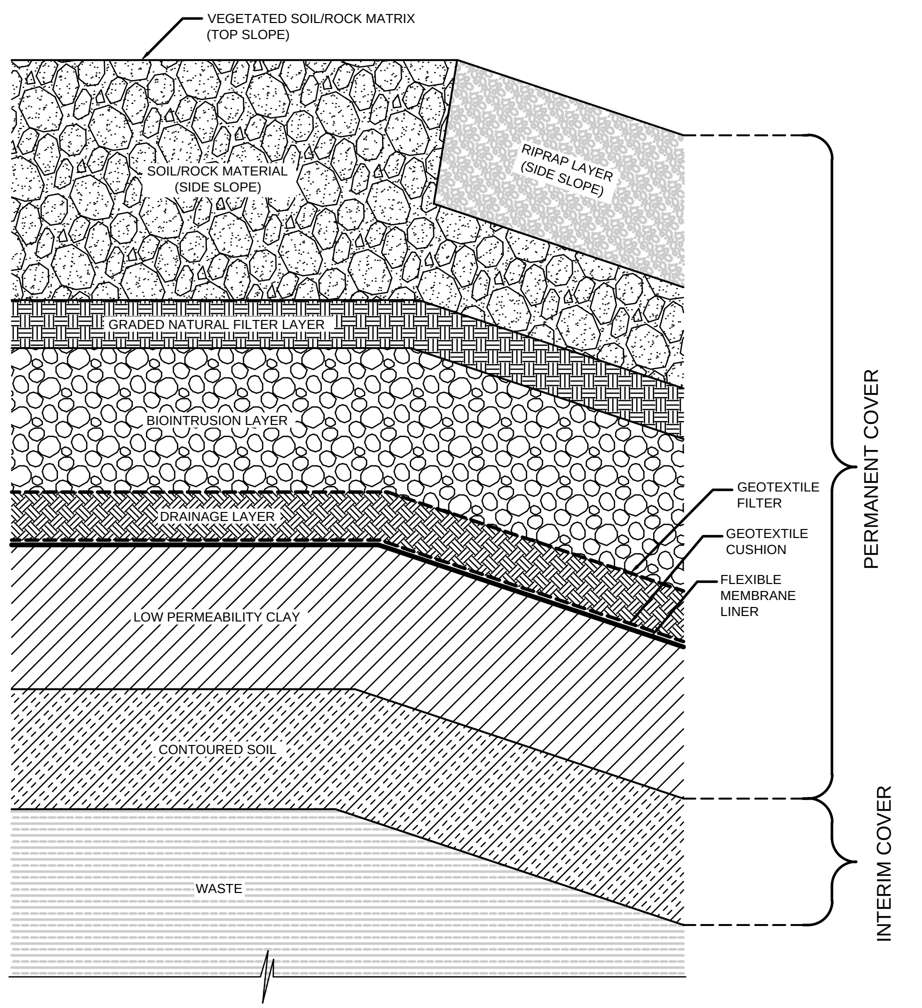


NOTES:

1. THE DISPOSAL CELL CROSS SECTION DIMENSIONS LISTED PROVIDE AN APPROXIMATE WASTE STORAGE CAPACITY BETWEEN 1.5 AND 4.0 MILLION CUBIC YARDS.
2. VEGETATIVE SOIL COVER DEPTH MAY VARY DEPENDING ON SITE-SPECIFIC CONDITIONS. VEGETATIVE SOIL WILL BE STRIPPED AND REPLACED WITH COMPACTED FILL BEFORE PERMANENT COVER IS CONSTRUCTED.

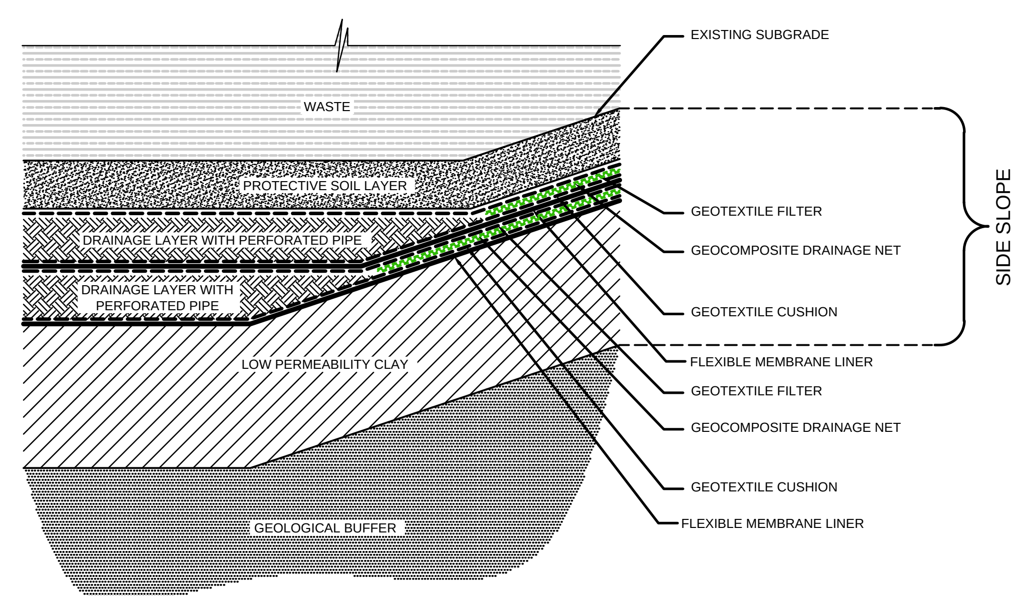
LINER AND COVER MATERIAL DESIGN CRITERIA

1. THE LOW PERMEABILITY CLAY LINER SHALL HAVE A HYDRAULIC CONDUCTIVITY OF NO MORE THAN 1 X 10^{-7} CM/SEC.
2. THE DRAINAGE LAYER MATERIALS SHALL HAVE A HYDRAULIC CONDUCTIVITY OF 1 X 10^{-2} cm/sec OR GREATER.
3. THE GEONET DRAINAGE MATERIALS SHALL HAVE A TRANSMISSITY OF 3 X 10^{-5} m^2/sec OR GREATER, AND MAY BE REPLACED BY A GRANULAR MATERIAL.
4. THE FLEXIBLE MEMBRANE LINER MATERIALS SHALL HAVE A DEMONSTRATED HYDRAULIC CONDUCTIVITY LESS THAN 1 X 10^{-12} cm/sec.
5. RIPRAP WILL BE USED ON PERMANENT COVER SIDE SLOPES ONLY IF NEEDED FOR EROSION CONTROL. THE THICKNESS OF VEGETATED SOIL/ROCK MATRIX AND RIPRAP WILL BE ESTABLISHED IN THE DETAILED DESIGN.
6. THE HEIGHT AND WIDTH OF EMBANKMENT DIKE WILL BE ESTABLISHED IN THE FINAL DESIGN.



DETAIL 2

NOT TO SCALE



DETAIL 3

NOT TO SCALE

SCALE

AS NOTED

THIS SCHEMATIC IS PROVIDED AS A SUPPLEMENT TO THE RI/FS ON-SITE DISPOSAL ALTERNATIVE. THIS DESIGN PLAN IS FOR A POTENTIAL CERCLA WASTE DISPOSAL FACILITY AT THE PADUCAH GASEOUS DIFFUSION PLANT IN PADUCAH, KENTUCKY. THIS SCHEMATIC IS FOR CONCEPTUAL DESIGN PURPOSES ONLY.

REVISIONS

REV	DESCRIPTION	EFFECTIVE DATE

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

CERCLA WASTE DISPOSAL FACILITY CONCEPTUAL CROSS SECTION

SHEET: 1 OF 9		SCALE: AS SHOWN	
		QA LEVEL: STD	DWG SIZE: D
		CONTRACT NO: -	
		DRAWING NUMBER:	REV
:		FIGURE F-1	D-1

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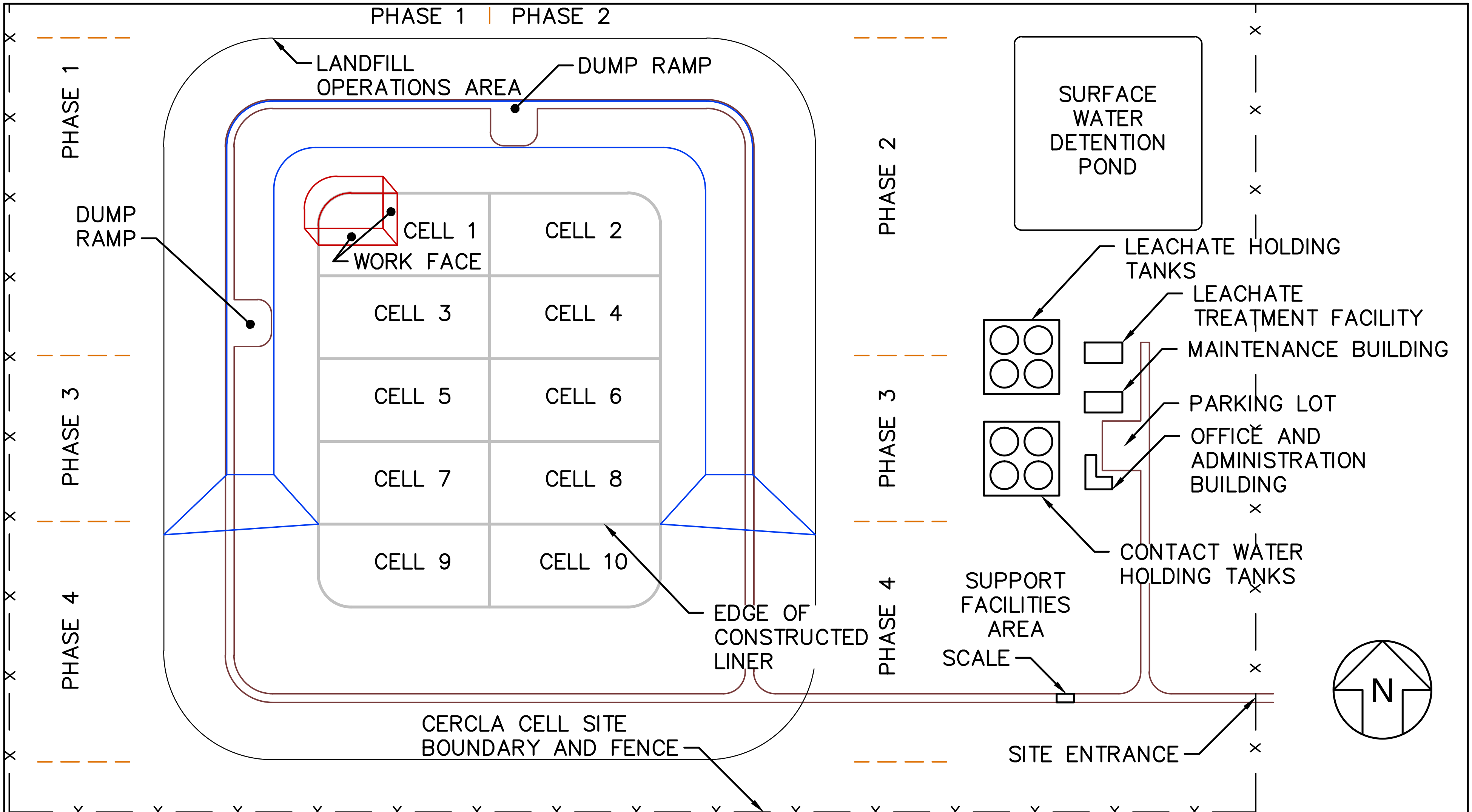


U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/
PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

CERCLA WASTE DISPOSAL CELL
CONCEPTUAL SITE DESIGN
SCHEMATIC SITE PLAN

SHEET: 2 OF 9	SCALE: AS SHOWN
QA LEVEL: STD	DWG SIZE: A
CONTRACT NO: -	
DRAWING NUMBER: FIGURE F-2	REV D-1

REVISIONS

REV	DESCRIPTION	EFFECTIVE DATE

0 400' 800'

LEGEND

- CELLS
- EARTHFILL DIKE
- ROAD
- WASTE
- LANDFILL OPERATIONS AREA
- LANDFILL ACTIVE AREA

NOTES:

1. PHASES, CELLS AND LIFTS ARE DEPICTED AS TYPICAL EXAMPLES. THE ACTUAL SIZE OF CELLS AND LIFTS TO BE DETERMINED BY ENGINEERING DESIGN.
2. WORKING FACE IS AN EXAMPLE. THE SEQUENCE OF WASTE PLACEMENT WILL BE DEVELOPED AS PART OF THE OPERATIONAL REQUIREMENTS IN WASTE PLACEMENT PLAN.

SURFACE WATER

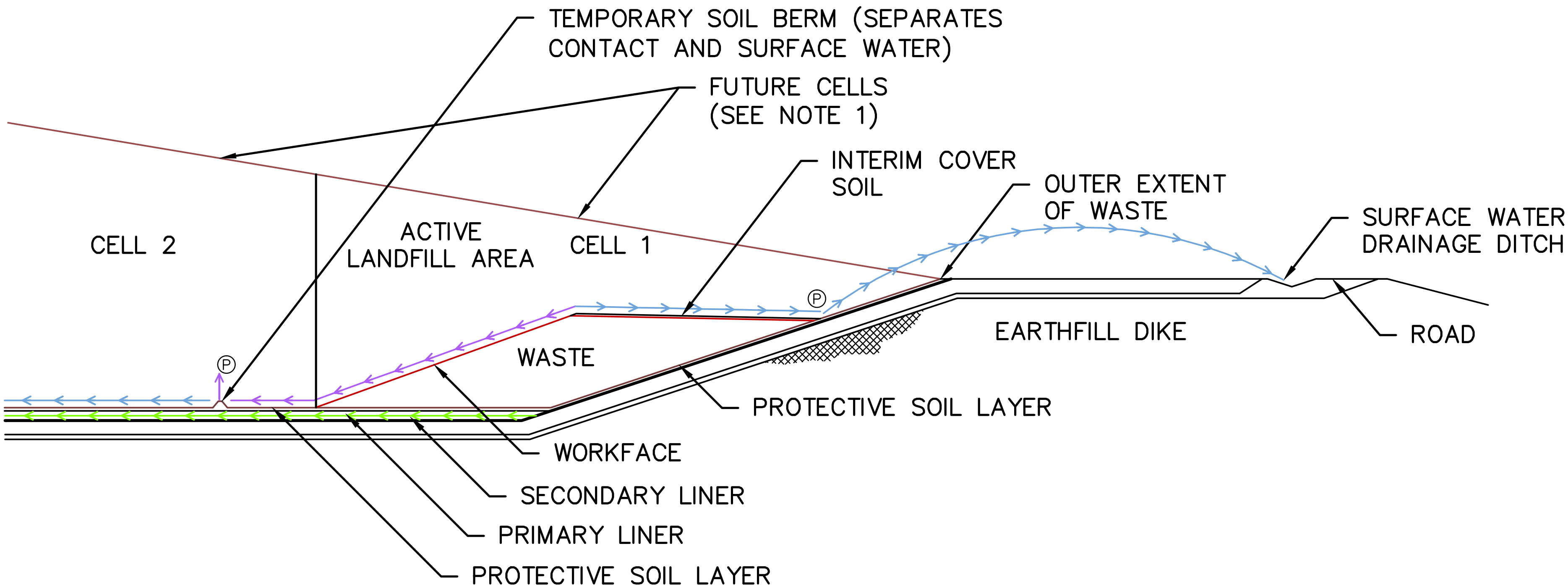
PRECIPITATION THAT HAS NOT CONTACTED WASTE. SURFACE WATER WILL BE REMOVED FROM CLEAN AREAS VIA PORTABLE PUMPS OR GRAVITY FLOW AND DIVERTED INTO DITCHES THAT WILL TRANSMIT THE WATER TO THE SURFACE WATER DETENTION POND.

LEACHATE

PRECIPITATION THAT HAS LEACHED THROUGH THE WASTE AND COLLECTED ON THE PRIMARY LINER. LEACHATE GRAVITY FLOWS TO THE LEACHATE COLLECTION SUMPS WHERE IT IS TRANSMITTED VIA PERMANENT AUTOMATED PUMPS TO THE ONSITE LEACHATE TANKS AND TREATMENT FACILITY. TREATED WATER DERIVED FROM LEACHATE WILL BE DISCHARGED VIA THE SURFACE WATER DETENTION POND.

CONTACT WATER

PRECIPITATION THAT HAS COME IN CONTACT WITH THE SURFACE OF THE ACTIVE WORKFACE.



U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/
PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

CERCLA WASTE DISPOSAL CELL
CONCEPTUAL SITE DESIGN
WATER MANAGEMENT SUMMARY

SHEET: 3 OF 9	SCALE: AS SHOWN		
	QA LEVEL: STD	DWG SIZE: A	
	CONTRACT NO: -		
	DRAWING NUMBER: FIGURE F-3	REV D-1	

THIS SCHEMATIC IS PROVIDED AS A SUPPLEMENT TO THE RI/FS ON-SITE DISPOSAL ALTERNATIVE. THIS CONCEPT DESIGN PLAN IS FOR A POTENTIAL CERCLA WASTE DISPOSAL FACILITY AT THE PADUCAH GASEOUS DIFFUSION PLANT IN PADUCAH, KENTUCKY. THIS SCHEMATIC IS FOR CONCEPTUAL DESIGN PURPOSES ONLY.

REVISIONS

REV	DESCRIPTION	EFFECTIVE DATE

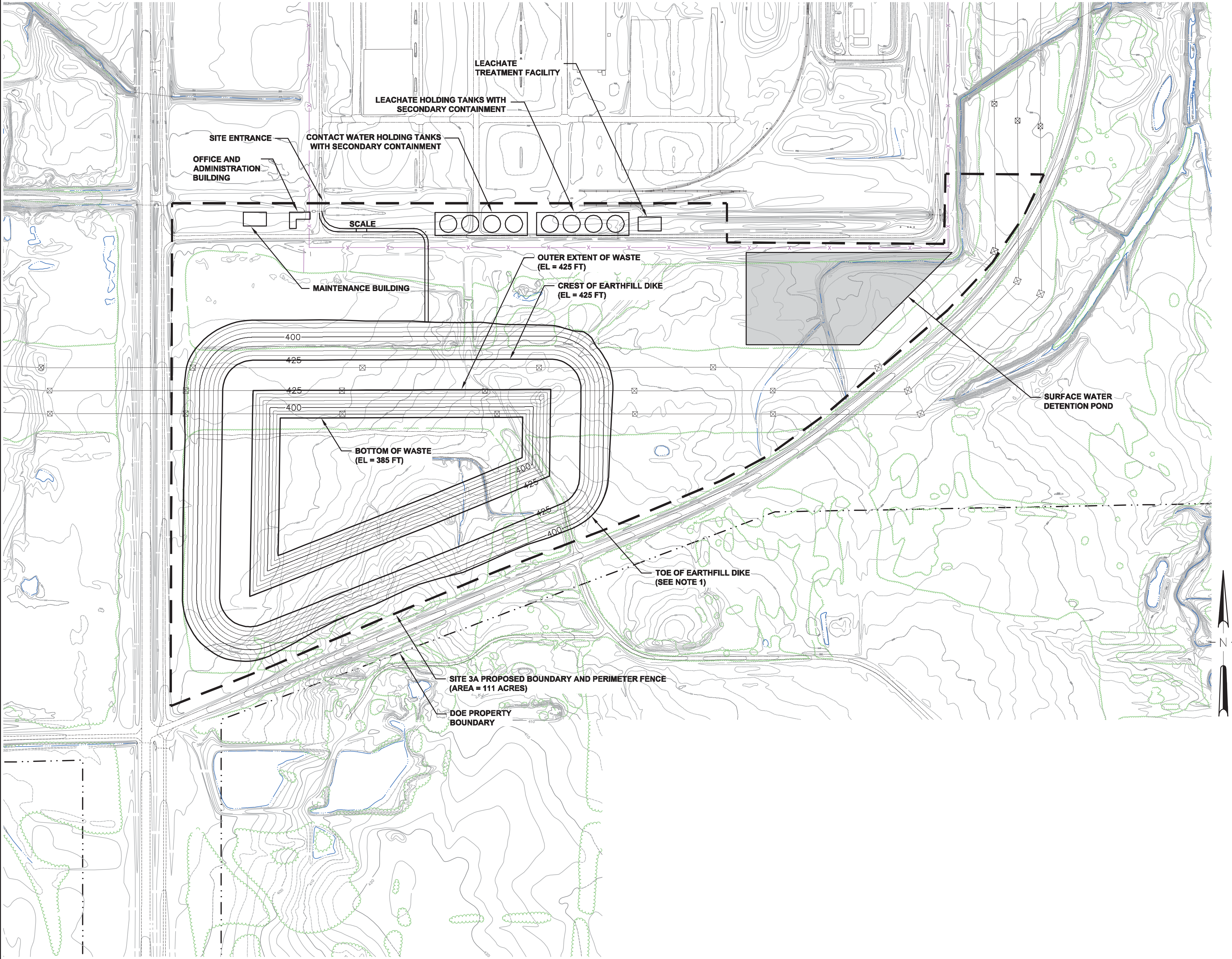
0 50' 100'

LEGEND

- CONTACT WATER
- SURFACE WATER
- LEACHATE
- FUTURE CELLS/LIFTS
- PRIMARY LINER
- SECONDARY LINER
- Ⓟ PUMP

NOTES:

1. PHASES, CELLS AND LIFTS ARE DEPICTED AS TYPICAL EXAMPLES. THE ACTUAL SIZE OF CELLS AND LIFTS TO BE DETERMINED BY ENGINEERING DESIGN.



LEGEND

- PROPOSED SITE BOUNDARY
- DOE BOUNDARY
- EXISTING ELEVATION CONTOURS
- FENCE
- GROUND COVER
- POWER LINES
- RAILROAD
- SURFACE WATER

NOTES

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SCALE

0' 100' 200' 300' 400' 500' 600'

THIS SCHEMATIC IS PROVIDED AS A SUPPLEMENT TO THE RI/FS ON-SITE DISPOSAL ALTERNATIVE. THIS DESIGN PLAN IS FOR A POTENTIAL CERCLA WASTE DISPOSAL FACILITY AT THE PADUCAH GASEOUS DIFFUSION PLANT IN PADUCAH, KENTUCKY. THIS SCHEMATIC IS FOR CONCEPTUAL DESIGN PURPOSES ONLY.

REVISIONS

REV	DESCRIPTION	EFFECTIVE DATE

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC

CERCLA WASTE DISPOSAL FACILITY
CONCEPTUAL SITE LAYOUT - SITE 3A
LOW END VOLUME - 1.5 MCY

SHEET: 4 OF 9		SCALE: AS SHOWN	
DESIGN: R. SCHWALLER	6/7/10	QA LEVEL: STD	DWG SIZE: D
DRAWN: D. STRATTON	6/7/10	CONTRACT NO.: -	
CHECKED: R. SCHWALLER	6/7/10	DRAWING NUMBER: FIGURE F-4	REV D-1
APPROVED: -	-		

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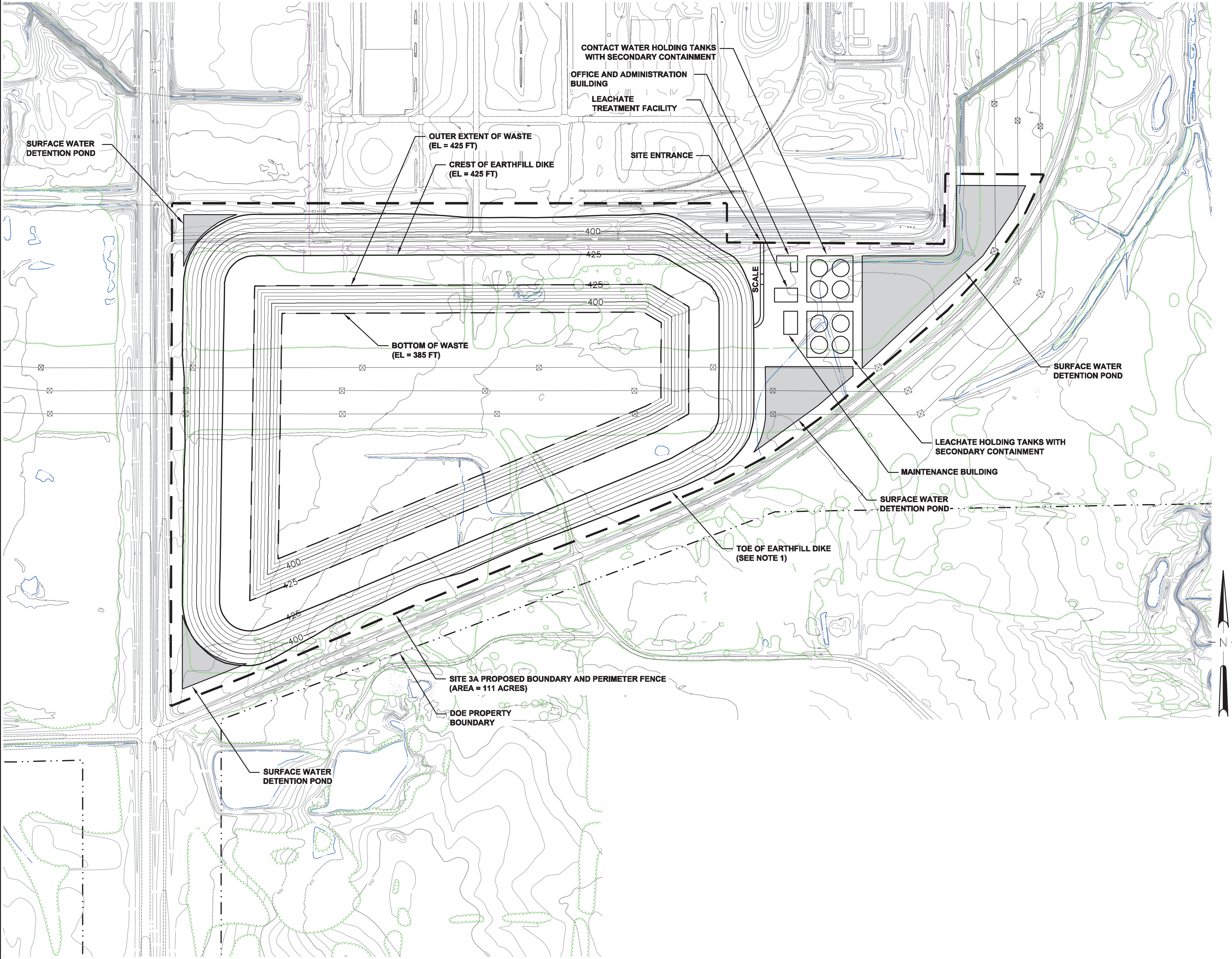

LEGEND

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DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC

CERCLA WASTE DISPOSAL FACILITY CONCEPTUAL SITE LAYOUT - SITE 3A HIGH END VOLUME - 4.0 MCY

SHEET: 5 OF 9		SCALE: AS SHOWN	
DESIGN: R. SCHWALLER	6/7/10	QA LEVEL: STD	DWG SIZE: D
DRAWN: D. STRATTON	6/7/10	CONTRACT NO.: -	
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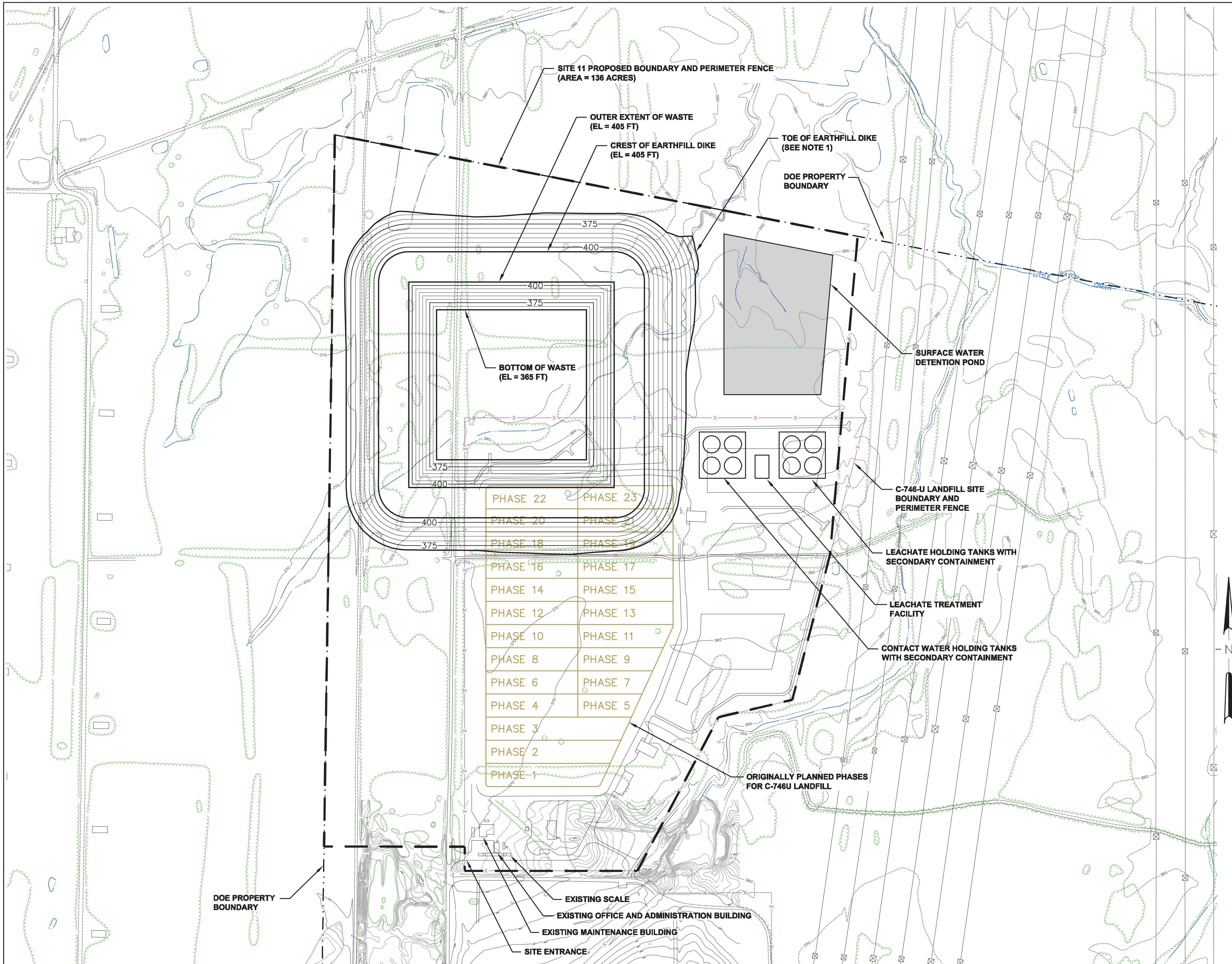

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PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC

CERCLA WASTE DISPOSAL FACILITY
CONCEPTUAL SITE LAYOUT - SITE 11
LOW END VOLUME - 1.5 MCY

SHEET: 6 OF 9		SCALE: AS SHOWN		
DESIGN: R. SCHWALLER	6/7/10	QA LEVEL: STD	DWG SIZE: D	
DRAWN: D. STRATTON	6/7/10	CONTRACT NO.: -		
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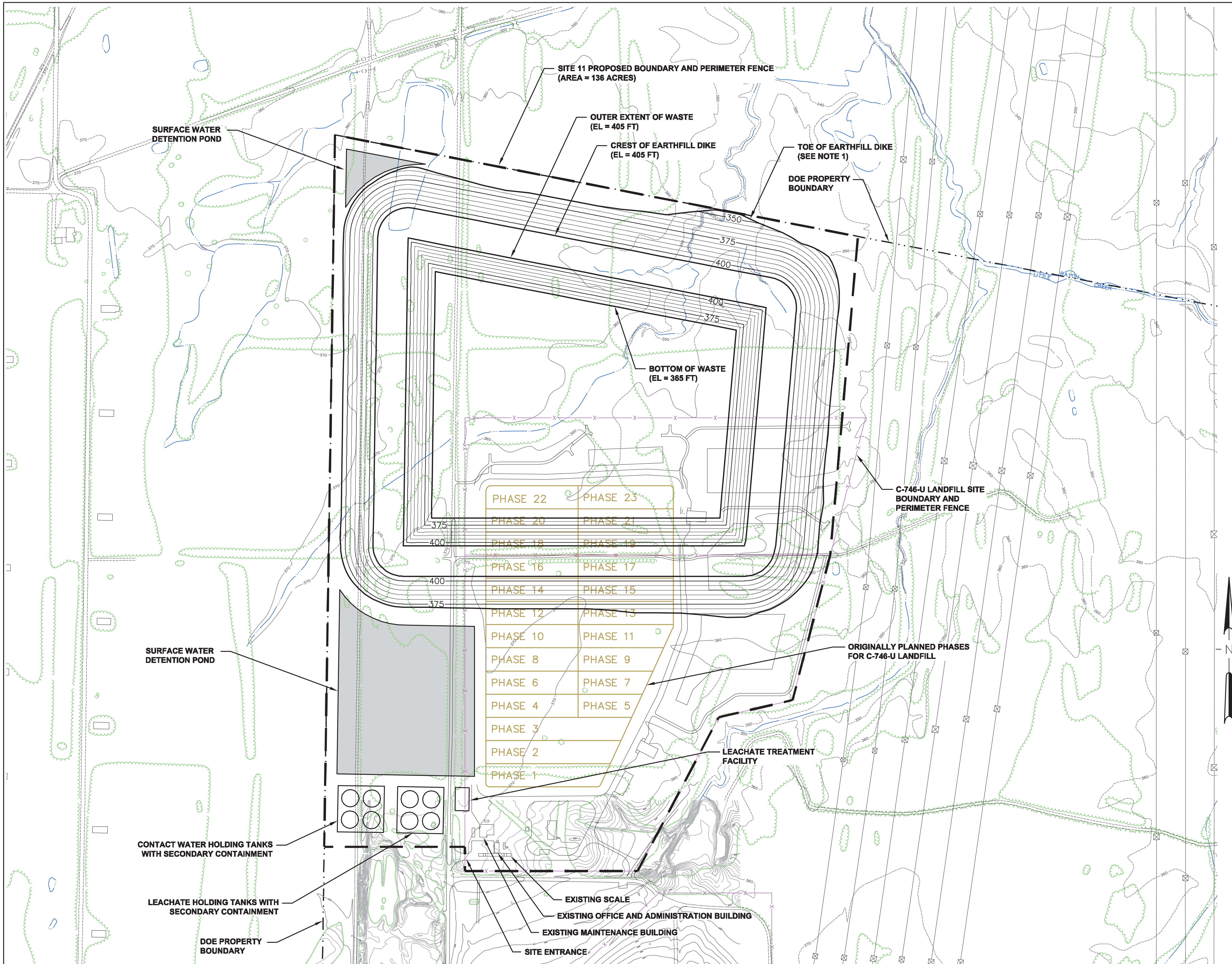
APPROVED: -	-	FIGURE F-6		D-1



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LEGEND

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LATA Environmental Services of Kentucky, LLC

CERCLA WASTE DISPOSAL FACILITY CONCEPTUAL SITE LAYOUT - SITE 11 HIGH END VOLUME - 4.0 MCY

SHEET: 7 OF 9		SCALE: AS SHOWN	
DESIGN: R. SCHWALLER	6/7/10	QA LEVEL: STD	DWG SIZE: D
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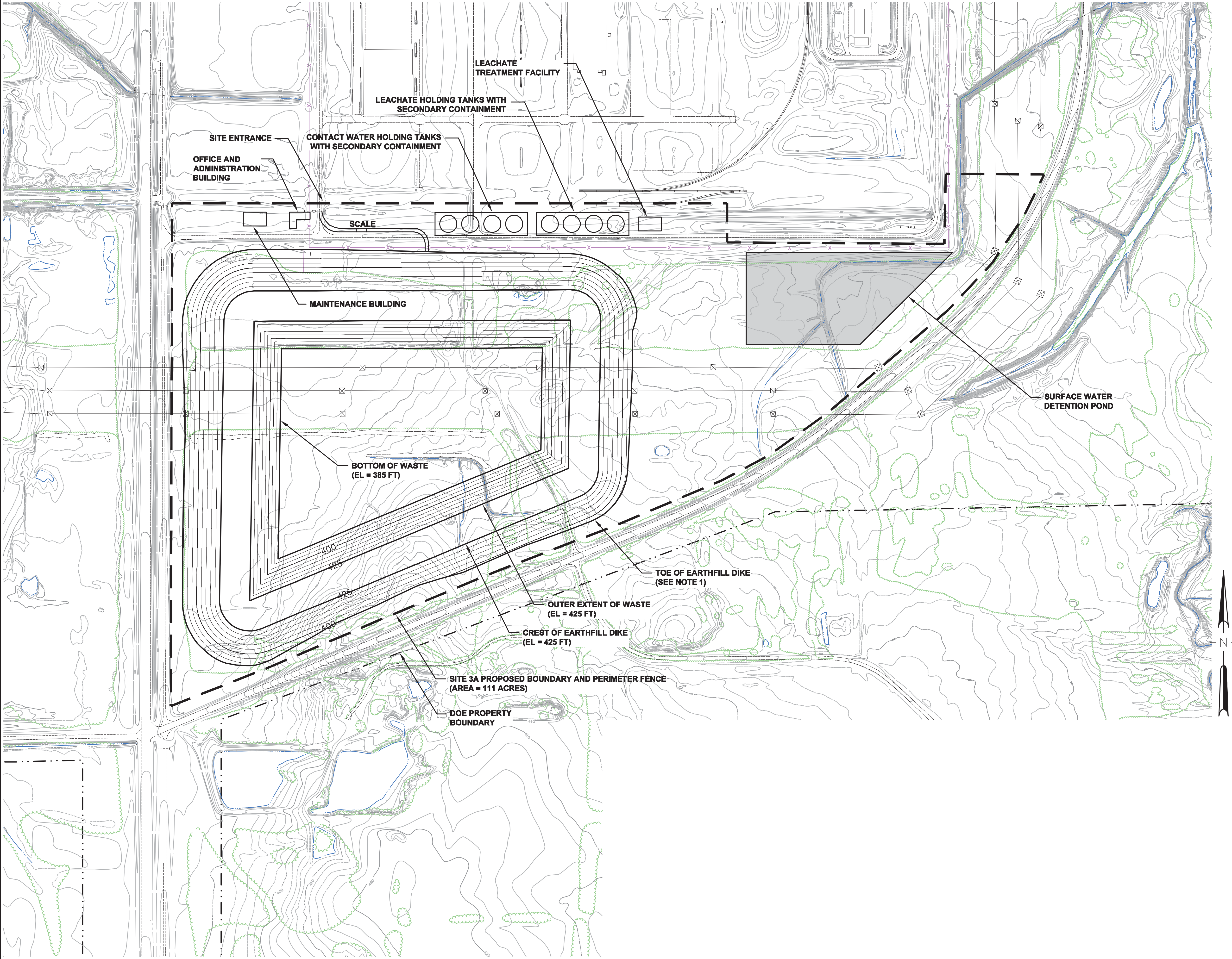

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PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC

CERCLA WASTE DISPOSAL FACILITY CONCEPTUAL SITE LAYOUT - SITE 3A MOST LIKELY VOLUME - 2.6 MCY

SHEET: 8 OF 9		SCALE: AS SHOWN		
DESIGN: R. SCHWALLER	6/7/10	QA LEVEL: STD	DWG SIZE: D	
DRAWN: D. STRATTON	6/7/10	CONTRACT NO.: -		
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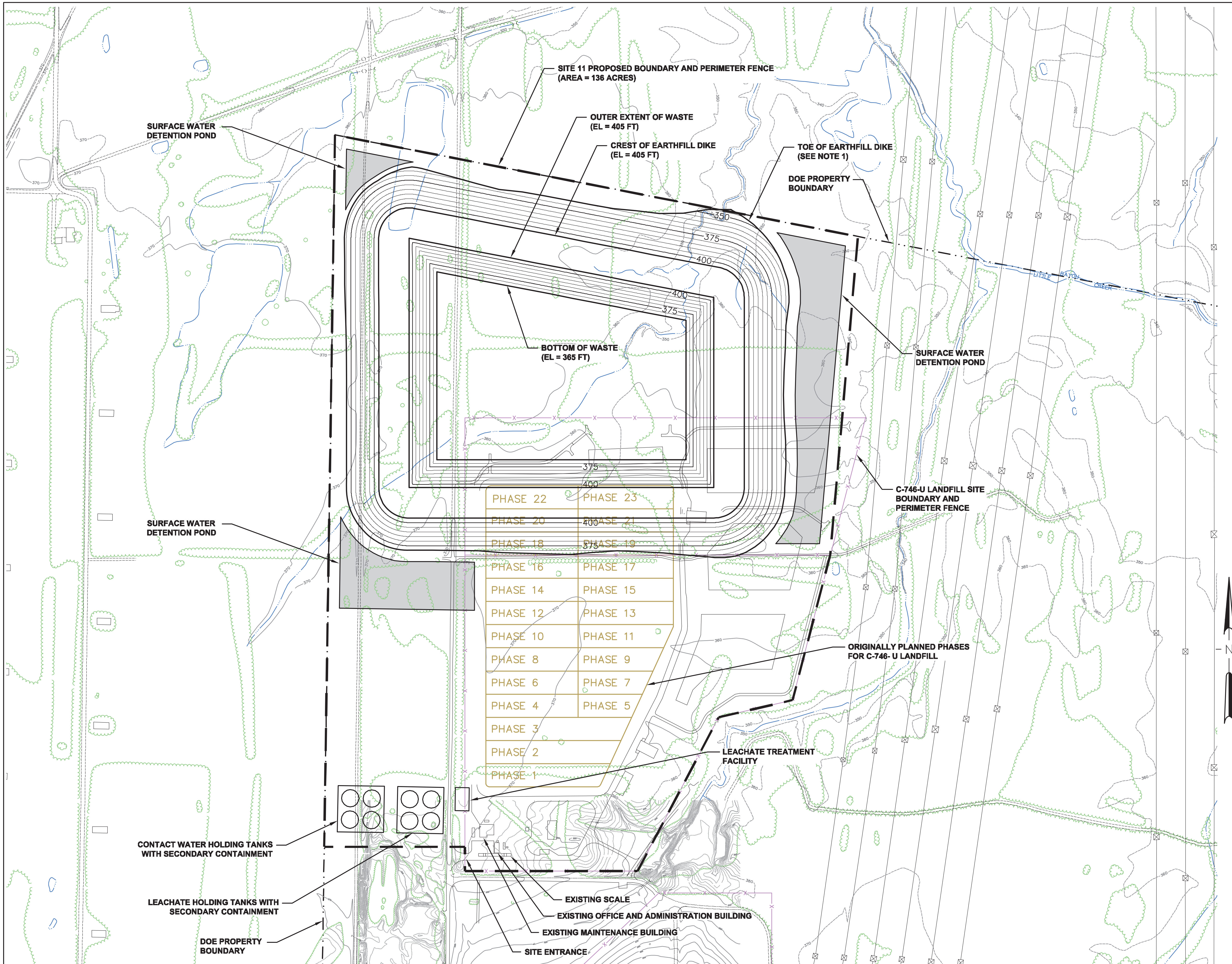
APPROVED: -	-	FIGURE F-8		D-1



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CERCLA WASTE DISPOSAL FACILITY CONCEPTUAL SITE LAYOUT - SITE 11 MOST LIKELY VOLUME - 2.6 MCY

SHEET: 9 OF 9		SCALE: AS SHOWN	
DESIGN: R. SCHWALLER	6/7/10	QA LEVEL: STD	DWG SIZE: D
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APPENDIX G

ARARS

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
CAMU	corrective action management unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COE	U.S. Army Corps of Engineers
DOE	U.S. Department of Energy
EDE	effective dose equivalent
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FR	*Federal Register*
KAR	*Kentucky Administrative Regulation*
KPDES	Kentucky Pollutant Discharge Elimination System
LLW	low-level waste
MTR	minimum technology requirement
NAGPRA	Native American Graves Protection and Repatriation Act
NRC	Nuclear Regulatory Commission
PCB	polychlorinated biphenyl
PGDP	Paducah Gaseous Diffusion Plant
PHC	principal hazardous constituents
PQL	practical quantitation limit
OSHA	Occupational Safety and Health Administration
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
T&E	threatened and endangered
TBC	to be considered
TSCA	Toxic Substances Control Act
USC	*United States Code*
WDF	waste disposal facility
WWTU	wastewater treatment unit

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G.1. ARARS

G.1.1 INTRODUCTION

Congress specified in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) § 121 that remedial actions for the cleanup of hazardous substances must require a level or standard of control that attains those requirements, criteria, standards, or limitations under federal or more stringent state environmental laws that are legally applicable or relevant and appropriate requirement (ARAR) to the hazardous substances or circumstances at a site (unless an ARAR is waived). ARARs include those federal and state laws/regulations that are designed to protect the environment. ARARs do not include occupational safety or worker radiation protection requirements. The U.S. Environmental Protection Agency (EPA) requires compliance with the Occupational Safety and Health Administration (OSHA) standards independent of the ARARs process. Neither the regulations promulgated by OSHA nor U.S. Department of Energy (DOE) Orders related to occupational safety are addressed as ARARs. These requirements would be addressed in the required health and safety plans for any action.

CERCLA § 121(e) exempts on-site CERCLA activities from administrative permitting requirements [see also 40 *Code of Federal Regulations* (*CFR)* § 300.400(e)]. In addition, CERCLA on-site remedial response actions are required to comply only with the substantive requirements of a law or regulation (see EPA guidance, *CERCLA Compliance with Other Laws Manual: Interim Final*, August 1988). Substantive requirements pertain directly to the actions or conditions at a site, while administrative requirements facilitate their implementation.

The following terms are used throughout this appendix.

- **Applicable Requirements.** Are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting law that are legally applicable and specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site (40 *CFR* § 300.5).

- **Relevant and Appropriate Requirements.** Are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site (40 *CFR* § 300.5).

- **To Be Considered (TBC) Guidance.** In addition to federal or state-promulgated regulations, there are other advisories, criteria, or guidance to be considered for a particular release that were developed by the U.S. Environmental Protection Agency, other federal agencies, or states that may be useful in developing CERCLA remedies. Published unpromulgated information that does not necessarily meet the definition of an ARAR may be necessary, under certain circumstances, to determine what is protective of human health and the environment. These are not potential ARARs, but are TBC guidance [40 *CFR* § 300.400(g)(3)].

The remainder of this appendix will address those requirements that apply to remedial actions through the CERCLA (i.e., ARARs) process. Development of ARARs is an iterative, negotiated process, beginning with a large realm of potential ARARs found in the RI/FS Report, with revisions, additions, and deletions occurring as the remedial process progresses, until the ARARs are finalized as the Record of Decision (ROD) is signed.

G.2. ON-SITE ALTERNATIVE

The ARARs discussed for the On-Site Alternative are based on the siting, construction, operation, monitoring, closure, and postclosure care of an on-site waste disposal facility at Paducah Gaseous Diffusion Plant (PGDP).

G.2.1 CHEMICAL-SPECIFIC ARARS

"Chemical-specific requirements set health or risk-based concentration limits or discharge limitations in various environmental media for specific hazardous substances, pollutants, or contaminants," (55 *FR* 8741, March 8, 1990). These requirements generally set protective cleanup levels for the chemicals of concern in the designated media or otherwise indicate a safe level of discharge that may be incorporated when considering a specific remedial activity. The scope of the Remedial Investigation (RI)/Feasibility Study Report (FS) focuses on the disposal options for CERCLA waste that will be generated from future remedial actions. Accordingly, because there is no single operable unit or medium being remediated, there are no chemical-specific ARARs for cleanup levels that will be developed for media in the RI/FS. Chemical-specific ARARs for individual CERCLA actions across the PGDP will be developed on a project-specific basis and presented in project-specific CERCLA documentation.

G.2.2 LOCATION-SPECIFIC ARARS

Location-specific ARARs generally are restrictions placed upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations [53 *FR* 51394, 51437 (December 21, 1988)]. As part of the evaluation of the On-Site Alternative, 12 candidate sites were identified and have undergone a screening process to narrow them down to the most viable location(s). If the On-Site Alternative is selected, DOE will seek regulator and public input throughout the CERCLA process to ensure that site screening and selection is responsive to stakeholder interests and concerns. Because a final site has not been chosen, some of the environmental programs described below may not apply to the selected site and, therefore, may not be ARARs at the time of the ROD.

The location specific ARARs for the On-Site Alternative are included in Table G.1.

G.2.3 WETLANDS

Potential wetland areas have been identified at PGDP. If the selected site contains wetlands and any action were to impact wetlands, the requirements of 10 *CFR* § 1022 would be an ARAR. Activities will be designed to avoid or minimize impacts to wetlands identified at PGDP. The requirements in 10 *CFR* § 1022 instruct DOE to avoid, to the extent possible, adverse impacts associated with the destruction of wetlands and the occupancy and modification of wetlands. In the event that wetlands would be impacted, mitigation activities would be incorporated into facility design where such impact occurs. Measures that mitigate the adverse effects of actions in a wetland may include, but are not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically sensitive areas; however, any necessary mitigation activities would be identified at a later date. The U.S. Army Corp of Engineers (COE) would be consulted. If any action involves the discharge of dredge or fill material into waters of the U.S., 40 *CFR* § 230.10 would be an ARAR.

G.2.3.1 Floodplains and Streams

Floodplain protection as described in 10 *CFR* § 1022 requires that floodplain values be protected to the extent possible. If the On-Site Alternative is selected and would impact a designated floodplain, the substantive requirements found in 10 *CFR* § 1022 would be considered ARARs.

The siting of a new waste site or facility is prohibited from restricting the flow of the 100-year flood, reducing the temporary water storage capacity of the floodplain, or locating in a manner likely to result in a washout of waste [401 *Kentucky Administrative Regulations* (*KAR*) 30:031§ 2].

G.2.3.2 Fish and Wildlife

The Fish and Wildlife Coordination Act [(16 *USC* 662(a)] requires federal agencies to consider the effects of water-related projects on wildlife resources with a view to the conservation of wildlife resources by preventing loss of and damage to such resources. This would include federal agency action that impounds, modifies, diverts, or controls a stream or other body of water except where the maximum surface area of an impoundment is less than ten acres or for land management activities by federal agencies with respect to federal lands under their jurisdiction.

G.2.4 THREATENED OR ENDANGERED SPECIES

Animal species and their critical habitats identified under the Endangered Species Act (ESA) (16 *USC* 1531 *et seq.*) have been identified in the vicinity of PGDP. The ESA provides for the protection from extinction of threatened and endangered (T&E) species. Pursuant to the ESA, federal agency actions that jeopardize the existence of a listed species or results in the destruction or adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures taken. Only the substantive provisions of the ESA apply to on-site actions.

An ecological resource investigation inside the PGDP security fence did not detect any T&E species or their preferred habitat (CDM Federal 1994). FWS has not designated critical habitat for any species within the DOE property. Outside the PGDP fence on the DOE site, potential habitat for federally listed T&E species were reviewed, and Indiana bat habitat was evaluated during the U.S. Army Corps of Engineers (COE) (1994) environmental investigation. The COE study determined that total potential bat habitat consisted of 20% of the 2,456-acre study area. These requirements are potential ARARs in the event T&E species or their habitats are found at the selected site.

While Kentucky has separate statutes governing endangered animals and plants, no state list has been promulgated. Kentucky regulation at 401 *KAR* 30:031 § 3 prohibits waste sites or facilities from taking federally listed endangered or threatened species or adversely impacting their critical habitat.

In addition, Executive Order 13186 directs federal agencies to further the purposes of the Migratory Bird Treaty Act (16 *USC* 703-711) by avoiding or minimizing, to the extent practicable, adverse impacts on migratory bird resources (i.e., birds and their habitat) when conducting agency actions.

G.2.5 PROTECTION OF HISTORIC PROPERTY AND ARCHEOLOGICAL RESOURCES

Federal agencies must take into account the effect of an undertaking that may impact any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register (16 *USC* 470f). Further, federal agencies must initiate measures to assure that where, as a result of federal action, a historic property is to be altered or demolished, timely steps are taken to make or have made appropriate records [16 *USC* 470h-2(b)]. If the historical resources are located on the selected site, the regulations may be applicable to the on-site alternative.

The Archaeological and Historic Preservation Act of 1974 (16 *USC* 469) provides for the preservation of historical and archaeological data that might be irreparably lost or destroyed as a result of alterations of terrain caused by the federal construction of a dam or other alteration caused by federal construction projects. The presence of archaeological or historic resources on the selected site may make these regulations applicable.

The Native American Graves Protection and Repatriation Act (NAGPRA) (25 *USC* 3001 *et seq.*) governs Native American remains and objects found on federal lands. Upon inadvertent discovery, all activity in the area must cease and a reasonable effort made to protect the items discovered before resuming such activity [25 *USC* 3002(d)]. The substantive provisions of the NAGPRA may be considered ARAR for the inadvertent discovery of Native American remains and objects.

G.2.6 SEISMIC CONSIDERATIONS

The general facility standards in 401 *KAR* 34:020 § 9(1) stipulate that a waste disposal facility cannot be located within approximately 200 ft of a fault that has had displacement in Holocene time.

G.2.7 ACTION-SPECIFIC ARARs

Performance, design, or other action-specific requirements set controls or restrictions on particular kinds of activities related to the management of hazardous waste (55 *FR* 8741, March 8, 1990). Selection of a particular action at a site would invoke appropriate action-specific ARARs that may specify particular performance standards or technologies.

The ARARs presented in this section address the siting, design, construction, operation, closure, and postclosure care for an on-site disposal facility. A key assumption in developing ARARs for this alternative is that the waste would be treated as required by the waste generator before disposal, including treatment to meet any applicable Resource Conservation and Recovery Act of 1984 (RCRA) land disposal restrictions, Toxic Substances Control Act of 1976 (TSCA) requirements, and any relevant and appropriate Kentucky regulations governing radioactive wastes. Transportation requirements for moving waste from the individual remediation site to an on-site disposal facility are not identified as ARARs because these activities and their corresponding regulatory requirements would be met by the individual waste generators before waste placement in an on-site facility.

Both solid and hazardous waste are allowed to be disposed of in a landfill meeting RCRA Subtitle C requirements. Although the Subtitle D solid waste requirements were evaluated as potential ARARs, the more stringent requirements of RCRA, TSCA, and standards governing land disposal of radioactive waste that more directly address the circumstances and situations being addressed by the facility were cited as ARARs. Accordingly, the solid waste regulations are not considered ARARs for the purposes of this action. The action specific ARARs are included in Table G.2.

G.2.7.1 General Construction/Operation Activities

General site preparation activities, such as excavation and construction of support buildings, would trigger general requirements for storm water runoff and air emission control measures. ARARs for these common activities are discussed here.

Storm Water Runoff. Storm-water discharges from activities involving construction operations that result in the disturbance of land equal to or greater than one acre and less than five acres require implementation of good site planning and best management practices.

Fugitive Emissions. Emission of airborne particulate concentrations may result from construction and operations activities. Fugitive emissions are regulated by Kentucky through administrative rules at 401 *KAR* 63:010. An operator must take reasonable precautions to prevent particulate matter from becoming airborne. These requirements would be applicable.

40 CFR § 61, Subpart H addresses atmospheric radionuclide emissions from DOE facilities and applies to airborne emissions during construction and operation activities. National Emissions Standards for Hazardous Air Pollutants limits ambient air radionuclide emissions from DOE facilities to levels that would prevent any individual from receiving an effective dose equivalent (EDE) of 10 mrem/year or more (40 *CFR* § 61.92). Nonpoint-source fugitive radionuclide emissions are estimated by plant monitoring stations.

Treatment of Leachate and Decontamination Wastewater. Due to the nature of wastes to be disposed, it is assumed that leachate from landfill operations will have the potential to be RCRA-hazardous and/or polychlorinated biphenyls (PCB)-regulated waste. Wastewater that is identifiable as RCRA-hazardous and/or PCB-regulated wastes from the leachate collection systems and any similar wastewater from decontamination activities at an on-site disposal facility is anticipated to require treatment prior to disposal. Such leachate would need to be evaluated to ensure that it would meet the waste acceptance criteria of the receiving facility. If collected leachate is treated on-site, any on-site wastewater treatment units that are part of a wastewater treatment facility subject to regulation under Clean Water Act § 402 or 307(b) [i.e., Kentucky Pollutant Discharge Elimination System (KPDES) permitted] are exempt from the requirements of RCRA Subtitle C standards for all tank systems, conveyance systems (whether piped or trucked), and ancillary equipment [40 *CFR* § 264.1(g)(6); 40 *CFR* § 260.10; 40 *CFR* § 270.1(c)(2); 53 *FR* 34079, September 2, 1988]. ARARs for an existing KPDES-permitted outfall or a new outfall established as part of this CERCLA action are included in Table G.2.

Off-site shipment of leachate is not expected to be needed; however, in the event leachate needs to be stored in tanks prior to being sent off-site for treatment (i.e., it is more economical or advantageous to dispose of wastewater off-site or the site treatment system is unavailable), the ARARs for RCRA Subtitle C standards for tank systems are included.

G.2.7.2 Operation of Staging Area for Soil/Sediment

Staging of soil/sediment waste material within the active waste disposal operations area may be done intermittently as part of normal operations (40 *CFR* § 264.554). The soil or sediment waste would be placed in a stockpile above the liner near the active workface. A fixative would be applied to the surface of the stockpile at the end of each operating day or at time intervals as necessary to manage fugitive dust. The soil or sediment waste would be disposed of as void fill when placing debris and waste materials in the disposal cell.

G.2.7.3 Location, Design, and Operation of a Landfill

The RCRA requirements for a hazardous waste landfill in 40 *CFR* § 264.301 and the TSCA requirements in 40 *CFR* § 761.75 for design and operation of a chemical waste landfill are applicable to the On-Site Alternative. Under the Atomic Energy Act and its amendments, DOE has been delegated the authority for control of its nuclear material. The DOE requirements for handling and cleanup of radioactive materials and waste are specified in DOE Orders 458.1 and 435.1, respectively. Portions of 902 *KAR* Chapter 100 regulations may be relevant and appropriate for the location, design, and operation of the on-site disposal facility. The Corrective Action Management Unit (CAMU) Rule under 40 *CFR* Part 264 Subpart S has been identified as applicable requirements under the ARARs. The design and closure requirements for the On-Site Disposal Alternative will not be based on the CAMU provisions, but rather designed and closed in accordance with ARARs associated with RCRA hazardous waste and TSCA Chemical Waste Landfills and the design/closure ARARs identified for low-level waste landfills.

RCRA Landfill Requirements. RCRA establishes general facility standards for all hazardous waste facilities in 40 *CFR* § 264, Subpart B. These standards include certain security measures and location restrictions that would be applicable to an on-site disposal facility. Location-specific requirements including restrictions on the siting of a new hazardous waste facility are included as ARARs.

The RCRA landfill design requirements at 40 *CFR* § 264.301, Subpart N, including the minimum technology requirements (MTRs), would be applicable to this alternative. To meet the MTRs, a two-liner system is required with a leachate collection and removal system between the liners. The top liner must prevent the migration of hazardous constituents into the liner throughout the postclosure care period. The bottom liner consists of two components. The first component of the bottom liner must be designed to prevent migration of hazardous constituents. The second component consists of a layer of compacted soil at least 3 ft thick. A leachate detection and collection system must be placed between the top and bottom liners. For disposal cells not located completely above the seasonal high water mark, the leachate detection system must demonstrate that the presence of groundwater will have no adverse impact on the functioning of the system. Throughout the closure period, leachate must be monitored and recorded. In addition, 40 *CFR* § 264.301 requires the control of fugitive emissions and the maintenance of a surface water run-on/runoff collection system that has the capacity to manage the water volume resulting from a 24-hour, 25-year storm event.

TSCA Chemical Waste Landfill Requirements. The TSCA chemical waste landfill requirements generally follow the RCRA landfill design requirements discussed in the preceding subsection. TSCA specifies, however, that if a synthetic liner is used, it must have a minimum thickness of 30 mil. In addition, the hydrologic requirements of TSCA are more stringent than RCRA since, under TSCA, the bottom of the liner must be located 50 ft above the historical-high groundwater mark and must prohibit any hydrologic connection between the site and any surface water. If the On-Site Alternative is selected, it is expected that an "equivalent protectiveness" demonstration in accordance with 40 *CFR* **§** 761.75(c)(4) will be sought for this TSCA requirement.

Standards for Radioactive Waste Disposal. DOE is authorized to regulate nuclear materials at sites under its jurisdiction, including PGDP. The NRC and NRC Agreement states have promulgated radioactive waste regulations. As an NRC Agreement state, Kentucky has its own licensing authority for commercial or private facilities handling and disposing of radioactive waste (902 *KAR* Chapter 100). DOE and its contractors, however, are specifically exempt from this authority as set forth in 902 *KAR* 100:015 § 7. Although the Kentucky regulations governing radioactive waste are not applicable to the on-site disposal of CERCLA wastes at PGDP, portions of 902 *KAR* 100:019, 902 *KAR* 100:021, and 902 *KAR* 100:022 are considered as relevant and appropriate for the development of an on-site disposal facility.

The general performance objective for the protection of individuals from inadvertent intrusion (902 *KAR* 100:022 § 19) is relevant but not appropriate for DOE wastes remaining on-site under DOE's custodial care. Based on the response to comments to NRC's final rule promulgating 10 *CFR* § 61, it appears that the requirement for the protection of individuals from inadvertent intrusion and the 100-year maximum allowable limit for institutional controls was based on a desire to limit the amount of time the federal government would need to maintain/control a private disposal site that was transferred to the government (47 *FR* 57458 and 57459, December 27, 1982). In the case of on-site disposal at PGDP, the federal government is the originator of the waste and owner/operator of the waste disposal facility; therefore, the federal government has an obligation to provide custodial care as long as the waste presents unacceptable risks. The CERCLA 5-Year Review process for waste ensures additional continued protection of human health and the environment for as long as necessary.

EPA requires compliance with worker protection standards in National Contingency Plan § 300.150, though independent of the ARARs process; therefore, 902 *KAR* 100:022 § 20, "Protection of Individuals During Operations," is not an ARAR.

Landfill Closure. Pursuant to RCRA regulations, a waste disposal cell that is filled to capacity must be covered with a final cover designed and constructed to provide long-term minimization of migration of liquids through the capped area, function with minimum maintenance, promote drainage and minimize erosion or abrasion of the cover, and accommodate settling and subsidence so that the cover's integrity is maintained. Additionally, the cap must have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present to keep water and leachate from collecting in the waste (401 *KAR* 34:230 § 7).

The capping of the disposal facility or its individual cells would not be regulated specifically under TSCA; however, EPA guidance indicates that closure of a chemical waste landfill should parallel a RCRA closure (EPA 1990).

Postclosure Maintenance and Monitoring. General post-closure care regulations for RCRA hazardous waste management units appear at 401 *KAR* 34:070 and 40 *CFR* § 264.117. Postclosure care must begin after closure and continue for at least 30 years. In particular, surveillance, maintenance, and monitoring of the waste-containment system and groundwater during the postclosure period are required. Postclosure care requirements for landfills [401 *KAR* 34:230; 40 *CFR* § 264.310(b)] include long-term maintenance of the cover, run-on and run-off diversion systems, etc. The TSCA regulations contain additional monitoring and closure requirements for a chemical waste landfill.

Management of Wastes in a CAMU. In 1993, EPA promulgated rules establishing special units under RCRA, called CAMUs, to facilitate cleanup actions by allowing the acceptance of remediation waste. EPA recognized that remediation of existing contamination problems are inherently different from management of "as-generated" industrial waste and that applying "as-generated" regulatory requirements to remediation wastes does not always result in implementation of the best remedies. In fact, EPA stated its preliminary analysis indicates that better remedies, in terms of increased environmental benefits, are more likely under a regulatory framework tailored to remediation wastes. EPA further stated that Subtitle C requirements, when applied to remediation waste, can act as disincentive to more protective remedies, and can limit the flexibility of a regulatory decision maker in choosing the most practicable remedy at a specific site (58 *FR* February 16, 1993).

The CAMU rule tailors design, operating, closure, postclosure, and waste treatment requirements to site- and waste-specific conditions. This approach allows a significantly broader range of cleanup options and has led to prompter and more aggressive cleanups (67 *FR* January 22, 2002). A major difference between as-generated waste and remediation waste is that remediation often involves management of large volumes of contaminated media, such as soils or groundwater. The physical characteristics of contaminated media can be quite different from those of as-generated waste (58 *FR* February 16, 1993). Placement of remediation waste (i.e., "CAMU-eligible wastes") into areas that have been designated a CAMU does not constitute land disposal of hazardous wastes subject to 40 *CFR* Part 268. CAMUs are required to be constructed to facilitate implementation of reliable, protective, and cost-effective remedies without creating unacceptable risks of exposure to human health or the environment.

The CAMU rule established minimum design and operating standards for CAMUs and minimum treatment standards for remediation waste placed in CAMUs. The On-Site Disposal Alternative under consideration at PGDP is being designated as a CAMU for disposal of CAMU-eligible wastes. The design and closure requirements for the On-Site Disposal Alternative will not be based on the CAMU provisions, but rather designed and closed in accordance with ARARs associated with RCRA hazardous waste and TSCA Chemical Waste Landfills and the design/closure ARARs identified for low-level waste landfills.

"CAMU-eligible waste" is defined in 40 *CFR* 264.552 (a)(1) and generally includes all solid and hazardous waste and all media (including groundwater, surface water, soil, and sediment) and debris that are managed for implementing cleanup, but excludes some intact containers or certain types of non-land-based units. A key concept of the CAMU rule is the identification and treatment of principal hazardous constituents (PHCs). CAMU-eligible wastes determined to contain PHCs, which otherwise would have been subject to the treatment standards of Part 268, must be treated to achieve minimum national treatment standards or site-specific treatment standards as specified in 40 *CFR* § 264.552(e)(4)(iv) and (e)(4)(v).

The PHC concept applies after a decision has been made to excavate and manage cleanup waste and is intended to identify higher-risk constituents in CAMU-eligible wastes. During site characterization, identification typically is made about which wastes are hazardous, which materials warrant remediation or removal, and which constituents will be used to establish site cleanup levels. This process results in the identification of what generally is known as the "risk drivers." PHCs are defined as those constituents that "pose a risk to human health or the environment that is substantially higher than the cleanup levels or goals at the site" as established in a site-specific decision document (e.g., ROD, final permit, order) [40 *CFR* 264.552(e)(4)(i)].

At PGDP, each of the cleanup projects associated with the individual operable units would be responsible for characterization, identification, and treatment of the PHCs it generates, provided that the selected remedy involves excavation and disposal in the proposed On-Site Waste Disposal Facility (WDF). The PHCs, minimum treatment standards, and treatment technologies will be identified by the individual cleanup projects generating CAMU-eligible wastes. The CAMU regulations pertaining to the minimum treatment standards shall be considered in the development of the waste acceptance criteria, should the On-site Disposal Alternative be selected as the preferred remedy.

G.3. OFF-SITE ALTERNATIVE

The Off-Site Alternative consists of shipment of CERCLA waste to and disposal of in licensed or permitted off-site disposal facilities. It is assumed that individual waste generators would be responsible for treatment before disposal; therefore, ARARs for waste treatment to meet any applicable land disposal restrictions or other treatment requirements under state or federal regulations are not addressed (DOE 2011a). Because wastes would be disposed of off-site at appropriately licensed facilities under this alternative, ARARs for waste disposal are not addressed for this alternative (DOE 2011a).

G.4. NO ACTION ALTERNATIVE

Under the No Action Alternative, ARARs would be developed and evaluated for each project-specific CERCLA action, whether on-site or off-site disposal. Accordingly, there are no ARARs associated with the No Action Alternative.

G.5. WASTE MINIMIZATION

The ARARs for waste minimization are presented in Table G.3. Waste minimization would be accomplished by a metal melting process which, for the purposes of this FS, uses an induction furnace as a representative technology. This RI/FS assumes that the individual projects would decontaminate any metal as to RCRA hazardous constituents or PCBs prior to transfer to the waste minimization facility. Some metal may contain volumetric radiological contamination. It is anticipated that the waste minimization facility would consist of two separate lines, one for metal without radiological contamination and one for radiological contaminated metal. Metal without any radiological contamination would be recycled. Metal contaminated with radiological contamination would be sent to the On-Site WDF, should the On-site Disposal Alternative be selected as the preferred remedy. ARARs presented in Table G.3 list only those ARARs unique to waste minimization. ARARs related to location of the facility, site preparation, and LLW characterization, storage, and disposal of secondary waste streams that appear in Table G.1 and G.2 have not been duplicated in Tables G.3. Air emissions from the waste minimization facility are assumed to be a minor source. This assumption is based on PGDP being non-operational when the waste minimization occurs. Any wastewater from the waste minimization facility will be managed in the on-site WWTU associated with the WDF.

The design specifications of the metal melting process are not known at this time to determine if any of the effluent limitations for the industrial categories in 40 *CFR* Subchapter N Effluent Guidelines and Standards would provide additional ARARs for the on-site-WWTU. As design is developed further in the CERCLA process, the requirements in 40 *CFR* Subchapter N will be evaluated for any additional requirements. If none of these effluent standards are determined to be ARAR, any effluent standards would be based on best professional judgment, which already is incorporated into the on-site WWTU ARARs in Table G.2.

Table G.1. Preliminary List of Potential Location-Specific ARARs and TBC Guidance

Location	Summary of Requirements	Prerequisite	Citation
	Floodplains/Wetlands		
Presence of wetlands as defined in 10 *CFR* § 1022.4	Avoid, to the extent possible, the long- and short-term adverse effects associated with destruction, occupancy, and modification of wetlands.	DOE actions that involve potential impacts to, or take place within, wetlands—**applicable**.	10 *CFR* § 1022.3(c)
	Take action, to extent practicable, to minimize destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands.		10 *CFR* § 1022.3(a)(7) and (8)
	Undertake a careful evaluation of the potential effects of any new construction in wetlands. Identify, evaluate, and, as appropriate, implement alternative actions that may avoid or mitigate adverse impacts on wetlands.		10 *CFR* § 1022.3(b) and (d)
	Measures that mitigate the adverse effects of actions in a wetland including, but not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically-sensitive areas.		10 *CFR* § 1022.13(a)(3)
	If no practicable alternative to locating or conducting the action in the wetland is available, then before taking action, design or modify the action in order to minimize potential harm to or within the wetland, consistent with the policies set forth in E.O. 11990.		10 *CFR* § 1022.14(a)
Presence of floodplain as defined in 10 *CFR* § 1022.4	Avoid, to the extent possible, the long- and short-term adverse effects associated with occupancy and modification of floodplains.	DOE actions that involve potential impacts to, or take place within, floodplains—**applicable**.	10 *CFR* § 1022.3(c)
	Undertake a careful evaluation of the potential effects of any action taken in a floodplain. Identify, evaluate, and, as appropriate, implement alternative actions that may avoid or mitigate adverse impacts on floodplains.		10 *CFR* § 1022.3(b) and (d)

Table G.1. Preliminary List of Potential Location-Specific ARARs and TBC Guidance (Continued)

Location	Summary of Requirements	Prerequisite	Citation
	Restore and preserve natural and beneficial values served by floodplains to the extent practicable.	DOE actions that involve potential impacts to, or take place within, floodplains—**applicable**	10 *CFR* § 1022.3(a)(3)
	Measures that mitigate the adverse effects of actions in a floodplain including, but not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically-sensitive areas.		10 *CFR* § 1022.13(a)(3)
	If no practicable alternative to locating or conducting the action in the floodplain is available, then before taking action, design or modify its action in order to minimize potential harm to or within the floodplain, consistent with the policies set forth in E.O. 11988 and E.O. 11990.		10 *CFR* § 1022.14(a)
Nationwide Permit Program	Must comply with the substantive requirements of the NWP 38, General Conditions, as appropriate.	Discharge of dredged or fill material into waters of the United States, including jurisdictional wetlands—**relevant and appropriate**.	NWP (38) Cleanup of Hazardous and Toxic Waste 33 *CFR* § 323.3(b)
Location encompassing aquatic ecosystem as defined in 40 *CFR* § 230.3(c)	Except as provided under § 404(b)(2), no discharge of dredged or fill material is permitted if there is a practicable alternative that would have less adverse impact on the aquatic ecosystem or if it will cause or contribute to significant degradation of the waters of the United States.	Action that involves the discharge of dredged or fill material into waters of the United States, including jurisdictional wetlands—**relevant and appropriate**.	40 *CFR* § 230.10(a) and (c)
	Except as provided under § 404(b)(2), no discharge of dredged or fill material shall be permitted unless appropriate and practicable steps have been taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem. 40 *CFR* § 30.70 *et seq*. identifies such possible steps.		40 *CFR* § 230.10(d)

Table G.1. Preliminary List of Potential Location-Specific ARARs and TBC Guidance (Continued)

Location	Summary of Requirements	Prerequisite	Citation
Within area impacting stream or any other body of water and presence of wildlife resources (e.g., fish)	Consider the effects of water-related projects on wildlife resources with a view to the conservation of wildlife resources by preventing loss of and damage to such resources.	Federal agency action that impounds, modifies, diverts, or controls a stream or other body of water except where the maximum surface area of an impoundment is less than ten acres or for land management activities by federal agencies with respect to federal lands under their jurisdiction—**relevant and appropriate**.	16 *U.S.C.* 662(a)
	Cultural Resources		
Presence of archaeological or historic resources	Provide for the preservation of significant historical and archeological data which might otherwise be irreparably lost or destroyed as a result of any alternation of terrain caused as a result of any federal construction project.	Federal construction project that would cause the irreparable loss or destruction of significant historical or archeological data—**relevant and appropriate**.	16 *U.S.C.* 469
Presence of historical resources	Federal agencies shall take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register.	Federal agency undertaking that may impact historical properties listed or eligible for inclusion on the National Register of Historic Places—**applicable**.	16 *U.S.C.* 470f
	Federal agencies must initiate measures to assure that where, as a result of federal action, a historic property is to be substantially altered or demolished, timely steps are taken to make or have made appropriate records.		16 *U.S.C.* 470h-2(b)
	Endangered, Threatened, or Rare Species		
Presence of federally endangered or threatened species, as designated in 50 *CFR* § 17.11 and § 17.12 or critical habitat of such species	Actions that jeopardize the existence of a listed species or results in the destruction or adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures taken.	Action that is likely to jeopardize fish, wildlife, or plant species or destroy or adversely modify critical habitat—**applicable**.	16 *U.S.C.* 1531 *et seq.*, Section 7(a)(2)

Table G.1. Preliminary List of Potential Location-Specific ARARs and TBC Guidance (Continued)

Location	Summary of Requirements	Prerequisite	Citation
Presence of migratory birds and migratory bird resources listed in 50 *CFR* 10.13.	Avoid or minimize, to the extent practicable, adverse impacts on migratory bird resources.	Federal Agency action that is likely to impact migratory birds—**TBC**.	E.O. 13186
	Disposal Site Suitability Requirements		
Siting of RCRA hazardous waste landfill	Portions of new facilities where treatment, storage, or disposal of hazardous waste will be conducted shall not be located within 61 meters (approximately 200 ft) of a fault that had displacement in Holocene time.	Construction of a new RCRA hazardous waste treatment, storage, or disposal facility—**applicable**.	401 *KAR* 34:020 § 9(1) 40 *CFR* § 264.18(a)
	Cannot construct a new hazardous waste disposal site or facility in the 100-year floodplain, a seasonal high-water table, or the floodway.	Construction of a new RCRA hazardous waste treatment, storage, or disposal facility—**applicable**.	401 *KAR* 34:020 § 9(2) (b)-(c)
Minimum environmental performance standards for a waste facility	No waste site or facility shall restrict the flow of the 100-year flood, reduce the temporary water storage capacity of the floodplain, or be placed in a manner likely to result in washout of waste, so as to pose a hazard to human health, wildlife, land, or water resources.	Construction of a waste facility as defined in *KRS* 224.01–010(27)—**applicable**.	401 *KAR* 30:031 § 2
	No waste site or facility shall cause or contribute to the taking of any endangered or threatened species or candidate species listed pursuant to 16 *U.S.C.* 1531 *et seq*. (the Endangered Species Act of 1983 as amended); or result in the destruction or adverse modification of the critical habitat of an endangered or threatened species or candidate species listed pursuant to 16 *U.S.C.* 1531 *et seq*. (the Endangered Species Act of 1983 as amended).		401 *KAR* 30:031 § 3
	No new or expanded waste site or facility shall be located in wetlands as defined in 401 *KAR* 30:005 § 38.		401 *KAR* 30:031 § 12

Table G.1. Preliminary List of Potential Location-Specific ARARs and TBC Guidance (Continued)

Location	Summary of Requirements	Prerequisite	Citation
Minimum environmental performance standards for a waste facility	A variance from the requirements of the waste management administrative regulations if a requirement or the process and equipment used is determined to be either: (a) Insignificant as a potential hazard to public health or the environment because of its small quantity; low concentration; physical, biological, or chemical characteristics; or method of operation used; or (b) Handled, processed, or disposed of pursuant to administrative regulations of another governmental agency, if the administrative regulations of other agencies meet the requirements of the waste management administrative regulations, including federal exemption rule-making actions pertaining to hazardous waste management. *NOTE: Variance shall be made as part of the FFA CERCLA document review and approval process.*	Construction of a waste facility—**applicable**.	401 *KAR* 30:020 § 2(1)
Design requirements for a TSCA chemical waste landfill	Shall be located in thick, relatively impermeable formations such as large area clay pans. Where this is not possible, the soil shall have a high clay and silt content with the following parameters:	Construction of a TSCA chemical waste landfill—**applicable**.	40 *CFR* § 761.75(b)(1)
	• In place soil thickness, 4-ft or compacted soil liner thickness, 3-ft;		40 *CFR* § 761.75(b)(1)(i)
	• Permeability (cm sec), equal to or less than 1×10^{-7};		40 *CFR* § 761.75(b)(1)(ii)
	• Percent soil passing No. 200 sieve > 30;		40 *CFR* § 761.75(b)(1)(iii)
	• Liquid limit, > 30; and		40 *CFR* § 761.75(b)(1)(iv)
	• Plasticity index > 15.		40 *CFR* § 761.75(b)(1)(v)

Table G.1. Preliminary List of Potential Location-Specific ARARs and TBC Guidance (Continued)

Location	Summary of Requirements	Prerequisite	Citation
Siting of a TSCA chemical waste landfill	The bottom of the landfill shall be above the historical high groundwater table. The bottom of the landfill liner system or natural in-place soil barrier shall be at least 50 ft from the historical high water table. Floodplains, shorelands, and groundwater recharge areas shall be avoided. There shall be no hydraulic connection between the site and standing or flowing surface water.	Construction of a TSCA chemical waste landfill—**applicable**.	40 *CFR* § 761.75(b)(3)
	The landfill site shall be located in an area of low to moderate relief to minimize erosion and to help prevent landslides or slumping.		40 *CFR* § 761.75(b)(5)
	Shall provide surface water diversion dikes around the perimeter of the landfill site with a minimum height equal to 2 ft above the 100-year floodwater elevation.	Construction of a TSCA chemical waste landfill (below the 100-year floodwater elevation)—**applicable**.	40 *CFR* § 761.75(b)(4)(i)
	Shall provide diversion structures capable of diverting all surface water runoff from a 24-hour, 25-year storm.	Construction of a TSCA chemical waste landfill (above the 100-year floodwater elevation)—**applicable**.	40 *CFR* § 761.75(b)(4)(ii)
Siting LLW disposal facility	Proposed locations for low-level waste facilities shall be evaluated considering environmental characteristics, geotechnical characteristics, and human activities including whether it is located in a floodplain, a tectonically active area, or in the zone of water table fluctuation.	Construction of a LLW disposal facility—**TBC**.	DOE M 435.1 1(IV)(M)(3)(a)(2)
	Proposed locations with environmental characteristics, geotechnical characteristics, and human activities for which adequate protection cannot be provided through facility design shall be deemed unsuitable for the location of the facility.		DOE M 435.1-1(IV)(M)(3)(b)

Table G.1. Preliminary List of Potential Location-Specific ARARs and TBC Guidance (Continued)

Location	Summary of Requirements	Prerequisite	Citation
Siting of LLW disposal facility	The disposal site shall be capable of being characterized, modeled, analyzed, and monitored. *NOTE: Any existing radiological contamination at the site does not prevent the siting of a disposal facility, as long as it would not prevent characterization, modeling, or monitoring.*	Construction of a LLW disposal facility—**relevant and appropriate**.	902 *KAR* 100:022 § 22(2)
	Areas shall be avoided having known natural resources that, if exploited, would result in failure to meet performance objectives contained in 902 *KAR* 100:022 § 21.		902 *KAR* 100:022 § 22(4)
	The disposal site shall be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-year floodplain, coastal high-hazard area, or wetland, as defined in U.S. E.O. 11988, "Floodplain Management Guidelines."		902 *KAR* 100:022 § 22(5)
	Upstream drainage areas shall be minimized to decrease the amount of run-off that could erode or inundate waste disposal units.		902 *KAR* 100:022 § 22(6)
	The disposal site shall provide sufficient depth to the water table that groundwater intrusion, perennial or otherwise, into the waste shall not occur unless it can be conclusively shown that disposal site characteristics will result in molecular diffusion being the predominant means of radionuclide movement and the rate of movement will result in the performance objectives contained in 902 *KAR* 100:022 § 21 being met.		902 *KAR* 100:022 § 22(7)
	The hydrogeologic unit used for disposal shall not discharge ground water to the surface within the disposal site.		902 *KAR* 100:022 § 22(8)

Table G.1. Preliminary List of Potential Location-Specific ARARs and TBC Guidance (Continued)

Location	Summary of Requirements	Prerequisite	Citation
Siting of LLW disposal facility	Areas shall be avoided if tectonic processes, such as faulting, folding, seismic activity, or vulcanism may occur with a frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of 902 *KAR* 100:022 or may preclude defensible modeling and prediction of long-term impacts.	Construction of a LLW disposal facility—**relevant and appropriate**.	902 *KAR* 100:022 § 22(9)
	Areas shall be avoided if surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering occur with a frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of 902 *KAR* 100:022, or may preclude defensible modeling and prediction of long-term impacts.		902 *KAR* 100:022 § 22(10)
	The disposal site shall not be located if nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of 902 *KAR* 100:022 or significantly mask the environmental monitoring program.		902 *KAR* 100:022 § 22(11)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance

Action	Summary of Requirements	Prerequisite	Citation
	Site Preparation and Excavation Activities		
Activities causing radionuclide emissions	Emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an EDE of 10 mrem per year.	Radionuclide emissions at a DOE facility—**applicable**.	40 *CFR* § 61.92 401 *KAR* 57:002
Activities causing fugitive dust emissions	No person shall cause, suffer, or allow any material to be handled, processed, transported, or stored; a building or its appurtenances to be constructed, altered, repaired, or demolished, or a road to be used without taking reasonable precaution to prevent particulate matter from becoming airborne. Such reasonable precautions shall include, when applicable, but not be limited to the following: • Use, where possible, of water or chemicals for control of dust in the demolition of existing buildings or structures, construction operations, the grading of roads or the clearing of land; • Application and maintenance of asphalt, oil, water, or suitable chemicals on roads, materials stockpiles, and other surfaces which can create airborne dusts; • Covering, at all times when in motion, open bodied trucks transporting materials likely to become airborne; • The maintenance of paved roadways in a clean condition; and • The prompt removal of earth or other material from a paved street which earth or other material has been transported thereto by trucking or earth moving equipment or erosion by water.	Fugitive emissions from land-disturbing activities (e.g., handling, processing, transporting, or storing of any material, demolition of structures, construction operations, grading of roads, or the clearing of land, etc.)—**applicable**.	401 *KAR* 63:010 § 3(1) and (1)(a), (b), (d), (e) and (f)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Activities causing fugitive dust emissions	No person shall cause or permit the discharge of visible fugitive dust emissions beyond the lot line of the property on which the emissions originate.	Fugitive emissions from land-disturbing activities (e.g., handling, processing, transporting, or storing of any material, demolition of structures, construction operations, grading of roads, or the clearing of land, etc.)—**applicable**.	401 *KAR* 63:010 § 3(2)
Activities causing toxic substances or potentially hazardous matter emissions	Persons responsible for a source from which hazardous matter or toxic substances may be emitted shall provide the utmost care and consideration in the handling of these materials to the potentially harmful effects of the emissions resulting from such activities. No affected facility shall emit potentially hazardous matter or toxic substances in such quantities or duration as to be harmful to the health and welfare of humans, animals, and plants.	Emissions of potentially hazardous matter or toxic substances as defined in 401 *KAR* 63:020 § 2 (2)—**applicable**.	401 *KAR* 63:020 § 3
Activities causing storm water runoff (e.g., clearing, grading, excavation)	Implement good construction techniques to control pollutants in storm water discharges during and after construction in accordance with substantive requirements provided by permits issued pursuant to 40 *CFR* § 122.26(c).	Storm water discharges associated with an industrial activity as defined in 40 *CFR* § 122.26(b)(14)(x) and 401 *KAR* 5:002 § 1(156)—**applicable**.	40 *CFR* § 122.26(c)(1)(ii)(C) and (D) 401 *KAR* 5:060 § 8

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Activities causing storm water runoff (e.g., clearing, grading, excavation)	Storm water runoff associated with construction activities taking place at a facility with an existing Best Management Practices (BMP) Plan shall be addressed under the facility BMP and not under a storm water general permit.	Storm water discharges associated with an industrial activity as defined in 40 *CFR* § 122.26(b)(14)(x) and 401 *KAR* 5:002 § 1(156)—**TBC**.	Fact Sheet for the KPDES General Permit For Storm Water Discharges Associated with Construction Activities, June 2009
	Best management storm water controls will be implemented and may include, as appropriate, erosion and sedimentation control measures, structural practices (e.g., silt fences, straw bale barriers) and vegetative practices (e.g., seeding); storm water management (e.g., diversion); and maintenance of control measures in order to ensure compliance with the standards in Section C.5 Storm Water Discharge Quality.	Storm water runoff associated with construction activities taking place at a facility [PGDP] with an existing BMP Plan—**TBC**.	Appendix C of the PGDP Best Management Practices Plan (2007)—Examples of Storm water Controls
	Design/Construction/Operation of a RCRA Hazardous Waste Landfill		
Design of a RCRA hazardous waste facility	Facilities must be designed, constructed, maintained, and operated to minimize the possibility of a fire, explosion, or any unplanned sudden or non-sudden release of hazardous waste or hazardous waste constituents to air, soil, or surface water which could threaten human health or the environment.	Construction of a RCRA hazardous waste facility—**applicable**.	40 *CFR* § 264.31 401 *KAR* 34:030 § 2
Liner and leachate collection design for a RCRA hazardous waste landfill	Must install two or more liners and a leachate collection and removal system above and between such liners.	Construction of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.301(c) 401 *KAR* 34:230 § 2
	The liner system must include the following:		40 *CFR* § 264.301(c)(1)(i) 401 *KAR* 34:230 § 2
	• A top liner designed and constructed of materials (e.g., geomembrane) to prevent the migration of hazardous constituents into the liner during active life and the postclosure period;		40 *CFR* § 264.301(c)(1)(i)(A) 401 *KAR* 34:230 § 2

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Liner and leachate collection design for a RCRA hazardous waste landfill	• A composite bottom liner consisting of at least two components: i. Upper component must be designed and constructed of materials to prevent migration of hazardous constituents into this component during the active life and postclosure period; ii. Lower component designed and constructed of materials to minimize the migration of hazardous constituents if a breach in the upper component were to occur; iii. The lower component must be constructed of at least 3 ft of compacted soil material with a hydraulic conductivity of no more than 1×10^{-7} cm/second.	Construction of a RCRA hazardous waste landfill—**applicable**	40 *CFR* § 264.301(c)(1)(i)(B) 401 *KAR* 34:230 § 2
Landfill liner requirements	The liners must comply with the requirements of 40 *CFR* § 264.301(a)(1)(i)-(iii).	Construction of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* 264.301(c)(1)(ii) 401 *KAR* 34:230 § 2
Top leachate collection and removal system (immediately above the top liner)	Must be designed, constructed, operated, and maintained to collect and remove leachate from the landfill during the active life and postclosure period and ensure that the leachate depth over the liner does not exceed 30 cm (1 ft). The leachate collection and removal system must comply with the requirements of 40 *CFR* § 264.301(c)(3)(iii) and (iv).	Construction of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.301(c)(2) 401 *KAR* 34:230 § 2
	Leachate collection system must be constructed of materials that are: • Chemically resistant to waste managed in landfill and leachate expected to be generated; and • Sufficient strength and thickness to prevent collapse under pressures exerted by overlying wastes, waste cover materials, and by any equipment used.		40 *CFR* § 264.301(c)(3)(iii) 401 *KAR* 34:230 § 2

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Top leachate collection and removal system (immediately above the top liner)	Must be designed and operated to minimize clogging during the active life and postclosure period of the landfill.	Construction of a RCRA hazardous waste landfill—**applicable**	40 *CFR* § 264.301(c)(3)(iv) 401 *KAR* 34:230 § 2
Bottom leachate collection and removal system/leak detection system	Leachate collection and removal system must be capable of detecting, collecting, and removing leaks of hazardous constituents at the earliest practicable time through all areas of the top liner likely to be exposed to waste or leachate during the active life and post-closure care period.	Construction of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.301(c)(3) 401 *KAR* 34:230 § 2
	Requirements for a leak detection system are satisfied by installation of a system that is at a minimum: • Constructed with a bottom slope of 1% or more;		40 *CFR* § 264.301(c)(3)(i) 401 *KAR* 34:230 § 2
	• Constructed of granular drainage materials with a hydraulic conductivity of 1×10^{-2} cm/second and a thickness of 12 inches or more or synthetic or geonet drainage materials with a transmissivity of 3×10^{-5} m^2/sec;		40 *CFR* § 264.301(c)(3)(ii) 401 *KAR* 34:230 § 2
	• Constructed of materials that are chemically resistant to waste managed and leachate expected to be generated, and structurally sufficient to resist pressures exerted by waste, cover, and equipment used at the landfill;		40 *CFR* § 264.301(c)(3)(iii) 401 *KAR* 34:230 § 2
	• Designed and operated to minimize clogging during the active life and postclosure care period; and		40 *CFR* § 264.301(c)(3)(iv) 401 *KAR* 34:230 § 2

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Bottom leachate collection and removal system/leak detection system	• Constructed with sumps and liquid removal methods (e.g., pumps) of sufficient size to collect and remove liquids from the sump and prevent liquids from backing up into the drainage layer. Each unit must have its own sump(s). The design of each sump and removal system must provide a method for measuring and recording the volume of liquids present in the sump and of liquids removed.	Construction of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.301(c)(3)(v) 401 *KAR* 34:230 § 2
	The owner or operator of a leak detection system that is not located completely above the seasonal high water table must demonstrate that the operation of the system will not be adversely affected by the presence of groundwater.		40 *CFR* § 264.301(c)(5)
Run-on control system/run-off management system	A run-on control system must be designed, constructed, operated, and maintained that is capable of preventing flow onto the active portion of the landfill during peak discharge from at least a 25-year storm.	Construction of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.301(g) 401 *KAR* 34:230 § 2
	A run-off management system must be designed, constructed, operated, and maintained to collect and control at least the water volume resulting from a 24-hour, 25-year storm.		40 *CFR* § 264.301(h) 401 *KAR* 34:230 § 2
	Collection and holding facilities (e.g., tanks or basins) associated with run-on and runoff control systems must be emptied or otherwise managed expeditiously after storms to maintain design capacity of the system.	Construction of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.301(i) 401 *KAR* 34:230 § 2
Daily cover	Cover or otherwise manage the landfill to control wind dispersal.	Construction of a RCRA hazardous waste landfill that contains any particulate matter that may be subject to wind dispersal —**applicable**.	40 *CFR* § 264.301(j) 401 *KAR* 34:230 § 2

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Action leakage rate testing for the leachate collection system	Must have an action leakage rate that includes an adequate safety margin to allow for uncertainties in the design (e.g., slope, hydraulic conductivity, thickness of drainage material), construction, operation, and location of the leak detection system, waste and leachate characteristics, likelihood and amounts of other sources of liquids in the leak detection system, and proposed response actions (e.g., the action leakage rate must consider decreases in the flow capacity of the system over time resulting from siltation and clogging, rib layover and creep of synthetic components of the system, overburden pressures, etc.).	Construction and operation of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.302(a) 401 *KAR* 34:230 § 3
	To determine if the action leakage rate has been exceeded, must convert the weekly or monthly flow rate from the monitoring data obtained under § 264.303(c) to an average daily flow rate (gal per acre per day) for each sump. The average daily flow rate for each sump must be calculated weekly during the active life and closure period and monthly during the post-closure care period when monthly monitoring is required under § 264.303(c).		40 *CFR* § 264.302(b) 401 *KAR* 34:230 § 3
Monitoring and inspection of liners, leak detection, run-on/runoff systems during the active life of the facility	• During construction or installation, liners and cover systems must be inspected for uniformity, damage, and imperfections (e.g., hole, cracks, thin spots, etc.)	Construction of a RCRA landfill—**applicable**.	40 *CFR* § 264.303(a) 401 *KAR* 34:230, § 4
Post-Construction monitoring	Must inspect landfill weekly and after storm events to ensure proper functioning of run-on and runoff control systems, wind dispersal control systems, and leachate collection and removal systems.	Operation of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.303(b) 401 *KAR* 34:230 § 4
Leak detection system	Must monitor the amount of liquids removed from the leak detection system sumps at least weekly during the active life and closure period.	Operation of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.303(c)(1) 401 *KAR* 34:230 § 4

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Must collect and remove liquids in the leak detection system sumps to minimize the head on the bottom liner.		40 *CFR* § 264.301(c)(4) 401 *KAR* 34:230 § 2
Monitoring of leachate detection system postclosure	After the final cover is installed, the amount of liquids removed from each leak detection system sump must be recorded at least monthly. If the liquid level in the sump stays below the pump operating level for two consecutive months, the amount of liquids in the sumps must be recorded at least quarterly. If the liquid level in the sump stays below the pump operating level for two consecutive quarters, the amount of liquids in the sumps must be recorded at least semiannually. If at any time during the post-closure care period the pump operating level is exceeded at units on quarterly or semiannual recording schedules, must return to monthly recording of amounts of liquids removed from each sump until the liquid level again stays below the pump operating level for two consecutive months.	Closure of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.303(c)(2) 401 *KAR* 34:230 § 4
Response actions for leak detection system	Must determine to the extent practicable the location, size, and cause of any leak.	Flow rate into the leak detection system exceeds action leakage rate for any sump—**applicable**.	40 *CFR* § 264.304(b)(3) 401 *KAR* 34:230 § 5
	Must determine whether waste receipt should cease or be curtailed, whether any waste should be removed from the unit for inspection, repairs, or controls, and whether or not the unit should be closed.		40 *CFR* § 264.304(b)(4) 401 *KAR* 34:230 § 5
	Must determine any other short- or long-term actions to be taken to mitigate or stop leaks.		40 *CFR* § 264.304(b)(5) 401 *KAR* 34:230 § 5
	To make the leak detection and/or remediation determinations in paragraphs 40 *CFR* § 264.304 (b)(3)-(5), the owner or operator must: • Assess the source of liquids and amounts of liquids by source,		40 *CFR* § 264.304 (c)(1)(i)-(iii) 401 *KAR* 34:230 § 5

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	• Conduct a fingerprint, hazardous constituent, or other analyses of the liquids in the leak detection system to identify the sources of liquids and possible location of any leaks, and the hazard and mobility of the liquid; or • Assess the seriousness of any leaks in terms of potential for escaping into the environment.		
	Document why such assessments are not needed.		40 *CFR* § 264.304(c)(2) 401 *KAR* 34:230 § 5
Waste inventory requirements	Record on a map the exact location, and dimensions, including depth, of each cell in reference to permanently surveyed benchmarks; and Document the contents of each cell and the approximate location of each hazardous waste type within each cell.	Operation of a RCRA hazardous waste facility—**applicable**.	40 *CFR* § 264.309(a) and (b) 401 *KAR* 34:230 § 6
Landfill final cover	Must cover the landfill or cell with a final cover designed and constructed to		40 *CFR* § 264.310(a) 401 *KAR* 34:230 § 7
	• Provide long-term minimization of migration of liquids through the closed landfill;		40 *CFR* § 264.310(a)(1) 401 *KAR* 34:230 § 7
	• Function with minimum maintenance;		40 *CFR* § 264.310(a)(2) 401 *KAR* 34:230 § 7
	• Promote drainage and minimize erosion or abrasion of the cover;		40 *CFR* § 264.310(a)(3) 401 *KAR* 34:230 § 7
	• Accommodate settling and subsidence so that the integrity of the cover is maintained; and		40 *CFR* § 264.310(a)(4) 401 *KAR* 34:230 § 7
	• Have a permeability less than or equal to the permeability any bottom liner system or natural subsoils present.		40 *CFR* § 264.310(a)(5) 401 *KAR* 34:230 § 7
General post-closure care	After final closure:	Closure of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.310(b) 401 *KAR* 34:230 § 7

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	• Must maintain the effectiveness and integrity of the final cover including making repairs to the cap as necessary to correct effects of settling, subsidence, erosion, or other events;		40 *CFR* § 264.310(b)(1) 401 *KAR* 34:230 § 7
	• Must continue to operate the leachate collection and removal system until leachate is no longer detected;		40 *CFR* § 264.310(b)(2) 401 *KAR* 34:230 § 7
	• Must maintain and monitor the leachate detection system in accordance with substantive requirements of 40 *CFR* § 264.301(a)(3)(iv) and (4), and 40 *CFR* § 264;		40 *CFR* § 264.310(b)(3) 401 *KAR* 34:230 § 7
	• Maintain and monitor a ground- water monitoring system and comply with all other applicable provisions 40 *CFR* § 264, Subpart F;		40 *CFR* § 264.310(b)(4) 401 *KAR* 34:230 § 7
	• Prevent run-on and run-off from eroding or otherwise damaging final cover; and		40 *CFR* § 264.310(b)(5) 401 *KAR* 34:230 § 7
	• Protect and maintain surveyed benchmarks used in complying with 40 *CFR* 264.309 to locate waste cells.		40 *CFR* § 264.310(b)(6) 401 *KAR* 34:230 § 7
Disposal requirements for particular RCRA waste forms and types	For disposal of ignitable or reactive RCRA waste, waste must not be placed into the landfill unless the waste and the landfill meet applicable provisions of 40 *CFR* Part 268 and: (1) the resulting waste, mixture or dissolution of material no longer is reactive or ignitable; (2) 40 *CFR* 264.17(b) is complied with.	Disposal of ignitable or reactive RCRA waste—**applicable**.	40 *CFR* § 264.312(a) 401 *KAR* 34:230, § 8

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Except for prohibited wastes which remain subject to treatment standards in subpart D of part 268, ignitable wastes in containers may be landfilled without meeting the requirements of paragraph (a) of this section, provided that the wastes are disposed of in such a way that they are protected from any material or conditions which may cause them to ignite. At a minimum, ignitable wastes must be disposed of in non-leaking containers which are carefully handled and placed so as to avoid heat, sparks, rupture, or any other condition that might cause ignition of the wastes; must be covered daily with soil or other noncombustible material to minimize the potential for ignition of the wastes; and must not be disposed of in cells that contain or will contain other wastes which may generate heat sufficient to cause ignition of the waste.		40 *CFR* § 264.312(b) 401 *KAR* 34:230, § 8
Disposal requirements for particular RCRA waste forms and types	Incompatible wastes shall not be placed in the same landfill cell unless 40 *CFR* § 264.17(b) is met (see above).	Disposal of incompatible waste—**applicable**.	40 *CFR* § 264.313 401 *KAR* 34:230 § 9
Disposal of bulk or non-containerized liquids in a RCRA landfill	The placement of bulk or non-containerized liquid hazardous waste or hazardous waste containing free liquids (whether or not sorbents have been added) in any landfill is prohibited.	Placement of bulk or non-containerized liquid RCRA hazardous waste in a landfill —**applicable**.	40 *CFR* § 264.314(a) 401 *KAR* 34:230 § 10
Disposal of containers in RCRA landfill	May not place containers holding free liquid in a landfill unless • Free standing liquid has been removed, mixed with an absorbent or solidified so that free-standing liquid is no longer observed or otherwise eliminated; • The container is very small; • The container is designed to hold free liquids for use other than storage; or • The container is a lab pack as defined in 40 *CFR* § 264.316 and is disposed of in accordance with 40 *CFR* § 264.316.	Placement of containers containing RCRA hazardous waste in a landfill—**applicable**.	40 *CFR* § 264.314(c) 401 *KAR* 34:230 § 10

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Sorbents used to treat free liquids to be disposed of in landfills must be non-biodegradable as described in 40 *CFR* § 264.314(d).		40 *CFR* § 264.314(d) 401 *KAR* 34:230 § 10
	Unless they are very small, containers either must be at least 90% full when placed in the landfill, or crushed, shredded, or similarly reduced in volume to the maximum practical extent before burial in the landfill.		40 *CFR* § 264.315 401 *KAR* 34:230 § 11
	Small containers of hazardous waste in overpacked drums (lab packs) may be placed in a landfill if the requirements of this section are met.	Disposal of small containers of hazardous waste in over-packed drums (lab packs) in a landfill—**applicable**.	40 *CFR* § 264.316 401 *KAR* 34:230 § 12
Operation of a waste facility	No waste site or facility shall cause a discharge of pollutants into waters of the Commonwealth, including wetlands, that violate any surface water standards identified as ARARs or cause a discharge of dredged material or fill material to waters of the Commonwealth that is in violation of the substantive requirements under 33 *U.S.C.* 1251 *et seq*. (§ 404 of the Clean Water Act of 1977 as amended).	Construction of a waste facility as defined in *KRS* 224.01–010(27)—**applicable**.	401 *KAR* 30:031 § 4
	No waste site or facility shall engage in open burning of wastes or violate applicable air pollution requirements.		401 *KAR* 30:031 § 9
	No waste site or facility shall result in a public nuisance because of blowing litter, debris, or other waste or material.		401 *KAR* 30:031 § 11
	Design/Construction/Operation of a Solid Waste Disposal Site		
Stormwater runoff	The emergency spillway shall be capable of passing a 100 year twenty-four (24) hour storm event with no flow overtopping the structure.	Construction of a solid waste (contained) landfill—**relevant and appropriate.**	401 *KAR* 48:70 § 2(4)(b)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Cap design for a solid waste (contained) landfill	A vegetative soil layer shall be sufficient to sustain vegetative growth and prevent root penetration of the underlying layers.	Construction of a solid waste (contained) landfill-**relevant and appropriate**.	401 *KAR* 48:080 § 9(3)
	The final cover shall be revegetated.		401 *KAR* 48:080 § 9(6)(a)
	The soil-water pH shall be adjusted and the soil fertilized based upon current soil test results.		401 *KAR* 48:080 § 9(6)(b)
	The seed bed shall be prepared and temporary nurse crops and permanent grasses planted following final cover grading.		401 *KAR* 48:080 § 9(6)(c)
Top leachate collection and removal system	The leachate collection pipe system shall be designed to allow internal inspection, cleaning and maintenance; and	Construction of a solid waste (contained) landfill-**relevant and appropriate**.	401 *KAR* 48:080 § 6(4)(h)
Application of long-term cover	Shall place, compact, and grade the long term cover to effect proper drainage; and	Operation of a solid waste (contained) landfill-**relevant and appropriate**.	401 *KAR* 48:90 §(3)(c)
	Shall complete erosion controls and proper seeding of interim and long-term cover during the fall seeding season.		401 *KAR* 48:90 §(3)(d)
Design/Construction/Operation of a LLW Disposal Facility			
Disposal of LLW	Waste shall not be pyrophoric. Pyrophoric material contained in waste shall be treated, prepared, and packaged to be nonflammable.	Disposal of LLW—**relevant and appropriate**.	902 *KAR* 100:021 § 7(1)(g)
Structural stability of LLW	Waste shall have structural stability. A structurally stable waste form shall maintain its physical dimension and its form under expected disposal conditions, such as: • Weight of overburden and compaction equipment; • Presence of moisture and microbial activity; and • Internal factors such as radiation effects and chemical changes.	Generation of LLW for disposal—**relevant and appropriate**.	902 *KAR* 100:021 § 7 (2)(a)(1)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Structural stability may be provided by: • The waste form itself; • Processing the waste to a stable form; or • Placing the waste in a disposal container or structure that provides stability after disposal.		902 *KAR* 100:021 § 7 (2)(a)(2)
Control and stabilization	Control and stabilization features shall be designed to (1) provide to the extent reasonably achievable an effective life of 1,000 years with a minimum of at least 200 years; (2) limit Rn-222 emanation to the atmosphere from the wastes to less than an annual average release rate of 20 pCi/m2/s and prevent increase in the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L.	Long-term management of uranium, thorium, and their decay products—**TBC**.	DOE O 458.1(4)(h)(1)(d)(1)
Disposal of LLW	Unless otherwise exempted in subsection (1)(c) and (d) of 902 *KAR* 100:021 § 7, liquid waste, or waste containing liquid, shall be converted into a form that contains as little free standing and noncorrosive liquid as is reasonably achievable. The liquid shall not exceed one (1) percent of the volume of the waste if the waste is in a disposal container designed to ensure stability, or five-tenths (0.5) percent of the volume of the waste for waste processed to a stable form.	Disposal of liquid LLW or LLW containing liquids at a LLW disposal facility—**relevant and appropriate**.	902 *KAR* 100:021 § 7 (2)(b)
General requirement for LLW disposal facility	Land disposal facilities shall be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to individuals are within the limits established in the performance objectives contained in 902 *KAR* 100:022 § 21.	Construction of a LLW disposal facility—**relevant and appropriate**.	902 *KAR* 100:022 § 17

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Stability of the disposal site after closure	The disposal facility shall be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.	Construction of a LLW disposal facility—**relevant and appropriate**.	902 *KAR* 100:022 § 21
Design of a LLW disposal facility	Site design features shall be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure.	Construction of a LLW disposal facility—**relevant and appropriate**.	902 *KAR* 100:022 § 23(1)
	The disposal site design and operation shall be compatible with the disposal site closure and stabilization plan and lead to disposal site closure that provides reasonable assurance that the performance objectives contained in 902 *KAR* 100:022 § 21 shall be met.		902 *KAR* 100:022 § 23(2)
	The disposal site shall be designed to complement and improve, where appropriate, the ability of the disposal site's natural characteristics to assure that the performance objectives contained in 902 *KAR* 100:022 § 21 are met.		902 *KAR* 100:022 § 23(3)
	Covers shall be designed to minimize; to the extent practicable, water infiltration to direct percolating or surface water away from the disposed waste and to resist degradation by surface geologic processes and biotic activity.		902 *KAR* 100:022 § 23(4)
	Surface features shall direct surface water drainage away from disposal units at velocities and gradients which shall not result in erosion that shall require ongoing active maintenance in the future.		902 *KAR* 100:022 § 23(5)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	The disposal site shall be designed to minimize to the extent practicable the contact of water with waste, contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal.		902 *KAR* 100:022 § 23(6)
	Wastes shall be emplaced in a manner that maintains the package integrity during emplacement, minimizes the void spaces between packages, and permits the void spaces to be filled. Void spaces between waste packages shall be filled with earth or other material to reduce future subsidence within the fill.	Disposal of LLW in containers —**relevant and appropriate**.	902 *KAR* 100:022 § 24(4-5) 10 *CFR* § 61.56(b)(3)
LLW disposal facility operation and disposal site closure	The boundaries and locations of each disposal unit shall be accurately located and mapped by means of a land survey. *NOTE: For purposes of implementation of these ARARs, the "disposal unit" is defined by the boundary of the cap.*	Closure of LLW land disposal facility—**relevant and appropriate**.	902 *KAR* 100:022 § 24(7)
	Near-surface disposal units shall be marked in a way that the boundaries of each unit can be easily defined.		902 *KAR* 100:022 § 24(8)
	Three (3) permanent survey marker control points, referenced to United States Geological Survey (USGS) or National Geodetic Survey (NGS) survey control stations, shall be established on the site to facilitate surveys.		902 *KAR* 100:022 § 24(9)
	The USGS or NGS control stations shall provide horizontal and vertical controls as checked against USGS or NGS record files.		902 *KAR* 100:022 § 24(10)
	Permanent identification marks for disposal excavations and monitoring wells shall be emplaced.	Operation of a LLW disposal facility at a DOE site—**TBC**.	DOE M 435.1-1 (IV)(P)(6)(b)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	A buffer zone of land shall be maintained between any buried waste and the disposal site boundary and beneath the disposed waste. The buffer zone shall be of adequate dimensions to carry out environmental monitoring activities specified in § 25(4) of 902 *KAR* 100:022 and take mitigative measures if needed.		902 *KAR* 100:022 § 24(11)
	Closure and stabilization measures shall be carried out as each disposal unit is filled and covered.	Operation of a LLW land disposal facility—**relevant and appropriate**.	902 *KAR* 100:022 § 24(12)
	Active waste disposal operations shall not have an adverse effect on completed closure and stabilization measures.		902 *KAR* 100:022 § 24(13)
Environmental monitoring	Conduct a preoperational monitoring program to provide basic environmental data on the disposal site characteristics. *NOTE*: *This requirement would not prevent siting or locating a landfill over an existing radionuclide plume so long as the landfill can be monitored.*	Disposal of LLW in a landfill—**relevant and appropriate**.	902 *KAR* 100:022 § 25(1)(a)
	During the land disposal facility site construction and operation, maintain an environmental monitoring program. *NOTE*: *This requirement would not prevent siting or locating a landfill over an existing radionuclide plume so long as the landfill can be monitored.*		902 *KAR* 100:022 § 25(2)(a)
	The monitoring system shall be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary.		902 *KAR* 100:022 § 25(2)(c)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	NOTE: This requirement would not prevent siting or locating a landfill over an existing radionuclide plume so long as the landfill can be monitored.		
	After the disposal site is closed, shall maintain a monitoring system based on the operating history and the closure and stabilization of the disposal site. The monitoring system shall be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary. *NOTE: This requirement would not prevent siting or locating a landfill over an existing radionuclide plume so long as the landfill can be monitored.*		902 *KAR* 100:022 § 25(3)
Monitoring of LLW disposal facility	The environmental monitoring program shall be designed to include measuring and evaluating releases, migration of radionuclides, disposal unit subsidence, and changes in disposal facility and disposal site parameters which may affect long-term performance.	Operation of a LLW disposal facility at a DOE site—**TBC**.	DOE M. 435.1-1 (IV)(R)(3)(b)
LLW disposal operations	Waste placement into disposal units shall minimize voids between containers with the voids filled to the extent practicable. Uncontainerized bulk waste shall be placed to minimize voids and subsidence.	Operation of a LLW disposal facility at a DOE site—**TBC**.	DOE M 435.1-1 (IV)(P)(6)(c)
	Operations shall be conducted so that disposal operations do not have adverse effects on other disposal units.		DOE M 435.1-1 (IV)(P)(6)(d)
	Void spaces within the waste and, if containers are used, between the waste and its container shall be reduced to the extent practical.		DOE M 435.1-1 (IV)(G)(1)(d)(1)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Design/Construction/Operation of a TSCA Chemical Waste Landfill		
Synthetic liner for a TSCA chemical waste landfill	Synthetic membrane liners shall be used when the hydrologic or geologic conditions at the landfill require such a liner in order to provide at least a permeability equivalent to the soils. A synthetic liner should be chemically compatible with PCBs. Adequate soil underlining and cover shall be provided to prevent excessive stress or rupture of the liner. The liner must have a minimum thickness of 30 mils.	Construction of a TSCA chemical waste landfill—**applicable**.	40 *CFR* § 761.75(b)(2)
Surface water monitoring	The groundwater and surface water from the disposal site area must be sampled prior to commencing operation for use as baseline data.	Operation of a TSCA chemical waste landfill—**applicable**.	40 *CFR* § 761.75 (b)(6)(i)(A)
	Designated surface water course shall be sampled at least monthly when the landfill is being used for disposal and on a frequency of no less than once every six months after final closure of the disposal area.		40 *CFR* § 761.75(b)(6)(i)(B) & (C)
Leachate collection system for TSCA landfill	A leachate collection monitoring system shall be installed above the chemical waste landfill. Leachate collection systems shall be monitored monthly for quantity and physicochemical characteristics of leachate produced. Water analysis shall be conducted as provided in 40 *CFR* § 761.75(b)(6)(iii). The leachate should be either treated to acceptable limits for discharge or disposed of by another approved method.	Construction of a TSCA chemical waste landfill—**applicable**.	40 *CFR* § 761.75(b)(7)
	A compound leachate collection system consists of a gravity flow drainfield installed above the waste disposal unit liner and above a secondary installed liner.		40 *CFR* § 761.75(b)(7)(ii)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Disposal of TSCA wastes	Shall be placed in manner that will prevent damage to containers or articles. Other wastes that are not chemically compatible with PCBs shall be segregated from the PCBs throughout the handling and disposal process.	Disposal of PCBs or PCB Items in chemical waste landfill—**applicable**.	40 *CFR* § 761.75(b)(8)(i)
	May be disposed of provided such waste is pretreated and/or stabilized (e.g., chemically fixed, evaporated, mixed with dry inert absorbent) to reduce its liquid content or increase its solid content so that a nonflowing consistency is achieved to eliminate the presence of free liquids prior to final disposal.	Disposal of PCB bulk liquids not exceeding 500 ppm—**applicable**.	40 *CFR* § 761.75(b)(8)(ii)
	May be disposed of if each container is surrounded by an amount of inert sorbent material capable of absorbing all of the liquid contents of the container.	Disposal of PCB container with liquid PCB between 50 ppm and 500 ppm—**applicable**.	40 *CFR* § 761.75(b)(8)(ii)
	Ignitable wastes shall not be disposed of in chemical waste landfills.	Disposal of PCBs in a TSCA chemical waste landfill—**applicable**.	40 *CFR* § 761.75(b)(8)(iii)
Waste inventory requirements	Disposal records shall include information on the PCB concentration in the liquid wastes and the three dimensional burial coordinates for PCBs and PCB items.	Operation of a TSCA chemical waste landfill—**applicable**.	40 *CFR* § 761.75(b)(8)(iv)
Support facilities	A 6 ft woven mesh fence, wall, or similar device shall be placed around the site to prevent unauthorized persons and animals from entering.	Construction of a TSCA chemical waste landfill—**applicable**.	40 *CFR* § 761.75(b)(9)(i)
	Roads shall be maintained to and within the site that are adequate to support the operation and maintenance of the site without causing safety or nuisance problems or hazardous conditions.		40 *CFR* § 761.75(b)(9)(ii)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	The site shall be operated and maintained in a manner to prevent safety problems or hazardous conditions resulting from spilled liquids and windblown materials. *Note: Does not include occupational safety.*		40 *CFR* § 761.75(b)(9)(iii)
	Technical requirements of 40 *CFR* 761.75(b) may be waived upon finding by the EPA Regional Administrator that the landfill will not present an unreasonable risk of injury to health or the environment from PCBs. *NOTE: Variance shall be made as part of the FFA CERCLA ROD or post-ROD decision document review and approval process.*	Construction of a TSCA chemical waste landfill —**applicable**.	40 *CFR* § 761.75(c)(4)
	Design/Construction/Operation of an Asbestos Waste Disposal Site		
Active asbestos waste disposal site	Must be no visible emissions to the outside air; or	Operation of an active waste disposal site that receives asbestos-containing material from a source covered under 40 *CFR* § 61.145—**applicable**.	40 *CFR* § 61.154(a)
	Unless a natural barrier adequately deters access by the general public, either: (1) Warning signs and fencings must be installed and maintained, or (2) The requirements of 40 *CFR* § 61.154(c)(1) must be met.	Operation of an active waste disposal site that receives asbestos-containing material from a source covered under 40 *CFR* § 61.145—**applicable**.	40 *CFR* § 61.154(b)
	Warning signs must be displayed at all entrances and at intervals of 330 ft or less along the property line of the site or along the perimeter of the sections of the site where asbestos-containing waste material is deposited. The warning signs must:		40 *CFR* § 61.154(b)(1)
	• Be posted in a manner and location that a person can easily read the legend;		40 *CFR* § 61.154(b)(1)(i)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	• Conform to the requirements of (20 inch x 14 inch) upright format signs in 29 *CFR* § 1901.145(d)(4); and		40 *CFR* § 61.154(b)(1)(ii)
	• Display the legend in 40 *CFR* § 61.154(b)(1)(iii) in the lower panel with letter sizes and styles of a visibility at least equal to those specified. Spacing between any two lines must be at least equal to the height of the upper of the two lines.		40 *CFR* § 61.154(b)(1)(iii)
	The perimeter of the disposal site must be fenced in a manner adequate to deter access by the general public.		40 *CFR* § 61.154(b)(2)
	At the end of each operating day, or at least every 24-hour period while the site is in continuous operation, cover the asbestos containing waste material that has been deposited at the site during the operating day or previous 24-hour period with the following:		40 *CFR* § 61.154(c)
	• At least 6 inches of compacted nonasbestos containing material, or		40 *CFR* § 61.154(c)(1)
	• A resinous or petroleum-based dust suppression agent that effectively binds dust and controls wind erosion in the manner and frequency specified by the manufacturer.		40 *CFR* § 61.154(c)(2)
	Record the location, depth and area, and quantity in cubic yards of asbestos-containing material within the disposal site on a map or diagram.	Operation of an active waste disposal site that receives asbestos-containing material from a source covered under 40 *CFR* § 61.145—**applicable**.	40 *CFR* § 61.154(f)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Closure of an inactive asbestos waste disposal site	Inactive asbestos waste disposal sites must either	Disposal of asbestos-containing waste material—**applicable**.	40 *CFR* § 61.154(g)
	• Discharge no visible emissions to the outside air; or		40 *CFR* § 61.151(a)(1)
	• Cover the asbestos-containing waste with at least (6 inches) of compacted nonasbestos-containing material, and grow and maintain a cover of vegetation on the area adequate to prevent exposure of the asbestos containing waste; or		40 *CFR* § 61.151(a)(2)
	• Cover the asbestos-containing waste with at least (2 ft) of compacted nonasbestos-containing material, and maintain it to prevent exposure of the waste.		40 *CFR* § 61.151 (a)(3)
	Unless a natural barrier adequately deters access by the general public, maintain warning signs and fencing as specified in 40 *CFR* § 61.151(b), or meet 40 *CFR* § 61.151 (a)(2) or (a)(3) (see above).		40 *CFR* § 61.151(b)
	Groundwater Monitoring Well Installation, Operation, and Abandonment		
Monitoring well construction	Permanent monitoring wells shall be constructed, modified, and abandoned in such a manner as to prevent the introduction or migration of contamination to a water-bearing zone or aquifer through the casing, drill hole, or annular materials.	Construction of a monitoring well as defined in 401 *KAR* 6:001 § 1(18)—**applicable**.	401 *KAR* 6:350 § 1(2)
	All permanent wells (including boreholes) shall be constructed to comply with the substantive requirements provided in the following Sections of 401 *KAR* 6:350: Section 2. Design Factors; Section 3. Monitoring Well Construction; Section 7. Materials for Monitoring Wells; and Section 8. Surface Completion.		401 *KAR* 6:350

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	If conditions exist or are believed to exist that preclude compliance with the requirements of 401 *KAR* 6:350, may request a variance prior to well construction or well abandonment. *NOTE: Variance shall be made as part of the FFA CERCLA document review and approval process and shall include:* • A justification for the variance; and • Proposed construction, modification, or abandonment procedures to be used in lieu of compliance with 401 *KAR* 6:350 and an explanation as to how the alternate well construction procedures ensure the protection of the quality of the groundwater and the protection of public health and safety.		401 *KAR* 6:350 § 1(6)(a)(6) and (7)
Development of monitoring wells	Newly installed wells shall be developed until the column of water in the well is free of visible sediment. This well-development protocol shall not be used as a method for purging prior to water quality sampling.	Construction of a monitoring well as defined in 401 *KAR* 6:001 § 1(18)—**applicable**.	401 *KAR* 6:350 § 9 (1) and (2)
Closure of groundwater monitoring well(s)	Monitoring wells shall be abandoned in such a manner as to prevent the migration of surface water or contaminants to the subsurface and to prevent migration of contaminants among water bearing zones.	Permanent plugging and abandonment of a well—**applicable**.	401 *KAR* 6:350 § 11(1)(a)
Monitoring well abandonment	A monitoring well that has been damaged or is otherwise unsuitable for use as a monitoring well, shall be abandoned within 30 days from the last sampling date or 30 days from the date it is determined that the well is no longer suitable for its intended use.	Construction of a monitoring well as defined in 401 *KAR* 6:001 § 1(18) for remedial action—**applicable**.	401 *KAR* 6:350 § 11 (1)
	Abandonment methods and sealing materials for all types of monitoring wells provided in subparagraphs (a)-(b) and (d)-(e) shall be followed.		401 *KAR* 6:350 § 11 (2)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Groundwater monitoring well construction	All monitoring wells must be cased in a manner that maintains the integrity of the monitoring-well bore hole. This casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of ground-water samples. The annular space (i.e., the space between the bore hole and well casing) above the sampling depth must be sealed to prevent contamination of samples and the ground water.	Construction of RCRA groundwater monitoring well—**applicable**.	40 *CFR* § 264.97(c) 401 *KAR* 34:060 § 8
	General Facility Requirements		
Security system	Must prevent the unknowing entry, and minimize the possibility for the unauthorized entry, of persons or livestock onto the active portion of this facility, unless: • Physical contact with the waste, structures, or equipment within the active portion of the facility will not injure unknowing or unauthorized persons or livestock which may enter the active portion of a facility; and • Disturbance of the waste or equipment, by the unknowing or unauthorized entry of persons or livestock onto the active portion of a facility, will not cause a violation of the requirements of this part, or comply with the substantive requirements of 40 *CFR* § 264.14(b) and (c).	Operation of a RCRA hazardous waste facility—**applicable**.	40 *CFR* § 264.14 (a)(1) and (2) 401 *KAR* 34:020 § 5

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Unless the owner or operator has made a successful demonstration under paragraphs (a)(1) and (2) of 40 *CFR* § 264.14, a facility must have: • A 24-hour surveillance system (e.g., television monitoring or surveillance by guards or facility personnel) that continuously monitors and controls entry onto the active portion of the facility; or • An artificial or natural barrier (e.g., a fence in good repair or a fence combined with a cliff), which completely surrounds the active portion of the facility, and a means to control entry, at all times, through the gates or other entrances to the active portion of the facility (e.g., an attendant, television monitors, locked entrance, or controlled roadway access to the facility).		40 *CFR* § 264.14 (b)(1) and (2) 401 *KAR* 34:020 § 5
	Unless the owner or operator has made a successful demonstration under paragraphs (a)(1) and (2) of this section, a sign with the legend, "Danger-Unauthorized Personnel Keep Out," must be posted at each entrance to the active portion of a facility and at other locations in sufficient numbers to be seen from any approach to this active portion. The legend must be written in English and in any other language predominant in the area surrounding the facility (e.g., facilities in counties bordering the Canadian province of Quebec must post signs in French; facilities in counties bordering Mexico must post signs in Spanish), and must be legible from a distance of at least 25 ft. Existing signs with a legend other than "Danger-Unauthorized Personnel Keep Out" may be used if the legend on the sign indicates that only authorized personnel are allowed to enter the active portion, and that entry onto the active portion can be dangerous.		40 *CFR* § 264.14 (c) 401 *KAR* 34:020 § 5

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
General inspections	For a RCRA landfill, must remedy any deterioration or malfunction of equipment or structures on a schedule that insures that the problem does not lead to an environmental or human health hazard.	Operation of a RCRA hazardous waste facility (e.g., landfill)—**applicable**.	40 *CFR* § 264.15(c) 401 *KAR* 34:020 § 6
	The facility must be inspected for malfunctions and deterioration, operator errors, and discharges that may be causing,-or may lead to, (1) release of hazardous waste constituents to the environment or (2) a threat to human health. The owner or operator must conduct these inspections often enough to identify problems in time to correct them before they harm human health or the environment.		40 *CFR* § 264.15(a) 401 *KAR* 34:020 § 6
General requirements for ignitable, reactive, or incompatible waste	Must take precautions to prevent accidental ignition or reaction of ignitable or reactive waste. This waste must be separated and protected from sources of ignition or reaction including, but not limited to, open flames, smoking, cutting and welding, hot surfaces, frictional heat, sparks (static, electrical, or mechanical), spontaneous ignition (e.g., from heat-producing chemical reactions), and radiant heat. While ignitable or reactive waste is being handled, smoking and open flames must be confined to specially designated locations. "No Smoking" signs must be placed conspicuously wherever there is a hazard from ignitable or reactive waste.	Operation of a RCRA hazardous waste facility (e.g., landfill)—**applicable**.	40 *CFR* § 264.17(a) 401 *KAR* 34:020 § 8

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Management of incompatible RCRA wastes	Must take precautions to prevent reactions which: • Generate extreme heat, pressure, fire or explosion, or violent reaction; • Produce uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to pose a risk of fire or explosion; • Produce uncontrolled flammable fumes or gases in sufficient quantities to pose a risk of fire or explosion; • Damage the structural integrity of the device or facility; or • Through other like means threaten human health and the environment.	Operation of a RCRA facility that treats, stores, or disposes of incompatible wastes—**applicable**.	40 *CFR* § 264.17(b) 401 *KAR* 34:020 § 8
Preparedness and prevention	When operating a RCRA hazardous waste facility, the facility must be designed, constructed, maintained, and operated to prevent any unplanned release of hazardous waste or hazardous waste constituents into the environment and minimize the possibility of fire or explosion.	Operation of a RCRA hazardous waste facility—**applicable**.	40 *CFR* §§ 264.31 401 *KAR* 34:030 § 2
	Unless it can be demonstrated to the Regional Administrator that none of the hazards posed by waste handled at the facility could require the particular kind of equipment specified in 40 *CFR* § 264.32, all facilities must be equipped with internal communication or alarm system; a device such as a telephone or hand-held two-way radio; fire suppression equipment; and undertake additional measures as specified in 40 *CFR* § 264.32. ***NOTE**: Any demonstration that none of the hazards posed by waste handled at the facility could require the particular kind of equipment in this section shall be made as part of the FFA CERCLA document review and approval process.*		40 *CFR* § 264.32 401 *KAR* 34:030 § 3

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Preparedness and prevention	All facility communication or alarm systems, fire protection equipment, spill control equipment, and decontamination equipment, where required, must be tested and maintained as necessary to assure its proper operation in time of emergency.	Operation of a RCRA hazardous waste facility—**applicable**.	40 *CFR* § 264.33 401 *KAR* 34:030, § 4
	Whenever hazardous waste is being poured, mixed, spread, or otherwise handled, all personnel must have immediate access to internal alarm or emergency communications device either directly or through visual or voice contact with another employee, unless such internal alarm or communications device is not required under 40 *CFR* § 264.32.		40 *CFR* § 264.34(a) 401 *KAR* 34:030, § 5
	If there is just one employee on the premises while the facility is operating, he must have immediate access to a device such as a telephone or hand-held two-way radio, unless such communication device is not required under 40 *CFR* § 264.32.		40 *CFR* § 264.34(b) 401 *KAR* 34:030 § 5
	Must maintain aisle space to allow the unobstructed movement of personnel, fire protection equipment, spill control equipment, and decontamination equipment to any area of the facility in an emergency unless it can be demonstrated to the Regional Administrator that aisle space is not needed for any of these purposes. ***NOTE**: This demonstration shall be made as part of the FFA CERCLA document review and approval process.*	Storage of RCRA hazardous waste in containers**—applicable**.	40 *CFR* § 264.35 401 *KAR* 34:030 § 6
Emergency coordinator	Must be at least one emergency coordinator on the facility premises or on call (i.e., available to respond to an emergency by reaching the facility within a short period of time) with responsibility for coordinating emergency response measures in accordance with 40 *CFR* § 264.56.	Operation of a RCRA hazardous waste facility (e.g., landfill)—**applicable**.	40 *CFR* § 264.55 401 *KAR* 34:040 § 6

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Air emissions from stationary diesel engines	Owners and operators of 2007 model year and later nonemergency stationary compression ignition (CI) internal combustion engine (ICE) with a displacement of less than 30 liters per cylinder must comply with the emission standards for new CI engines in §60.4201 for their 2007 model year and later stationary CI ICE, as applicable.	Owners and operators of stationary diesel engines that commence construction after July 11, 2005, where the stationary engines are manufactured after April 1, 2006—**applicable**.	40 *CFR* § 60.4204 (b)
Waste Generation Associated with Landfill Operations (e.g., Storm Water Runoff, Leachate)			
Characterization of industrial wastewater	Industrial wastewater discharges that are point source discharges subject to regulation under § 402 of the Clean Water Act, as amended, are not solid wastes for the purpose of hazardous waste management. [Comment: This exclusion applies only to the actual point source discharge. It does not exclude industrial wastewaters while they are being collected, stored, or treated before discharge, nor does it exclude sludges that are generated by industrial wastewater treatment.] *NOTE: For the purpose of this exclusion, the CERCLA on-site treatment system will be considered equivalent to a wastewater treatment unit and the point source discharges subject to regulation under CWA Section 402, provided the effluent meets all identified CWA ARARs.*	Generation of industrial wastewater for treatment and discharge into surface water—**applicable**.	40 *CFR* § 261.4(a)(2) 401 *KAR* 31:010 § 4
Characterization of solid waste associated with landfill operations	Must determine if solid waste is excluded from regulation under 40 *CFR* § 261.4.	Generation of solid waste as defined in 40 *CFR* § 261.2—**applicable**.	40 *CFR* § 262.11(a) 401 *KAR* 32:010 § 2
	Must determine if waste is listed as a hazardous waste in subpart D of 40 *CFR* Part 261.	Generation of solid waste that is not excluded under 40 *CFR* § 261.4—**applicable**.	40 *CFR* § 262.11(b) 401 *KAR* 32:010 § 2

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Must determine whether the waste is identified in subpart C of 40 *CFR* Part 261 by using prescribed testing methods or applying generator knowledge based on information regarding material or processes used.	Generation of solid waste that is not listed in subpart D of 40 *CFR* Part 261 and not excluded under 40 *CFR* § 261.4—**applicable**.	40 *CFR* § 262.11(c) 401 *KAR* 32:010 § 2
	Must refer to Parts 261, 262, 264, 265, 266, 268, and 273 of Chapter 40 for possible exclusions or restrictions pertaining to management of the specific waste.	Generation of solid waste that is determined to be hazardous—**applicable**.	40 *CFR* § 262.11(d) 401 *KAR* 32:010 § 2
Characterization of hazardous waste associated with landfill operations	Must determine if the hazardous waste meets the treatment standards in 40 *CFR* § 268.40, 268.45, or 268.49 by testing in accordance with prescribed methods or use of generator knowledge of waste.	Generation of a hazardous waste—**applicable**.	40 *CFR* § 268.7(a) 401 *KAR* 37:010 § 7
Characterization of LLW associated with landfill operations	Shall be characterized using direct or indirect methods and the characterization documented in sufficient detail to ensure safe management and compliance with the waste acceptance criteria of the receiving facility.	Generation of LLW for disposal at a DOE facility—**TBC**.	DOE M 435.1-1 (IV)(I)
	Characterization data shall, at a minimum, include the following information relevant to the management of the waste:		DOE M 435.1-1(IV)(I)(2)
	• physical and chemical characteristics;		DOE M 435.1-1(IV)(I)(2)(a)
	• volume, including the waste and any stabilization or absorbent media;		DOE M 435.1-1(IV)(I)(2)(b)
	• weight of the container and contents;		DOE M 435.1-1(IV)(I)(2)(c)
	• identities, activities, and concentration of major radionuclides;		DOE M 435.1-1(IV)(I)(2)(d)
	• characterization date;		DOE M 435.1-1(IV)(I)(2)(e)
	• generating source; and		DOE M 435.1-1(IV)(I)(2)(f)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	• any other information that may be needed to prepare and maintain the disposal facility performance assessment, or demonstrate compliance with the performance objectives contained in DOE O 435.1.		DOE M 435.1-1(IV)(I)(2)(g)
	Staging and Storage of Wastes for Disposal		
Temporary on-site storage of remediation waste in staging piles	Must be located within the contiguous property under the control of the owner/operator where the wastes are to be managed in the staging pile originated. For purposes of this section, storage includes mixing, sizing, blending or other similar physical operations so long as intended to prepare the wastes for subsequent management or treatment.	Accumulation of non-flowing hazardous remediation waste (or remediation waste otherwise subject to land disposal restrictions) as defined in 40 *CFR* § 260.10—**applicable**.	40 *CFR* § 264.554(a)(1) 401 *KAR* 34:287 § 5(1)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Staging piles may be used to store hazardous remediation waste (or remediation waste otherwise subject to land disposal restrictions) based on approved standards and design criteria designated for that staging pile. *NOTE: Design and standards of the staging pile should be included in CERCLA remedial design document approved by EPA.*		40 *CFR* § 264.554(b)
Operation of a staging pile	Must not operate for more than two years, except when an operating term extension under 40 *CFR* § 264.554(i) is granted. *NOTE: Must measure the two-year limit (or other operating term specified) from first time remediation waste placed in staging pile.* *NOTE: It is recognized that a staging pile for the WDF may need to be operated past the two-year time limit. Any time period greater than two years will be documented and justified in the ROD. The ROD would provide a process for further Post-ROD extensions of the operating term by using a memorandum in the administrative record that documents the justification with the concurrence of the FFA parties.*	Storage of remediation waste in a staging pile—**applicable**.	40 *CFR* §264.554(d)(1)(iii)
	Must not use staging pile longer than the length of time designated by EPA in appropriate decision document. *NOTE: It is recognized that a staging pile for the WDF may need to be operated past the two-year time limit. Any time period greater than two years will be documented and justified in the ROD. The ROD would provide a process for further Post-ROD extensions of the operating term by using a memorandum in the administrative record that documents the justification with the concurrence of the FFA parties.*		40 *CFR* §264.554(h)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Performance criteria for staging pile	The standards and design criteria for a staging pile must: • facilitate a reliable, effective, and protective remedy; and • be designed to prevent or minimize releases of hazardous wastes and constituents into the environment, and minimize or adequately control cross-media transfer as necessary to protect human health and the environment (e.g., use of liners, covers, runoff/run-on controls as appropriate).		40 *CFR* § 264.554(d)(1)(i)and (ii) 401 *KAR* 34:287 § 5
Design criteria for staging pile	In setting the standards and design criteria the director must consider the following factors: • Length of time pile will be in operation; • Volumes of waste you intend to store in the pile; • Physical and chemical characteristics of the wastes to be stored in the unit; • Potential for releases from the unit; • Hydrogeological and other relevant environmental conditions at the facility that may influence the migration of any potential releases; and • Potential for human and environmental exposure to potential releases from the unit.	Accumulation of non-flowing hazardous remediation waste (or remediation waste otherwise subject to land disposal restrictions) as defined in 40 *CFR* § 260.10—**applicable**.	40 *CFR* § 264.554(d)(2)(i)–(vi) 401 *KAR* 34:287 § 5
	Must not place ignitable or reactive remediation waste in a staging pile unless the remediation waste has been treated, rendered, or mixed before placed in the staging pile so that: • The remediation waste no longer meets the definition of ignitable or reactive under 40 *CFR* § 261.21 or 40 *CFR* § 261.23; and • You have complied with 40 *CFR* § 264.17(b); or	Storage of ignitable or reactive remediation waste in staging pile—**applicable.**	40 *CFR* § 264.554(e) 401 *KAR* 34:287 § 5 40 *CFR* § 264.554(e)(1)(i) 401 *KAR* 34:287 § 5 40 *CFR* § 264.554(e)(1)(ii) 401 *KAR* 34:287 § 5

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Must manage the remediation waste to protect it from exposure to any material or condition that may cause it to ignite or react.		40 *CFR* § 264.554(e)(2) 401 *KAR* 34:287 § 5
	Must not place incompatible wastes in the same staging pile unless you have complied with 40 *CFR* § 264.17(b).	Storage of "incompatible" remediation waste, as defined in 40 *CFR* § 260.10, in staging pile—**applicable**.	40 *CFR* § 264.554(f)(1) 401 *KAR* 34.287 § 5
	Must separate the incompatible materials, or protect them from one another by using a dike, berm, wall, or other device.		40 *CFR* § 264.554(f)(2) 401 *KAR* 34:287 § 5
	Must not pile remediation waste on same base where incompatible wastes or materials were previously piled unless the base has been decontaminated sufficiently to comply with 40 *CFR* § 264.17(b).		40 *CFR* § 264.554(f)(3) 401 *KAR* 34:.287 § 5
Operation of a staging pile	Does not constitute land disposal of hazardous waste or create a unit that is subject to the minimum technological requirements of Section 3004(o) of RCRA.	Placement of hazardous remediation wastes into a staging pile—**applicable**.	40 *CFR* § 264.554(g) 401 *KAR* 34:287 § 5
Closure of staging pile of remediation waste	Must be closed within 180 days after the operating term by removing or decontaminating all remediation waste, contaminated containment system components, and structures and equipment contaminated with waste and leachate. Must decontaminate contaminated sub-soils in a manner that EPA determines will protect human and the environment. *NOTE: The time period for closure will be specified in the appropriate CERCLA documentation, which may be greater than 180 days.*	Storage of remediation waste in staging pile in ***previously contaminated area***—**applicable**.	40 *CFR* § 264.554(j)(1) and (2)
	Must be closed within 180 days after the operating term according to 40 *CFR* 264.558(a) and 264.111 or 265.258(a) and 265.111.	Storage of remediation waste in staging pile in ***uncontaminated area***—**applicable**.	40 *CFR* § 264.554(k)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	NOTE: The time period for closure will be specified in the appropriate CERCLA documentation, which may be greater than 180 days.		
Temporary on-site storage of hazardous waste in containers	A generator may accumulate hazardous waste at the facility provided that waste is placed in containers that comply with 40 *CFR* § 265.171–173;	Accumulation of RCRA hazardous waste on-site as defined in 40 *CFR* §260.10**—applicable**.	40 *CFR* § 262.34(a) 401 *KAR* 32:030 § 5 40 *CFR* § 262.34(a)(1)(i) 401 *KAR* 32:030 § 5
	the date upon which accumulation begins is clearly marked and visible for inspection on each container;		40 *CFR* § 262.34(a)(2) 401 *KAR* 32:030 § 5
	container is marked with the words “hazardous waste.”		40 *CFR* § 262.34(a)(3) 401 *KAR* 32:030 § 5
	If container is not in good condition or if it begins to leak, must transfer waste into a container in good condition.	Storage of RCRA hazardous waste in containers—**applicable**.	40 *CFR* § 265.171 401 *KAR* 35:180 § 2
	Use container made or lined with materials compatible with waste to be stored so that the ability of the container is not impaired.		40 *CFR* § 265.172 401 *KAR* 35:180 § 3
	Keep containers closed during storage, except to add/remove waste.		40 *CFR* § 265.173(a) 401 *KAR* 35:180 § 4
	Open, handle, and store containers in a manner that will not cause containers to rupture or leak.		40 *CFR* § 265.173(b) 401 *KAR* 35:180 § 4
Closure of RCRA container accumulation area	Must close the unit in a manner that	Closure of a RCRA container accumulation area—**applicable**.	40 *CFR* § 264.111(a)
	• Minimizes the need for further maintenance.		401 *KAR* 34:070 § 2

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	• Controls, minimizes, or eliminates to the extent necessary to protect human health and the environment, postclosure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to ground or surface waters or to the atmosphere.		40 *CFR* § 264.111(b) 401 *KAR* 34:070 § 2
	• Complies with the substantive closure requirements of 40 *CFR* §§ 265.111 and 265.114.		40 *CFR* § 264.111(c) 401 *KAR* 34:070 § 2
Use and management of containers holding hazardous waste	If container is not in good condition or if it begins to leak, must transfer waste into container in good condition.	Storage of RCRA hazardous waste in containers**—applicable**.	40 *CFR* § 264.171 401 *KAR* 34:180 § 2
	Use container made or lined with materials compatible with waste to be stored so that the ability of the container is not impaired.		40 *CFR* § 264.172 401 *KAR* 34:180 § 3
	Keep containers closed during storage, except to add/remove waste.		40 *CFR* § 264.173(a) 401 *KAR* 34:180 § 4
	Open, handle, and store containers in a manner that will not cause containers to rupture or leak.		40 *CFR* § 264.173(b) 401 *KAR* 34:180 § 4
	Area must have a containment system designed and operated in accordance with 40 *CFR* § 264.175(b)	Storage of RCRA hazardous waste in containers with free liquids—**applicable**.	40 *CFR* § 264.175(a) 401 *KAR* 34:180 § 6
	Base must underlie containers which is free of cracks or gaps and is sufficiently impervious to contain leaks, spills, and accumulated precipitation until the collected material is detected and removed.		40 *CFR* § 264.175(b)(1) 401 *KAR* 34:180 § 6

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	The base must be sloped or the containment system must be otherwise designed and operated to drain and remove liquids resulting from leaks, spills, or precipitation, unless the containers are elevated or are otherwise protected from contact with accumulated liquids.		40 *CFR* § 264.175(b)(2) 401 *KAR* 34:180 § 6
	The containment system must have sufficient capacity to contain 10% of the volume of containers or the volume of the largest container, whichever is greater.		40 *CFR* § 264.175(b)(3) 401 *KAR* 34:180 § 6
	Run-on into the containment system must be prevented unless the collection system has sufficient excess capacity in addition to that required in paragraph (b)(3) of this section to contain any run-on which might enter the system.		40 *CFR* § 264.175(b)(4) 401 *KAR* 34:180 § 6
	Spilled or leaked waste and accumulated precipitation must be removed from the sump or collection area in a timely manner as is necessary to prevent overflow of the collection system.	Storage of RCRA hazardous waste in containers with free liquids—**applicable**.	40 *CFR* § 264.175(b)(5) 401 *KAR* 34:180 § 6
	Area must be sloped or otherwise designed and operated to drain liquid from precipitation, or containers must be elevated or otherwise protected from contact with accumulated liquid.	Storage of RCRA hazardous waste in containers that do not contain free liquids (other than F020, F021, F022, F023, F026, and F027)—**applicable**.	40 *CFR* § 264.175(c) 401 *KAR* 34:180 § 6
Special requirements for ignitable or reactive waste	Containers holding ignitable or reactive waste must be located at least 15 m (50 ft) from the facility's property line.	Storage of ignitable or reactive RCRA hazardous waste in containers—**applicable.**	40 *CFR* § 264.176 401 *KAR* 34:180 § 7

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Special requirements for incompatible waste	• Incompatible wastes or incompatible wastes and materials must not be placed in the same container, unless § 264.17(b) is complied with. • Hazardous waste must not be placed in an unwashed container that previously held an incompatible waste or material. • A storage container holding a hazardous waste that is incompatible with any waste or other materials stored nearby in other containers, piles, open tanks, or surface impoundments must be separated from the other materials or protected from them by means of a dike, berm, wall, or other device.	Storage of incompatible RCRA hazardous waste in containers—**applicable**.	40 *CFR* § 264.177(a)-(c) 401 *KAR* 34:180 § 8
	At closure, all hazardous waste and hazardous waste residues must be removed from the containment system. Remaining containers, liners, bases, and soils containing or contaminated with hazardous waste and hazardous waste residues must be decontaminated or removed. [Comment: At closure, as throughout the operating period, unless the owner or operator can demonstrate in accordance with 40 *CFR* § 261.3(d) of this chapter that the solid waste removed from the containment system is not a hazardous waste, the owner or operator becomes a generator of hazardous waste and must manage it in accordance with all applicable requirements of Parts 262 through 266 of this chapter.]	Storage of RCRA hazardous waste in containers in a unit with a containment system—**applicable**.	40 *CFR* § 264.178 401 *KAR* 34:180 § 9

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Closure performance standard for RCRA container storage unit	Must close the facility (e.g., container storage unit) in a manner that: • Minimizes the need for further maintenance; • Controls, minimizes, or eliminates to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or the atmosphere; and • Complies with the closure requirements of subpart, but not limited to, the requirements of 40 *CFR* § 264.178 for containers.	Storage of RCRA hazardous waste in containers—**applicable**.	40 *CFR* § 264.111 401 *KAR* 34:070 § 2
Storage of PCB waste and/or PCB/radioactive waste in non-RCRA regulated unit	Except as provided in 40 *CFR* § 761.65 (b)(2), (c)(1), (c)(7), (c)(9), and (c)(10), after July 1, 1978, owners or operators of any facilities used for the storage of PCBs and PCB items designated for disposal shall comply with the storage unit requirements in 40 *CFR* § 761.65(b)(1).	Storage of PCBs and PCB Items at concentrations ≥ 50 ppm designated for disposal—**applicable**.	40 *CFR* § 761.65(b)
	Storage facility shall meet the following criteria:		40 *CFR* § 761.65(b)(1)
	Adequate roof and walls to prevent rainwater from reaching stored PCBs and PCB items;		40 *CFR* § 761.65(b)(1)(i)
	Adequate floor that has continuous curbing with a minimum 6-inch high curb. Floor and curb must provide a containment volume equal to at least two times the internal volume of the largest PCB article or container or 25% of the internal volume of all articles or containers stored there, whichever is greater. *NOTE*: *6-inch minimum curbing not required for area storing PCB/radioactive waste;*		40 *CFR* § 761.65(b)(1)(ii)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	No drain valves, floor drains, expansion joints, sewer lines, or other openings that would permit liquids to flow from curbed area;		40 *CFR* § 761.65(b)(1)(iii)
	Floors and curbing constructed of Portland cement, concrete, or a continuous, smooth, nonporous surface that prevents or minimizes penetration of PCBs; and		40 *CFR* § 761.65(b)(1)(iv)
	Not located at a site that is below the 100-year flood water elevation.		40 *CFR* § 761.65(b)(1)(v)
Storage of PCB waste and/or PCB/radioactive waste in a RCRA-regulated container storage area	Does not have to meet storage unit requirements in 40 *CFR* § 761.65(b)(1) provided unit:	Storage of PCBs and PCB Items at concentrations ≥ 50 ppm designated for disposal—**applicable**.	40 *CFR* § 761.65(b)(2)
	• is permitted by EPA under RCRA § 3004 to manage hazardous waste in containers and spills of PCBs cleaned up in accordance with Subpart G of 40 *CFR* § 761; or		40 *CFR* § 761.65(b)(2)(i)
	• qualifies for interim status under RCRA § 3005 to manage hazardous waste in containers and spills of PCBs cleaned up in accordance with Subpart G of 40 *CFR* § 761; or		40 *CFR* § 761.65(b)(2)(ii)
	• is permitted by an authorized state under RCRA § 3006 to manage hazardous waste in containers and spills of PCBs cleaned up in accordance with Subpart G of 40 *CFR* § 761. *NOTE: For purpose of this exclusion, CERCLA remediation waste (which is also considered PCB waste), can be stored on-site provided the area meets all of the identified RCRA container storage ARARs and spills of PCBs are cleaned up in accordance with Subpart G of 40 CFR § 761.*		40 *CFR* § 761.65(b)(2)(iii)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Storage area must be properly marked as required by 40 *CFR* § 761.40(a)(10).	Storage of PCBs and PCB items at concentrations ≥ 50 ppm in containers for disposal—**applicable**.	40 *CFR* § 761.65(c)(3)
	Any leaking PCB Items and their contents shall be transferred immediately to a properly marked nonleaking container(s).		40 *CFR* § 761.65(c)(5)
	Except as provided in 40 *CFR* § 761.65(c)(6)(i) and (c)(6)(ii), container(s) shall be in accordance with requirements set forth in DOT HMR at 49 *CFR* §§ 171–180.		40 *CFR* § 761.65(c)(6)
	Container(s) shall be marked as illustrated in 40 *CFR* § 761.45(a).		40 *CFR* § 761.40(a)(1)
Risk-based storage of PCB remediation waste	May store PCB remediation waste in a manner other than prescribed in 40 *CFR* § 761.65(b) if approved in writing from EPA provided the method will not pose an unreasonable risk of injury to human health or the environment. *NOTE*: *EPA approval of alternative storage method will be obtained by approval of the FFA CERCLA document.*	Storage of waste containing PCBs in a manner other than prescribed in 40 *CFR* § 761.65(b) (see above)—**applicable**.	40 *CFR* § 761.61(c)
Temporary storage of bulk PCB remediation waste or PCB bulk product waste in a waste pile	May be stored at the clean-up site or site of generation subject to the following conditions: • waste must be placed in a pile designed and operated to control dispersal by wind, where necessary, by means other than wetting; • waste must not generate leachate through decomposition or other reactions.	Storage of PCB remediation waste or PCB bulk product waste in a waste pile—**applicable**.	40 *CFR* § 761.65(c)(9)(i) 40 *CFR* § 761.65(c)(9)(ii)
	Storage site must have a liner designed, constructed, and installed to prevent any migration of wastes off or through liner into adjacent subsurface soil, groundwater or surface water at any time during the active life (including closure period) of the storage site.		40 *CFR* § 761.65(c)(9)(iii)(A)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Liner must be • constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure because of pressure gradients, physical contact with waste or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;		40 *CFR* § 761.65(c)(9)(iii)(A)(*1*)
	• placed on foundation or base capable of providing support to liner and resistance to pressure gradients above and below the liner to prevent failure because of settlement compression or uplift;		40 *CFR* § 761.65(c)(9)(iii)(A)(*2*)
	• installed to cover all surrounding earth likely to be in contact with waste.		40 *CFR* § 761.65(c)(9)(iii)(A)(*3*)
	Has a cover that meets the above requirements and installed to cover all of the stored waste likely to be contacted by precipitation, and is secured so as not to be functionally disabled by winds expected under normal weather conditions at the storage site; and		40 *CFR* § 761.65(c)(9)(iii)(B)
	Has a run-on control system designed, constructed, operated and maintained such that: • It prevents flow on the stored waste during peak discharge from at least a 25-year storm; • It collects and controls at least the water volume resulting from a 24-hour, 25-year storm. Collection and holding facilities (e.g., tanks or basins) must be emptied or otherwise managed expeditiously after storms to maintain design capacity of the system.		40 *CFR* § 761.65(c)(9) (iii)(C) 40 *CFR* § 761.65(c)(9) (iii)(C)(*1*) 40 *CFR* § 761.65(c)(9)(iii)(C)(*2*)
	Requirements of 40 *CFR* § 761.65(c)(9) may be modified under the risk-based disposal option of 40 *CFR* § 761.61(c).		40 *CFR* § 761.65(c)(9)(iv)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Design and installation of RCRA tank system (tanks, associated piping, etc.)	Must prepare an assessment [reviewed and certified by an independent registered professional engineer in accordance with 40 *CFR* § 270.11(d)] attesting that the tank system design has sufficient structural integrity and is acceptable for storing/treating hazardous waste. The assessment must include the information specified in 40 *CFR* § 264.192(a)(1)-(5). *NOTE: Assessment and certification that the tank design has sufficient structural integrity and acceptability for storage of the leachate will be reflected in the remedial design, remedial action work plan, or other appropriate FFA CERCLA document.*	Storage of RCRA hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site wastewater treatment unit (WWTU) or storage of leachate in a temporary unit.*	40 *CFR* § 264.192(a) 401 *KAR* 34:190 § 3
	Prior to use, must ensure that proper handling procedures are adhered to in order to prevent damage to the system during installation. Prior to use, must inspect the system for the presence of weld breaks, punctures, scrapes of protective coatings, cracks, corrosion, other structural damage, or inadequate construction/installation.		40 *CFR* § 264.192(b) 40 *CFR* § 264.192(b)(1)-(6) 401 *KAR* 34:190 § 3
	Must be provided with a backfill material that is a noncorrosive, porous, homogenous substance and that is installed so that backfill is placed completely around the tank and compacted to ensure that the tank and piping are fully and uniformly supported.	Storage of RCRA hazardous waste leachate in a new tank system prior to shipment off- site for disposal that are placed underground—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.192(c) 401 *KAR* 34:190 § 3

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Prior to use, tanks and ancillary equipment must be tested for tightness prior to being covered, enclosed, or placed in use. If a tank system is found not to be tight, all repairs necessary to remedy the leak(s) must be performed prior to the system being covered, enclosed, or placed into use.	Storage of RCRA hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.192(d) 401 *KAR* 34:190 § 3
	Ancillary equipment (i.e., piping) must be supported and protected against physical damage and excessive stress due to settlement, vibration, expansion, or contraction.		40 *CFR* § 264.192(e) 401 *KAR* 34:190 § 3
	Must provide the degree of corrosion protection based upon the information in 40 *CFR* § 264.192(a)(3) to ensure the integrity of the tank system during use. Installation of field fabricated corrosion protection system must be supervised by an independent corrosion expert.		40 *CFR* § 264.192(f) 401 *KAR* 34:190 § 3
	Double-walled tanks must be: • Designed as an integral structure (i.e., an inner tank completely enveloped within and outer shell) so that any release from the inner tank is contained by the outer shell; • Protected, if constructed of metal, from both corrosion of the primary tank interior and of the external surface of the outer shell; and • Provided with a built-in continuous leak detection system capable of detecting a release within 24 hours, or at the earliest practicable time.		40 *CFR* § 264.193(e)(3)(i) 40 *CFR* § 264.193(e)(3)(ii) 40 *CFR* § 264.193(e)(3)(iii) 401 *KAR* 34:190 § 4

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Ancillary equipment must be provided with secondary containment (e.g., trench, jacketing, double-walled piping) that meets the requirements of 40 *CFR* § 264.193(b) and (c) except for: • Aboveground piping (exclusive of flanges, joints, valves, and other connections) that are visually inspected for leaks on a daily basis; • Welded flanges, welded joints and welded connections, that are visually inspected for leaks on a daily basis; • Seamless or magnetic coupling pumps and seamless valves, that are visually inspected for leaks on a daily basis; and • Pressurized aboveground piping systems with automatic shut-off devices (e.g., excess flow check valves, flow metering shutdown devices, loss of pressure actuated shut-off devices) that are visually inspected for leaks on a daily basis.	Storage of RCRA hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.193(f)(1)-(4) 401 *KAR* 34:190 § 4
Design of RCRA tank secondary containment system	Must provide secondary containment in order to prevent release of hazardous waste or constituents into the environment.	Storage of RCRA hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.193(a)(1) 401 *KAR* 34:190 § 4

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Secondary containment systems must be: • Designed, installed, and operated to prevent any migration of wastes or accumulated liquid out of the system to the soil, ground water, or surface water at any time during the use of the tank system; and • Capable of detecting and collecting releases and accumulated liquids until the collected material is removed.		40 *CFR* § 264.193(b)(1) 40 *CFR* § 264.193(b)(2) 401 *KAR* 34:190 § 4
	Secondary containment systems must be at a minimum: • Constructed or lined with materials that are compatible with the wastes to be placed in the tank system and must have sufficient strength and thickness to prevent failure owing to pressure gradients (including static head and external hydrological forces), physical contact with the waste to which it is exposed, climatic conditions, and the stress of daily operation (including stresses from nearby vehicular traffic); • Placed on a foundation or base capable of providing support to the secondary containment system, resistance to pressure gradients above and below the system, and capable of preventing failure due to settlement, compression, or uplift; • Provided with a leak-detection system that is designed and operated so that it will detect the failure of either the primary or secondary containment structure or the presence of any release of hazardous waste or accumulated liquid in the secondary containment system within 24 hours; and	Storage of RCRA hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.193(c)(1)-(4) 401 *KAR* 34:190 § 4

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	• Sloped or otherwise designed or operated to drain and remove liquids resulting from leaks, spills, or precipitation. Spilled or leaked waste and accumulated precipitation must be removed from the secondary containment system within 24 hours, or in as timely a manner as is possible to prevent harm to human health and the environment.		
	The secondary containment for tanks must include one or more of the following devices: • A liner (external to the tank); • A vault; • A double-walled tank; or • An equivalent device as approved by the EPA Regional Administrator. *NOTE*: *EPA approval of an equivalent device will be obtained by approval of the FFA CERCLA document.*		40 *CFR* § 264.193(d)(1-4) 401 *KAR* 34:190 § 4
	External liner systems must be: • Designed and operated to contain 100 percent of the capacity of the largest tank within its boundary; • Designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration (such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event);		40 *CFR* § 264.193(e)(1)(i) 40 *CFR* § 264.193(e)(1)(ii) 40 *CFR* § 264.193(e)(1)(iii) 40 *CFR* § 264.193(e)(1)(iv) 401 *KAR* 34:190 § 4

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	• Free of cracks or gaps; and • Designed and installed to surround the tank completely and to cover all surrounding earth likely to come into contact with the waste if the waste is released from the tank(s) (i.e., capable of preventing lateral as well as vertical migration of the waste).		
	Vault system must be: • Designed or operated to contain 100 percent of the capacity of the largest tank within its boundary; • Designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration (such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event); • Constructed of chemical-resistant water stops in all joints (if any); • Provided with an impermeable interior coating or lining that is compatible with the stored waste and that will prevent migration of the waste in to the concrete; • Provided with a means to protect against formation of and ignition of vapors within the vault if the waste being stored or treated meets the definition of ignitable or reactive waste under 40 *CFR* § 261.21 or § 261.23; and • Provide with an exterior moisture barrier or otherwise designed or operated to prevent migration of moisture into the vault if the vault is subject to hydraulic pressure.	Storage of RCRA hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.193(e)(2)(i) 40 *CFR* § 264.193(e)(2)(ii) 40 *CFR* § 264.193(e)(2)(iii) 40 *CFR* § 264.193(e)(2)(iv) 40 *CFR* § 264.193(e)(2)(v) 40 *CFR* § 264.193(e)(2)(vi) 401 *KAR* 34:190 § 4

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Operation of RCRA tank system	Hazardous wastes or treatment reagents must not be placed in the tank system if they could cause the tank, its ancillary equipment, or the containment system to rupture, leak, corrode, or otherwise fail.	Storage of RCRA hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.194(a) 401 *KAR* 34:190 § 5
	Must use appropriate controls and practices to prevent spills and overflows from the tank or containment system. These include at a minimum: • Spill prevention controls (e.g., check valves, dry disconnect couplings); • Overfill prevention controls (e.g., level sensing devices, high level alarms, automatic feed cutoff, or bypass to a standby tank); and • Maintenance of sufficient freeboard in uncovered tanks to prevent overtopping by wave or wind action or by precipitation.		40 *CFR* § 264.194(b)(1)-(3) 401 *KAR* 34:190 §5
	Must comply with the substantive requirements of 40 *CFR* § 264.196 if a leak or a spill occurs in the tank system.		40 *CFR* § 264.194(c) 401 *KAR* 34:190 §5
Inspection of RCRA tank system	Must develop and follow a schedule for inspecting overfill controls. *NOTE: Inspection schedule for overfill controls will be developed as part of the CERCLA process and included in a remedial action work plan or other appropriate FFA CERCLA document.*	Storage of RCRA hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.195(a) 401 *KAR* 34:190 § 6

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Must inspect at least once each operating day: • Aboveground portions of the tank system, if any, to detect corrosion or releases of waste; • Data gathered from monitoring and leak detection equipment (e.g., pressure or temperature gauges monitoring wells) to ensure that the tank system is being operated according to its design; and • The construction materials and the area immediately surrounding the externally accessible portion of the tank system, including the secondary containment system (e.g., dikes) to detect erosion or signs of releases of hazardous waste (e.g., wet spots, dead vegetation).		40 *CFR* § 264.195(b) 40 *CFR* § 264.195(c) 401 *KAR* 34:190 § 6
Operation of RCRA tank system	Must not be placed in tank system unless: • Waste is treated, rendered, or mixed before or immediately after placement in the tank system so that the resulting waste, mixture or dissolved material is no longer ignitable or reactive and 40 *CFR* § 264.17(b) is complied with; or • Waste is stored or treated in such a way that it is protected from any material or conditions that may cause the waste to ignite or react; or • The tank system is used solely for emergencies.	Storage of RCRA ignitable or reactive hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.198(a)(1)-(3) 401 *KAR* 34:190 §9
	Must not be placed in the same tank system, unless 40 *CFR* § 264.17(b) is complied with. Hazardous waste must not be placed in a tank system that has not been decontaminated and that previously held an incompatible waste or material unless 40 *CFR* § 264.17(b) is complied with.	Storage of incompatible RCRA hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: these requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.199(a) 40 *CFR* § 264.199(b) 401 *KAR* 34:190 § 10

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Control of emissions from a RCRA tank system	The requirements of 40 *CFR* 264 Subpart CC, do not apply to a waste management unit that is used solely for on-site treatment or storage of hazardous waste that is generated as the result of implementing remedial activities required under CERCLA authorities.	Storage of RCRA hazardous waste leachate in a new tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.1080(b)(5) 401 *KAR* 34:281 §1
Closure of a RCRA tank system	Must close the facility in a manner that: • Minimizes the need for further maintenance; • Controls, minimizes, or eliminates to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to ground or surface waters or to the atmosphere; and • Complies with the substantive closure requirements of 40 *CFR* § 264.197	Operation of a RCRA hazardous waste leachate in a tank system prior to shipment off-site for disposal—**applicable**. *NOTE: These requirements would not be ARAR for leachate sent to an on-site WWTU or storage of leachate in a temporary unit.*	40 *CFR* § 264.111(a)-(c) 401 *KAR* 34:070 §2
	Must remove or decontaminate all waste residues, contaminated containment system components (liners, etc.), contaminated soils, and structures and equipment contaminated with waste, and manage them as hazardous waste, unless 40 *CFR* § 261.3(d) applies.		40 *CFR* § 264.197(a) 401 *KAR* 34:190 §8
	If owner/operator demonstrates that not all contaminated soils can be practicably removed or decontaminated as required in 40 *CFR* § 264.197(a), then must close the tank system and perform post-closure care in accordance with the requirements that apply to landfills at 40 *CF*R § 264.310.		40 *CFR* § 264.197(b) 401 *KAR* 34:190 §8

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Low-Level Radioactive Waste Management		
Staging of LLW	Shall be for the purpose of the accumulation of such quantities of wastes necessary to facilitate transportation, treatment, and disposal.	Staging of LLW at a DOE facility—**TBC**.	DOE M 435.1-1 (IV)(N)(7)
Packaging of LLW	Vents or other measures shall be provided if the potential exists for pressurizing or generating flammable or explosive concentrations of gases within the waste container.	Storage of LLW in containers at a DOE facility—**TBC**.	DOE M 435.1-1 (IV)(L)(1)(b)
	Treatment, Discharge and Disposal of Waste Generated From Landfill Operation		
Treatment of leachate from a Chemical Waste Landfill	Distilling, filtering, or oil/water separation, may be used to remove or separate PCBs to the decontamination standards for liquids as listed in 40 *CFR* 761.79(b).	Decontamination of PCB contaminated materials prior to use, reuse, distribution in commerce, or disposal as a non-TSCA waste—**applicable**.	40 *CFR* § 761.79(b)
Treatment of LLW	Treatment to provide more stable waste forms and to improve the long-term performance of a LLW disposal facility shall be implemented as necessary to meet the performance objectives of the disposal facility.	Treatment of LLW for disposal at a DOE LLW disposal facility—**TBC**.	DOE M 435.1-1(IV)(O)
Treatment of uranium- and thorium-bearing LLW	Such wastes shall be properly conditioned so that the generation and escape of biogenic gases will not cause exceedance of RN-222 emission limits of DOE O 458.1(4)(h)(1)(d)(3) and will not result in premature structure failure of the facility.	Placement of potentially biodegradable contaminated waste in a long-term management facility—**TBC**.	DOE O 458.1(4)(h)(1)(d)(3)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Transport or conveyance of collected RCRA wastewater to a WWTU located on the facility	All tank systems, conveyance systems, and ancillary equipment used to treat, store, or convey wastewater to an on-site wastewater treatment facility are exempt from the requirements of RCRA Subtitle C standards. *NOTE*: *For purposes of this exclusion, any dedicated tank systems, conveyance systems, and ancillary equipment used to treat, store or convey CERCLA remediation wastewater to a CERCLA on-site wastewater treatment unit that meets all of the identified CWA ARARs for point source discharges from such a facility, are exempt from the requirements of RCRA Subtitle C standards.*	On-site wastewater treatment units (as defined in 40 *CFR* § 260.10) subject to regulation under § 402 or § 307(b) of the CWA (i.e., KPDES-permitted) that managed hazardous wastewaters —**applicable**.	40 *CFR* § 264.1(g)(6) 401 *KAR* 34:010 § 1
	Discharge of Wastewater from Treatment System		
General duty to mitigate for discharge of wastewater	Take all reasonable steps to minimize or prevent any discharge or sludge use or disposal in violation of effluent standards which has a reasonable likelihood of adversely affecting human health or the environment.	Discharge of pollutants to surface waters—**applicable**.	401 *KAR* 5:065 § 2(1) and 40 *CFR* § 122.41(d)
Operation and maintenance of treatment system	Properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used to achieve compliance with the effluent standards. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures.	Discharge of pollutants to surface waters—**applicable**.	401 *KAR* 5:065 § 2(1) and 40 *CFR* § 122.41(e)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Effluent limitations for RCRA Subtitle C landfills	Any existing point source (except as provided in 40 *CFR* § 125.30 through 125.32) or new point source subject to this subpart must achieve the effluent limitations in the table of 40 *CFR* § 445.11 for the 14 parameters listed. *Note: All of the parameters within the table at 40 CFR § 445.11 are not anticipated to be present in the leachate. Monitoring parameters, including frequency of sampling, will be developed as part of the CERCLA process and included in a remedial design, remedial action work plan, or other appropriate FFA CERCLA document.*	Discharges of landfill wastewaters as defined in 40 *CFR* §445.2(f) from landfills subject to the provisions of 40 *CFR* Part 264—**relevant and appropriate**.	401 *KAR* 5:065 § 2(9) 40 *CFR* § 445.11 40 *CFR* § 445.14
Technology-based treatment requirements for wastewater discharge	To the extent that EPA-promulgated effluent limitations are inapplicable, shall develop on a case-by-case Best Professional Judgment (BPJ) basis under § 402(a)(1)(B) of the CWA, technology-based effluent limitations by applying the appropriate factors listed in 40 *CFR* § 125.3(d) and shall consider: • The appropriate technology for this category or class of point sources, based upon all available information; and • Any unique factors relating to the discharger.	Discharge of pollutants to surface waters—**applicable**.	40 *CFR* § 125.3(c)(2)
Variance from technology-based effluent limitations	If conditions exist or are believed to exist that preclude compliance with the requirements of technology-based effluent limitations, a non-POTW may request a variance from otherwise applicable effluent limitations as established in 40 *CFR* § 122.21(m). *NOTE: Variance shall be made as part of the FFA CERCLA document review and approval process.*	Discharge of pollutants to surface waters—**applicable**.	401 *KAR* 5:055 § 6

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Water quality-based effluent limits for wastewater discharge	Must develop water quality-based effluent limits that ensure that: • the level of water quality to be achieved by limits on point source(s) established under this paragraph is derived from and complies with all applicable water quality standards; and • effluent limits developed to protect narrative or numeric water quality criteria are consistent with the assumptions and any available waste load allocation for the discharge prepared by the state and approved by EPA pursuant to 40 *CFR* § 130.7.	Discharge of pollutants to surface waters that causes, or has reasonable potential to cause, or contributes to an instream excursion above a narrative or numeric criteria within a state water quality standard established under § 303 of the CWA—**applicable**.	40 *CFR* § 122.44(d)(1)(vii)
	Must attain or maintain a specified water quality through water quality related effluent limits established under § 302 of the CWA.	Discharge of pollutants to surface waters that causes, or has reasonable potential to cause, or contributes to an instream excursion above a narrative or numeric criteria within a state water quality standard—**applicable**.	40 *CFR* § 122.44(d)(2)
	Table 1 of 401 *KAR* 10:031 Section 6(1) provides allowable instream concentrations of pollutants that may be found in surface waters or discharged into surface waters.		401 *KAR* 10:031 § 6(1)
Monitoring requirements for treatment system discharges	In addition to 40 *CFR* § 122.48(a) and (b) and to assure compliance with effluent limitations, one must monitor, as provided in subsections (i) thru (iv) of 122.44(i)(1). NOTE: *Monitoring parameters, including frequency of sampling, will be developed as part of the CERCLA process and included in a Remedial Design ,Remedial Action Work Plan, or other appropriate FFA CERCLA document.*	Discharge of pollutants to surface waters—**applicable**.	40 *CFR* § 122.44(i)(1)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	All effluent limitations, standards, and prohibitions shall be established for each outfall or discharge point, except as provided under § 122.44(k).		40 *CFR* § 122.45(a)
Effluent limits for radionuclides in wastewater	Shall not exceed the limits for radionuclides listed on Table 2—Effluent Limitations.	Discharge of wastewater with radionuclides from an NRC Agreement State licensed facility into surface waters—**relevant and appropriate**.	902 *KAR* 100:019 § 44 10 *CFR* § 20 Appendix B
Criteria for discharge of wastewater with radionuclides into surface water	Conduct activities to ensure that liquid discharges containing radionuclides from DOE activities do not exceed an annual average (at the point of discharge) of either of the following: (a) 5 pCi (0.2 Bq) per gram above background of settleable solids for alpha-emitting radionuclides. (b) 50 pCi (2 Bq) per gram above background of settleable solids for beta-emitting radionuclides.	Discharge of radioactive concentrations in sediments to surface water from a DOE facility—**TBC**.	DOE O 458.1(4)(g)(4)
Discharge of Wastewater from Treatment System through a CERCLA Outfall			
Mixing zone for discharge of pollutants	The relevant requirements provided in 401 *KAR* 10:029 § 4 shall apply to a mixing zone for a discharge of pollutants. *NOTE: Determination of the appropriate mixing zone will, if necessary, be documented in the CERCLA remedial design or other appropriate CERCLA document.*	Discharge of pollutants to surface waters through a separate CERCLA Outfall—**applicable**.	401 *KAR* 10:029 § 4
Minimum criteria applicable to all surface waters	Surface waters shall not be aesthetically or otherwise degraded by substances that: • Settle to form objectionable deposits; • Float as debris, scum, oil, or other matter to form a nuisance; • Produce objectionable color, odor, taste, or turbidity;	Discharge of pollutants to surface waters through a separate CERCLA Outfall —**applicable**.	401 *KAR* 10:031 § 2(1)(a-f)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	• Injure, are chronically or acutely toxic to or produce adverse physiological or behavioral responses in humans, animals, fish, and other aquatic life; • Produce undesirable aquatic life or result in the dominance of nuisance species; 1. Cause fish flesh tainting. 2. The concentration of phenol shall not exceed 300 mg/L as an in stream value.		
	The water quality criteria for the protection of human health related to fish consumption in Table 1 of 401 *KAR* 10:031 § 6 are applicable to all surface water at the edge of assigned mixing zone except for those points where water is withdrawn for domestic water supply use. (a) The criteria are established to protect human health from the consumption of fish tissue and shall not be exceeded. (b) For those substances associated with a cancer risk, an acceptable risk level of not more than one (1) additional cancer case in a population of 1,000,000 people, (or 1 x 10^{-6}) shall be utilized to establish the allowable concentration.		401 *KAR* 10:031 § 2(2)(a) and (b)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Criteria for surface water designated as Warm Water Aquatic Life Habitat	The following parameters and associated criteria shall apply for the protection of productive warm water aquatic communities, fowl, animal wildlife, arborous growth, agricultural, and industrial uses: • Natural alkalinity as $CaCO_3$ shall not be reduced by more than 25 percent; • pH shall not be less than 6.0 nor more than 9.0 and shall not fluctuate more than 1.0 pH units over a period of 24 hours; • Flow shall not be altered to a degree that will adversely affect the aquatic community; • Temperature shall not exceed 31.7°C (89°F); • Dissolved oxygen shall be maintained at a minimum concentration of 5.0 mg/L as a 24 hour average; instantaneous minimum shall not be less than 4.0 mg/L; • Total dissolved solids or specific conductance shall not be changed to the extent that the indigenous aquatic community is adversely affected; • Total suspended solids shall not be changed to the extent that the indigenous aquatic community is adversely affected; • Addition of settleable solids that may alter the stream bottom so as to adversely affect productive aquatic communities shall be prohibited; • Concentration of the un-ionized ammonia shall not be greater than 0.05 mg/L at any time instream after mixing; • Instream concentrations for total residual chlorine shall not exceed an acute criteria value of 19 µg/L or a chronic criteria value of 11 µg/L.	Discharge of pollutants to surface waters designated as Warm Water Aquatic Life Habitat through a separate CERCLA Outfall—**applicable**.	401 *KAR* 10:031 § 4(1)(a)-(i) and (k)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	The allowable instream concentration of toxic substances, or whole effluents containing toxic substances, which are noncumulative or nonpersistent with a half-life of less than 96 hours, shall not exceed: (a) 0.1 of the 96 hour median LC_{50} of representative indigenous or indicator aquatic organisms; or (b) A chronic toxicity unit of 1.00 utilizing the 25 percent inhibition concentration, or LC_{25}.	Discharge of toxic pollutants to surface waters designated as Warm Water Aquatic Life Habitat through a separate CERCLA Outfall —**applicable**.	401 *KAR* 10:031 § 4(1)(j)(1)
	The allowable instream concentration of toxic substances, or whole effluents containing toxic substances, which are bioaccumulative or persistent, including pesticides, if not otherwise regulated, shall not exceed: (a) 0.01 of the 96 hour median LC_{50} of representative indigenous or indicator aquatic organisms; or (b) A chronic toxicity unit of 1.00 utilizing the LC_{25}.		401 *KAR* 10:031 § 4(1)(j)(2)
	In the absence of acute criteria for pollutants listed in Table 1 of 401 *KAR* 10:031 § 6, for other substances known to be toxic but not listed in this regulation, or for whole effluents that are acutely toxic, the allowable instream concentration shall not exceed the LC_1 or 1/3 LC_{50} concentration derived from toxicity tests on representative indigenous or indicator aquatic organisms or exceed 0.3 acute toxicity units.		401 *KAR* 10:031 § 4(1)(j)(3)
	If specific factors have been determined for a toxic substance or whole effluent such as an acute to chronic ratio or water effect ratio, they may be used instead of the 0.1 and 0.01 factors upon demonstration that such factors are scientifically defensible.		401 *KAR* 10:031 § 4(1)(j)(4)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	NOTE: Demonstration that such factors are scientifically defensible will be reflected in the appropriate CERCLA document.		
	If a discharge causes, has the reasonable potential to cause, or contribute to an in-stream excursion above the numeric criterion for whole effluent toxicity using the procedures in paragraph (d)(1)(ii), develop effluent limits for whole effluent toxicity.	Discharge of wastewater through a separate CERCLA Outfall causes, has the reasonable potential to cause, or contributes to an in-stream excursion above the numeric criterion for whole effluent toxicity**—applicable**.	40 *CFR* § 122.44(d)(1)(iv)
	Treatment of Sanitary Wastewaters in an On-Site Septic System		
Computation of design waste flows for On-Site Sewage Disposal System	Daily waste flow volumes for system design and sizing purposes shall be computed, based upon the design flow per designated flow unit listed in Table 1 multiplied by the number of flow units involved.	Treatment/Disposal of Sewage as defined in 902 *KAR* 10:085 § 1 from CERCLA supporting facilities to an on-site sewage disposal system as defined in 902 *KAR* 10:085 § 1—**relevant and appropriate**.	902 *KAR* 10:085 § 6(1)
	An on-site sewage system shall be designed to provide dosing of the lateral field through the use of dosing tanks and pumps or siphons, or through the installation of an LPP system.	Treatment/Disposal of Sewage as defined in 902 *KAR* 10:085 § 1 from CERCLA supporting facilities to an on-site sewage disposal system as defined in 902 *KAR* 10:085 § 1 that receives a design daily waste flow of 2,000 gallons or more—**relevant and appropriate**.	902 *KAR* 10:085 § 6(1)(c)
Computation of design waste flows for On-Site Sewage Disposal System	Minimum working liquid capacities for a septic tank for a commercial or public facility on-site sewage disposal system shall be determined by multiplying the daily design waste flow per unit times the total number of units, plus an additional fifty (50) percent of that figure for solids storage. (Gallons/Unit/Day × Number of Units) + 50% = MINIMUM CAPACITY REQUIRED	Treatment/Disposal of Sewage as defined in 902 *KAR* 10:085 § 1 from CERCLA supporting facilities to an on-site sewage disposal system as defined in 902 *KAR* 10:085 § 1—**relevant and appropriate**.	902 *KAR* 10:085 § 6(3)(a)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Sizing of gravity distribution lateral field	Gravity distribution lateral fields for an on-site sewage disposal system shall be sized based upon the design daily waste flow for the residence, commercial or public facility involved, as determined from Table 1. The total daily waste flow multiplied by the linear footage requirement per gallon found in Table 3 for the specific site soil characteristics, shall determine the minimum linear footage of lateral trench required.	Treatment/Disposal of Sewage as defined in 902 *KAR* 10:085 § 1 from CERCLA supporting facilities to an on-site sewage disposal system as defined in 902 *KAR* 10:085 § 1—**relevant and appropriate**.	902 *KAR* 10:085 § 6(4)
Sizing of LPP distribution lateral fields	LPP distribution lateral fields for on-site sewage disposal systems shall be sized based upon the calculated total design daily waste flow for the residence, commercial, or public facility involved, as determined from Table 1. The total daily waste flow divided by the allowable daily loading rate found in Table 4, for the specific site soil characteristics, shall determine the minimum square footage of absorption area required.	Treatment/Disposal of Sewage as defined in 902 *KAR* 10:085 § 1 from CERCLA supporting facilities to an on-site sewage disposal system as defined in 902 *KAR* 10:085 § 1 that receives a design daily waste flow of 2,000 gallons or more—**relevant and appropriate**.	902 *KAR* 10:085 § 6(5)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Sizing of subsurface flow constructed wetlands systems.	Constructed wetlands cells shall contain a minimum of one and three-tenths (1.3) cubic feet of fill material for each one (1) gallon of total daily waste flow. Total interior square footage shall be based on one and three-tenths (1.3) cubic feet per one (1) gallon of total daily design wasteflow; if twelve (12) inches of fill material is used, then the square footage equals the cubic footage. The length to width ratio of the cell shall range between three (3) to one (1) and five (5) to one (1) for gravity flow. The length to width ratio for pressure distribution shall be determined based on system size and available installation area. The overflow lateral field footage shall be calculated by using fifty (50) percent of the standard sizing for the chosen type of system; all approved lateral field types shall be acceptable.	Treatment/Disposal of Sewage as defined in 902 *KAR* 10:085 § 1 from CERCLA supporting facilities to an on-site sewage disposal system as defined in 902 *KAR* 10:085 § 1—**relevant and appropriate**.	902 *KAR* 10:085 § 6(13)
On-Site Sewage Disposal System Installation Layout and Installation	Maximum length for individual lateral trenches or beds for gravity distribution systems shall be no more than 200 feet. Maximum length for individual lateral trenches in LPP systems shall be seventy (70) feet.	Treatment/Disposal of Sewage as defined in 902 *KAR* 10:085 § 1 from CERCLA supporting facilities to an on-site sewage disposal system as defined in 902 *KAR* 10:085 § 1—**relevant and appropriate**.	902 *KAR* 10:085 § 7(1)(c)
	Individual lateral lines or beds receiving effluent from an equal flow distribution box shall be of equivalent size within ten (10) percent of the longest line or bed.		902 *KAR* 10:085 § 7(1)(d)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Lateral trenches, and leaching chambers two (2) feet wide or less, for gravity distribution systems shall be spaced a minimum of eight (8) feet on centers. Lateral trenches for LPP systems shall be spaced a minimum of five (5) feet on centers. Lateral beds, and leaching chambers greater than two (2) feet wide, for gravity distribution systems shall be spaced a minimum of eight (8) feet from side wall to side wall. Spacing shall be increased two (2) feet on all sites with slopes greater than fifteen (15) percent and up to and including twenty (20) percent. On slopes greater than twenty (20) percent, each five (5) percent increase in slope, or fraction thereof, shall require an additional spacing of two (2) feet for lateral trenches.		902 *KAR* 10:085 § 7(1)(e)
	Lateral line spacing in gravity distribution bed systems shall be as follows: • For beds of four (4) to six (6) feet in width, one (1) lateral line placed on the centerline of the bed; • For beds of seven (7) to ten (10) feet in width, two (2) lateral lines, spaced two and one-half (2 1/2) feet from the side walls; • For beds eleven (11) feet and wider, the two (2) laterals spaced two and one-half (2 1/2) feet from the side walls, and additional lateral lines installed five (5) feet on centers, or fraction thereof, from the side wall laterals.		902 *KAR* 10:085 § 7(1)(f)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
System Installation Standards for conventional gravity lateral lines.	Lateral lines for conventional gravity distribution trenches or beds shall be laid as follows: • A six (6) inch deep layer of approved trench rock or other fill material is carefully placed in the trench or bed to prevent sealing of absorption surfaces from fill impact, and leveled; • Lateral piping is placed and leveled on the trench fill material in the center of the trench (or properly spaced in beds), and retained in place to prevent movement, while additional trench fill material is added to a point two (2) inches above the top of the top of the lateral piping, for a total of twelve (12) inches of trench fill material; • Other methods of lateral piping and trench rock placement may be approved by the cabinet upon demonstration of equivalent compliance. • A four (4) inch layer of approved barrier material, whole straw, or a single layer of synthetic filter fabric, is then placed over the trench fill material to prevent entry of backfill soil fines.	Treatment/Disposal of Sewage as defined in 902 *KAR* 10:085 § 1 from CERCLA supporting facilities to an on-site sewage disposal system as defined in 902 *KAR* 10:085 § 1—**relevant and appropriate**.	902 *KAR* 10:085 § 7(3)(i)
System Installation Standards for LPP lateral lines.	Lateral lines for LPP systems shall be laid as follows: • At the beginning of each trench and at twenty (20) foot intervals thereafter, barrier walls of undisturbed earth or compacted earthfill at least one (1) foot thick shall be placed from sidewall to sidewall of the trench to the level at which lateral piping is to be installed; • Six (6) inches of pea gravel or approved alternate trench rock shall be placed in the trench and leveled;	Treatment/Disposal of Sewage as defined in 902 *KAR* 10:085 § 1 from CERCLA supporting facilities to an on-site sewage disposal system as defined in 902 *KAR* 10:085 § 1 that receives a design daily waste flow of 2,000 gallons or more—**relevant and appropriate**.	902 *KAR* 10:085 § 7(3)(j)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	• Lateral piping shall be laid in place and assembled, or may be preassembled, and leveled; • Trench earth barrier walls shall be completed to ground surface and additional pea gravel or other trench fill material carefully placed over the laterals to a height of two (2) inches over the top of the piping; • Other methods of lateral piping and trench rock or pea gravel placement shall be approved by the cabinet upon demonstration of equivalent compliance. • A two (2) inch layer of approved barrier material, whole straw, or a single layer of synthetic filter fabric shall be placed over the pea gravel to prevent entry of backfill soil fines. *NOTE*: *Approval of other methods for placement of lateral piping or alternate trench rock will be obtained by approval of the FFA CERCLA document.*		
	Minimum setback distances for installation of on-site sewage disposal systems from structures, water supplies, roads, streams, bodies of water, and other structural or topographic features are listed in Table 7.	Treatment/Disposal of Sewage as defined in 902 *KAR* 10:085 § 1 from CERCLA supporting facilities to an on-site sewage disposal system as defined in 902 *KAR* 10:085 § 1—**relevant and appropriate**.	902 *KAR* 10:085 § 8
	RCRA Waste Land Disposal Requirements		
Disposal of RCRA prohibited waste in a land-based unit	May be land disposed if it meets the requirements in the table "Treatment Standards for Hazardous Waste" at 40 *CFR* § 268.40 before land disposal.	Land disposal, as defined in 40 *CFR* § 268.2, of prohibited RCRA hazardous waste—**applicable**.	40 *CFR* § 268.40(a) 401 *KAR* 37:040 § 2

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	May be disposed of if it is treated according to the alternative treatment standards of 40 *CFR* § 268.49(c) or according to the UTSs specified in 40 *CFR* § 268.48, applicable to the listed hazardous waste and/or applicable characteristic of hazardous waste if the soil is characteristic.	Land disposal, as defined in 40 *CFR* § 268.2, of restricted hazardous soils—**applicable**.	40 *CFR* § 268.49(b) 401 *KAR* 37:040 § 10
	May be disposed if treated prior to land disposal as provided in 40 *CFR* § 268.45(a)(1)-(5) unless it is determined under 40 *CFR* § 261.3(f)(2) that the debris is no longer contaminated with hazardous waste or the debris is treated to the waste-specific treatment standard provided in 40 *CFR* § 268.40 for the waste contaminating the debris.	Land disposal, as defined in 40 *CFR* § 268.2, of restricted hazardous debris—**applicable**.	40 *CFR* § 268.45(a) 401 *KAR* 37:040 § 7
Disposal of treated hazardous debris	Debris treated by one of the specified extraction or destruction technologies on Table 1 of 40 *CFR* § 268.45 and which no longer exhibits a characteristic, is not a hazardous waste, and need not be managed in RCRA Subtitle C facility.	Treated debris contaminated with RCRA-listed or characteristic waste—**applicable**.	40 *CFR* § 268.45(c) 401 *KAR* 37:040 § 7
	Hazardous debris contaminated with listed waste that is treated by immobilization technology must be managed in a RCRA Subtitle C facility.		401 *KAR* 37:040 § 7
	Groundwater Monitoring Requirements		
Determining RCRA Concentration Limits	Concentration limits shall be determined taking into account those constituents that are reasonably expected to be contained in or derived from waste present in the landfill. These limits must not exceed those listed in 401 *KAR* 34:060 § 5.	RCRA hazardous constituents detected groundwater in the uppermost aquifer underlying a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.94(a) 401 *KAR* 34:060 § 5

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Groundwater monitoring requirements for RCRA hazardous waste landfills	The groundwater monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths to yield samples from the uppermost aquifer that • Represent the quality of background groundwater; • Represent the quality of groundwater passing the point of compliance; and • Allow for the detection of contamination when the hazardous waste or constituents have migrated from the waste management area to the uppermost aquifer.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.97(a) 401 *KAR* 34:060 § 8
	Groundwater monitoring program must include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide a reliable indication of groundwater quality below the waste management area.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.97(d) 401 *KAR* 34:060 § 8
Groundwater monitoring requirements for RCRA hazardous waste landfills	Groundwater monitoring program must include sampling and analytical methods that are appropriate and accurately measure hazardous constituents in groundwater samples.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.97(e) 401 *KAR* 34:060 § 8
	Groundwater monitoring program must include a determination of the groundwater surface elevation each time groundwater is sampled.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.97(f) 401 *KAR* 34:060 § 8
	The number and size of samples collected to establish background and measure groundwater quality at the point of compliance shall be appropriate for the form of statistical test employed following generally accepted statistical principles.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.97(g) 401 *KAR* 34:060 § 8

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	The owner or operator will specify one of the following statistical methods to be used in evaluating groundwater monitoring data for each hazardous constituent. The statistical test chosen shall be conducted separately for each hazardous constituent in each well. Where PQLs are used in any of the following statistical procedures to comply with § 264.97(i)(5), the PQL must be proposed by the owner or operator and approved by Kentucky and EPA through the CERCLA process. Use of any of the following statistical methods must be protective of human health and the environment and must comply with the performance standards outlined in paragraph (i) of this section.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.97(h) 401 *KAR* 34:060 § 8
	A parametric analysis of variance (ANOVA) followed by multiple comparisons procedures to identify statistically significant evidence of contamination. The method must include estimation and testing of the contrasts between each compliance well's mean and the background mean levels for each constituent.		40 *CFR* § 264.97(h)(1) 401 *KAR* 34:060 § 8
	• An analysis of variance (ANOVA) based on ranks followed by multiple comparisons procedures to identify statistically significant evidence of contamination. The method must include estimation and testing of the contrasts between each compliance well's median and the background median levels for each constituent.		40 *CFR* § 264.97(h)(2) 401 *KAR* 34:060 § 8
	• A tolerance or prediction interval procedure in which an interval for each constituent is established from the distribution of the background data and the level of each constituent in each compliance well is compared to the upper tolerance or prediction limit.		40 *CFR* § 64.97(h)(3) 401 *KAR* 34:060 § 8

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	• A control chart approach that gives control limits for each constituent.		40 *CFR* § 264.97(h)(4) 401 *KAR* 34:060 § 8
	• Another statistical test method submitted by the owner or operator and approved by Kentucky and EPA through the CERCLA process.		40 *CFR* § 264.97(h)(5) 401 *KAR* 34:060 § 8
	Any statistical method chosen under § 264.97(h) shall comply with the following performance standards, as appropriate.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.97(i) 401 *KAR* 34:060 § 8
	The statistical method used to evaluate groundwater monitoring data shall be appropriate for the distribution of chemical parameters or hazardous constituents. If the distribution of the chemical parameters or hazardous constituents is shown by the owner or operator to be inappropriate for a normal theory test, then the data should be transformed or a distribution-free theory test should be used. If the distributions for the constituents differ, more than one statistical method may be needed.		40 *CFR* § 264.97(i)(1) 401 *KAR* 34:060 § 8
	If an individual well comparison procedure is used to compare an individual compliance well constituent concentration with background constituent concentrations or a ground-water protection standard, the test shall be done at a Type I error level no less than 0.01 for each testing period. If a multiple comparisons procedure is used, the Type I experiment wise error rate for each testing period shall be no less than 0.05; however, the Type I error of no less than 0.01 for individual well comparisons must be maintained. This performance standard does not apply to tolerance intervals, prediction intervals, or control charts.		40 *CFR* § 264.97(i)(2) 401 *KAR* 34:060 § 8

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	If a control chart approach is used to evaluate groundwater monitoring data, the specific type of control chart and its associated parameter values shall be proposed by the owner or operator and approved by Kentucky and EPA through the CERCLA process.		40 *CFR* § 264.97(i)(3) 401 *KAR* 34:060 § 8
	If a tolerance interval or a prediction interval is used to evaluate groundwater monitoring data, the levels of confidence, and, for tolerance intervals, the percentage of the population that the interval must contain, shall be proposed by the owner or operator and approved by Kentucky and EPA through the CERCLA process. These parameters will be determined after considering the number of samples in the background data base, the data distribution, and the range of the concentration values for each constituent of concern.		40 *CFR* § 264.97(i)(4) 401 *KAR* 34:060 § 8
	The statistical method shall account for data below the limit of detection with one or more statistical procedures that are protective of human health and the environment. Any PQL approved by Kentucky and EPA through the CERCLA process under § 264.97(h) that is used in the statistical method shall be the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions that are available to the facility.		40 *CFR* § 264.97(i)(5) 401 *KAR* 34:060 § 8
	If necessary, the statistical method shall include procedures to control or correct for seasonal and spatial variability as well as temporal correlation in the data.		40 *CFR* § 264.97(i)(6) 401 *KAR* 34:060 § 8

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Detection monitoring	Must monitor for specified indicator parameters, waste constituents or reaction products that provide a reliable indication of the presence of hazardous constituents in groundwater.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.98(a) 401 *KAR* 34:060 § 9
	Must install a groundwater monitoring system at the compliance point as specified under 40 *CFR* § 264.95 that complies with 40 *CFR* § 264.97(a)(2) and (c).	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.98(b) 401 *KAR* 34:060 § 9
	Must conduct a monitoring program for each specified chemical parameter and hazardous constituent.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.98(c) 401 *KAR* 34:060 § 9
	Sampling frequency shall be sufficient to determine whether there is statistically significant evidence of contamination.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.98(d) 401 *KAR* 34:060 § 9
	Must determine the groundwater flow rate and direction in the uppermost aquifer annually at a minimum.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.98(e) 401 *KAR* 34:060 § 9
	Must determine whether there is statistically significant evidence of contamination of any specified chemical parameter or hazardous constituent at a specified frequency.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.98(f) 401 *KAR* 34:060 § 9
	If there is statistically significant evidence of contamination at any monitoring well at the compliance point, must follow the substantive provisions of this subsection.	Operation of a detection monitoring program under 40 *CFR* § 264.98—**applicable**.	40 *CFR* § 264.98(g) 401 *KAR* 34:060 § 9
Monitoring for TSCA chemical landfills	If underlying earth materials are homogenous, impermeable, and uniformly sloping in one direction, only three sampling points shall be necessary. These three points shall be equally spaced on a line through the center of the disposal area and extending from the area of highest water table elevation to the area of the lowest water table elevation.	Construction of TSCA monitoring well—**applicable**.	40 *CFR* § 761.75(b)(6)(ii)(A)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	All monitor wells shall be cased and the annular space between the monitor zone (zone of saturation) and the surface shall be completely backfilled with Portland cement or an equivalent material and plugged with Portland cement to effectively prevent percolation of surface water into the well bore. The well opening at the surface shall have a removable cap to provide access and to prevent entrance of rainfall or storm water runoff. The groundwater monitoring well shall be pumped before obtaining a sample for analysis to remove the volume of liquid initially contained in the well. The discharge shall be treated to meet applicable state or federal standards or recycled to the chemical waste landfill.		40 *CFR* § 761.75(b)(6)(ii)(B)
Water analysis requirements	As a minimum, all samples [groundwater and surface water] shall be analyzed for the following parameters: PCBs, pH, specific conductance, chlorinated organics. Sampling methods and analytical procedures for these parameters shall comply with those specified in 40 *CFR* Part 136, as amended in 41 *FR* 52779 on December 1, 1976.	Construction of TSCA monitoring well—**applicable**.	40 *CFR* § 761.75(b)(6)(iii)
	Closure		
Closure of a RCRA Subtitle C Landfill	Submit survey plat to local zoning authority *NOTE: This requirement will be met by filing a survey plat with the McCracken County Clerk's Office.*	Survey plat—**applicable**.	40 *CFR* § 264.116 401 *KAR* 34:070 § 7
Decontamination/disposal of equipment	During the partial and final closure periods, all contaminated equipment, structures and soils must be properly disposed of or decontaminated unless otherwise specified in §§ 264.197, 264.228, 264.258, 264.280 or § 264.310.	Closure of RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.114 401 *KAR* 34:070 § 5

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Post-Closure Care		
Duration	Post-closure care must begin after closure of the unit and continue for at least 30 years after that date.	Closure of a RCRA hazardous waste management unit subject to 40 *CFR* §§ 264.117 through 264.120—**applicable**.	40 *CFR* § 264.117(a)(1) 401 *KAR* 34:070 § 8
Protection of facility	Post-closure use of property on or in which hazardous wastes remain after partial or final closure must never be allowed to disturb the integrity of the final cover, liner(s), or any other components of the containment system, or the function of the facility's monitoring systems, unless the disturbance • Is necessary to the proposed use of the property, and will not increase the potential hazard to human health or the environment; or • Is necessary to reduce a threat to human health or the environment.	Closure of a RCRA hazardous waste facility—**applicable**.	40 *CFR* § 264.117(c) 401 *KAR* 34:070 § 8
Post-closure notices	Must submit to the local zoning authority a record of the type, location, and quantity of hazardous wastes disposed of within each cell of the unit *NOTE: This requirement will be met by filing a property record notice with the McCracken County Clerk's Office.*	Closure of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* § 264.119(a)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Post-closure notices *continued*	Must record, in accordance with State law, a notation on the deed to the facility property, or on some other instrument which is normally examined during a title search, that will in perpetuity notify any potential purchaser of the property that: • Land has been used to manage hazardous wastes; • Its use is restricted under 40 *CFR* Part 264 Subpart G regulations; and • The survey plat and record of the type, location, and quantity of hazardous wastes disposed within each cell or other hazardous waste disposal unit of the facility required by Sections 264.116 and 264.119(a) have been filed with the local zoning authority and with the EPA Regional Administrator. *NOTE: This requirement will be met by filing a property record notice with the McCracken County Clerk's Office.*	Closure of a RCRA hazardous waste landfill—**applicable**.	40 *CFR* 264.119(b)(1)(i)-(iii)
	Management of Wastes in a CAMU		
Designation and management of CAMUs	CAMUs may be designated at a facility. CAMUs are areas within a facility that are used only for managing CAMU-eligible wastes for implementing corrective action or cleanup at the facility. A CAMU must be located within the contiguous property under the control of the owner or operator where the wastes to be managed in the CAMU originated. One or more CAMUs may be designated at a facility.	Management of CAMU-eligible wastes within a CAMU—**applicable**.	40 *CFR* § 264.552(a)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	CAMU-eligible waste means all solid and hazardous wastes, and all media (including ground water, surface water, soils, and sediments) and debris that are managed for implementing cleanup. As-generated wastes from ongoing industrial operations at a site are not CAMU-eligible wastes.		40 *CFR* 264.552(a)(1)(i)
	Wastes that would otherwise meet the description in paragraph (a)(1)(i) of this section are not "CAMU-Eligible Wastes" where: (A) The wastes are hazardous wastes found during cleanup in intact or substantially intact containers, tanks, or other non-land-based units found above ground, unless the wastes are first placed in these units as part of cleanup, or the units are excavated during the course of cleanup;		40 *CFR* 264.552(a)(1)(ii)
	Notwithstanding paragraph (a)(1)(i) of this section, where appropriate, as-generated non-hazardous waste may be placed in a CAMU where such waste is being used to facilitate treatment or the performance of the CAMU.		40 *CFR* 264.552(a)(1)(iii)
	The placement of bulk or noncontainerized liquid hazardous waste or free liquids contained in hazardous waste (whether or not sorbents have been added) in any CAMU is prohibited except where placement of such wastes facilitates the remedy selected for the waste.		40 *CFR* 264.552(a)(3)
	Placement of CAMU-eligible wastes into or within a CAMU does not constitute land disposal of hazardous wastes.		40 *CFR* 264.552(a)(4)
	Consolidation or placement of CAMU-eligible wastes into or within a CAMU does not constitute creation of a unit subject to minimum technology requirements.		40 *CFR* 264.552(a)(5)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	May designate a regulated unit as a CAMU, or may incorporate a regulated unit into a CAMU, if the regulated unit is closed or closing and inclusion of the unit will enhance implementation of effective, protective, and reliable remedial actions for the facility.		40 *CFR* 264.552(b)(1)
	The subpart F and G requirements and unit-specific requirements of this part of 264 or part 265 of this chapter that applied to the regulated unit will continue to apply to that portion of the CAMU after incorporation into the CAMU.		40 *CFR* 264.552(b)(2)
	CAMU shall facilitate implementation of reliable, effective, protective and cost-effective remedies.		40 *CFR* 264.552(c)(1)
	Waste management activities shall not create unacceptable risks or to the environment resulting from exposure to hazardous wastes or hazardous constituents.		40 *CFR* 264.552(c)(2)
	CAMU shall include uncontaminated areas of the facility, only if including such areas for the purpose of managing CAMU-eligible waste is more protective than management of such wastes at contaminated areas of the facility.		40 *CFR* 264.552(c)(3)
	Areas within the CAMU, where wastes remain in place after closure of the CAMU, shall be managed and contained so as to minimize future releases, to the extent practicable.		40 *CFR* 264.552(c)(4)
	CAMU shall expedite the timing of remedial activity implementation, when appropriate and practicable.		40 *CFR* 264.552(c)(5)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	CAMU shall enable the use, when appropriate, of treatment technologies (including innovative technologies) to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of wastes that will remain in place after closure of the CAMU.		40 *CFR* 264.552(c)(6)
	CAMU shall, to the extent practicable, minimize the land area of the facility upon which wastes will remain in place after closure of the CAMU.		40 *CFR* 264.552(c)(7)
Design, operation, and closure of a CAMU	The requirements for a CAMU designation shall include the following:	Placement of CAMU-eligible wastes within a new, replacement, or laterally expanded CAMUs located within the contiguous property under the control of the owner or operator where the wastes to be managed in the CAMU originated—**applicable**.	40 *CFR* 264.552(e)
	Areal configuration of the CAMU.		40 *CFR* 264.552(e)(1)
	Treatment of principal hazardous constituents		40 *CFR* 264.552(e)(4)
Designation, design, operation, and closure of a CAMU used for storage and/or treatment only	CAMUs used for storage and/or treatment only are CAMUs in which wastes will not remain after closure. Such CAMUs must be designated in accordance with all of the requirements 40 *CFR* 264.552, except as follows:	Management of CAMU-eligible wastes within a CAMU used for storage and/or treatment only—**applicable**.	40 *CFR* 264.552(f)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	Such CAMUs that operate in accordance with time limits established in the staging pile regulations are subject to requirements for staging piles in lieu of performance standards and requirements for CAMUs. *NOTE: It is recognized that a CAMU for storage and/or treatment for the WDF may need to be operated past the two-year time limit. Any time period greater than two years will be documented and justified in the ROD. The ROD would provide a process for further Post-ROD extensions of the operating term by using a memorandum in the administrative record that documents the justification with the concurrence of the FFA parties.*	CAMU used for storage and/or treatment only and that operate in accordance with the time limits established in the staging pile regulations at 40 *CFR* 264.554(d)(1)(iii), (h) and (i)—**applicable**.	40 *CFR* 264.552(f)(1)
Operation of a temporary unit	A temporary unit must be located within the contiguous property under the control of the owner/operator where the wastes to be managed in the temporary unit originated. The Regional Administrator may replace the design, operating, or closure standards applicable to these units under 40 *CFR* § 264 or part 265 with alternative requirements which protect human health and the environment. *NOTE: Alternative design, operating, or closure standards will be developed as part of the CERCLA process and approved by EPA in a remedial design, remedial action work plan, or other appropriate FFA CERCLA document.*	Use of temporary tanks and container storage areas to treat or store hazardous remediation wastes during remedial activities—**applicable**.	40 *CFR* 264.553(a)
	Any temporary unit to which alternative requirements are applied in accordance with part 264.553(a) shall be: • Located within the facility boundary; and • Used only for treatment and storage of remediation wastes.		40 *CFR* 264.553(b)(1) and (2)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	NOTE: Alternate requirements for a temporary unit would be approved through the CERCLA document review process.		
Design criteria for temporary unit	In establishing standards to be applied to a temporary unit, the Regional Administrator shall consider the following factors: (1) Length of time such unit will be in operation; (2) Type of unit; (3) Volumes of wastes to be managed; (4) Physical and chemical characteristics of the wastes to be managed in the unit; (5) Potential for releases from the unit; (6) Hydrogeological and other relevant environmental conditions at the facility which may influence the migration of any potential releases; and (7) Potential for exposure of humans and environmental receptors if releases were to occur from the unit.		40 *CFR* 264.553(c)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
Off-site disposal of CAMU-eligible wastes	The Regional Administrator with regulatory oversight at the location where the cleanup is taking place may approve, using the CERCLA process, placement of CAMU-eligible wastes in hazardous waste landfills not located at the site from which the waste originated, without the wastes meeting the requirements of RCRA 40 *CFR* Part 268, if the conditions in paragraphs (a)(1) through (3) of this section are met: (1) The waste meets the definition of CAMU-eligible waste in §264.552(a)(1) and (2). (2) The principal hazardous constitutes in such waste are identified, in accordance with § 264.552(e)(4)(i) and (ii), and such principal hazardous constituents are treated to any of the following standards specified for CAMU-eligible wastes: (i) The treatment standards under § 264.552(e)(4)(iv); or (ii) Treatment standards adjusted in accordance with § 264.552(e)(4)(v)(A), (C), (D) or (E)(*1*); or (iii) Treatment standards adjusted in accordance with § 264.552(e)(4)(v)(E)(*2*), where treatment has been used and that treatment significantly reduces the toxicity or mobility of the principal hazardous constituents in the waste, minimizing the short-term and long-term threat posed by the waste, including the threat at the remediation site.	Placement of CAMU-eligible wastes in hazardous waste landfills not located at the site from which the waste originated—**applicable**.	40 *CFR* § 264.555(a)

Table G.2. Preliminary List of Potential Action-Specific ARARs and TBC Guidance (Continued)

Action	Summary of Requirements	Prerequisite	Citation
	(3) The landfill receiving the CAMU-eligible waste must have a RCRA hazardous waste permit, meet the requirements for new landfills in Subpart N of this part, and be authorized to accept CAMU-eligible wastes; for the purposes of this requirement, "permit" does not include interim status. *NOTE: Approval of disposal in an off-site hazardous waste landfill shall be made as part of the FFA CERCLA document review and approval process.*		
Activities causing radionuclide emissions	Emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an EDE of 10 mrem per year.	Radionuclide emissions at a DOE facility—**applicable**.	40 *CFR* § 61.92 401 *KAR* 57:002
Air emissions from metal melting	Shall not cause, suffer, allow, or permit any continuous emission into the open air from a control device or stack associated with any affected facility, which is equal to or greater than twenty (20) percent opacity.	Release of particulates from an affected facility or source associated with process operations as defined in 401 *KAR* 59:010 Section 2, which are not subject to another emission standard in Chapter 59—**applicable.**	401 *KAR* 59:010 § 3(1)(a)
	Shall not cause, suffer, allow, or permit any continuous emission into the open air from a control device or stack associated with any affected facility which is in excess of the quantity specified in Appendix A.		401 *KAR* 59:010 § 3(2)
Treatment of LLW	Treatment to provide more stable waste forms and to improve the long-term performance of a LLW disposal facility shall be implemented as necessary to meet the performance objectives of the disposal facility.	Treatment of LLW for disposal at a DOE LLW disposal facility—**TBC**.	DOE M 435.1-1(IV)(O)

Table G.3. Preliminary List of Potential Location-Specific ARARs and TBC Guidance for Waste Minimization

Action	Summary of Requirements	Prerequisite	Citation
Release of property with residual radioactive material to an off-site commercial facility	Residual Radioactive Material. Property potentially containing residual radioactive material must not be cleared from DOE control unless either (a) The property is demonstrated not to contain residual radioactive material based on process and historical knowledge, radiological monitoring or surveys, or a combination of these; or (b) The property is evaluated and appropriately monitored or surveyed to determine: 1. The types and quantities of residual radioactive material within the property; 2. The quantities of removable and total residual radioactive material on property surfaces (including residual radioactive material present on and under any coating); 3. That for property with potentially contaminated surfaces that are difficult to access for radiological monitoring or surveys, an evaluation of residual radioactive material on such surfaces is performed which is (a) Based on process and historical knowledge meeting the requirements of paragraph 4.k.(5) of this Order and monitoring and or surveys, to the extent feasible; (b) Sufficient to demonstrate that applicable specific or pre-approved DOE Authorized Limits will not be exceeded; and 4. That any residual radioactive material within or on the property is in compliance with applicable specific or pre-approved DOE Authorized Limits.	Generation of DOE materials and equipment with residual radioactive material—**TBC**.	DOE Order 458.1(4)(k)(3)

APPENDIX H

NO ACTION AND OFF-SITE COST ESTIMATES

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Table H.1. No Action Alternative Cost Estimate

Base Case Waste Volume (3.6 mcy)	PV Cost	Source
LLW		
Containers & Transportation	$ 401,400,000	Table H1.1
Disposal	$ 527,714,000	Table H1.2
MLLW		
Containers & Transportation	$ 26,353,000	Table H1.3
Disposal	$ 86,038,000	Table H1.4
TSCA Waste		
Containers & Transportation	$ 948,000	Table H1.5
Disposal	$ 8,261,000	Table H1.6
Classified Waste		
Containers & Transportation	$ 101,262,000	Table H1.7
Disposal	$ 84,026,000	Table H1.8
C-746-U Landfill Operations Costs		
Operations 2014–039	$ 22,277,000	Table H4.1
Construct Phases 12-23	$ 22,080,000	
Closure	$ 24,440,000	
Postclosure Care (30 years)	$ 6,183,000	
TOTAL PRESENT VALUE COST	**$1,310,982,000**	

Table H.2. Offsite Alternative Cost Estimate

High-end Waste Volume (4.0 mcy)	PV Cost	Source
LLW		
Containers & Transportation	$ 580,717,000	Table H2.1
Disposal	$ 1,147,118,000	Table H2.2
MLLW		
Containers & Transportation	$ 28,978,000	Table H2.3
Disposal	$ 94,607,000	Table H2.4
TSCA Waste		
Containers & Transportation	$ 1,014,000	Table H2.5
Disposal	$ 9,154,000	Table H2.6
Classified Waste		
Containers & Transportation	$ 111,382,000	Table H2.7
Disposal	$ 92,424,000	Table H2.8
C-746-U Landfill Operations Costs		
Operations 2014–2039	$ -	
Construct Phases 12–23	$ -	
Closure	$ -	
Postclosure Care (30 years)	$ -	
TOTAL PRESENT VALUE COST	**$ 2,065,394,000**	

Low-End Waste Volume (3.2 mcy)	Cost	Source
LLW		
Containers & Transportation	$ 275,169,000	Table H3.1
Disposal	$ 338,608,000	Table H3.2
MLLW		
Containers & Transportation	$ 23,716,000	Table H3.3
Disposal	$ 77,430,000	Table H3.4
TSCA Waste		
Containers & Transportation	$ 765,000	Table H3.5
Disposal	$ 5,805,000	Table H3.6
Classified Waste		
Containers & Transportation	$ -	
Disposal	$ -	
C-746-U Landfill Operations Costs		
Operations 2014–2039	$ 22,277,000	Table H4.1
Construct Phases 12–23	$ 22,080,000	
Closure	$ 24,440,000	
Postclosure Care (30 years)	$ 6,183,000	
TOTAL PRESENT VALUE COST	**$ 796,473,000**	

APPENDIX H
ATTACHMENT H1

OFF-SITE AND NO ACTION ALTERNATIVES PRESENT VALUE COSTS (BASE CASE WASTE VOLUME)

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Table H1.1. No Action Alternative Present Value Costs

LIFE CYCLE COST ANALYSIS
No Action Alternative
LLW Containers and Transportation

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	Total Off-site Waste Volume for 2014 to 2039	3,592,840	Cubic Yards
	LLW Volume	2,415,820	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

No Action Off-Site Waste (FROM 2014 TO 2039) - - - LLW Containers and Transportation Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 21,646,044	$ 20,219,570	5.0%
Year 2015	$ 21,646,041	$ 19,765,000	4.9%
Year 2016	$ 21,646,041	$ 19,319,092	4.8%
Year 2017	$ 21,646,041	$ 18,886,171	4.7%
Year 2018	$ 21,646,041	$ 18,459,744	4.6%
Year 2019	$ 21,646,041	$ 18,046,304	4.5%
Year 2020	$ 21,646,041	$ 17,639,359	4.4%
Year 2021	$ 21,646,041	$ 17,243,236	4.3%
Year 2022	$ 21,646,041	$ 16,855,772	4.2%
Year 2023	$ 21,646,041	$ 16,476,966	4.1%
Year 2024	$ 21,646,041	$ 16,106,819	4.0%
Year 2025	$ 21,646,041	$ 15,743,166	3.9%
Year 2026	$ 21,646,041	$ 15,390,335	3.8%
Year 2027	$ 21,646,041	$ 15,043,998	3.7%
Year 2028	$ 21,646,041	$ 14,706,320	3.7%
Year 2029	$ 21,646,041	$ 14,375,136	3.6%
Year 2030	$ 21,646,041	$ 14,052,610	3.5%
Year 2031	$ 21,646,041	$ 13,736,578	3.4%
Year 2032	$ 21,646,041	$ 13,427,039	3.3%
Year 2033	$ 21,646,041	$ 13,126,159	3.3%
Year 2034	$ 21,646,041	$ 12,829,609	3.2%
Year 2035	$ 21,646,041	$ 12,541,716	3.1%
Year 2036	$ 21,646,041	$ 12,260,318	3.1%
Year 2037	$ 21,646,041	$ 11,983,248	3.0%
Year 2038	$ 21,646,041	$ 11,714,837	2.9%
Year 2039	$ 21,646,041	$ 11,450,756	2.9%
TOTAL PRESENT WORTH VALUE No Action LLW Container/Transport		**$ 401,399,858**	100.0%

Table H1.2. No Action Alternative Present Value Costs

LIFE CYCLE COST ANALYSIS
No Action Alternative
LLW Landfill Disposal

Economic Analysis

Assumptions:			
	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	No Action Off-site Volume for 2014 to 2039	3,592,840	Cubic Yards
	LLW Volume	2,415,820	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

No Action Off-Site Waste (FROM 2014 TO 2039) - - - LLW Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 28,457,715	$ 26,582,352	5.0%
Year 2015	$ 28,457,707	$ 25,984,732	4.9%
Year 2016	$ 28,457,707	$ 25,398,503	4.8%
Year 2017	$ 28,457,707	$ 24,829,349	4.7%
Year 2018	$ 28,457,707	$ 24,268,733	4.6%
Year 2019	$ 28,457,707	$ 23,725,190	4.5%
Year 2020	$ 28,457,707	$ 23,190,185	4.4%
Year 2021	$ 28,457,707	$ 22,669,409	4.3%
Year 2022	$ 28,457,707	$ 22,160,016	4.2%
Year 2023	$ 28,457,707	$ 21,662,007	4.1%
Year 2024	$ 28,457,707	$ 21,175,380	4.0%
Year 2025	$ 28,457,707	$ 20,697,290	3.9%
Year 2026	$ 28,457,707	$ 20,233,430	3.8%
Year 2027	$ 28,457,707	$ 19,778,106	3.7%
Year 2028	$ 28,457,707	$ 19,334,166	3.7%
Year 2029	$ 28,457,707	$ 18,898,763	3.6%
Year 2030	$ 28,457,707	$ 18,474,743	3.5%
Year 2031	$ 28,457,707	$ 18,059,261	3.4%
Year 2032	$ 28,457,707	$ 17,652,316	3.3%
Year 2033	$ 28,457,707	$ 17,256,754	3.3%
Year 2034	$ 28,457,707	$ 16,866,883	3.2%
Year 2035	$ 28,457,707	$ 16,488,395	3.1%
Year 2036	$ 28,457,707	$ 16,118,445	3.1%
Year 2037	$ 28,457,707	$ 15,754,187	3.0%
Year 2038	$ 28,457,707	$ 15,401,311	2.9%
Year 2039	$ 28,457,707	$ 15,054,127	2.9%
	TOTAL PRESENT WORTH VALUE No Action LLW Landfill Disposal	**$ 527,714,033**	100.0%

Table H1.3. No Action Alternative Present Value Costs

LIFE CYCLE COST ANALYSIS
No Action Alternative
MLLW Containers and Transportation

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	No Action Off-site Volume for 2014 to 2039	3,592,840	Cubic Yards
	MLLW Volume	67,130	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

No Action Off-Site Waste (FROM 2014 TO 2039) - - - MLLW Containers and Transportation Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 1,421,109	$ 1,327,458	5.0%
Year 2015	$ 1,421,119	$ 1,297,624	4.9%
Year 2016	$ 1,421,119	$ 1,268,349	4.8%
Year 2017	$ 1,421,119	$ 1,239,926	4.7%
Year 2018	$ 1,421,119	$ 1,211,930	4.6%
Year 2019	$ 1,421,119	$ 1,184,787	4.5%
Year 2020	$ 1,421,119	$ 1,158,070	4.4%
Year 2021	$ 1,421,119	$ 1,132,063	4.3%
Year 2022	$ 1,421,119	$ 1,106,625	4.2%
Year 2023	$ 1,421,119	$ 1,081,756	4.1%
Year 2024	$ 1,421,119	$ 1,057,455	4.0%
Year 2025	$ 1,421,119	$ 1,033,580	3.9%
Year 2026	$ 1,421,119	$ 1,010,416	3.8%
Year 2027	$ 1,421,119	$ 987,678	3.7%
Year 2028	$ 1,421,119	$ 965,508	3.7%
Year 2029	$ 1,421,119	$ 943,765	3.6%
Year 2030	$ 1,421,119	$ 922,590	3.5%
Year 2031	$ 1,421,119	$ 901,842	3.4%
Year 2032	$ 1,421,119	$ 881,520	3.3%
Year 2033	$ 1,421,119	$ 861,767	3.3%
Year 2034	$ 1,421,119	$ 842,297	3.2%
Year 2035	$ 1,421,119	$ 823,396	3.1%
Year 2036	$ 1,421,119	$ 804,922	3.1%
Year 2037	$ 1,421,119	$ 786,731	3.0%
Year 2038	$ 1,421,119	$ 769,110	2.9%
Year 2039	$ 1,421,119	$ 751,772	2.9%
	TOTAL PRESENT WORTH VALUE No Action MLLW Container/Transport	**$ 26,352,937**	100.0%

Table H1.4. No Action Alternative Present Value Costs

LIFE CYCLE COST ANALYSIS
No Action Alternative
MLLW Landfill Disposal

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	No Action Off-site Volume for 2014 to 2039	3,592,840	Cubic Yards
	MLLW Volume	67,130	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

No Action Off-Site Waste (FROM 2014 TO 2039) - - - MLLW Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 4,639,724	$ 4,333,966	5.0%
Year 2015	$ 4,639,721	$ 4,236,529	4.9%
Year 2016	$ 4,639,721	$ 4,140,951	4.8%
Year 2017	$ 4,639,721	$ 4,048,157	4.7%
Year 2018	$ 4,639,721	$ 3,956,754	4.6%
Year 2019	$ 4,639,721	$ 3,868,135	4.5%
Year 2020	$ 4,639,721	$ 3,780,909	4.4%
Year 2021	$ 4,639,721	$ 3,696,002	4.3%
Year 2022	$ 4,639,721	$ 3,612,951	4.2%
Year 2023	$ 4,639,721	$ 3,531,756	4.1%
Year 2024	$ 4,639,721	$ 3,452,416	4.0%
Year 2025	$ 4,639,721	$ 3,374,469	3.9%
Year 2026	$ 4,639,721	$ 3,298,842	3.8%
Year 2027	$ 4,639,721	$ 3,224,606	3.7%
Year 2028	$ 4,639,721	$ 3,152,226	3.7%
Year 2029	$ 4,639,721	$ 3,081,239	3.6%
Year 2030	$ 4,639,721	$ 3,012,107	3.5%
Year 2031	$ 4,639,721	$ 2,944,367	3.4%
Year 2032	$ 4,639,721	$ 2,878,019	3.3%
Year 2033	$ 4,639,721	$ 2,813,527	3.3%
Year 2034	$ 4,639,721	$ 2,749,963	3.2%
Year 2035	$ 4,639,721	$ 2,688,254	3.1%
Year 2036	$ 4,639,721	$ 2,627,938	3.1%
Year 2037	$ 4,639,721	$ 2,568,550	3.0%
Year 2038	$ 4,639,721	$ 2,511,017	2.9%
Year 2039	$ 4,639,721	$ 2,454,412	2.9%
	TOTAL PRESENT WORTH VALUE No Action MLLW Landfill Disposal	**$ 86,038,062**	100.0%

Table H1.5. No Action Alternative Present Value Costs

LIFE CYCLE COST ANALYSIS
No Action Alternative
TSCA Containers and Transportation

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	No Action Off-site Volume for 2014 to 2039	3,592,840	Cubic Yards
	TSCA Volume	6,410	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

No Action Off-Site Waste (FROM 2014 TO 2039) - - - TSCA Containers and Transportation Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 51,116	$ 47,747	5.0%
Year 2015	$ 51,104	$ 46,663	4.9%
Year 2016	$ 51,104	$ 45,610	4.8%
Year 2017	$ 51,104	$ 44,588	4.7%
Year 2018	$ 51,104	$ 43,581	4.6%
Year 2019	$ 51,104	$ 42,605	4.5%
Year 2020	$ 51,104	$ 41,645	4.4%
Year 2021	$ 51,104	$ 40,709	4.3%
Year 2022	$ 51,104	$ 39,795	4.2%
Year 2023	$ 51,104	$ 38,900	4.1%
Year 2024	$ 51,104	$ 38,026	4.0%
Year 2025	$ 51,104	$ 37,168	3.9%
Year 2026	$ 51,104	$ 36,335	3.8%
Year 2027	$ 51,104	$ 35,517	3.7%
Year 2028	$ 51,104	$ 34,720	3.7%
Year 2029	$ 51,104	$ 33,938	3.6%
Year 2030	$ 51,104	$ 33,177	3.5%
Year 2031	$ 51,104	$ 32,431	3.4%
Year 2032	$ 51,104	$ 31,700	3.3%
Year 2033	$ 51,104	$ 30,989	3.3%
Year 2034	$ 51,104	$ 30,289	3.2%
Year 2035	$ 51,104	$ 29,610	3.1%
Year 2036	$ 51,104	$ 28,945	3.1%
Year 2037	$ 51,104	$ 28,291	3.0%
Year 2038	$ 51,104	$ 27,657	2.9%
Year 2039	$ 51,104	$ 27,034	2.9%
TOTAL PRESENT WORTH VALUE No Action TSCA Container/Transport		**$ 947,670**	100.0%

Table H1.6. No Action Alternative Present Value Costs

LIFE CYCLE COST ANALYSIS
No Action Alternative
TSCA Landfill Disposal

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	No Action Off-site Volume for 2014 to 2039	3,592,840	Cubic Yards
	TSCA Volume	6,410	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

No Action Off-Site Waste (FROM 2014 TO 2039) - - - TSCA Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 445,490	$ 416,132	5.0%
Year 2015	$ 445,481	$ 406,769	4.9%
Year 2016	$ 445,481	$ 397,592	4.8%
Year 2017	$ 445,481	$ 388,682	4.7%
Year 2018	$ 445,481	$ 379,906	4.6%
Year 2019	$ 445,481	$ 371,398	4.5%
Year 2020	$ 445,481	$ 363,022	4.4%
Year 2021	$ 445,481	$ 354,870	4.3%
Year 2022	$ 445,481	$ 346,896	4.2%
Year 2023	$ 445,481	$ 339,100	4.1%
Year 2024	$ 445,481	$ 331,482	4.0%
Year 2025	$ 445,481	$ 323,998	3.9%
Year 2026	$ 445,481	$ 316,737	3.8%
Year 2027	$ 445,481	$ 309,609	3.7%
Year 2028	$ 445,481	$ 302,660	3.7%
Year 2029	$ 445,481	$ 295,844	3.6%
Year 2030	$ 445,481	$ 289,206	3.5%
Year 2031	$ 445,481	$ 282,702	3.4%
Year 2032	$ 445,481	$ 276,332	3.3%
Year 2033	$ 445,481	$ 270,140	3.3%
Year 2034	$ 445,481	$ 264,037	3.2%
Year 2035	$ 445,481	$ 258,112	3.1%
Year 2036	$ 445,481	$ 252,320	3.1%
Year 2037	$ 445,481	$ 246,618	3.0%
Year 2038	$ 445,481	$ 241,094	2.9%
Year 2039	$ 445,481	$ 235,659	2.9%
TOTAL PRESENT WORTH VALUE No Action TSCA Landfill Disposal		**$ 8,260,917**	100.0%

Table H1.7. No Action Alternative Present Value Costs

LIFE CYCLE COST ANALYSIS
No Action Alternative
Classified Waste Containers and Transportation

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	No Action Off-site Volume for 2014 to 2039	3,592,840	Cubic Yards
	Classified Waste Volume	196,000	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

No Action Off-Site Waste (FROM 2014 TO 2039) - - - Classified Waste Containers and Transportation Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 5,460,685	$ 5,100,826	5.0%
Year 2015	$ 5,460,678	$ 4,986,145	4.9%
Year 2016	$ 5,460,678	$ 4,873,655	4.8%
Year 2017	$ 5,460,678	$ 4,764,442	4.7%
Year 2018	$ 5,460,678	$ 4,656,866	4.6%
Year 2019	$ 5,460,678	$ 4,552,567	4.5%
Year 2020	$ 5,460,678	$ 4,449,907	4.4%
Year 2021	$ 5,460,678	$ 4,349,976	4.3%
Year 2022	$ 5,460,678	$ 4,252,230	4.2%
Year 2023	$ 5,460,678	$ 4,156,668	4.1%
Year 2024	$ 5,460,678	$ 4,063,290	4.0%
Year 2025	$ 5,460,678	$ 3,971,551	3.9%
Year 2026	$ 5,460,678	$ 3,882,542	3.8%
Year 2027	$ 5,460,678	$ 3,795,171	3.7%
Year 2028	$ 5,460,678	$ 3,709,985	3.7%
Year 2029	$ 5,460,678	$ 3,626,436	3.6%
Year 2030	$ 5,460,678	$ 3,545,072	3.5%
Year 2031	$ 5,460,678	$ 3,465,346	3.4%
Year 2032	$ 5,460,678	$ 3,387,259	3.3%
Year 2033	$ 5,460,678	$ 3,311,355	3.3%
Year 2034	$ 5,460,678	$ 3,236,544	3.2%
Year 2035	$ 5,460,678	$ 3,163,917	3.1%
Year 2036	$ 5,460,678	$ 3,092,928	3.1%
Year 2037	$ 5,460,678	$ 3,023,031	3.0%
Year 2038	$ 5,460,678	$ 2,955,319	2.9%
Year 2039	$ 5,460,678	$ 2,888,699	2.9%
TOTAL PRESENT WORTH VALUE No Action Classified Waste Container/Transport		**$ 101,261,727**	100.0%

Table H1.8. No Action Alternative Present Value Costs

LIFE CYCLE COST ANALYSIS
No Action Alternative
Classified Waste Landfill Disposal

Economic Analysis

Assumptions:			
	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	No Action Off-site Volume for 2014 to 2039	3,592,840	Cubic Yards
	Classified Waste Volume	196,000	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

No Action Off-Site Waste (FROM 2014 TO 2039) - - - Classified Waste Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 4,531,229	$ 4,232,621	5.0%
Year 2015	$ 4,531,232	$ 4,137,468	4.9%
Year 2016	$ 4,531,232	$ 4,044,125	4.8%
Year 2017	$ 4,531,232	$ 3,953,500	4.7%
Year 2018	$ 4,531,232	$ 3,864,235	4.6%
Year 2019	$ 4,531,232	$ 3,777,688	4.5%
Year 2020	$ 4,531,232	$ 3,692,501	4.4%
Year 2021	$ 4,531,232	$ 3,609,579	4.3%
Year 2022	$ 4,531,232	$ 3,528,470	4.2%
Year 2023	$ 4,531,232	$ 3,449,174	4.1%
Year 2024	$ 4,531,232	$ 3,371,690	4.0%
Year 2025	$ 4,531,232	$ 3,295,565	3.9%
Year 2026	$ 4,531,232	$ 3,221,706	3.8%
Year 2027	$ 4,531,232	$ 3,149,206	3.7%
Year 2028	$ 4,531,232	$ 3,078,519	3.7%
Year 2029	$ 4,531,232	$ 3,009,191	3.6%
Year 2030	$ 4,531,232	$ 2,941,676	3.5%
Year 2031	$ 4,531,232	$ 2,875,520	3.4%
Year 2032	$ 4,531,232	$ 2,810,723	3.3%
Year 2033	$ 4,531,232	$ 2,747,739	3.3%
Year 2034	$ 4,531,232	$ 2,685,661	3.2%
Year 2035	$ 4,531,232	$ 2,625,396	3.1%
Year 2036	$ 4,531,232	$ 2,566,490	3.1%
Year 2037	$ 4,531,232	$ 2,508,490	3.0%
Year 2038	$ 4,531,232	$ 2,452,303	2.9%
Year 2039	$ 4,531,232	$ 2,397,022	2.9%
	TOTAL PRESENT WORTH VALUE No Action Classified Waste Landfill Disposal	**$ 84,026,258**	100.0%

Table H1.9. No Action Alternative - LLW
Engineer Estimate 2011 Constant Dollars

No Action Packaging/Shipping Alternative: [LLW - Non-Classified]

CERCLA Waste Disposal RI/FS

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal
High Density: Includes Concrete and Soil

Assumptions

1. Assume Non-classified waste (Low-Level).
2. Assume FY'11 costs (Nonescalated).

Low Density Waste			High Density Waste		
Waste Volume:	**663,180**	yd^3	Waste Volume:	**1,556,540**	yd^3
Waste Volume:	17,905,860	ft^3	Waste Volume:	42,026,580	ft^3
Project Duration:	312	Months	Project Duration:	312	Months

TSDF:	Energy Solutions	
Transportation (Rail):	$20,265 per railcar (Low-Sided Gondola)	* Assumes Loading & shipping within (7) days and offloading within (7) days.
Transportation (Rail):	$20,265 per railcar (High-Sided Gondola)	
Disposal Cost (Debris):	$19.76 ft^3	
Disposal Cost (Soil):	$7.12 ft^3	

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal

Container/Transportation Cost

6,275 ft^3 / Container [Assumes High-Sided Gondola]
75.0% Packaging Efficiency
4,706 ft^3 * Amount of Waste per Container

17,905,860 ft^3 / 4,706 ft^3 / Cont. = 3,805 Gondolas

3,805 Cont. / 312 Months = 13 Gondolas/month

Fleet Size = 39 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 39 containers X 312 months X $1,300 per container
= $15,818,400

Pkg/Trans. Cost = 3,805 Gondolas X $20,265 per Gondola
= $77,108,325

Pkg/Trans. Cost & Container Rental = $92,926,725

Disposal Cost

Disposal Volume = 3,805 Cont. X 6,275 ft^3/cont. X 80% Int. Vol.
= 19,101,100 ft^3

Debris Price
Disposal Cost = 19,101,100 ft^3 X $19.76 per ft^3 = $377,437,736

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$106,865,734
Disposal:	$434,053,396
Totals	$540,919,130

High Density: Includes Concrete and Soil

Container/Transportation Cost

2,743 ft^3 / Container [Assumes Low-Sided Gondola]
90.0% Packaging Efficiency
2,469 ft^3 * Amount of Waste per Container

42,026,580 ft^3 / 2,469 ft^3 / Cont. = 17,022 Gondolas

17,022 Cont. / 312 Months = 55 Gondolas/month

Fleet Size = 165 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 127 containers X 312 months X $1,300 per container
= $51,511,200

Pkg/Trans. Cost = 17,022 Gondolas X $20,265 per Gondola
= $344,950,830

Pkg/Trans. Cost & Container Rental = $396,462,030

Disposal Cost

Disposal Volume = 17,022 Cont. X 2,743 ft^3/cont. X 80% Int. Vol.
= 37,353,077 ft^3

Soil Price
Disposal Cost = 37,353,077 ft^3 X $7.12 per ft^3 = $265,953,908

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$455,931,335
Disposal:	$305,846,994
Totals	$761,778,329

Total Containers & Transportation Cost:	**$562,797,069**	->	**Total per year (2014-2039):**	**$21,646,041**
Total Disposal Cost:	**$739,900,390**	->	**Total per year (2014-2039):**	**$28,457,707**
Total Cost	**$1,302,697,459**			

All costs based on current 2011 transportation and disposal rates.

Table H1.10. No Action Alternative - TSCA Waste
Engineer Estimate 2011 Constant Dollars

No Action Packaging/Shipping Alternative: [TSCA - Non-Classified]

CERCLA Waste Disposal RI/FS

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal
High Density: Includes Concrete and Soil

Assumptions

1. Assume Non-classified waste (Low-Level).
2. Assume FY'11 costs (Nonescalated).

Low Density Waste		High Density Waste	
Waste Volume:	**6,410** yd^3	Waste Volume:	**0** yd^3
Waste Volume:	173,070 ft^3	Waste Volume:	0 ft^3
Project Duration:	312 Months	Project Duration:	312 Months

TSDF:	Energy Solutions	
Transportation (Rail):	$20,265 per railcar (Low-Sided Gondola)	* Assumes Loading & shipping within (7) days and offloading within (7) days.
Transportation (Rail):	$20,265 per railcar (High-Sided Gondola)	
Disposal Cost (Debris):	$43.38 ft^3	* Assumes Remediation Waste
Disposal Cost (Soil):	$42.04 ft^3	* Assumes Remediation Waste

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal

Container/Transportation Cost

6,275 ft^3 / Container [Assumes High-Sided Gondola]
75.0% Packaging Efficiency
4,706 ft^3 * Amount of Waste per Container

173,070 ft^3 / 4,706 ft^3 / Cont. = 37 Gondolas

37 Cont. / 26 Years = 2 Gondolas/Year

Fleet Size = 1 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 1 containers X 312 months X $1,300 per container
= $405,600

Pkg/Trans. Cost = 37 Gondolas X $20,265 per Gondola
= $749,805

Pkg/Trans. Cost & Container Rental = $1,155,405

Disposal Cost

Disposal Volume = 37 Cont. X 6,275 ft^3/cont.
= 232,175 ft^3

Debris Price
Disposal Cost = 232,175 ft^3 X $43.38 per ft^3 = $10,071,752

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$1,328,716
Disposal:	$11,582,515
Totals	$12,911,231

High Density: Includes Concrete and Soil

Container/Transportation Cost

2,743 ft^3 / Container [Assumes Low-Sided Gondola]
90.0% Packaging Efficiency
2,469 ft^3 * Amount of Waste per Container

0 ft^3 / 2,469 ft^3 / Cont. = 0 Gondolas

0 Cont. / 26 Years = 0 Gondolas/Year

Fleet Size = 0 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 0 containers X 312 months X $1,300 per container
= $0

Pkg/Trans. Cost = 0 Gondolas X $20,265 per Gondola
= $0

Pkg/Trans. Cost & Container Rental = $0

Disposal Cost

Disposal Volume = 0 Cont. X 2,743 ft^3/cont.
= 0 ft^3

Soil Price
Disposal Cost = 0 ft^3 X $42.04 per ft^3 = $0

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$0
Disposal:	$0
Totals	$0

Total Containers & Transportation Cost:	**$1,328,716**	->	**Total per year (2014-2039):**	**$51,104**
Total Disposal Cost:	**$11,582,515**	->	**Total per year (2014-2039):**	**$445,481**
Total Cost	**$12,911,231**			

All costs based on current 2011 transportation and disposal rates.

Table H1.11. No Action Alternative - MLLW
Engineer Estimate 2011 Constant Dollars

No Action Packaging/Shipping Alternative: [MLLW - Non-Classified]

CERCLA Waste Disposal RI/FS
Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal
High Density: Includes Concrete and Soil

Assumptions
1. Assume the MLLW does not require treatment.
2. Assume Non-classified waste.
3. Assume FY'11 costs (Nonescalated)

Low Density Waste			**High Density Waste**		
Waste Volume:	**61,810**	yd^3	Waste Volume:	**5,320**	yd^3
Waste Volume:	1,668,870	ft^3	Waste Volume:	143,640	ft^3
Project Duration:	312	Months	Project Duration:	312	Months
TSDF (EnergySolutions):			**TSDF (EnergySolutions):**		
Disposal:	$43.38	ft^3	Disposal:	$43.38	ft^3
Containers:	$8,850	3/4 High (6') Sealand	Transportation:	$20,265	per railcar (Low-Sided Gondola)
Transportation:	$5,500	per truck			* Assumes Loading & shipping within (7) days and offloading within (7) days.

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal

Container/Transportation Cost
1,080 ft^3 / Container [Assumes 3/4 High (6') Sea/Land (Associated Container)]
75.0% Packaging Efficiency
810 ft^3 * Amount of Waste per Container

1,668,870 ft^3 / 810 ft^3 / Cont. = 2,061 Containers

Container Cost
2,061 Containers X $8,850 per container = $18,239,850

Transportation Cost (trucking)
2,061 Containers (1 per truck) X $5,500 per truck = $11,335,500

Subtotal Containers & Transportation = $29,575,350

Disposal Cost
Cont. Type: 3/4 High (6') Sea/Land
Disposal (debris) = 2,061 Cont. X 1,080 ft^3/cont. X $43.38 per ft^3

Subtotal Disposal = $96,558,674

Total Cost (Including 15% Management Reserve)

	3/4 High Sea/Land
Containers & Transportation:	$34,011,653
Disposal:	$111,042,475
Totals	$145,054,128

High Density: Includes Concrete and Soil

Container/Transportation Cost
1,080 ft^3 / Container [Assumes 3/4 High (6') Sea/Land (Associated Container)]
75.0% Packaging Efficiency
810 ft^3 * Amount of Waste per Container

143,640 ft^3 / 810 ft^3 / Cont. = 178 Containers

Container Cost
178 Containers X $8,850 per container = $1,575,300

Transportation Cost (trucking)
178 Containers (1 per truck) X $5,500 per truck = $979,000

Subtotal Containers & Transportation = $2,554,300

Disposal Cost
Cont. Type: 3/4 High (6') Sea/Land
Disposal (soil) = 178 Cont. X 1,080 ft^3/cont. X $43.38 per ft^3

Subtotal Disposal = $8,339,371

Total Cost (Including 15% Management Reserve)

	3/4 High Sea/Land
Containers & Transportation:	$2,937,445
Disposal:	$9,590,277
Totals	$12,527,722

Total Containers & Transportation Cost:	**$36,949,098**	**->**	**Total per year (2014-2039):**	**$1,421,119**
Total Disposal Cost:	**$120,632,752**	**->**	**Total per year (2014-2039):**	**$4,639,721**
Total Cost	**$157,581,850**			

All costs based on current 2011 transportation and disposal rates.

Table H1.12. No Action Alternative - Classified Waste
Engineer Estimate 2011 Constant Dollars

No Action Packaging/Shipping Alternative: [Classified Waste]

CERCLA Waste Disposal RI/FS
Consists of Scrap Metal

Assumptions
1. Assume classified waste
2. Assume FY'11 costs (Nonescalated)

	LLW		B-25s/ST-90s	Sea/Lands
Waste Volume (yd^3):	**196,100**	->	**14,800**	**181300**
Waste Volume (ft^3):	5,294,700	->	**399,600**	**4,895,100**
Project Duration (Months):	312			

TSDF:	NNSS
Transportation (Truck):	$9,830 per truck
Transportation (Rail):	N/A
Disposal Cost (Debris):	$14.51 ft^3
Disposal Cost (Soil):	$14.51 ft^3

Waste Type: Low-level Waste Classified

Container Cost

Cont. Type: B-25s / ST-90s
96 ft^3 / Container
75.0% Packaging Efficiency
72 ft^3 * Amount of Waste per Container

399,600 ft^3 / 72 ft^3 / Cont. = 5,550 Containers

Cont. Cost = 5,550 Cont. @ $1,200 per container
= $6,660,000

Cont. Type: 3/4 High (6') Sea/Lands [Associated Container]
1080 ft^3 / Container
75.0% Packaging Efficiency
810 ft^3 * Amount of Waste per Container

4,895,100 ft^3 / 810 ft^3 / Cont. = 6,044 Containers

Cont. Cost = 6,044 Cont. @ $8,850 per container
= $53,489,400

Transportation Cost (Trucking)

Cont. Type: B-25s / ST-90s
5,550 Cont. / 14 Cont./Truck X $9,830 per truck = $3,896,893

Cont. Type: 3/4 High (6') Sea/Lands [Associated Container]
6,044 Cont. / 1 Cont./Truck X $9,830 per truck = $59,412,520

Disposal Cost

Cont. Type: B-25s / ST-90s
Disposal Cost = 5,550 Cont. X 96 ft^3/cont. X $14.51 per ft^3
= $7,730,928

Cont. Type: 3/4 High (6') Sea/Lands [Associated Container]
Disposal Cost = 6,044 Cont. X 1,080 ft^3/cont. X $14.51 per ft^3
= $94,714,315

Total Cost (Including 15% Management Reserve)

	B-25s / ST-90s	3/4 High S/Ls
Containers:	7,659,000	$61,512,810
Transportation:	4,481,427	$68,324,398
Disposal:	8,890,567	$108,921,462
Totals	21,030,994	238,758,670

Total Containers & Transportation Cost:	**$141,977,635**	**->**	**Total per year (2014-2039):**	**$5,460,678**
Total Disposal Cost:	**$117,812,029**	**->**	**Total per year (2014-2039):**	**$4,531,232**
Total Cost	**$259,789,664**			

All costs based on current 2011 transportation and disposal rates.

APPENDIX H
ATTACHMENT H2

OFF-SITE ALTERNATIVE
PRESENT VALUE COSTS
(HIGH-END WASTE VOLUME)

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Table H2.1. Off-Site Alternative Present Value Costs (High-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: High-End Volume - LLW
Containers and Transportation

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	High-End Volume for 2014 to 2039	4,000,000	Cubic Yards
	LLW Volume	2,657,400	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - LLW Containers and Transportation Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 31,315,980	$ 29,252,257	5.0%
Year 2015	$ 31,315,978	$ 28,594,620	4.9%
Year 2016	$ 31,315,978	$ 27,949,510	4.8%
Year 2017	$ 31,315,978	$ 27,323,191	4.7%
Year 2018	$ 31,315,978	$ 26,706,266	4.6%
Year 2019	$ 31,315,978	$ 26,108,131	4.5%
Year 2020	$ 31,315,978	$ 25,519,390	4.4%
Year 2021	$ 31,315,978	$ 24,946,308	4.3%
Year 2022	$ 31,315,978	$ 24,385,752	4.2%
Year 2023	$ 31,315,978	$ 23,837,722	4.1%
Year 2024	$ 31,315,978	$ 23,302,219	4.0%
Year 2025	$ 31,315,978	$ 22,776,111	3.9%
Year 2026	$ 31,315,978	$ 22,265,660	3.8%
Year 2027	$ 31,315,978	$ 21,764,605	3.7%
Year 2028	$ 31,315,978	$ 21,276,075	3.7%
Year 2029	$ 31,315,978	$ 20,796,941	3.6%
Year 2030	$ 31,315,978	$ 20,330,333	3.5%
Year 2031	$ 31,315,978	$ 19,873,120	3.4%
Year 2032	$ 31,315,978	$ 19,425,301	3.3%
Year 2033	$ 31,315,978	$ 18,990,009	3.3%
Year 2034	$ 31,315,978	$ 18,560,980	3.2%
Year 2035	$ 31,315,978	$ 18,144,478	3.1%
Year 2036	$ 31,315,978	$ 17,737,370	3.1%
Year 2037	$ 31,315,978	$ 17,336,525	3.0%
Year 2038	$ 31,315,978	$ 16,948,207	2.9%
Year 2039	$ 31,315,978	$ 16,566,152	2.9%
	TOTAL PRESENT WORTH VALUE LLW High-End Volume	**$ 580,717,233**	100.0%

Table H2.2. Off-Site Alternative Present Value Costs (High-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: High-End Volume - LLW
Landfill Disposal

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	High-End Volume for 2014 to 2039	4,000,000	Cubic Yards
	LLW Volume	2,657,400	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - LLW Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 61,859,952	$ 57,783,381	5.0%
Year 2015	$ 61,859,944	$ 56,484,315	4.9%
Year 2016	$ 61,859,944	$ 55,210,000	4.8%
Year 2017	$ 61,859,944	$ 53,972,801	4.7%
Year 2018	$ 61,859,944	$ 52,754,160	4.6%
Year 2019	$ 61,859,944	$ 51,572,635	4.5%
Year 2020	$ 61,859,944	$ 50,409,668	4.4%
Year 2021	$ 61,859,944	$ 49,277,631	4.3%
Year 2022	$ 61,859,944	$ 48,170,338	4.2%
Year 2023	$ 61,859,944	$ 47,087,789	4.1%
Year 2024	$ 61,859,944	$ 46,029,984	4.0%
Year 2025	$ 61,859,944	$ 44,990,737	3.9%
Year 2026	$ 61,859,944	$ 43,982,420	3.8%
Year 2027	$ 61,859,944	$ 42,992,661	3.7%
Year 2028	$ 61,859,944	$ 42,027,646	3.7%
Year 2029	$ 61,859,944	$ 41,081,189	3.6%
Year 2030	$ 61,859,944	$ 40,159,476	3.5%
Year 2031	$ 61,859,944	$ 39,256,320	3.4%
Year 2032	$ 61,859,944	$ 38,371,723	3.3%
Year 2033	$ 61,859,944	$ 37,511,870	3.3%
Year 2034	$ 61,859,944	$ 36,664,389	3.2%
Year 2035	$ 61,859,944	$ 35,841,652	3.1%
Year 2036	$ 61,859,944	$ 35,037,472	3.1%
Year 2037	$ 61,859,944	$ 34,245,665	3.0%
Year 2038	$ 61,859,944	$ 33,478,602	2.9%
Year 2039	$ 61,859,944	$ 32,723,910	2.9%
	TOTAL PRESENT WORTH VALUE LLW High-End Volume	**$ 1,147,118,434**	100.0%

Table H2.3. Off-Site Alternative Present Value Costs (High-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: High-End Volume - MLLW
Containers and Transportation

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	High-End Volume for 2014 to 2039	4,000,000	Cubic Yards
	MLLW Volume	73,840	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - MLLW Containers and Transportation

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 1,562,657	$ 1,459,678	5.0%
Year 2015	$ 1,562,660	$ 1,426,865	4.9%
Year 2016	$ 1,562,660	$ 1,394,674	4.8%
Year 2017	$ 1,562,660	$ 1,363,421	4.7%
Year 2018	$ 1,562,660	$ 1,332,636	4.6%
Year 2019	$ 1,562,660	$ 1,302,790	4.5%
Year 2020	$ 1,562,660	$ 1,273,412	4.4%
Year 2021	$ 1,562,660	$ 1,244,815	4.3%
Year 2022	$ 1,562,660	$ 1,216,843	4.2%
Year 2023	$ 1,562,660	$ 1,189,497	4.1%
Year 2024	$ 1,562,660	$ 1,162,775	4.0%
Year 2025	$ 1,562,660	$ 1,136,523	3.9%
Year 2026	$ 1,562,660	$ 1,111,051	3.8%
Year 2027	$ 1,562,660	$ 1,086,049	3.7%
Year 2028	$ 1,562,660	$ 1,061,671	3.7%
Year 2029	$ 1,562,660	$ 1,037,763	3.6%
Year 2030	$ 1,562,660	$ 1,014,479	3.5%
Year 2031	$ 1,562,660	$ 991,664	3.4%
Year 2032	$ 1,562,660	$ 969,318	3.3%
Year 2033	$ 1,562,660	$ 947,597	3.3%
Year 2034	$ 1,562,660	$ 926,189	3.2%
Year 2035	$ 1,562,660	$ 905,405	3.1%
Year 2036	$ 1,562,660	$ 885,091	3.1%
Year 2037	$ 1,562,660	$ 865,089	3.0%
Year 2038	$ 1,562,660	$ 845,712	2.9%
Year 2039	$ 1,562,660	$ 826,647	2.9%
TOTAL PRESENT WORTH VALUE MLLW High-End Volume		**$ 28,977,654**	100.0%

Table H2.4. Off-Site Alternative Present Value Costs (High-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: High-End Volume - MLLW
Landfill Disposal

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	High-End Volume for 2014 to 2039	4,000,000	Cubic Yards
	MLLW Volume	73,840	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - MLLW Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 5,101,827	$ 4,765,617	5.0%
Year 2015	$ 5,101,828	$ 4,658,479	4.9%
Year 2016	$ 5,101,828	$ 4,553,381	4.8%
Year 2017	$ 5,101,828	$ 4,451,345	4.7%
Year 2018	$ 5,101,828	$ 4,350,839	4.6%
Year 2019	$ 5,101,828	$ 4,253,394	4.5%
Year 2020	$ 5,101,828	$ 4,157,480	4.4%
Year 2021	$ 5,101,828	$ 4,064,116	4.3%
Year 2022	$ 5,101,828	$ 3,972,793	4.2%
Year 2023	$ 5,101,828	$ 3,883,511	4.1%
Year 2024	$ 5,101,828	$ 3,796,270	4.0%
Year 2025	$ 5,101,828	$ 3,710,560	3.9%
Year 2026	$ 5,101,828	$ 3,627,400	3.8%
Year 2027	$ 5,101,828	$ 3,545,770	3.7%
Year 2028	$ 5,101,828	$ 3,466,182	3.7%
Year 2029	$ 5,101,828	$ 3,388,124	3.6%
Year 2030	$ 5,101,828	$ 3,312,107	3.5%
Year 2031	$ 5,101,828	$ 3,237,620	3.4%
Year 2032	$ 5,101,828	$ 3,164,664	3.3%
Year 2033	$ 5,101,828	$ 3,093,748	3.3%
Year 2034	$ 5,101,828	$ 3,023,853	3.2%
Year 2035	$ 5,101,828	$ 2,955,999	3.1%
Year 2036	$ 5,101,828	$ 2,889,675	3.1%
Year 2037	$ 5,101,828	$ 2,824,372	3.0%
Year 2038	$ 5,101,828	$ 2,761,109	2.9%
Year 2039	$ 5,101,828	$ 2,698,867	2.9%
	TOTAL PRESENT WORTH VALUE MLLW High-End Volume	**$ 94,607,275**	100.0%

Table H2.5. Off-Site Alternative Present Value Costs (High-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: High-End Volume - TSCA
Containers and Transportation

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	High-End Volume for 2014 to 2039	4,000,000	Cubic Yards
	TSCA Volume	7,050	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - TSCA Containers and Transportation Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 54,677	$ 51,074	5.0%
Year 2015	$ 54,690	$ 49,937	4.9%
Year 2016	$ 54,690	$ 48,811	4.8%
Year 2017	$ 54,690	$ 47,717	4.7%
Year 2018	$ 54,690	$ 46,640	4.6%
Year 2019	$ 54,690	$ 45,595	4.5%
Year 2020	$ 54,690	$ 44,567	4.4%
Year 2021	$ 54,690	$ 43,566	4.3%
Year 2022	$ 54,690	$ 42,587	4.2%
Year 2023	$ 54,690	$ 41,630	4.1%
Year 2024	$ 54,690	$ 40,695	4.0%
Year 2025	$ 54,690	$ 39,776	3.9%
Year 2026	$ 54,690	$ 38,885	3.8%
Year 2027	$ 54,690	$ 38,010	3.7%
Year 2028	$ 54,690	$ 37,156	3.7%
Year 2029	$ 54,690	$ 36,320	3.6%
Year 2030	$ 54,690	$ 35,505	3.5%
Year 2031	$ 54,690	$ 34,706	3.4%
Year 2032	$ 54,690	$ 33,924	3.3%
Year 2033	$ 54,690	$ 33,164	3.3%
Year 2034	$ 54,690	$ 32,415	3.2%
Year 2035	$ 54,690	$ 31,687	3.1%
Year 2036	$ 54,690	$ 30,976	3.1%
Year 2037	$ 54,690	$ 30,276	3.0%
Year 2038	$ 54,690	$ 29,598	2.9%
Year 2039	$ 54,690	$ 28,931	2.9%
	TOTAL PRESENT WORTH VALUE TSCA High-End Volume	**$ 1,014,148**	100.0%

Table H2.6. Off-Site Alternative Present Value Costs
(High-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: High-End Volume - TSCA
Landfill Disposal

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	High-End Volume for 2014 to 2039	4,000,000	Cubic Yards
	TSCA Volume	7,050	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - TSCA Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 493,633	$ 461,103	5.0%
Year 2015	$ 493,642	$ 450,745	4.9%
Year 2016	$ 493,642	$ 440,575	4.8%
Year 2017	$ 493,642	$ 430,703	4.7%
Year 2018	$ 493,642	$ 420,978	4.6%
Year 2019	$ 493,642	$ 411,549	4.5%
Year 2020	$ 493,642	$ 402,269	4.4%
Year 2021	$ 493,642	$ 393,235	4.3%
Year 2022	$ 493,642	$ 384,399	4.2%
Year 2023	$ 493,642	$ 375,760	4.1%
Year 2024	$ 493,642	$ 367,319	4.0%
Year 2025	$ 493,642	$ 359,026	3.9%
Year 2026	$ 493,642	$ 350,979	3.8%
Year 2027	$ 493,642	$ 343,081	3.7%
Year 2028	$ 493,642	$ 335,380	3.7%
Year 2029	$ 493,642	$ 327,828	3.6%
Year 2030	$ 493,642	$ 320,472	3.5%
Year 2031	$ 493,642	$ 313,265	3.4%
Year 2032	$ 493,642	$ 306,206	3.3%
Year 2033	$ 493,642	$ 299,345	3.3%
Year 2034	$ 493,642	$ 292,582	3.2%
Year 2035	$ 493,642	$ 286,016	3.1%
Year 2036	$ 493,642	$ 279,599	3.1%
Year 2037	$ 493,642	$ 273,280	3.0%
Year 2038	$ 493,642	$ 267,159	2.9%
Year 2039	$ 493,642	$ 261,137	2.9%
	TOTAL PRESENT WORTH VALUE TSCA High-End Volume	**$ 9,153,990**	100.0%

Table H2.7. Off-Site Alternative Present Value Costs
(High-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: High-End Volume - Classified Waste
Containers and Transportation

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	High-End Volume for 2014 to 2039	4,000,000	Cubic Yards
	Classified Waste Volume	215,600	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - Classified Waste Containers and Transportation Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 6,006,405	$ 5,610,583	5.0%
Year 2015	$ 6,006,416	$ 5,484,458	4.9%
Year 2016	$ 6,006,416	$ 5,360,726	4.8%
Year 2017	$ 6,006,416	$ 5,240,598	4.7%
Year 2018	$ 6,006,416	$ 5,122,272	4.6%
Year 2019	$ 6,006,416	$ 5,007,549	4.5%
Year 2020	$ 6,006,416	$ 4,894,628	4.4%
Year 2021	$ 6,006,416	$ 4,784,711	4.3%
Year 2022	$ 6,006,416	$ 4,677,196	4.2%
Year 2023	$ 6,006,416	$ 4,572,084	4.1%
Year 2024	$ 6,006,416	$ 4,469,374	4.0%
Year 2025	$ 6,006,416	$ 4,368,466	3.9%
Year 2026	$ 6,006,416	$ 4,270,562	3.8%
Year 2027	$ 6,006,416	$ 4,174,459	3.7%
Year 2028	$ 6,006,416	$ 4,080,759	3.7%
Year 2029	$ 6,006,416	$ 3,988,861	3.6%
Year 2030	$ 6,006,416	$ 3,899,365	3.5%
Year 2031	$ 6,006,416	$ 3,811,672	3.4%
Year 2032	$ 6,006,416	$ 3,725,780	3.3%
Year 2033	$ 6,006,416	$ 3,642,291	3.3%
Year 2034	$ 6,006,416	$ 3,560,003	3.2%
Year 2035	$ 6,006,416	$ 3,480,117	3.1%
Year 2036	$ 6,006,416	$ 3,402,034	3.1%
Year 2037	$ 6,006,416	$ 3,325,152	3.0%
Year 2038	$ 6,006,416	$ 3,250,672	2.9%
Year 2039	$ 6,006,416	$ 3,177,394	2.9%
	TOTAL PRESENT WORTH VALUE Classified Waste High-End Volume	**$ 111,381,766**	100.0%

Table H2.8. Off-Site Alternative Present Value Costs (High-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: High-End Volume - Classified Waste
Landfill Disposal

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	High-End Volume for 2014 to 2039	4,000,000	Cubic Yards
	Classified Waste Volume	215,600	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - Classified Waste Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 4,984,074	$ 4,655,624	5.0%
Year 2015	$ 4,984,078	$ 4,550,962	4.9%
Year 2016	$ 4,984,078	$ 4,448,290	4.8%
Year 2017	$ 4,984,078	$ 4,348,608	4.7%
Year 2018	$ 4,984,078	$ 4,250,422	4.6%
Year 2019	$ 4,984,078	$ 4,155,226	4.5%
Year 2020	$ 4,984,078	$ 4,061,525	4.4%
Year 2021	$ 4,984,078	$ 3,970,317	4.3%
Year 2022	$ 4,984,078	$ 3,881,102	4.2%
Year 2023	$ 4,984,078	$ 3,793,880	4.1%
Year 2024	$ 4,984,078	$ 3,708,652	4.0%
Year 2025	$ 4,984,078	$ 3,624,920	3.9%
Year 2026	$ 4,984,078	$ 3,543,679	3.8%
Year 2027	$ 4,984,078	$ 3,463,934	3.7%
Year 2028	$ 4,984,078	$ 3,386,183	3.7%
Year 2029	$ 4,984,078	$ 3,309,926	3.6%
Year 2030	$ 4,984,078	$ 3,235,663	3.5%
Year 2031	$ 4,984,078	$ 3,162,896	3.4%
Year 2032	$ 4,984,078	$ 3,091,624	3.3%
Year 2033	$ 4,984,078	$ 3,022,345	3.3%
Year 2034	$ 4,984,078	$ 2,954,063	3.2%
Year 2035	$ 4,984,078	$ 2,887,775	3.1%
Year 2036	$ 4,984,078	$ 2,822,982	3.1%
Year 2037	$ 4,984,078	$ 2,759,186	3.0%
Year 2038	$ 4,984,078	$ 2,697,383	2.9%
Year 2039	$ 4,984,078	$ 2,636,577	2.9%
TOTAL PRESENT WORTH VALUE Classified Waste High-End Volume		**$ 92,423,744**	100.0%

Table H2.9. Off-Site Alternative - LLW
[High-End Volume Scenario]
Engineer Estimate 2011 Constant Dollars

Off-Site Packaging/Shipping Alternative: LLW - Non-Classified [High-End Volume Estimate]

CERCLA Waste Disposal RI/FS
Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal
High Density: Includes Concrete and Soil

Assumptions
1. Assume Non-classified waste (Low-Level).
2. Assume FY'11 costs (Nonescalated)

Low Density Waste		High Density Waste		
Waste Volume:	**1,943,320** yd^3	Waste Volume:	**1,712,200** yd^3	3,655,520
Waste Volume:	52,469,640 ft^3	Waste Volume:	46,229,400 ft^3	
Project Duration:	312 Months	Project Duration:	312 Months	

TSDF: **Energy Solutions**

Transportation (Rail):	$20,265 per railcar (Low-Sided Gondola)	* Assumes Loading & shipping within (7) days and offloading within (7) days.
Transportation (Rail):	$20,265 per railcar (High-Sided Gondola)	
Disposal Cost (Debris):	$19.76 ft^3	
Disposal Cost (Soil):	$7.12 ft^3	

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal

Container/Transportation Cost
6,275 ft^3 / Container [Assumes High-Sided Gondola]
75.0% Packaging Efficiency
4,706 ft^3 * Amount of Waste per Container

52,469,640 ft^3 / 4,706 ft^3 / Cont. = 11,150 Gondolas

11,150 Cont. / 312 Months = 36 Gondolas/month

Fleet Size = 108 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 108 containers X 312 months X $1,300 per container
= $43,804,800

Pkg/Trans. Cost = 11,150 Gondolas X $20,265 per Gondola
= $225,954,750

Pkg/Trans. Cost & Container Rental = $269,759,550

Disposal Cost

Disposal Volume = 11,150 Cont. X 6,275 ft^3/cont. X 80% Int. Vol.
= 55,973,000 ft^3

Debris Price
Disposal Cost = 55,973,000 ft^3 X $19.76 per ft^3 = $1,106,026,480

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$310,223,483
Disposal:	$1,271,930,452
Totals	$1,582,153,935

High Density: Includes Concrete and Soil

Container/Transportation Cost
2,743 ft^3 / Container [Assumes Low-Sided Gondola]
90.0% Packaging Efficiency
2,469 ft^3 * Amount of Waste per Container

46,229,400 ft^3 / 2,469 ft^3 / Cont. = 18,724 Gondolas

18,724 Cont. / 312 Months = 61 Gondolas/month

Fleet Size = 183 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 145 containers X 312 months X $1,300 per container
= $58,812,000

Pkg/Trans. Cost = 18,724 Gondolas X $20,265 per Gondola
= $379,441,860

Pkg/Trans. Cost & Container Rental = $438,253,860

Disposal Cost

Disposal Volume = 18,724 Cont. X 2,743 ft^3/cont. X 80% Int. Vol.
= 41,087,946 ft^3

Soil Price
Disposal Cost = 41,087,946 ft^3 X $7.12 per ft^3 = $292,546,176

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$503,991,939
Disposal:	$336,428,102
Totals	$840,420,041

Total Containers & Transportation Cost:	**$814,215,422**	**->**	**Total per year (2014-2039):**	**$31,315,978**
Total Disposal Cost:	**$1,608,358,554**	**->**	**Total per year (2014-2039):**	**$61,859,944**
Total Cost	**$2,422,573,976**			

All costs based on current 2011 transportation and disposal rates.

Table H2.10. Off-Site Alternative - TSCA Waste
[High-End Volume Scenario]
Engineer Estimate 2011 Constant Dollars

Off-Site Packaging/Shipping Alternative: TSCA - Non-Classified [High-End Volume Estimate]

CERCLA Waste Disposal RI/FS
Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal
High Density: Includes Concrete and Soil

Assumptions
1. Assume Non-classified waste (Low-Level).
2. Assume FY'11 costs (Nonescalated)

Low Density Waste		**High Density Waste**	
Waste Volume:	**7,050** yd^3	Waste Volume:	**0** yd^3
Waste Volume:	190,350 ft^3	Waste Volume:	0 ft^3
Project Duration:	312 Months	Project Duration:	312 Months

TSDF:	**Energy Solutions**	
Transportation (Rail):	$20,265 per railcar (Low-Sided Gondola)	* Assumes Loading & shipping within (7) days and offloading within (7) days.
Transportation (Rail):	$20,265 per railcar (High-Sided Gondola)	
Disposal Cost (Debris):	$43.38 ft^3	* Assumes Remediation Waste
Disposal Cost (Soil):	$42.04 ft^3	* Assumes Remediation Waste

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal

Container/Transportation Cost
6,275 ft^3 / Container [Assumes High-Sided Gondola]
75.0% Packaging Efficiency
4,706 ft^3 * Amount of Waste per Container

190,350 ft^3 / 4,706 ft^3 / Cont. = 41 Gondolas

41 Cont. / 26 Years = 2 Gondolas/Year

Fleet Size = 1 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 1 containers X 312 months X $1,300 per container
= $405,600

Pkg/Trans. Cost = 41 Gondolas X $20,265 per Gondola
= $830,865

Pkg/Trans. Cost & Container Rental = $1,236,465

Disposal Cost
Disposal Volume = 41 Cont. X 6,275 ft^3/cont.
= 257,275 ft^3

Debris Price
Disposal Cost = 257,275 ft^3 X $43.38 per ft^3 = $11,160,590

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$1,421,935
Disposal:	$12,834,679
Totals	$14,256,614

High Density: Includes Concrete and Soil

Container/Transportation Cost
2,743 ft^3 / Container [Assumes Low-Sided Gondola]
90.0% Packaging Efficiency
2,469 ft^3 * Amount of Waste per Container

0 ft^3 / 2,469 ft^3 / Cont. = 0 Gondolas

0 Cont. / 26 Years = 0 Gondolas/Year

Fleet Size = 0 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 0 containers X 312 months X $1,300 per container
= $0

Pkg/Trans. Cost = 0 Gondolas X $20,265 per Gondola
= $0

Pkg/Trans. Cost & Container Rental = $0

Disposal Cost
Disposal Volume = 0 Cont. X 2,743 ft^3/cont.
= 0 ft^3

Soil Price
Disposal Cost = 0 ft^3 X $42.04 per ft^3 = $0

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$0
Disposal:	$0
Totals	$0

Total Containers & Transportation Cost:	**$1,421,935**	**->**	**Total per year (2014-2039):**	**$54,690**
Total Disposal Cost:	**$12,834,679**	**->**	**Total per year (2014-2039):**	**$493,642**
Total Cost	**$1,421,935**			

All costs based on current 2011 transportation and disposal rates.

Table H2.11. Off-Site Alternative - MLLW
[High-End Volume Scenario]
Engineer Estimate 2011 Constant Dollars

Off-Site Packaging/Shipping Alternative: MLLW - Non-Classified [High-End Volume Estimate]

CERCLA Waste Disposal RI/FS
Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal
High Density: Includes Concrete and Soil

Assumptions
1. Assume the MLLW does not require treatment.
2. Assume Non-classified waste.
3. Assume FY'11 costs (Nonescalated)

Low Density Waste		**High Density Waste**	
Waste Volume:	**67,980** yd^3	Waste Volume:	**5,860** yd^3
Waste Volume:	1,835,460 ft^3	Waste Volume:	158,220 ft^3
Project Duration:	312 Months	Project Duration:	312 Months
TSDF (Energy Solutions)		**TSDF (Energy Solutions)**	
Disposal:	$43.38 ft^3	Disposal:	$43.38 ft^3
Containers;	$8,850 3/4 High (6') Sealand	Transportation:	$20,265 per railcar (Low-Sided Gondola)
Transportation:	$5,500 per truck		* Assumes Loading & shipping within (7) days and offloading within (7) days.

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal

Container/Transportation Cost
Cont. Type: Assumes 3/4 High (6') Sealand (Associated Container)
1080 ft^3 / Container
75.0% Packaging Efficiency
810 ft^3 * Amount of Waste per Container

1,835,460 ft^3 / 810 ft^3 / Cont. = 2,266 Containers

Container Cost
2,266 Containers X $8,850 per container = $20,054,100

Transportation Cost (Trucking)
2,266 Containers (1 per truck) X $5,500 per truck = $12,463,000

Subtotal Containers & Transportation = $32,517,100

Disposal Cost
Cont. Type: 3/4 High (6') Sea/Land
Disposal (debris) = 2,266 Cont. X 1,080 ft^3/cont. X $43.38 per ft^3

Subtotal Disposal = $106,163,006

Total Cost (Including 15% Management Reserve)

	3/4 High (6') Sea/Land
Containers & Transportation:	$37,394,665
Disposal:	$122,087,457
Totals	$159,482,122

High Density: Includes Concrete and Soil

Container/Transportation Cost
Cont. Type: Assumes 3/4 High (6') Sealand (Associated Container)
1080 ft^3 / Container
75.0% Packaging Efficiency
810 ft^3 * Amount of Waste per Container

158,220 ft^3 / 810 ft^3 / Cont. = 196 Containers

Container Cost
196 Containers X $8,850 per container = $1,734,600

196 Containers (1 per truck) X $5,500 per truck = $1,078,000
0

Subtotal Containers & Transportation = $2,812,600

Disposal Cost
Cont. Type: 3/4 High (6') Sea/Land
Disposal (debris) = 196 Cont. X 1,080 ft^3/cont. X $43.38 per ft^3

Subtotal Disposal = $9,182,678

Total Cost (Including 15% Management Reserve)

	3/4 High (6') Sea/Land
Containers & Transportation:	$3,234,490
Disposal:	$10,560,080
Totals	$13,794,570

Total Containers & Transportation Cost:	**$40,629,155**	**->**	**Total per year (2014-2039):**	**$1,562,660**
Total Disposal Cost:	**$132,647,537**	**->**	**Total per year (2014-2039):**	**$5,101,828**
Total Cost	**$173,276,692**			

All costs based on current 2011 transportation and disposal rates.

Table H2.12. Off-Site Alternative - Classified Waste
[High-End Volume Scenario]
Engineer Estimate 2011 Constant Dollars

Off-Site Packaging/Shipping Alternative: Classified [High-End Volume Estimate]

CERCLA Waste Disposal RI/FS
Consists of Scrap Metal

Assumptions
1. Assume classified waste
2. Assume FY'11 costs (Nonescalated)

	LLW		B-25s/ST-90s	Sea/Lands
Waste Volume (yd^3):	**215,700**	- >	**16,280**	**199,430**
Waste Volume (ft^3):	5,823,900	- >	**439,560**	**5,384,610**
Project Duration (Months):	312			

TSDF:	NNSS
Transportation (Truck):	$9,830 per truck
Transportation (Rail):	N/A
Disposal Cost (Debris):	$14.51 ft^3
Disposal Cost (Soil):	$14.51 ft^3

Waste Type: Low-Level Waste (Classified)

Container Cost

Cont. Type: B-25s / ST-90s
96 ft^3 / Container
75.0% Packaging Efficiency
72 ft^3 * Amount of Waste per Container

439,560 ft^3 / 72 ft^3 / Cont. = 6,105 Containers

Cont. Cost = 6,105 Cont. @ $1,200 per container
= $7,326,000

Cont. Type: 3/4 High (6') Sea/Lands [Associated Container]
1080 ft^3 / Container
75.0% Packaging Efficiency
810 ft^3 * Amount of Waste per Container

5,384,610 ft^3 / 810 ft^3 / Cont. = 6,648 Containers

Cont. Cost = 6,648 Cont. @ $8,850 per container
= $58,834,800

Transportation Cost (Trucking)

Cont. Type: B-25s / ST-90s
6,105 Cont. / 14 Cont./Truck X $9,830 per truck = $4,286,582

Cont. Type: 3/4 High (6') Sea/Lands [Associated Container]
6,648 Cont. / 1 Cont./Truck X $9,830 per truck = $65,349,840

Disposal Cost

Cont. Type: B-25s / ST-90s
Disposal Cost = 6,105 Cont. X 96 ft^3/cont. X $14.51 per ft^3
= $8,504,021

Cont. Type: 3/4 High (6') Sea/Lands [Associated Container]
Disposal Cost = 6,648 Cont. X 1,080 ft^3/cont. X $14.51 per ft^3
= $104,179,478

Total Cost (Including 15% Management Reserve)

	B-25s / ST-90s	3/4 High S/Ls
Containers:	8,424,900	$67,660,020
Transportation:	4,929,569	$75,152,316
Disposal:	9,779,624	$119,806,400
Totals	23,134,093	262,618,736

Total Containers & Transportation Cost:	**$156,166,805**	**->**	**Total per year (2014-2039):**	**$6,006,416**
Total Disposal Cost:	**$129,586,024**	**->**	**Total per year (2014-2039):**	**$4,984,078**
Total Cost	**$285,752,829**			

All costs based on current 2011 transportation and disposal rates.

APPENDIX H
ATTACHMENT H3

OFF-SITE ALTERNATIVE
PRESENT VALUE COSTS
(LOW-END WASTE VOLUME)

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Table H3.1. Off-Site Alternative Present Value Costs (Low-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: Low-End Volume - LLW
Containers and Transportation

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	Low-End Volume for 2014 to 2039	1,500,000	Cubic Yards
	LLW Volume	1,434,443	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - LLW Containers and Transportation Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 14,838,860	$ 13,860,979	5.0%
Year 2015	$ 14,838,850	$ 13,549,354	4.9%
Year 2016	$ 14,838,850	$ 13,243,674	4.8%
Year 2017	$ 14,838,850	$ 12,946,897	4.7%
Year 2018	$ 14,838,850	$ 12,654,571	4.6%
Year 2019	$ 14,838,850	$ 12,371,149	4.5%
Year 2020	$ 14,838,850	$ 12,092,179	4.4%
Year 2021	$ 14,838,850	$ 11,820,628	4.3%
Year 2022	$ 14,838,850	$ 11,555,012	4.2%
Year 2023	$ 14,838,850	$ 11,295,333	4.1%
Year 2024	$ 14,838,850	$ 11,041,588	4.0%
Year 2025	$ 14,838,850	$ 10,792,296	3.9%
Year 2026	$ 14,838,850	$ 10,550,422	3.8%
Year 2027	$ 14,838,850	$ 10,313,001	3.7%
Year 2028	$ 14,838,850	$ 10,081,515	3.7%
Year 2029	$ 14,838,850	$ 9,854,480	3.6%
Year 2030	$ 14,838,850	$ 9,633,381	3.5%
Year 2031	$ 14,838,850	$ 9,416,734	3.4%
Year 2032	$ 14,838,850	$ 9,204,539	3.3%
Year 2033	$ 14,838,850	$ 8,998,279	3.3%
Year 2034	$ 14,838,850	$ 8,794,986	3.2%
Year 2035	$ 14,838,850	$ 8,597,630	3.1%
Year 2036	$ 14,838,850	$ 8,404,725	3.1%
Year 2037	$ 14,838,850	$ 8,214,787	3.0%
Year 2038	$ 14,838,850	$ 8,030,786	2.9%
Year 2039	$ 14,838,850	$ 7,849,752	2.9%
	TOTAL PRESENT WORTH VALUE LLW Low-End Volume	**$ 275,168,677**	100.0%

Table H3.2. Off-Site Alternative Present Value Costs
(Low-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: Low-End Volume - LLW
Landfill Disposal

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	Low-End Volume for 2014 to 2039	1,500,000	Cubic Yards
	LLW Volume	1,434,443	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - LLW Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 18,259,930	$ 17,056,601	5.0%
Year 2015	$ 18,259,924	$ 16,673,137	4.9%
Year 2016	$ 18,259,924	$ 16,296,982	4.8%
Year 2017	$ 18,259,924	$ 15,931,784	4.7%
Year 2018	$ 18,259,924	$ 15,572,063	4.6%
Year 2019	$ 18,259,924	$ 15,223,299	4.5%
Year 2020	$ 18,259,924	$ 14,880,012	4.4%
Year 2021	$ 18,259,924	$ 14,545,855	4.3%
Year 2022	$ 18,259,924	$ 14,219,003	4.2%
Year 2023	$ 18,259,924	$ 13,899,454	4.1%
Year 2024	$ 18,259,924	$ 13,587,209	4.0%
Year 2025	$ 18,259,924	$ 13,280,443	3.9%
Year 2026	$ 18,259,924	$ 12,982,806	3.8%
Year 2027	$ 18,259,924	$ 12,690,647	3.7%
Year 2028	$ 18,259,924	$ 12,405,792	3.7%
Year 2029	$ 18,259,924	$ 12,126,416	3.6%
Year 2030	$ 18,259,924	$ 11,854,343	3.5%
Year 2031	$ 18,259,924	$ 11,587,748	3.4%
Year 2032	$ 18,259,924	$ 11,326,631	3.3%
Year 2033	$ 18,259,924	$ 11,072,818	3.3%
Year 2034	$ 18,259,924	$ 10,822,657	3.2%
Year 2035	$ 18,259,924	$ 10,579,800	3.1%
Year 2036	$ 18,259,924	$ 10,342,421	3.1%
Year 2037	$ 18,259,924	$ 10,108,694	3.0%
Year 2038	$ 18,259,924	$ 9,882,271	2.9%
Year 2039	$ 18,259,924	$ 9,659,500	2.9%
	TOTAL PRESENT WORTH VALUE LLW Low-End Volume	**$ 338,608,386**	100.0%

Table H3.3. Off-Site Alternative Present Value Costs (Low-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: Low-End Volume - MLLW
Containers and Transportaion

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	Low-End Volume for 2014 to 2039	1,500,000	Cubic Yards
	MLLW Volume	60,021	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - MLLW Containers and Transportation Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 1,278,939	$ 1,194,657	5.0%
Year 2015	$ 1,278,944	$ 1,167,804	4.9%
Year 2016	$ 1,278,944	$ 1,141,458	4.8%
Year 2017	$ 1,278,944	$ 1,115,879	4.7%
Year 2018	$ 1,278,944	$ 1,090,683	4.6%
Year 2019	$ 1,278,944	$ 1,066,256	4.5%
Year 2020	$ 1,278,944	$ 1,042,211	4.4%
Year 2021	$ 1,278,944	$ 1,018,807	4.3%
Year 2022	$ 1,278,944	$ 995,914	4.2%
Year 2023	$ 1,278,944	$ 973,532	4.1%
Year 2024	$ 1,278,944	$ 951,662	4.0%
Year 2025	$ 1,278,944	$ 930,176	3.9%
Year 2026	$ 1,278,944	$ 909,329	3.8%
Year 2027	$ 1,278,944	$ 888,866	3.7%
Year 2028	$ 1,278,944	$ 868,915	3.7%
Year 2029	$ 1,278,944	$ 849,347	3.6%
Year 2030	$ 1,278,944	$ 830,290	3.5%
Year 2031	$ 1,278,944	$ 811,618	3.4%
Year 2032	$ 1,278,944	$ 793,329	3.3%
Year 2033	$ 1,278,944	$ 775,552	3.3%
Year 2034	$ 1,278,944	$ 758,030	3.2%
Year 2035	$ 1,278,944	$ 741,020	3.1%
Year 2036	$ 1,278,944	$ 724,394	3.1%
Year 2037	$ 1,278,944	$ 708,023	3.0%
Year 2038	$ 1,278,944	$ 692,164	2.9%
Year 2039	$ 1,278,944	$ 676,561	2.9%
	TOTAL PRESENT WORTH VALUE MLLW Low-End Volume	**$ 23,716,477**	100.0%

Table H3.4. Off-Site Alternative Present Value Costs (Low-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: Low-End Volume - MLLW
Landfill Disposal

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	Low-End Volume for 2014 to 2039	1,500,000	Cubic Yards
	MLLW Volume	60,021	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - MLLW Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 4,175,535	$ 3,900,367	5.0%
Year 2015	$ 4,175,542	$ 3,812,687	4.9%
Year 2016	$ 4,175,542	$ 3,726,671	4.8%
Year 2017	$ 4,175,542	$ 3,643,160	4.7%
Year 2018	$ 4,175,542	$ 3,560,902	4.6%
Year 2019	$ 4,175,542	$ 3,481,149	4.5%
Year 2020	$ 4,175,542	$ 3,402,649	4.4%
Year 2021	$ 4,175,542	$ 3,326,237	4.3%
Year 2022	$ 4,175,542	$ 3,251,495	4.2%
Year 2023	$ 4,175,542	$ 3,178,423	4.1%
Year 2024	$ 4,175,542	$ 3,107,021	4.0%
Year 2025	$ 4,175,542	$ 3,036,872	3.9%
Year 2026	$ 4,175,542	$ 2,968,810	3.8%
Year 2027	$ 4,175,542	$ 2,902,002	3.7%
Year 2028	$ 4,175,542	$ 2,836,863	3.7%
Year 2029	$ 4,175,542	$ 2,772,977	3.6%
Year 2030	$ 4,175,542	$ 2,710,762	3.5%
Year 2031	$ 4,175,542	$ 2,649,799	3.4%
Year 2032	$ 4,175,542	$ 2,590,089	3.3%
Year 2033	$ 4,175,542	$ 2,532,049	3.3%
Year 2034	$ 4,175,542	$ 2,474,844	3.2%
Year 2035	$ 4,175,542	$ 2,419,309	3.1%
Year 2036	$ 4,175,542	$ 2,365,027	3.1%
Year 2037	$ 4,175,542	$ 2,311,580	3.0%
Year 2038	$ 4,175,542	$ 2,259,803	2.9%
Year 2039	$ 4,175,542	$ 2,208,862	2.9%
TOTAL PRESENT WORTH VALUE MLLW Low-End Volume		**$ 77,430,409**	100.0%

Table H3.5. Off-Site Alternative Present Value Costs
(Low-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: Low-End Volume - TSCA
Containers and Transportation

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	Low-End Volume for 2014 to 2039	1,500,000	Cubic Yards
	TSCA Volume	7,324	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - TSCA Containers and Transportation Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 41,257	$ 38,538	5.0%
Year 2015	$ 41,245	$ 37,661	4.9%
Year 2016	$ 41,245	$ 36,811	4.8%
Year 2017	$ 41,245	$ 35,986	4.7%
Year 2018	$ 41,245	$ 35,174	4.6%
Year 2019	$ 41,245	$ 34,386	4.5%
Year 2020	$ 41,245	$ 33,611	4.4%
Year 2021	$ 41,245	$ 32,856	4.3%
Year 2022	$ 41,245	$ 32,117	4.2%
Year 2023	$ 41,245	$ 31,396	4.1%
Year 2024	$ 41,245	$ 30,690	4.0%
Year 2025	$ 41,245	$ 29,997	3.9%
Year 2026	$ 41,245	$ 29,325	3.8%
Year 2027	$ 41,245	$ 28,665	3.7%
Year 2028	$ 41,245	$ 28,022	3.7%
Year 2029	$ 41,245	$ 27,391	3.6%
Year 2030	$ 41,245	$ 26,776	3.5%
Year 2031	$ 41,245	$ 26,174	3.4%
Year 2032	$ 41,245	$ 25,584	3.3%
Year 2033	$ 41,245	$ 25,011	3.3%
Year 2034	$ 41,245	$ 24,446	3.2%
Year 2035	$ 41,245	$ 23,897	3.1%
Year 2036	$ 41,245	$ 23,361	3.1%
Year 2037	$ 41,245	$ 22,833	3.0%
Year 2038	$ 41,245	$ 22,322	2.9%
Year 2039	$ 41,245	$ 21,819	2.9%
TOTAL PRESENT WORTH VALUE TSCA Low-End Volume		**$ 764,849**	100.0%

Table H3.6. Off-Site Alternative Present Value Costs (Low-End Waste Volume)

LIFE CYCLE COST ANALYSIS
Off-Site Alternative: Low-End Volume - TSCA
Landfill Disposal

Economic Analysis

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	Low-End Volume for 2014 to 2039	1,500,000	Cubic Yards
	TSCA Volume	7,324	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039) - - - TSCA Disposal Cost

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*
Year 2014	$ 313,046	$ 292,416	5.0%
Year 2015	$ 313,041	$ 285,838	4.9%
Year 2016	$ 313,041	$ 279,389	4.8%
Year 2017	$ 313,041	$ 273,128	4.7%
Year 2018	$ 313,041	$ 266,961	4.6%
Year 2019	$ 313,041	$ 260,982	4.5%
Year 2020	$ 313,041	$ 255,097	4.4%
Year 2021	$ 313,041	$ 249,368	4.3%
Year 2022	$ 313,041	$ 243,765	4.2%
Year 2023	$ 313,041	$ 238,287	4.1%
Year 2024	$ 313,041	$ 232,934	4.0%
Year 2025	$ 313,041	$ 227,675	3.9%
Year 2026	$ 313,041	$ 222,572	3.8%
Year 2027	$ 313,041	$ 217,563	3.7%
Year 2028	$ 313,041	$ 212,680	3.7%
Year 2029	$ 313,041	$ 207,891	3.6%
Year 2030	$ 313,041	$ 203,226	3.5%
Year 2031	$ 313,041	$ 198,656	3.4%
Year 2032	$ 313,041	$ 194,179	3.3%
Year 2033	$ 313,041	$ 189,828	3.3%
Year 2034	$ 313,041	$ 185,539	3.2%
Year 2035	$ 313,041	$ 181,376	3.1%
Year 2036	$ 313,041	$ 177,306	3.1%
Year 2037	$ 313,041	$ 173,299	3.0%
Year 2038	$ 313,041	$ 169,418	2.9%
Year 2039	$ 313,041	$ 165,599	2.9%
TOTAL PRESENT WORTH VALUE TSCA Low-End Volume		**$ 5,804,972**	100.0%

Table H3.7. Off-Site Alternative - LLW
[Low-End Volume Scenario]
Engineer Estimate 2011 Constant Dollars

Off-Site Packaging/Shipping Alternative: LLW - Non-Classified [Low-End Volume Estimate]

CERCLA Waste Disposal RI/FS

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal
High Density: Includes Concrete and Soil

Assumptions

1. Assume Non-classified waste (Low-Level).
2. Assume FY'11 costs (Nonescalated)

Low Density Waste		**High Density Waste**	
Waste Volume:	**409,580** yd^3	Waste Volume:	**1,051,810** yd^3
Waste Volume:	11,058,660 ft^3	Waste Volume:	28,398,870 ft^3
Project Duration:	312 Months	Project Duration:	312 Months

TSDF:	**Energy Solutions**		
Transportation (Rail):	$20,265 per railcar	(Low-Sided Gondola)	* Assumes Loading & shipping within (7) days and offloading within (7) days.
Transportation (Rail):	$20,265 per railcar	(High-Sided Gondola)	
Disposal Cost (Debris):	$19.76 ft^3		
Disposal Cost (Soil):	$7.12 ft^3		

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal

Container/Transportation Cost

6,275 ft^3 / Container [Assumes High-Sided Gondola]
75.0% Packaging Efficiency
4,706 ft^3 * Amount of Waste per Container

11,058,660 ft^3 / 4,706 ft^3 / Cont. = 2,350 Gondolas

2,350 Cont. / 312 Months = 8 Gondolas/month

Fleet Size = 24 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 24 containers X 312 months X $1,300 per container
= $9,734,400

Pkg/Trans. Cost = 2,350 Gondolas X $20,265 per Gondola
= $47,622,750

Pkg/Trans. Cost & Container Rental = $57,357,150

Disposal Cost

Disposal Volume = 2,350 Cont. X 6,275 ft^3/cont. X 80% Int. Vol.
= 11,797,000 ft^3

Debris Price
Disposal Cost = 11,797,000 ft^3 X $19.76 per ft^3 = $233,108,720

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$65,960,723
Disposal:	$268,075,028
Totals	$334,035,751

High Density: Includes Concrete and Soil

Container/Transportation Cost

2,743 ft^3 / Container [Assumes Low-Sided Gondola]
90.0% Packaging Efficiency
2,469 ft^3 * Amount of Waste per Container

28,398,870 ft^3 / 2,469 ft^3 / Cont. = 11,503 Gondolas

11,503 Cont. / 312 Months = 37 Gondolas/month

Fleet Size = 111 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 111 containers X 312 months X $1,300 per container
= $45,021,600

Pkg/Trans. Cost = 11,503 Gondolas X $20,265 per Gondola
= $233,108,295

Pkg/Trans. Cost & Container Rental = $278,129,895

Disposal Cost

Disposal Volume = 11,503 Cont. X 2,743 ft^3/cont. X 80% Int. Vol.
= 25,242,184 ft^3

Soil Price
Disposal Cost = 25,242,184 ft^3 X $7.12 per ft^3 = $179,724,350

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$319,849,379
Disposal:	$206,683,003
Totals	$526,532,382

Total Containers & Transportation Cost:	**$385,810,102**	**->**	**Total per year (2014-2039):**	**$14,838,850**
Total Disposal Cost:	**$474,758,031**	**->**	**Total per year (2014-2039):**	**$18,259,924**
Total Cost	**$860,568,133**			

All costs based on current 2011 transportation and disposal rates.

Table H3.8. Off-Site Alternative - TSCA Waste
[Low-End Volume Scenario]
Engineer Estimate 2011 Constant Dollars

Off-Site Packaging/Shipping Alternative: TSCA - Non-Classified [Low-End Volume Estimate]

CERCLA Waste Disposal RI/FS

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal
High Density: Includes Concrete and Soil

Assumptions

1. Assume Non-classified waste (Low-Level).
2. Assume FY'11 costs (Nonescalated)

Low Density Waste		**High Density Waste**	
Waste Volume:	**4,430** yd^3	Waste Volume:	**0** yd^3
Waste Volume:	119,610 ft^3	Waste Volume:	0 ft^3
Project Duration:	312 Months	Project Duration:	312 Months

TSDF:	**Energy Solutions**		
Transportation (Rail):	$20,265 per railcar	(Low-Sided Gondola)	* Assumes Loading & shipping within (7) days and offloading within (7) days.
Transportation (Rail):	$20,265 per railcar	(High-Sided Gondola)	
Disposal Cost (Debris):	$43.38 ft^3	* Assumes Remediation Waste	
Disposal Cost (Soil):	$42.04 ft^3	* Assumes Remediation Waste	

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal

Container/Transportation Cost

6,275 ft^3 / Container [Assumes High-Sided Gondola]
75.0% Packaging Efficiency
4,706 ft^3 * Amount of Waste per Container

119,610 ft^3 / 4,706 ft^3 / Cont. = 26 Gondolas

26 Cont. / 26 Years = 1 Gondolas/Year

Fleet Size = 1 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 1 containers X 312 months X $1,300 per container
= $405,600

Pkg/Trans. Cost = 26 Gondolas X $20,265 per Gondola
= $526,890

Pkg/Trans. Cost & Container Rental = $932,490

Disposal Cost

Disposal Volume = 26 Cont. X 6,275 ft^3/cont.
= 163,150 ft^3

Debris Price
Disposal Cost = 163,150 ft^3 X $43.38 per ft^3 = $7,077,447

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$1,072,364
Disposal:	$8,139,064
Totals	$9,211,428

High Density: Includes Concrete and Soil

Container/Transportation Cost

2,743 ft^3 / Container [Assumes Low-Sided Gondola]
90.0% Packaging Efficiency
2,469 ft^3 * Amount of Waste per Container

0 ft^3 / 2,469 ft^3 / Cont. = 0 Gondolas

0 Cont. / 26 Years = 0 Gondolas/Year

Fleet Size = 0 [Assumes (3) times the # of cont. per month (Thruput)]
Fleet Rental Cost = 0 containers X 312 months X $1,300 per container
= $0

Pkg/Trans. Cost = 0 Gondolas X $20,265 per Gondola
= $0

Pkg/Trans. Cost & Container Rental = $0

Disposal Cost

Disposal Volume = 0 Cont. X 2,743 ft^3/cont.
= 0 ft^3

Soil Price
Disposal Cost = 0 ft^3 X $42.04 per ft^3 = $0

Total Cost (Including 15% Management Reserve)

Containers & Transportation:	$0
Disposal:	$0
Totals	$0

Total Containers & Transportation Cost:	**$1,072,364**	**->**	**Total per year (2014-2039):**	**$41,245**
Total Disposal Cost:	**$8,139,064**	**->**	**Total per year (2014-2039):**	**$313,041**
Total Cost	**$9,211,428**			

All costs based on current 2011 transportation and disposal rates.

Table H3.9. Off-Site Alternative - MLLW
[Low-End Volume Scenario]
Engineer Estimate 2011 Constant Dollars

Off-Site Packaging/Shipping Alternative: MLLW - Non-Classified [Low-End Volume Estimate]

CERCLA Waste Disposal RI/FS

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal
High Density: Includes Concrete and Soil

Assumptions

1. Assume the MLLW does not require treatment.
2. Assume Non-classified waste.
3. Assume FY'11 costs (Nonescalated)

Low Density Waste		**High Density Waste**	
Waste Volume:	**55,640** yd^3	Waste Volume:	**4,780** yd^3
Waste Volume:	1,502,280 ft^3	Waste Volume:	129,060 ft^3
Project Duration:	312 Months	Project Duration:	312 Months
TSDF (Energy Solutions)		**TSDF (Energy Solutions)**	
Disposal:	$43.38 ft^3	Disposal:	$43.38 ft^3
Containers;	$8,850 3/4 High (6') Sealand	Transportation:	$20,265 per railcar (Low-Sided Gondola)
Transportation:	$5,500 per truck		* Assumes Loading & shipping within (7) days and offloading within (7) days.

Low Density: Includes Asbestos, General Construction Debris, Other Dry Solids, and Scrap Metal

Container Cost

Cont. Type: Assumes 3/4 High (6') Sealand (Associated Container)

1080 ft^3 / Container
75.0% Packaging Efficiency
810 ft^3 * Amount of Waste per Container

1,502,280 ft^3 / 810 ft^3 / Cont. = 1,855 Containers

Container Cost (3/4 High (6') Sea/Land)

1,855 Containers X $8,850 per container = $16,416,750

Transportation Cost (Trucking)

1,855 Containers (1 per truck) X $5,500 per truck = $10,202,500

Subtotal Containers $ Transportation = $26,619,250

Disposal Cost

Cont. Type: 3/4 High (6') Sealand

Disposal (debris) = 1,855 Cont. X 1,080 ft^3/cont. X $43.38 per ft^3

Subtotal Disposal = $86,907,492

Total Cost (Including 15% Management Reserve)

	3/4 High (6') Sea/Land
Containers & Transportation:	$30,612,138
Disposal:	$99,943,616
Totals	$130,555,754

High Density: Includes Concrete and Soil

Container/Transportation Cost

Cont. Type: Assumes 3/4 High (6') Sealand (Associated Container)

1080 ft^3 / Container
75.0% Packaging Efficiency
810 ft^3 * Amount of Waste per Container

129,060 ft^3 / 810 ft^3 / Cont. = 160 Containers

Container Cost (3/4 High (6') Sea/Land)

160 Containers X $8,850 per container = $1,416,000

Transportation Cost (Trucking)

160 Containers (1 per truck) X $5,500 per truck = $880,000

Subtotal Containers $ Transportation = $2,296,000

Disposal Cost

Cont. Type: 3/4 High (6') Sealand

Disposal (debris) = 160 Cont. X 1,080 ft^3/cont. X $43.38 per ft^3

Subtotal Disposal = $7,496,064

Total Cost (Including 15% Management Reserve)

	3/4 High (6') Sea/Land
Containers & Transportation:	$2,640,400
Disposal:	$8,620,474
Totals	$11,260,874

Total Containers & Transportation Cost:	**$33,252,538**	**->**	**Total per year (2014-2039):**	**$1,278,944**
Total Disposal Cost:	**$108,564,090**	**->**	**Total per year (2014-2039):**	**$4,175,542**
Total Cost	**$141,816,628**			

All costs based on current 2011 transportation and disposal rates.

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APPENDIX H
ATTACHMENT H4

OFF-SITE AND NO ACTION ALTERNATIVES
PRESENT VALUE COSTS
(C-746-U LANDFILL) AND
WASTE MINIMIZATION

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Table H4.1. Present Value Costs
(C-746-U Landfill)

LIFE CYCLE COST ANALYSIS
Engineer's Cost Estimate for
C-746-U Landfill Construction, Operations, and Closure

Economic Analysis of Alternatives

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular A94 Appendix C)
	Disposal Waste Volume (2014-2039)	1,100,000	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(F/P, i, n)	1.4719	17	Single Payment Future Worth: from 1994 to 2011
(F/P, i, n)	1.1204	5	Single Payment Future Worth: from 2006 to 2011
(P/F, i, n)	0.9775	1	Single Payment Present Worth: from 2010 to 2011
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2019 to 2014
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2020 to 2014
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2025 to 2014
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2026 to 2014
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2031 to 2014
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2032 to 2014
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2039 to 2014
(P/F, i, n)	0.5055	30	Single Payment Present Worth: from 2044 to 2014
(P/A, i, n)	20.9940	29	Uniform Series Present Worth: Annual from 2011 to 2040
(P/A, i, n)	4.6727	5	Uniform Series Present Worth: Annual from 2014 to 2019
(P/A, i, n)	18.8530	25	Uniform Series Present Worth: Annual from 2014 to 2039
(P/A, i, n)	15.8878	20	Uniform Series Present Worth: Annual from 2019 to 2039
(P/A, i, n)	4.6727	5	Uniform Series Present Worth: Annual from 2039 to 2044
(P/A, i, n)	20.3829	30	Uniform Series Present Worth: Annual from 2039 to 2069
(P/A, i, n)	39.0041	100	Uniform Series Present Worth: Annual from 2044 to 2144

U-Landfill 2014-2039

Activity	**Type / Year(s) Cost is Incurred**	**Estimated Cost**	**Present Value Cost**	**Percent of Total Cost***
Phases 12-15 Construction	2019	$ 10,056,133	$ 8,383,640	11.2%
Phases 16-19 Construction	2025	$ 10,056,133	$ 7,314,667	9.8%
Phases 20-23 Construction	2031	$ 10,056,133	$ 6,381,899	8.5%
Operations	Annual, 2014 to 2039	$ 1,265,000	$ 22,277,393	29.7%
Closure of Phases 1-23	2039	$ 41,229,939	$ 24,440,068	32.6%
Post-Closure Care (30 years)	Annual, 2039 to 2069	$ 573,372	$ 6,183,282	8.2%
		TOTAL PRESENT WORTH COST	$ 74,980,949	100.0%
		Cost per Cubic Yard	$ 68	*present value basis

Notes:
Costs for Phases 12-23 Constuction and Closure of Phases 1-23 include 15% Management Reserve and 25% Contingency.
Costs for Operations and Post Closure Care include 15% Management Reserve.
Operations costs under Estimated Cost are annual costs; Present Value Cost is for the period 2014 through 2039.
Post-closure costs assumed to be those used for the On-Site Disposal Alternative (Low End Volume Scenario).
Annual operating costs assume that soil fill at a 1:1 soil to waste ratio will be sufficient.

Table H4.2. Present Value Costs
(Waste Minimization)

LIFE CYCLE COST ANALYSIS
Engineer's Cost Estimate for
Waste Minimization Construction and Operations

Economic Analysis of Alternatives

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular No. A-94, Appendix C)
Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	1.0000	0	Single Payment Present Worth: from 2011 to 2011
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2039 to 2014
(P/F, i, n)	0.5055	30	Single Payment Present Worth: from 2044 to 2014
(P/A, i, n)	4.6727	5	Uniform Series Present Worth: Annual from 2014 to 2019
(P/A, i, n)	18.8530	25	Uniform Series Present Worth: Annual from 2014 to 2039
(P/A, i, n)	12.5655	15	Uniform Series Present Worth: Annual from 2024 to 2039

Waste Minimization

Activity	Type / Year(s) Cost is Incurred	Estimated Cost	Present Value Cost	Percent of Total Cost
Construction - Concrete	2024	$ 13,901,875	$ 8,239,641	1.4%
Construction - Metal	2024	$ 574,807,188	$ 340,688,220	59.8%
Concrete Operations - During Site D&D	Annual, 2024 to 2039	$ 5,767,681	$ 42,955,219	7.5%
Metal Operations - During Site D&D	Annual, 2024 to 2039	$ 23,870,946	$ 177,780,585	31.2%
		TOTAL PRESENT WORTH COST	$ 569,663,665	100.0%

Metal Values Based on Recent Market Values

Material	Type / Year(s) Value is Realized	Estimated Value	Present Value	Percent of Value
Steel - Clean	Annual, 2024 to 2039	$ 3,366,261	$ 25,070,471	10.7%
Steel	Annual, 2024 to 2039	$ 12,185,766	$ 90,754,368	38.6%
Copper	Annual, 2024 to 2039	$ 3,252,217	$ 24,221,120	10.3%
Aluminum	Annual, 2024 to 2039	$ 1,135,859	$ 8,459,392	3.6%
Nickel	Annual, 2024 to 2039	$ 11,634,444	$ 86,648,358	36.8%
		TOTAL PRESENT WORTH COST	$ 235,153,709	89.3%

Metal Values Based on 20-Year Historical Market Value Average

Material	Type / Year(s) Value is Realized	Estimated Value	Present Value	Percent of Value
Steel - Clean	Annual, 2024 to 2039	$ 2,099,587	$ 15,636,825	10.0%
Steel	Annual, 2024 to 2039	$ 7,600,443	$ 56,604,845	36.1%
Copper	Annual, 2024 to 2039	$ 1,602,353	$ 11,933,639	7.6%
Aluminum	Annual, 2024 to 2039	$ 970,961	$ 7,231,302	4.6%
Nickel	Annual, 2024 to 2039	$ 8,801,509	$ 65,549,871	41.8%
		TOTAL PRESENT WORTH COST	$ 156,956,482	90.0%

Notes:
Metal tonnages for recycling are assumed to be 75% of total estimated metal tonnage.
Construction-Concrete and Construction-Metal costs include 30% contingency and 15% management reserve.
Operations costs include 15% management reserve.

APPENDIX H
ATTACHMENT H5

OFF-SITE COST SENSITIVITY ASSESSMENT

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COST SENSITIVITY ASSESSMENT SUMMARY

Under the high-end volume scenario for the Off-Site Alternative, the C-746-U Landfill is assumed to be unavailable; hence, the volume of waste projected to meet that facility's WAC is assumed to be disposed of off-site at the Energy*Solutions* facility in Clive, Utah. To understand the relative impact of this assumption versus disposal of this volume at a more local Subtitle D landfill, such as the Waste Path facility in Calvert City, Kentucky, a cost sensitivity assessment was conducted comparing the costs of disposal at both facilities. For the purposes of the cost sensitivity, it was assumed that up to 100% of the waste projected to meet the WAC of the C-746-U Landfill would meet the WAC for the Waste Path facility; however, there is a large degree of uncertainty with this assumption[1]. Therefore, a range of volume percentages is considered. Table H5.1 presents the waste volumes used for the sensitivity assessment and the associated total present value (PV) costs associated with waste transportation and disposal for the different percentages. These costs also are illustrated in Figure H5.1. The total PV cost for transportation and disposal of waste under the Off-Site Alternative, high-end volume scenario is approximately $2.07 billion compared to approximately $1.47 billion if 100% of the projected waste meeting the WAC of the C-746-U Landfill were disposed of at the Waste Path facility. This sensitivity cost of $1.47 billion is still nearly twice the cost of the On-Site Alternative high-end scenario ($843 million). Based on this cost sensitivity assessment, the assumption of the C-746-U Landfill no longer being available and the associated projected waste volume being disposed of at the Energy*Solutions* facility in Clive, Utah, versus a more local Subtitle D facility does not affect the relative cost comparison of the alternatives.

By extension, if this volume of waste is instead assumed to be disposed of at the C-746-U Landfill, the costs would be similar to those of the No Action Alternative (which serves as the base case for the Off-Site Alternative) or approximately $1.31 billion. This cost does not account for the 10% increase in volume between the base and high-end costs.

[1] This assumption is valid only for cost sensitivity purposes, because it is likely that not all waste meeting the WAC of the C-746-U Landfill will meet the WAC of an off-site Subtitle D facility.

Table H5.1 Cost Sensitivity Assessment Summary

	Off-Site Alternative	Sensitivity 1	Sensitivity 2	Sensitivity 3	Sensitivity 4
Item	**100% Nonhazardous High-End Volume to Energy*Solutions***	**25% Nonhazardous High-End Volume to Waste Path**	**50% Nonhazardous High-End Volume to Waste Path**	**75% Nonhazardous High-End Volume to Waste Path**	**100% Nonhazardous High-End Volume to Waste Path**
Volume Summary (cubic yards)					
LLW+NH Volume to Energy*Solutions**	3,655,520	3,352,065	3,048,610	2,745,155	2,441,700
NH Volume to Waste Path	0	303,455	606,910	910,365	1,213,820
Total Volume Estimate	3,655,520	3,655,520	3,655,520	3,655,520	3,655,520
Present Value Cost Summary					
Energy*Solutions* Containers, Transportation, and Disposal	$ 1,727,835,667	$ 1,552,258,800	$ 1,375,683,909	$ 1,199,109,024	$ 1,023,532,156
Waste Path Containers, Transportation, and Disposal	$ -	$ 26,478,395	$ 52,956,795	$ 79,435,185	$ 105,913,335
MLLW Containers, Transportation, Disposal	$ 123,584,929	$ 123,584,929	$ 123,584,929	$ 123,584,929	$ 123,584,929
TSCA Containers, Transportation, Disposal	$ 10,168,138	$ 10,168,138	$ 10,168,138	$ 10,168,138	$ 10,168,138
Classified Waste Containers, Transportation, Disposal	$ 203,805,510	$ 203,805,510	$ 203,805,510	$ 203,805,510	$ 203,805,510
Total Present Value Cost	$ 2,065,394,244	$ 1,916,295,772	$ 1,766,199,281	$ 1,616,102,786	$ 1,467,004,068

Notes:
LLW = Low-level waste
NH = Nonhazardous waste
* = Volume represents the sum of the LLW volume and NH volume minus the classified waste volume for the high-end scenario.
- LLW (2,657,400 cy)
- NH volume (100% = 1,213,820 cy; 75% = 910,365 cy; 50% = 606,910 cy; 25% = 303,455 cy)
- Classified waste volume (215,700 cy)

Percentages of nonhazardous waste assumed to go to Waste Path facility in Calvert City, KY have not been confirmed as eligible for disposal at the facility. Costs are evaluated for sensitivity cost comparison only.

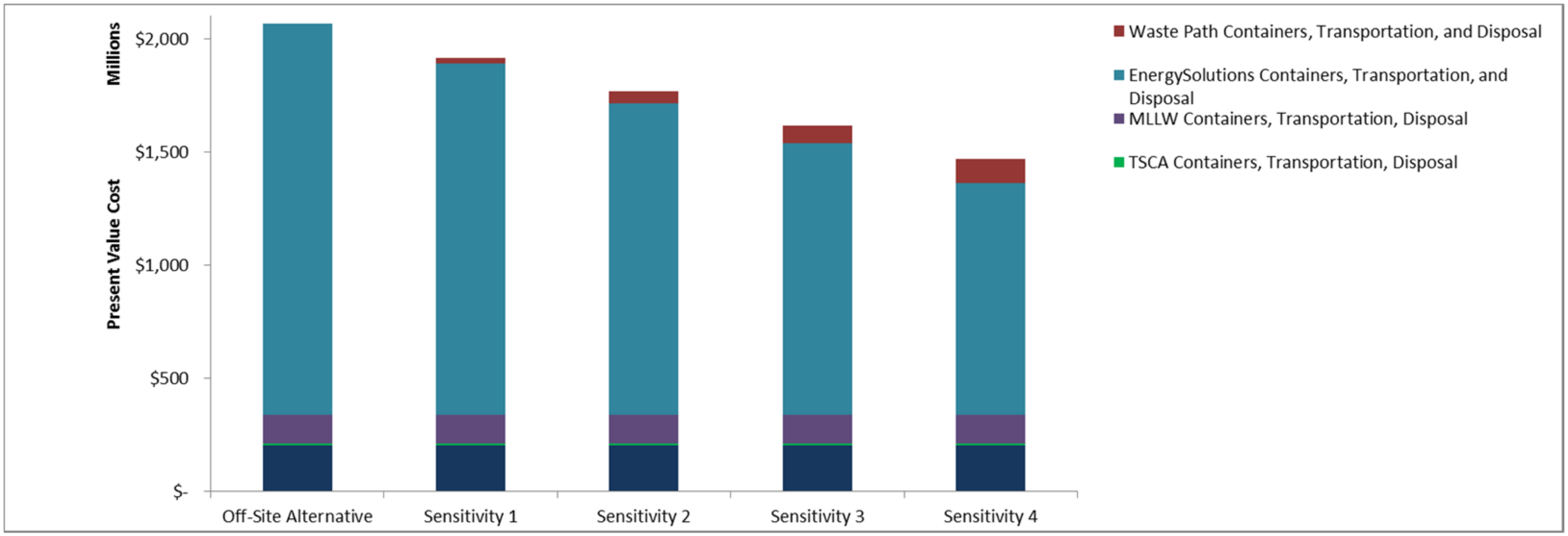
Millions
$2,000
$1,500
$1,000
$500
$-
Present Value Cost
Off-Site Alternative
Sensitivity 1
Sensitivity 2
Sensitivity 3
Sensitivity 4
Waste Path Containers, Transportation, and Disposal
EnergySolutions Containers, Transportation, and Disposal
MLLW Containers, Transportation, Disposal
TSCA Containers, Transportation, Disposal

Figure H5.1

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APPENDIX I

ON-SITE COST ESTIMATE

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Table I.1. On-Site Alternatives Summary and Costs

Assumptions: Discount Rate for Cost Analysis	2.3%	APR (Based on OMB Circular No. A-94, Appendix C)	
High End Total Managed Volume for On-site Facility Disposal (cubic yards)	4,000,000	CERCLA Generated LLW, RCRA, TSCA, MLLW and Nonhazardous Solid Waste	
Base Case Total Managed Volume for On-site Facility Disposal (cubic yards)	3,600,000	CERCLA Generated LLW, RCRA, TSCA, MLLW and Nonhazardous Solid Waste	
Low End Total Managed Volume for On-site Facility Disposal (cubic yards)	3,200,000	CERCLA Generated LLW, RCRA, TSCA, MLLW and Nonhazardous Solid Waste	

Planning Period:	Beginning Year	2011	Ending Year	2014
Phase 1 Construction:	Beginning Year	2013	Ending Year	2014
Disposal Period:	Beginning Operating Year	2015	Ending Operating Year	2039
For On-site Disposal:	Final Site Closure Year	2044	End of Post-Closure Period	3044

See notes for cost breakdown structure.

ON-SITE DISPOSAL SITE 3A - HIGH END VOLUME

On-site Disposal	Estimated Cost	Present Value	Percent of Total*
Planning, Environmental and Engineering Services	$ 18,606,120	$ 18,606,120	2%
Construction	$ 440,938,930	$ 361,744,350	43%
Operations & Monitoring	$ 391,375,490	$ 261,358,100	31%
5% Off-site (Non-WAC Waste)	$ 144,793,012	$ 103,269,720	12%
Closure	$ 114,469,190	$ 74,189,430	9%
Post-Closure	$ 1,173,672,000	$ 24,095,380	3%
TOTAL	$ 2,283,854,740	$ 843,263,100	100%
Cost per Cubic Yard	$ 571	$ 211	**present value basis*

ON-SITE DISPOSAL SITE 11 - HIGH END VOLUME

On-site Disposal	Estimated Cost	Present Value	Percent of Total*
Planning, Environmental and Engineering Services	$ 18,606,120	$ 18,606,120	2%
Construction	$ 441,612,710	$ 363,286,180	43%
Operations & Monitoring	$ 391,375,490	$ 261,358,100	31%
5% Off-site (Non-WAC Waste)	$ 144,793,012	$ 103,269,720	12%
Closure	$ 111,531,670	$ 72,277,140	9%
Post-Closure	$ 1,173,672,000	$ 24,095,380	3%
TOTAL	$ 2,281,591,000	$ 842,892,640	100%
Cost per Cubic Yard	$ 570.00	$ 211	**present value basis*

ON-SITE DISPOSAL SITE 3A - LOW END VOLUME

On-site Disposal	Estimated Cost	Present Value	Percent of Total*
Planning, Environmental and Engineering Services	$ 18,606,120	$ 18,606,120	3%
Construction	$ 274,706,750	$ 228,253,540	36%
Operations & Monitoring	$ 344,495,310	$ 230,349,340	36%
5% Off-site (Non-WAC Waste)	$ 50,579,814	$ 36,074,690	6%
Closure	$ 57,385,760	$ 37,024,080	6%
Post-Closure	$ 573,372,000	$ 11,771,280	2%
C-746-U Landfill	$ 103,596,710	$ 74,980,949	12%
TOTAL	$ 1,422,742,460	$ 637,060,000	100%
Cost per Cubic Yard	$ 445	$ 199	**present value basis*

ON-SITE DISPOSAL SITE 11 - LOW END VOLUME

On-site Disposal	Estimated Cost	Present Value	Percent of Total*
Planning, Environmental and Engineering Services	$ 18,606,120	$ 18,606,120	3%
Construction	$ 276,606,610	$ 231,129,120	36%
Operations & Monitoring	$ 344,495,310	$ 230,349,340	36%
5% Off-site (Non-WAC Waste)	$ 50,579,814	$ 36,074,690	6%
Closure	$ 54,300,250	$ 35,014,220	5%
Post-Closure	$ 573,372,000	$ 11,771,280	2%
C-746-U Landfill	$ 103,596,710	$ 74,980,949	12%
TOTAL	$ 1,421,556,810	$ 637,925,720	100%
Cost per Cubic Yard	$ 444	$ 199	**present value basis*

Table I.1. On-Site Alternatives Summary and Costs

ON-SITE DISPOSAL SITE 3A - BASE CASE VOLUME

On-site Disposal	Estimated Cost	Present Value	Percent of Total*
Planning, Environmental and Engineering Services	$ 18,606,120	$ 18,606,120	2%
Construction	$ 351,668,820	$ 290,515,260	38%
Operations & Monitoring	$ 371,398,950	$ 248,128,230	32%
5% Off-site (Non-WAC Waste)	$ 86,649,004	$ 61,800,070	8%
Closure	$ 82,564,320	$ 53,416,450	7%
Post-Closure	$ 873,522,000	$ 17,933,330	2%
C-746-U Landfill	$ 103,596,710	$ 74,980,949	10%
TOTAL	$ 1,888,005,920	$ 765,380,410	100%
Cost per Cubic Yard	$ 524	$ 213	*present value basis*

ON-SITE DISPOSAL SITE 11 - BASE CASE VOLUME

On-site Disposal	Estimated Cost	Present Value	Percent of Total*
Planning, Environmental and Engineering Services	$ 18,606,120	$ 18,606,120	2%
Construction	$ 359,570,030	$ 297,809,640	39%
Operations & Monitoring	$ 371,398,950	$ 248,128,230	32%
5% Off-site (Non-WAC Waste)	$ 86,649,004	$ 61,800,070	8%
Closure	$ 81,073,780	$ 52,446,130	7%
Post-Closure	$ 873,522,000	$ 17,933,330	2%
C-746-U Landfill	$ 103,596,710	$ 74,980,949	10%
TOTAL	$ 1,894,416,590	$ 771,704,470	100%
Cost per Cubic Yard	$ 526	$ 214	*present value basis*

Notes:
1. Planning, Environmental and Engineering Services costs are included in Attachment I2.
2. Construction costs includes Support Buildings (Table I2.7) and Phases 1-4 Construction (See Attachment I2).
3. Operations & Monitoring costs for each on-site disposal option are included in Attachment I3.
4. 5% Off-site (Non-WAC Waste) for each on-site disposal option are included in Attachment I8.
5. Closure costs for each on-site disposal option are included in Attachment I4.
6. Post-Closure costs for each on-site disposal optoin are included in Attachment I5.
7. C-746-U Landfill costs are included in Attachment I9.

COST COMPARISON TO OTHER DOE CERCLA DISPOSAL SITES, as reported by DOE to Congress, July 2002.

Facility	Est. Waste Qty (CY)	Disposal Cost[a] ($/CY)	Present Value[b] ($/CY)
Existing DOE CERCLA Disposal Sites			
Hanford ERDF	11,800,000	$22	$28
Oak Ridge EMWMF	1,700,000	$107	$136
INEEL ICDF	420,000	$120	$152
Fernald OSDF	2,500,000	$143	$181
On-site Disposal			
PGDP (Site 3A High End Estimate)	4,000,000	N/A	$211
PGDP (Site 3A Low End Estimate)	3,200,000	N/A	$199
PGDP (Site 11 High End Estimate)	4,000,000	N/A	$211
PGDP (Site 11 Low End Estimate)	3,200,000	N/A	$199

a. Present Value: Existing DOE CERCLA Disposal Sites costs are based on 2002 dollars.

b. Present Value: Existing DOE CERCLA Disposal costs adjusted for present value.

Table I.2. Economic Analysis of On-Site Alternatives

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular No. A-94, Appendix C)
	High End On-site Facility Disposal Waste Volume	4,000,000	Cubic Yards
	Base Case On-site Facility Disposal Waste Volume	2,500,000	Cubic Yards
	Low End On-site Facility Disposal Waste Volume	1,500,000	Cubic Yards

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	1.0000	0	Single Payment Present Worth: from 2011 to 2011
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2019 to 2014
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2020 to 2014
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2025 to 2014
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2026 to 2014
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2031 to 2014
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2032 to 2014
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2039 to 2014
(P/F, i, n)	0.5055	30	Single Payment Present Worth: from 2044 to 2014
(P/A, i, n)	20.9940	29	Uniform Series Present Worth: Annual from 2011 to 2040
(P/A, i, n)	4.6727	5	Uniform Series Present Worth: Annual from 2014 to 2019
(P/A, i, n)	18.8530	25	Uniform Series Present Worth: Annual from 2014 to 2039
(P/A, i, n)	4.6727	5	Uniform Series Present Worth: Annual from 2015 to 2019
(P/A, i, n)	15.8878	20	Uniform Series Present Worth: Annual from 2019 to 2039
(P/A, i, n)	4.6727	5	Uniform Series Present Worth: Annual from 2039 to 2044
(P/A, i, n)	43.4783	1,000	Uniform Series Present Worth: Annual from 2044 to 3044

ON-SITE DISPOSAL AT SITE 3A - HIGH END VOLUME

Activity	Type / Year(s) Cost is Incurred	Estimated Cost	Present Value Cost	Percent of Total Cost*
Planning, Environmental, and Engineering	2011	$ 18,606,119	$ 18,606,119	2.5%
Phase 1 Construction	2014	$ 175,821,900	$ 164,235,237	22.2%
Phase 2 Construction	2019	$ 105,767,687	$ 88,176,855	11.9%
Phase 3 Construction	2025	$ 88,455,369	$ 64,340,991	8.7%
Phase 4 Construction	2031	$ 70,893,977	$ 44,991,270	6.1%
Operations - First 5 Years	Annual, 2015 to 2019	$ 10,080,369	$ 43,998,483	5.9%
Operations - During Site D&D	Annual, 2019 to 2039	$ 14,529,115	$ 192,444,065	26.0%
Operations - During Final Closure	Annual, 2039 to 2044	$ 10,078,269	$ 24,915,549	3.4%
Closure of Area 1	2020	$ 22,433,382	$ 18,283,257	2.5%
Closure of Area 2	2026	$ 28,043,376	$ 19,939,876	2.7%
Closure of Area 3	2032	$ 28,043,376	$ 17,396,310	2.4%
Closure of Area 4	2039	$ 28,043,376	$ 14,837,028	2.0%
Finalize Closure	2044	$ 7,905,676	$ 3,732,962	0.5%
Post-Closure (Institutional) SM&M	Annual, 2044 to 3044	$ 1,173,672	$ 24,095,383	3.3%
		TOTAL PRESENT WORTH COST	$ 739,993,385	100.0%
		Cost per Cubic Yard	$ 185	*present value basis

ON-SITE DISPOSAL AT SITE 11 - HIGH END VOLUME

Activity	Type / Year(s) Cost is Incurred	Estimated Cost	Present Value Cost	Percent of Total Cost*
Planning, Environmental, and Engineering	2011	$ 18,606,119	$ 18,606,119	2.5%
Phase 1 Construction	2014	$ 185,522,479	$ 173,296,548	23.4%
Phase 2 Construction	2019	$ 96,780,964	$ 80,684,765	10.9%
Phase 3 Construction	2025	$ 88,434,271	$ 64,325,645	8.7%
Phase 4 Construction	2031	$ 70,874,994	$ 44,979,223	6.1%
Operations - First 5 Years	Annual, 2015 to 2019	$ 10,080,369	$ 43,998,483	5.9%
Operations - During Site D&D	Annual, 2019 to 2039	$ 14,529,115	$ 192,444,065	26.0%
Operations - During Final Closure	Annual, 2039 to 2044	$ 10,078,269	$ 24,915,549	3.4%
Closure of Area 1	2020	$ 21,850,791	$ 17,808,444	2.4%
Closure of Area 2	2026	$ 27,310,055	$ 19,418,457	2.6%
Closure of Area 3	2032	$ 27,310,055	$ 16,941,405	2.3%
Closure of Area 4	2039	$ 27,310,055	$ 14,449,047	2.0%
Finalize Closure	2044	$ 7,750,713	$ 3,659,790	0.5%
Post-Closure (Institutional) SM&M	Annual, 2044 to 3044	$ 1,173,672	$ 24,095,383	3.3%
		TOTAL PRESENT WORTH COST	$ 739,622,923	100.0%
		Cost per Cubic Yard	$ 185	*present value basis

ON-SITE DISPOSAL AT SITE 3A - LOW END VOLUME

Activity	Type / Year(s) Cost is Incurred	Estimated Cost	Present Value Cost	Percent of Total Cost*
Planning, Environmental, and Engineering	2011	$ 18,606,119	$ 18,606,119	3.5%
Phase 1 Construction	2014	$ 121,151,928	$ 113,168,016	21.5%
Phase 2 Construction	2019	$ 65,936,887	$ 54,970,544	10.5%
Phase 3 Construction	2025	$ 48,624,570	$ 35,368,718	6.7%
Phase 4 Construction	2031	$ 38,993,362	$ 24,746,261	4.7%
Operations - First 5 Years	Annual, 2015 to 2019	$ 10,080,369	$ 43,998,483	8.4%
Operations - During Site D&D	Annual, 2019 to 2039	$ 12,196,606	$ 161,549,030	30.7%
Operations - During Final Closure	Annual, 2039 to 2044	$ 10,032,269	$ 24,801,828	4.7%
Closure of Area 1	2020	$ 11,058,139	$ 9,012,408	1.7%
Closure of Area 2	2026	$ 13,824,207	$ 9,829,522	1.9%
Closure of Area 3	2032	$ 13,824,207	$ 8,575,651	1.6%
Closure of Area 4	2039	$ 13,824,207	$ 7,314,032	1.4%
Finalize Closure	2044	$ 4,855,002	$ 2,292,471	0.4%
Post-Closure (Institutional) SM&M	Annual, 2044 to 3044	$ 573,372	$ 11,771,277	2.2%
		TOTAL PRESENT WORTH COST	$ 526,004,360	100.0%
		Cost per Cubic Yard	$ 351	*present value basis

Table I.2. Economic Analysis of On-Site Alternatives

ON-SITE DISPOSAL AT SITE 11 - LOW END VOLUME

Activity	Type / Year(s) Cost is Incurred	Estimated Cost	Present Value Cost	Percent of Total Cost*
Planning, Environmental, and Engineering	2011	$ 18,606,119	$ 18,606,119	3.5%
Phase 1 Construction	2014	$ 133,044,035	$ 124,276,433	23.6%
Phase 2 Construction	2019	$ 56,605,232	$ 47,190,890	9.0%
Phase 3 Construction	2025	$ 48,258,536	$ 35,102,471	6.7%
Phase 4 Construction	2031	$ 38,698,804	$ 24,559,327	4.7%
Operations - First 5 Years	Annual, 2015 to 2019	$ 10,080,369	$ 43,998,483	8.4%
Operations - During Site D&D	Annual, 2019 to 2039	$ 12,196,606	$ 161,549,030	30.7%
Operations - During Final Closure	Annual, 2039 to 2044	$ 10,032,269	$ 24,801,828	4.7%
Closure of Area 1	2020	$ 10,440,393	$ 8,508,944	1.6%
Closure of Area 2	2026	$ 13,055,641	$ 9,283,043	1.8%
Closure of Area 3	2032	$ 13,055,641	$ 8,098,882	1.5%
Closure of Area 4	2039	$ 13,055,641	$ 6,907,403	1.3%
Finalize Closure	2044	$ 4,692,929	$ 2,215,943	0.4%
Post-Closure (Institutional) SM&M	Annual, 2044 to 3044	$ 573,372	$ 11,771,277	2.2%
		TOTAL PRESENT WORTH COST	$ 526,870,073	100.0%
		Cost per Cubic Yard	$ 351	*present value basis

ON-SITE DISPOSAL AT SITE 3A - BASE CASE VOLUME

Activity	Type / Year(s) Cost is Incurred	Estimated Cost	Present Value Cost	Percent of Total Cost*
Planning, Environmental, and Engineering	2011	$ 18,606,119	$ 18,606,119	3.0%
Phase 1 Construction	2014	$ 148,820,968	$ 139,013,666	22.1%
Phase 2 Construction	2019	$ 83,528,129	$ 69,636,086	11.1%
Phase 3 Construction	2025	$ 66,215,810	$ 48,164,299	7.7%
Phase 4 Construction	2031	$ 53,103,916	$ 33,701,208	5.4%
Operations - First 5 Years	Annual, 2015 to 2019	$ 10,080,369	$ 43,998,483	7.0%
Operations - During Site D&D	Annual, 2019 to 2039	$ 13,530,288	$ 179,214,193	28.5%
Operations - During Final Closure	Annual, 2039 to 2044	$ 10,078,269	$ 24,915,549	4.0%
Closure of Area 1	2020	$ 16,074,838	$ 13,101,029	2.1%
Closure of Area 2	2026	$ 20,095,133	$ 14,288,381	2.3%
Closure of Area 3	2032	$ 20,095,133	$ 12,465,731	2.0%
Closure of Area 4	2039	$ 20,095,133	$ 10,631,817	1.7%
Finalize Closure	2044	$ 6,204,085	$ 2,929,492	0.5%
Post-Closure (Institutional) SM&M	Annual, 2044 to 3044	$ 873,522	$ 17,933,330	2.9%
		TOTAL PRESENT WORTH COST	$ 628,599,383	100.0%
		Cost per Cubic Yard	$ 251	*present value basis

ON-SITE DISPOSAL AT SITE 11 - BASE CASE VOLUME

Activity	Type / Year(s) Cost is Incurred	Estimated Cost	Present Value Cost	Percent of Total Cost*
Planning, Environmental, and Engineering	2011	$ 18,606,119	$ 18,606,119	2.9%
Phase 1 Construction	2014	$ 160,631,069	$ 150,045,482	23.6%
Phase 2 Construction	2019	$ 76,371,617	$ 63,669,814	10.0%
Phase 3 Construction	2025	$ 68,024,924	$ 49,480,219	7.8%
Phase 4 Construction	2031	$ 54,542,420	$ 34,614,122	5.5%
Operations - First 5 Years	Annual, 2015 to 2019	$ 10,080,369	$ 43,998,483	6.9%
Operations - During Site D&D	Annual, 2019 to 2039	$ 13,530,288	$ 179,214,193	28.2%
Operations - During Final Closure	Annual, 2039 to 2044	$ 10,078,269	$ 24,915,549	3.9%
Closure of Area 1	2020	$ 15,776,986	$ 12,858,279	2.0%
Closure of Area 2	2026	$ 19,724,788	$ 14,025,053	2.2%
Closure of Area 3	2032	$ 19,724,788	$ 12,235,992	1.9%
Closure of Area 4	2039	$ 19,724,788	$ 10,435,877	1.6%
Finalize Closure	2044	$ 6,122,425	$ 2,890,933	0.5%
Post-Closure (Institutional) SM&M	Annual, 2044 to 3044	$ 873,522	$ 17,933,330	2.8%
		TOTAL PRESENT WORTH COST	$ 634,923,445	100.0%
		Cost per Cubic Yard	$ 254	*present value basis

ATTACHMENT 1

BREAK EVEN ANALYSIS

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BREAK EVEN ANALYSIS SUMMARY

The first step in performing the break even analysis (BEA) was to develop cost estimates for off-site disposal. The PGDP waste forecast data was categorized prior to developing these cost estimates. The categorization process determined the quantity of waste as soil and debris for the following waste types: low-level waste (LLW), mixed low-level waste (MLLW), Resource Conservation and Recover Act/Toxic Substances Control Act waste, and classified waste.

It was assumed that all waste, with the exception of MLLW debris and classified waste, would be shipped to Energy*Solutions* by rail. Debris would be shipped in high-sided gondolas and soil/sludge would be shipped in low-sided gondolas. MLLW debris would be packaged in Sealand containers and shipped to Energy Solutions by truck. Classified waste would be packaged into Sealand containers and shipped by truck to the Nevada National Security Site. Container, transportation, and disposal costs were calculated annually for each waste category.

After completing the off-site disposal cost estimate, the BEA was performed. The first step in the BEA was to calculate the present value (PV) of off-site disposal for the period 2014 through 2039 (the final year of waste disposal) for the base case volume scenario. These results were graphed against the PV of on-site disposal costs for 2011 (projected first year of planning for the on-site alternative) through 2044 (projected year of closure of the on-site WDF). The conceptual design cost estimate for the Site 3A base case scenario was used as the basis for the on-site disposal comparison. The overall costs for Sites 3A and 11 are relatively similar (relative percent difference of less than 1%). The costs for Site 3A were used for the break-even analysis. Costs associated with both Sites 3A and 11 are included in Appendix I. In both the on-site and off-site disposal scenarios, it is assumed that approximately 1.1 mcy of forecast nonhazardous solid waste is disposed of at the C-746-U Landfill. The C-746-U Landfill costs were not included since it would be the same for either the on-site or off-site cost scenarios, and therefore, would not be a differentiating factor in the BEA. Cost for the on-site alternative related to the 5% of the waste that is assumed will not meet the WAC is not included in the break even analysis. The intersection of the cumulative PV costs over time for the on-site and off-site scenarios is the breakeven point.

The chart of cumulative cost accrual for the on-site scenario shows the PV of on-site disposal costs of CERCLA Waste Disposal Facility predevelopment, construction and operations through site closure in 2044 (Figure I1.1). The postclosure care surveillance, monitoring, and maintenance (SM&M) period for the CERCLA Waste Disposal Facility is from 2044 through 2144. The 2044 data point shown on Figure I1.1 accounts for the PV of this 100 years of SM&M cost by including it as a single accrual. As shown on Figure I1.1, the breakeven point occurs at a PV cost of approximately $174 million and the disposal of approximately 200,000 yd^3 of waste at year 2015.

Table I1.1 presents a summary of BEA results.

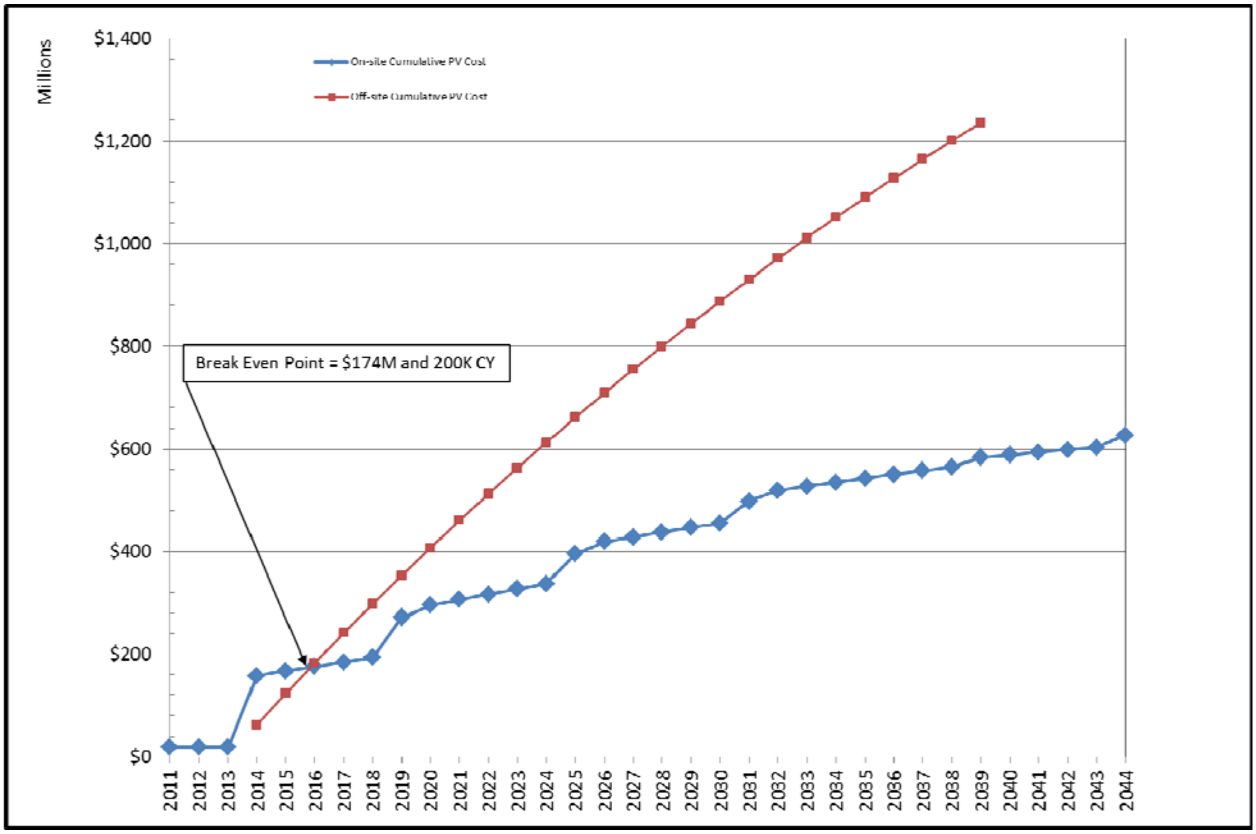

Figure I1.1. Year vs. On-Site and Off-Site Cumulative Costs

Table I1.1. BEA Summary

Alternative	Total Cost (PV)[a]	Break Even Year	Break Even Volume (yd^3)[b]	Break Even Cost (PV)
Off-site	$1,236 M	2015	200,000	$174 M
On-site	$627 M	2015	200,000	$174 M

[a] The total cost for the on-site scenario is all cost accrued from 2011–2144. Off-site cost accrual ends in 2069. On–site costs are included in Appendix I Table I.1 for the On-Site Disposal Site 3A - Base Case Volume, Elements Planning, Environmental and Engineering Services; Construction; Operations & Monitoring; Closure; and Postclosure. Off-site total costs are the sum of the Total Present Worth Values included in Appendix H, Attachment 1, Tables H1.1–H1.8.

[b] Cumulative disposal volume at the end of Year 2015.

ATTACHMENT 2

DEVELOPMENT AND CONSTRUCTION COST ESTIMATES

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Table I2.1. Development and Construction Cost Estimate for Site 3A - High End Volume Scenario

General Information and Assumptions:

Landfill Operations Area	3,710,262	SF	85.18	AC
Total Centerline Length of Earthfill Dike	6,327	LF		
Average Cross Sectional Area of Earthfill Dike	10,840	SF		
Liner Crest Footprint	1,826,236	SF	41.92	AC
Liner Base Area	1,187,275	SF	27.26	AC
Area of Liner on Side Slopes	673,524	SF	15.46	AC
Total Liner Area	1,860,799	SF	42.72	AC
Total Liner Anchor Trench Length	5,804	LF		
Dike Fill Volume	2,387,260	CY		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Construction Phases:	Year	Percent of Liner Area Constructed		
Phase 1	2014	30%		
Phase 2	2019	25%		
Phase 3	2025	25%		
Phase 4	2031	20%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Planning, Environmental, and Engineering Services	$ 16,179,234	$ 2,426,885	$ -	$ 18,606,119
Phase 1 Construction	$ 121,256,483	$ 18,188,472	$ 36,376,945	$ 175,821,900
Phase 2 Construction	$ 72,943,232	$ 10,941,485	$ 21,882,970	$ 105,767,687
Phase 3 Construction	$ 61,003,703	$ 9,150,555	$ 18,301,111	$ 88,455,369
Phase 4 Construction	$ 48,892,398	$ 7,333,860	$ 14,667,719	$ 70,893,977
TOTAL SITE 3A CAPITAL COST	**$ 320,275,050**	**$ 48,041,257**	**$ 91,228,745**	**$ 459,545,052**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***PLANNING, ENVIRONMENTAL AND ENGINEERING SERVICES***						***$16,179,234***
1.1	**NEPA Substantive Requirements Documentation**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.2	**Environmental Site Studies[a]**	**1**	**LS**	**$ 400,000.00**	**$ 400,000**	**$400,000**	
1.3	**Remedial Design Work Plan and Associated Field Work[b]**	**1**	**LS**	**$ 2,219,800.00**	**$ 2,219,800**	**$2,219,800**	
1.4	**Hydrogeological Studies, GW Wells and Monitoring Plan[c]**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.5	**OSWDF Remedial Action Work Plan (1 per Phase)**	**4**	**EA**	**$ 270,700.00**	**$ 1,082,800**	**$1,082,800**	
1.6	**Develop Construction Work Control Documents and Procedures**	**1**	**LS**	**$ 231,595.00**	**$ 231,595**	**$231,595**	
1.7	**Develop Operations Documents**	**1**	**LS**	**$ 635,785.00**	**$ 635,785**	**$635,785**	
1.8	**OSWDF Procurement**	**1**	**LS**	**$ 829,254.00**	**$ 829,254**	**$829,254**	
1.9	**Critical Decision Packages (1 per Phase)**	**4**	**EA**	**$ 560,000.00**	**$ 2,240,000**	**$2,240,000**	
1.10	**OSWDF Design[d]**	**1**	**LS**	**$ 5,420,000.00**	**$ 5,420,000**	**$5,420,000**	
1.11	**Safety Basis Documents**	**1**	**LS**	**$ 440,000.00**	**$ 440,000**	**$440,000**	
1.12	**OSWDF Remedial Action Completion Report (1 per Phase)**	**4**	**EA**	**$ 120,000.00**	**$ 480,000**	**$480,000**	
1.13	**Construction QC Plan, Post-construction Report, O&M Plan (1 per Phase)**	**4**	**EA**	**$ 250,000.00**	**$ 1,000,000**	**$1,000,000**	
2.0	***PHASE 1 CONSTRUCTION***						***$121,256,483***
2.1	**General Costs**					**$25,801,761**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 95,454,722.00	$ 6,681,831		
2.1.2	Wetlands Replacement Cost	21.4	AC	$ 1,354.50	$ 28,986		
2.1.3	Worker Health and Safety Program	5%	LS	$ 95,454,722.00	$ 4,772,736		
2.1.4	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 95,454,722.00	$ 14,318,208		
2.2	**Site Work and Improvements**					**$5,406,077**	
2.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
2.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 41,042.37	$ 41,042		
2.2.3	Additional GW Monitoring Well(s)	14	EA	$ 16,494.00	$ 230,916		
2.2.4	Clearing and Grubbing (Forested Areas)	50	AC	$ 6,856.25	$ 342,813		
2.2.5	Clearing and Grubbing (Semi-open Areas)	40	AC	$ 4,784.50	$ 191,380		
2.2.6	Site Perimeter Run-on Control Berm and Road	10,400	LF	$ 85.80	$ 892,320		
2.2.7	Paved Road Construction	2,000	LF	$ 75.85	$ 151,700		
2.2.8	Graveled Road Construction	5,000	LF	$ 52.76	$ 263,800		
2.2.9	Parking Areas	14,000	LS	$ 6.36	$ 89,040		
2.2.10	Site Perimeter Fence	10,900	LF	$ 41.71	$ 454,639		
2.2.11	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	5,000	LF	$ 52.61	$ 263,050		
2.2.12	Entrance Gate	3	EA	$ 4,272.50	$ 12,818		
2.2.13	Truck Scale	3	EA	$ 75,000.00	$ 225,000		
2.2.14	Outside Lights	1	LS	$ 397,687.80	$ 397,688		
2.2.15	High Security Area Lighting and Electrical	1	LS	$ 226,756.86	$ 226,757		
2.2.16	Signs	1	LS	$ 41,186.30	$ 41,186		
2.2.17	Site Topographic Survey	110	AC	$ 4,736.59	$ 521,025		
2.2.18	Site Layout Survey	85	AC	$ 4,736.59	$ 402,610		
2.2.19	Construction Surveying	90	AC	$ 4,736.59	$ 426,293		
2.3	**Buildings, Utilities, and Supplies**					**$28,377,062**	
2.3.1	Administrative/Office Building	5,400	SF	$ 316.64	$ 1,709,856		
2.3.2	Office Computers, Furniture, Administrative Supplies	1	LS	$ 300,000.00	$ 300,000		
2.3.3	Maintenance Shop	1	EA	$ 744,960.00	$ -		
	Pre-engineered Steel Building	4,800	SF	$ 155.20	$ 744,960		
2.3.4	Leachate Treatment Building	1	EA	$ 25,219,885.00	$ -		
	Sitework	1	LS	$ 192,760.00	$ 192,760		
	Building Construction	1	LS	$ 1,622,490.00	$ 1,622,490		
	System Equipment	1	LS	$ 20,199,135.00	$ 20,199,135		
	Accessory Equipment and Tanks	1	LS	$ 1,219,850.00	$ 1,219,850		
	Electrical, Monitoring, and Controls	1	LS	$ 1,985,650.00	$ 1,985,650		
2.3.5	Sanitary Treatment System	1	LS	$ 21,840.00	$ 21,840		
2.3.6	Water Supply and Distribution System	1	LS	$ 92,640.00	$ 92,640		
2.3.7	Fire Hydrants and Service Connections	1	LS	$ 27,300.00	$ 27,300		
2.3.8	Telecommunications	1	LS	$ 248,889.00	$ 248,889		
2.3.9	Guard Shacks and Equipment	2	EA	$ 5,846.00	$ 11,692		

Table I2.1. Development and Construction Cost Estimate for Site 3A - High End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
2.4	**Sitewide Surface Water Improvements**					**$616,317**	
2.4.1	Strip and Stockpile Topsoil, Ditch and Pond Areas	8,000	CY	$ 5.49	$ 43,920		
2.4.2	Large Surface Water Ditches with Riprap Armor (incl. Outfall)	4,000	LF	$ 7.77	$ 31,080		
2.4.3	Small Surface Water Ditches with Riprap Armor	4,000	LF	$ 7.77	$ 31,080		
2.4.4	Surface Water Pond Excavation	82,280	CY	$ 4.18	$ 343,930		
2.4.5	Surface Water Pond Overflow	1,000	LF	$ 7.77	$ 7,770		
2.4.6	Surface Water Pumps, Pipes, Fittings, and Ancillary Equipment	1	LS	$ 91,036.50	$ 91,037		
2.4.7	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 67,500.00	$ 67,500		
2.5	**Earthwork for Landfill Operations Area**					**$52,339,335**	
2.5.1	Strip and Stockpile Topsoil	20,613	CY	$ 5.49	$ 113,165		
2.5.2	Geologic Buffer: Excavation and Replacement	202,915	CY	$ 35.69	$ 7,242,036		
2.5.3	Place/Compact Earthfill Dike	1,085,409	CY	$ 39.33	$ 42,689,136		
2.5.4	Liner Subgrade: Compact and Grade Side Slopes	22,451	SY	$ 3.32	$ 74,537		
2.5.5	Liner Subgrade: Compact and Grade Base	39,576	SY	$ 3.32	$ 131,392		
2.5.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	62,027	CY	$ 33.68	$ 2,089,069		
2.6	**Geosynthetic Liner and Leachate Collection Systems**					**$3,410,930**	
2.6.1	Geosynthetics Anchor Trench Preparation	1,741	LF	$ 1.54	$ 2,681		
2.6.2	Geosynthetics Anchor Trench Backfill and Compaction	1,741	LF	$ 4.39	$ 7,643		
2.6.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	558,240	SF	$ 0.66	$ 368,438		
2.6.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	202,057	SF	$ 0.57	$ 115,172		
2.6.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	1,424,730	SF	$ 0.30	$ 427,419		
2.6.6	Gravel Leak Detection Layer	13,192	CY	$ 58.23	$ 768,170		
2.6.7	Leak Detection Pipes: Installation and Materials	3,562	LF	$ 25.60	$ 91,187		
2.6.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	558,240	SF	$ 0.81	$ 452,174		
2.6.9	Gravel Leachate Collection Layer	13,192	CY	$ 58.23	$ 768,170		
2.6.10	Leachate Collection Pipes: Installation and Materials	3,562	LF	$ 25.60	$ 91,187		
2.6.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	202,057	SF	$ 0.57	$ 115,172		
2.6.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
2.6.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
2.6.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 54,714.80	$ 54,715		
2.6.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
2.6.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 78,964.10	$ 78,964		
2.7	**Leachate Treatment Facility: Hydraulic Structures & Equipment**					**$2,091,574**	
2.7.1	Leachate Transmission Pipeline	5,000	LF	$ 61.80	$ 309,000		
2.7.2	Steel Tank Structure	2	EA	$ 150,000.00	$ 300,000		
2.7.3	Steel Tank Secondary Containment	2,140	CY	$ 471.72	$ 1,009,481		
2.7.4	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.7.5	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.7.6	Overhead Crane	1	LS	$ 6,685.69	$ 6,686		
2.7.7	Post-Treatment Steel Holding Tank	2	EA	$ 150,000.00	$ 300,000		
2.7.8	Analytical Test Facilities and Equipment	1	LS	$ 50,000.00	$ 50,000		
2.8	**Contact Water System: Hydraulic Structures & Equipment**					**$3,213,427**	
2.8.1	Contact Water Transmission Pipeline	1,000	LF	$ 61.80	$ 61,800		
2.8.2	Drain Ports	12	EA	$ 4,450.75	$ 53,409		
2.8.3	Lift Station	1	LS	$ 292,567.00	$ 292,567		
2.8.4	Steel Tank Structure	4	EA	$ 150,000.00	$ 600,000		
2.8.5	Steel Tank Secondary Containment	4,270	CY	$ 471.72	$ 2,014,244		
2.8.6	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.8.7	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.8.8	Electrical Equipment, Control Systems	1	LS	$ 75,000.00	$ 75,000		
3.0	***PHASE 2 CONSTRUCTION***						***$72,943,232***
3.1	**General Costs**					**$15,507,616**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 57,435,616.00	$ 4,020,493		
3.1.2	Worker Health and Safety Program	5%	LS	$ 57,435,616.00	$ 2,871,781		
3.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 57,435,616.00	$ 8,615,342		
3.2	**Site Work**					**$10,930,058**	
3.2.1	Relocate Overhead Electrical Power Lines and Towers	1	LS	$ 4,868,653.00	$ 4,868,653		
3.2.2	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
3.2.3	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
3.2.4	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
3.2.5	Small Surface Water Ditches with Riprap Armor	1,000	LF	$ 7.77	$ 7,770		
3.2.6	Graveled Road Construction	2,600	LF	$ 52.76	$ 137,176		
3.2.7	Site Grubbing	7	AC	$ 4,784.50	$ 33,492		
3.2.8	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
3.2.9	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
3.2.10	High Security Area Lighting and Electrical	1	LS	$ 188,964.05	$ 188,964		
3.2.11	Signs	1	LS	$ 41,186.30	$ 41,186		
3.2.12	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
3.2.13	Sanitary Treatment System	1	LS	$ 4,522,000.00	$ 4,522,000		
3.2.14	Construction Surveying	75	AC	$ 4,736.59	$ 355,244		
3.3	**Earthwork for Landfill Operations Area**					**$43,616,092**	
3.3.1	Strip and Stockpile Topsoil	17,177	CY	$ 5.49	$ 94,302		
3.3.2	Geologic Buffer: Excavation and Replacement	169,096	CY	$ 35.69	$ 6,035,036		
3.3.3	Place/Compact Earthfill Dike	904,507	CY	$ 39.33	$ 35,574,260		
3.3.4	Liner Subgrade: Compact and Grade Side Slopes	18,709	SY	$ 3.32	$ 62,114		
3.3.5	Liner Subgrade: Compact and Grade Base	32,980	SY	$ 3.32	$ 109,494		
3.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	51,689	CY	$ 33.68	$ 1,740,886		

Table I2.1. Development and Construction Cost Estimate for Site 3A - High End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.4	**Geosynthetic Liner and Leachate Collection Systems**					**$2,854,029**	
3.4.1	Geosynthetics Anchor Trench Preparation	1,451	LF	$ 1.54	$ 2,235		
3.4.2	Geosynthetics Anchor Trench Backfill and Compaction	1,451	LF	$ 4.39	$ 6,370		
3.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	465,200	SF	$ 0.66	$ 307,032		
3.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	168,381	SF	$ 0.57	$ 95,977		
3.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	1,187,275	SF	$ 0.30	$ 356,183		
3.4.6	Gravel Leak Detection Layer	10,993	CY	$ 58.23	$ 640,122		
3.4.7	Leak Detection Pipes: Installation and Materials	2,968	LF	$ 25.60	$ 75,981		
3.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	465,200	SF	$ 0.81	$ 376,812		
3.4.9	Gravel Leachate Collection Layer	10,993	CY	$ 58.23	$ 640,122		
3.4.10	Leachate Collection Pipes: Installation and Materials	2,968	LF	$ 25.60	$ 75,981		
3.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	168,381	SF	$ 0.57	$ 95,977		
3.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
3.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
3.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
3.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
3.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
3.5	**Contact Water System Additions**					**$35,437**	
3.5.1	Drain Ports	5	EA	$ 4,450.75	$ 22,254		
3.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
4.0	***PHASE 3 CONSTRUCTION***						***$61,003,703***
4.1	**General Costs**					**$12,969,292**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 48,034,411.00	$ 3,362,409		
4.1.2	Worker Health and Safety Program	5%	LS	$ 48,034,411.00	$ 2,401,721		
4.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 48,034,411.00	$ 7,205,162		
4.2	**Site Work**					**$1,528,853**	
4.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
4.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
4.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
4.2.4	Small Surface Water Ditches with Riprap Armor	1,000	LF	$ 7.77	$ 7,770		
4.2.5	Graveled Road Construction	2,400	LF	$ 52.76	$ 126,624		
4.2.6	Site Grubbing	7	AC	$ 4,784.50	$ 33,492		
4.2.7	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
4.2.8	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
4.2.9	High Security Area Lighting and Electrical	1	LS	$ 188,964.05	$ 188,964		
4.2.10	Signs	1	LS	$ 41,186.30	$ 41,186		
4.2.11	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
4.2.12	Construction Surveying	75	AC	$ 4,736.59	$ 355,244		
4.3	**Earthwork for Landfill Operations Area**					**$43,616,092**	
4.3.1	Strip and Stockpile Topsoil	17,177	CY	$ 5.49	$ 94,302		
4.3.2	Geologic Buffer: Excavation and Replacement	169,096	CY	$ 35.69	$ 6,035,036		
4.3.3	Place/Compact Earthfill Dike	904,507	CY	$ 39.33	$ 35,574,260		
4.3.4	Liner Subgrade: Compact and Grade Side Slopes	18,709	SY	$ 3.32	$ 62,114		
4.3.5	Liner Subgrade: Compact and Grade Base	32,980	SY	$ 3.32	$ 109,494		
4.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	51,689	CY	$ 33.68	$ 1,740,886		
4.4	**Geosynthetic Liner and Leachate Collection Systems**					**$2,854,029**	
4.4.1	Geosynthetics Anchor Trench Preparation	1,451	LF	$ 1.54	$ 2,235		
4.4.2	Geosynthetics Anchor Trench Backfill and Compaction	1,451	LF	$ 4.39	$ 6,370		
4.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	465,200	SF	$ 0.66	$ 307,032		
4.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	168,381	SF	$ 0.57	$ 95,977		
4.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	1,187,275	SF	$ 0.30	$ 356,183		
4.4.6	Gravel Leak Detection Layer	10,993	CY	$ 58.23	$ 640,122		
4.4.7	Leak Detection Pipes: Installation and Materials	2,968	LF	$ 25.60	$ 75,981		
4.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	465,200	SF	$ 0.81	$ 376,812		
4.4.9	Gravel Leachate Collection Layer	10,993	CY	$ 58.23	$ 640,122		
4.4.10	Leachate Collection Pipes: Installation and Materials	2,968	LF	$ 25.60	$ 75,981		
4.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	168,381	SF	$ 0.57	$ 95,977		
4.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
4.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
4.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
4.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
4.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
4.5	**Contact Water System Additions**					**$35,437**	
4.5.1	Drain Ports	5	EA	$ 4,450.75	$ 22,254		
4.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Table I2.1. Development and Construction Cost Estimate for Site 3A - High End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
5.0	***PHASE 4 CONSTRUCTION***						***$48,892,398***
5.1	**General Costs**					**$10,394,448**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 38,497,950.00	$ 2,694,857		
5.1.2	Worker Health and Safety Program	5%	LS	$ 38,497,950.00	$ 1,924,898		
5.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 38,497,950.00	$ 5,774,693		
5.2	**Site Work**					**$1,272,327**	
5.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
5.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 27,361.58	$ 27,362		
5.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
5.2.4	Small Surface Water Ditches with Riprap Armor	1,000	LF	$ 7.77	$ 7,770		
5.2.5	Graveled Road Construction	1,200	LF	$ 52.76	$ 63,312		
5.2.6	Site Grubbing	7	AC	$ 4,784.50	$ 33,492		
5.2.7	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
5.2.8	Outside Lights	1	LS	$ 265,125.20	$ 265,125		
5.2.9	High Security Area Lighting and Electrical	1	LS	$ 151,171.24	$ 151,171		
5.2.10	Signs	1	LS	$ 41,186.30	$ 41,186		
5.2.11	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 45,000.00	$ 45,000		
5.2.12	Construction Surveying	60	AC	$ 4,736.59	$ 284,195		
5.3	**Earthwork for Landfill Operations Area**					**$34,892,891**	
5.3.1	Strip and Stockpile Topsoil	13,742	CY	$ 5.49	$ 75,444		
5.3.2	Geologic Buffer: Excavation and Replacement	135,277	CY	$ 35.69	$ 4,828,036		
5.3.3	Place/Compact Earthfill Dike	723,606	CY	$ 39.33	$ 28,459,424		
5.3.4	Liner Subgrade: Compact and Grade Side Slopes	14,967	SY	$ 3.32	$ 49,690		
5.3.5	Liner Subgrade: Compact and Grade Base	26,384	SY	$ 3.32	$ 87,595		
5.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	41,351	CY	$ 33.68	$ 1,392,702		
5.4	**Geosynthetic Liner and Leachate Collection Systems**					**$2,297,295**	
5.4.1	Geosynthetics Anchor Trench Preparation	1,161	LF	$ 1.54	$ 1,788		
5.4.2	Geosynthetics Anchor Trench Backfill and Compaction	1,161	LF	$ 4.39	$ 5,097		
5.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	372,160	SF	$ 0.66	$ 245,626		
5.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	134,705	SF	$ 0.57	$ 76,782		
5.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	949,820	SF	$ 0.30	$ 284,946		
5.4.6	Gravel Leak Detection Layer	8,795	CY	$ 58.23	$ 512,133		
5.4.7	Leak Detection Pipes: Installation and Materials	2,375	LF	$ 25.60	$ 60,800		
5.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	372,160	SF	$ 0.81	$ 301,450		
5.4.9	Gravel Leachate Collection Layer	8,795	CY	$ 58.23	$ 512,133		
5.4.10	Leachate Collection Pipes: Installation and Materials	2,375	LF	$ 25.60	$ 60,800		
5.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	134,705	SF	$ 0.57	$ 76,782		
5.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
5.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
5.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 36,476.53	$ 36,477		
5.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
5.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 52,642.73	$ 52,643		
5.5	**Contact Water System Additions**					**$35,437**	
5.5.1	Drain Ports	5	EA	$ 4,450.75	$ 22,254		
5.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Notes:

a. Includes pre-construction geotechnical investigation.

b. Includes seismic investigation.

c. Includes pre-construction groundwater investigation to assess water table and background conditions for constituents predicted to be in proposed waste streams.

d. Includes 30%, 60%, 90% and for construction design packages, test pad, methane gas generation study, etc.

Table I2.2. Development and Construction Cost Estimate for Site 11 - High End Volume Scenario

General Information and Assumptions:

Landfill Operations Area	3,661,748	SF	84.06	AC
Total Centerline Length of Earthfill Dike	5,935	LF		
Average Cross Sectional Area of Earthfill Dike	10,840	SF		
Liner Crest Footprint	1,793,519	SF	41.17	AC
Liner Base Area	1,201,268	SF	27.58	AC
Area of Liner on Side Slopes	624,271	SF	14.33	AC
Total Liner Area	1,825,539	SF	41.91	AC
Total Liner Anchor Trench Length	5,416	LF		
Dike Fill Volume	2,399,111	CY		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Construction Phases:	Year	Percent of Liner Area Constructed		
Phase 1	2014	30%		
Phase 2	2019	25%		
Phase 3	2025	25%		
Phase 4	2031	20%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Planning, Environmental, and Engineering Services	$ 16,179,234	$ 2,426,885	$ -	$ 18,606,119
Phase 1 Construction	$ 127,946,537	$ 19,191,981	$ 38,383,961	$ 185,522,479
Phase 2 Construction	$ 66,745,492	$ 10,011,824.00	$ 20,023,648	$ 96,780,964
Phase 3 Construction	$ 60,989,152	$ 9,148,373	$ 18,296,746	$ 88,434,271
Phase 4 Construction	$ 48,879,306	$ 7,331,896	$ 14,663,792	$ 70,874,994
TOTAL SITE 11 CAPITAL COST	**$ 320,739,721**	**$ 48,110,959**	**$ 91,368,147**	**$ 460,218,827**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***PLANNING, ENVIRONMENTAL AND ENGINEERING SERVICES***						***$ 16,179,234***
1.1	**NEPA Substantive Requirements Documentation**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.2	**Environmental Site Studies[a]**	**1**	**LS**	**$ 400,000.00**	**$ 400,000**	**$400,000**	
1.3	**Remedial Design Work Plan and Associated Field Work[b]**	**1**	**LS**	**$ 2,219,800.00**	**$ 2,219,800**	**$2,219,800**	
1.4	**Hydrogeological Studies, GW Wells and Monitoring Plan[c]**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.5	**OSWDF Remedial Action Work Plan (1 per Phase)**	**4**	**EA**	**$ 270,700.00**	**$ 1,082,800**	**$1,082,800**	
1.6	**Develop Construction Work Control Documents and Procedures**	**1**	**LS**	**$ 231,595.00**	**$ 231,595**	**$231,595**	
1.7	**Develop Operations Documents**	**1**	**LS**	**$ 635,785.00**	**$ 635,785**	**$635,785**	
1.8	**OSWDF Procurement**	**1**	**LS**	**$ 829,254.00**	**$ 829,254**	**$829,254**	
1.9	**Critical Decision Packages (1 per Phase)**	**4**	**EA**	**$ 560,000.00**	**$ 2,240,000**	**$2,240,000**	
1.10	**OSWDF Design[d]**	**1**	**LS**	**$ 5,420,000.00**	**$ 5,420,000**	**$5,420,000**	
1.11	**Safety Basis Documents**	**1**	**LS**	**$ 440,000.00**	**$ 440,000**	**$440,000**	
1.12	**OSWDF Remedial Action Completion Report (1 per Phase)**	**4**	**EA**	**$ 120,000.00**	**$ 480,000**	**$480,000**	
1.13	**Construction QC Plan, Post-construction Report, O&M Plan (1 per Phase)**	**4**	**EA**	**$ 250,000.00**	**$ 1,000,000**	**$1,000,000**	
2.0	***PHASE 1 CONSTRUCTION***						***$ 127,946,537***
2.1	**General Costs**					**$ 27,204,229**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 100,742,308.00	$ 7,051,962		
2.1.2	Wetlands Replacement Cost	2.81	AC	$ 1,354.50	$ 3,806		
2.1.3	Worker Health and Safety Program	5%	LS	$ 100,742,308.00	$ 5,037,115		
2.1.4	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 100,742,308.00	$ 15,111,346		
2.2	**Site Work and Improvements**					**$ 11,501,628**	
2.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
2.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 41,042.37	$ 41,042		
2.2.3	Additional GW Monitoring Well(s)	10	EA	$ 16,494.00	$ 164,940		
2.2.4	Clearing and Grubbing (Forested Areas)	40	AC	$ 6,856.25	$ 274,250		
2.2.5	Indiana Bat Habitat Mitigation	40	AC	$ 6,000.00	$ 240,000		
2.2.6	Clearing and Grubbing (Semi-open Areas)	40	AC	$ 4,784.50	$ 191,380		
2.2.7	Re-route Little Bayou Creek	1	LS	$ 20,000.00	$ 20,000		
2.2.8	Site Perimeter Run-on Control Berm and Road	10,000	LF	$ 85.80	$ 858,000		
2.2.9	Paved Road Construction	2,800	LF	$ 75.85	$ 212,380		
2.2.10	Graveled Road Construction	4,600	LF	$ 52.76	$ 242,696		
2.2.11	Haul Road Overpass	1	LS	$ 6,000,000.00	$ 6,000,000		
2.2.12	Parking Areas	14,000	LS	$ 6.36	$ 89,040		
2.2.13	Site Perimeter Fence	10,500	LF	$ 41.71	$ 437,955		
2.2.14	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	5,000	LF	$ 52.61	$ 263,050		
2.2.15	Entrance Gate (secure area)	2	EA	$ 4,272.50	$ 8,545		
2.2.16	Truck Scale (Replacement or Improvements to Existing)	3	EA	$ 75,000.00	$ 225,000		
2.2.17	Outside Lights	1	LS	$ 397,687.80	$ 397,688		
2.2.18	High Security Area Lighting and Electrical	1	LS	$ 226,756.86	$ 226,757		
2.2.19	Signs	1	LS	$ 41,186.30	$ 41,186		
2.2.20	Site Topographic Survey	110	AC	$ 4,736.59	$ 521,025		
2.2.21	Site Layout Survey	84	AC	$ 4,736.59	$ 397,874		
2.2.22	Construction Surveying	88	AC	$ 4,736.59	$ 416,820		
2.3	**Buildings, Utilities, and Supplies**					**$ 27,632,102**	
2.3.1	Administrative/Office Building Addition	5,400	SF	$ 316.64	$ 1,709,856		
2.3.2	Office Computers, Furniture, Administrative Supplies	1	LS	$ 300,000.00	$ 300,000		
2.3.3	Maintenance Shop [Existing Shop Will Be Used]	0	EA				
2.3.4	Leachate Treatment Building	1	EA	$ 25,219,885.00			
	Sitework	1	LS	$ 192,760.00	$ 192,760		
	Building Construction	1	LS	$ 1,622,490.00	$ 1,622,490		
	System Equipment	1	LS	$ 20,199,135.00	$ 20,199,135		
	Accessory Equipment and Tanks	1	LS	$ 1,219,850.00	$ 1,219,850		
	Electrical, Monitoring, and Controls	1	LS	$ 1,985,650.00	$ 1,985,650		
2.3.5	Sanitary Treatment System	1	LS	$ 21,840.00	$ 21,840		
2.3.6	Water Supply and Distribution System	1	LS	$ 92,640.00	$ 92,640		
2.3.7	Fire Hydrants and Service Connections	1	LS	$ 27,300.00	$ 27,300		
2.3.8	Telecommunications	1	LS	$ 248,889.00	$ 248,889		
2.3.9	Guard Shacks and Equipment	2	EA	$ 5,846.00	$ 11,692		

Table I2.2. Development and Construction Cost Estimate for Site 11 - High End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
2.4	**Sitewide Surface Water Improvements**					**$ 600,777**	
2.4.1	Strip and Stockpile Topsoil, Ditch and Pond Areas	8,000	CY	$ 5.49	$ 43,920		
2.4.2	Large Surface Water Ditches with Riprap Armor (incl. Outfall)	3,000	LF	$ 7.77	$ 23,310		
2.4.3	Small Surface Water Ditches with Riprap Armor	3,000	LF	$ 7.77	$ 23,310		
2.4.4	Surface Water Pond Excavation	82,280	CY	$ 4.18	$ 343,930		
2.4.5	Surface Water Pond Overflow	1,000	LF	$ 7.77	$ 7,770		
2.4.6	Surface Water Pumps, Pipes, Fittings, and Ancillary Equipment	1	LS	$ 91,036.50	$ 91,037		
2.4.7	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 67,500.00	$ 67,500		
2.5	**Earthwork for Landfill Operations Area**					**$ 52,304,427**	
2.5.1	Strip and Stockpile Topsoil	20,343	CY	$ 5.49	$ 111,683		
2.5.2	Geologic Buffer: Excavation and Replacement	199,280	CY	$ 35.69	$ 7,112,303		
2.5.3	Place/Compact Earthfill Dike	1,088,964	CY	$ 39.33	$ 42,828,954		
2.5.4	Liner Subgrade: Compact and Grade Side Slopes	20,809	SY	$ 3.32	$ 69,086		
2.5.5	Liner Subgrade: Compact and Grade Base	40,042	SY	$ 3.32	$ 132,939		
2.5.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	60,851	CY	$ 33.68	$ 2,049,462		
2.6	**Geosynthetic Liner and Leachate Collection Systems**					**$ 3,403,090**	
2.6.1	Geosynthetics Anchor Trench Preparation	1,625	LF	$ 1.54	$ 2,503		
2.6.2	Geosynthetics Anchor Trench Backfill and Compaction	1,625	LF	$ 4.39	$ 7,134		
2.6.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	547,662	SF	$ 0.66	$ 361,457		
2.6.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	187,281	SF	$ 0.57	$ 106,750		
2.6.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	1,441,522	SF	$ 0.30	$ 432,457		
2.6.6	Gravel Leak Detection Layer	13,347	CY	$ 58.23	$ 777,196		
2.6.7	Leak Detection Pipes: Installation and Materials	3,604	LF	$ 25.60	$ 92,262		
2.6.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	547,662	SF	$ 0.81	$ 443,606		
2.6.9	Gravel Leachate Collection Layer	13,347	CY	$ 58.23	$ 777,196		
2.6.10	Leachate Collection Pipes: Installation and Materials	3,604	LF	$ 25.60	$ 92,262		
2.6.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	187,281	SF	$ 0.57	$ 106,750		
2.6.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
2.6.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
2.6.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 54,714.80	$ 54,715		
2.6.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
2.6.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 78,964.10	$ 78,964		
2.7	**Leachate Treatment Facility: Hydraulic Structures & Equipment**					**$ 2,091,574**	
2.7.1	Leachate Transmission Pipeline	5,000	LF	$ 61.80	$ 309,000		
2.7.2	Steel Tank Structure	2	EA	$ 150,000.00	$ 300,000		
2.7.3	Steel Tank Secondary Containment	2,140	CY	$ 471.72	$ 1,009,481		
2.7.4	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.7.5	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.7.6	Overhead Crane	1	LS	$ 6,685.69	$ 6,686		
2.7.7	Post-Treatment Steel Holding Tank	2	EA	$ 150,000.00	$ 300,000		
2.7.8	Analytical Test Facilities and Equipment	1	LS	$ 50,000.00	$ 50,000		
2.8	**Contact Water System: Hydraulic Structures & Equipment**					**$ 3,208,710**	
2.8.1	Contact Water Transmission Pipeline	1,000	LF	$ 61.80	$ 61,800		
2.8.2	Drain Ports	12	EA	$ 4,450.75	$ 53,409		
2.8.3	Lift Station	1	LS	$ 292,567.00	$ 292,567		
2.8.4	Steel Tank Structure	4	EA	$ 150,000.00	$ 600,000		
2.8.5	Steel Tank Secondary Containment	4,260	CY	$ 471.72	$ 2,009,527		
2.8.6	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.8.7	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.8.8	Electrical Equipment, Control Systems	1	LS	$ 75,000.00	$ 75,000		
3.0	***PHASE 2 CONSTRUCTION***						***$ 66,745,492***
3.1	**General Costs**					**$ 14,189,986**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 52,555,506.00	$ 3,678,885		
3.1.2	Worker Health and Safety Program	5%	LS	$ 52,555,506.00	$ 2,627,775		
3.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 52,555,506.00	$ 7,883,326		
3.2	**Site Work**					**$ 6,085,447**	
3.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
3.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
3.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
3.2.4	Small Surface Water Ditches with Riprap Armor	750	LF	$ 7.77	$ 5,828		
3.2.5	Graveled Road Construction	3,000	LF	$ 52.76	$ 158,280		
3.2.6	Site Grubbing	10	AC	$ 4,784.50	$ 47,845		
3.2.7	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
3.2.8	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
3.2.9	High Security Area Lighting and Electrical	1	LS	$ 188,964.05	$ 188,964		
3.2.10	Signs	1	LS	$ 41,186.30	$ 41,186		
3.2.11	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
3.2.12	Sanitary Treatment System	1	LS	$ 4,522,000.00	$ 4,522,000		
3.2.13	Construction Surveying	73	AC	$ 4,736.59	$ 345,771		
3.3	**Earthwork for Landfill Operations Area**					**$ 43,587,034**	
3.3.1	Strip and Stockpile Topsoil	16,953	CY	$ 5.49	$ 93,072		
3.3.2	Geologic Buffer: Excavation and Replacement	166,067	CY	$ 35.69	$ 5,926,931		
3.3.3	Place/Compact Earthfill Dike	907,470	CY	$ 39.33	$ 35,690,795		
3.3.4	Liner Subgrade: Compact and Grade Side Slopes	17,341	SY	$ 3.32	$ 57,572		
3.3.5	Liner Subgrade: Compact and Grade Base	33,369	SY	$ 3.32	$ 110,785		
3.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	50,709	CY	$ 33.68	$ 1,707,879		

Table I2.2. Development and Construction Cost Estimate for Site 11 - High End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 2,847,588**	
3.4.1	Geosynthetics Anchor Trench Preparation	1,354	LF	$ 1.54	$ 2,085		
3.4.2	Geosynthetics Anchor Trench Backfill and Compaction	1,354	LF	$ 4.39	$ 5,944		
3.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	456,385	SF	$ 0.66	$ 301,214		
3.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	156,068	SF	$ 0.57	$ 88,959		
3.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	1,201,268	SF	$ 0.30	$ 360,380		
3.4.6	Gravel Leak Detection Layer	11,123	CY	$ 58.23	$ 647,692		
3.4.7	Leak Detection Pipes: Installation and Materials	3,003	LF	$ 25.60	$ 76,877		
3.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	456,385	SF	$ 0.81	$ 369,672		
3.4.9	Gravel Leachate Collection Layer	11,123	CY	$ 58.23	$ 647,692		
3.4.10	Leachate Collection Pipes: Installation and Materials	3,003	LF	$ 25.60	$ 76,877		
3.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	156,068	SF	$ 0.57	$ 88,959		
3.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
3.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
3.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
3.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
3.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
3.5	**Contact Water System Additions**					**$ 35,437**	
3.5.1	Drain Ports	5	EA	$ 4,450.75	$ 22,254		
3.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
4.0	***PHASE 3 CONSTRUCTION***						***$ 60,989,152***
4.1	**General Costs**					**$ 12,966,198**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 48,022,954.00	$ 3,361,607		
4.1.2	Worker Health and Safety Program	5%	LS	$ 48,022,954.00	$ 2,401,148		
4.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 48,022,954.00	$ 7,203,443		
4.2	**Site Work**					**$ 1,552,895**	
4.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
4.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
4.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
4.2.4	Small Surface Water Ditches with Riprap Armor	750	LF	$ 7.77	$ 5,828		
4.2.5	Graveled Road Construction	2,800	LF	$ 52.76	$ 147,728		
4.2.6	Site Grubbing	10	AC	$ 4,784.50	$ 47,845		
4.2.7	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
4.2.8	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
4.2.9	High Security Area Lighting and Electrical	1	LS	$ 188,964.05	$ 188,964		
4.2.10	Signs	1	LS	$ 41,186.30	$ 41,186		
4.2.11	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
4.2.12	Construction Surveying	73	AC	$ 4,736.59	$ 345,771		
4.3	**Earthwork for Landfill Operations Area**					**$ 43,587,034**	
4.3.1	Strip and Stockpile Topsoil	16,953	CY	$ 5.49	$ 93,072		
4.3.2	Geologic Buffer: Excavation and Replacement	166,067	CY	$ 35.69	$ 5,926,931		
4.3.3	Place/Compact Earthfill Dike	907,470	CY	$ 39.33	$ 35,690,795		
4.3.4	Liner Subgrade: Compact and Grade Side Slopes	17,341	SY	$ 3.32	$ 57,572		
4.3.5	Liner Subgrade: Compact and Grade Base	33,369	SY	$ 3.32	$ 110,785		
4.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	50,709	CY	$ 33.68	$ 1,707,879		
4.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 2,847,588**	
4.4.1	Geosynthetics Anchor Trench Preparation	1,354	LF	$ 1.54	$ 2,085		
4.4.2	Geosynthetics Anchor Trench Backfill and Compaction	1,354	LF	$ 4.39	$ 5,944		
4.4.2	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	456,385	SF	$ 0.66	$ 301,214		
4.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	156,068	SF	$ 0.57	$ 88,959		
4.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	1,201,268	SF	$ 0.30	$ 360,380		
4.4.6	Gravel Leak Detection Layer	11,123	CY	$ 58.23	$ 647,692		
4.4.7	Leak Detection Pipes: Installation and Materials	3,003	LF	$ 25.60	$ 76,877		
4.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	456,385	SF	$ 0.81	$ 369,672		
4.4.9	Gravel Leachate Collection Layer	11,123	CY	$ 58.23	$ 647,692		
4.4.10	Leachate Collection Pipes: Installation and Materials	3,003	LF	$ 25.60	$ 76,877		
4.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	156,068	SF	$ 0.57	$ 88,959		
4.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
4.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
4.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
4.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
4.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
4.5	**Contact Water System Additions**					**$ 35,437**	
4.5.1	Drain Ports	5	EA	$ 4,450.75	$ 22,254		
4.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Table I2.2. Development and Construction Cost Estimate for Site 11 - High End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
5.0	***PHASE 4 CONSTRUCTION***						***$ 48,879,306***
5.1	**General Costs**					**$ 10,391,663**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 38,487,643.00	$ 2,694,135		
5.1.2	Worker Health and Safety Program	5%	LS	$ 38,487,643.00	$ 1,924,382		
5.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 38,487,643.00	$ 5,773,146		
5.2	**Site Work**					**$ 1,290,554**	
5.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
5.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 27,361.58	$ 27,362		
5.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
5.2.4	Small Surface Water Ditches with Riprap Armor	750	LF	$ 7.77	$ 5,828		
5.2.5	Graveled Road Construction	1,400	LF	$ 52.76	$ 73,864		
5.2.6	Site Grubbing	10	AC	$ 4,784.50	$ 47,845		
5.2.7	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
5.2.8	Outside Lights	1	LS	$ 265,125.20	$ 265,125		
5.2.9	High Security Area Lighting and Electrical	1	LS	$ 151,171.24	$ 151,171		
5.2.10	Signs	1	LS	$ 41,186.30	$ 41,186		
5.2.11	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 45,000.00	$ 45,000		
5.2.12	Construction Surveying	59	AC	$ 4,736.59	$ 279,459		
5.3	**Earthwork for Landfill Operations Area**					**$ 34,869,630**	
5.3.1	Strip and Stockpile Topsoil	13,562	CY	$ 5.49	$ 74,455		
5.3.2	Geologic Buffer: Excavation and Replacement	132,853	CY	$ 35.69	$ 4,741,524		
5.3.3	Place/Compact Earthfill Dike	725,976	CY	$ 39.33	$ 28,552,636		
5.3.4	Liner Subgrade: Compact and Grade Side Slopes	13,873	SY	$ 3.32	$ 46,058		
5.3.5	Liner Subgrade: Compact and Grade Base	26,695	SY	$ 3.32	$ 88,627		
5.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	40,568	CY	$ 33.68	$ 1,366,330		
5.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 2,292,022**	
5.4.1	Geosynthetics Anchor Trench Preparation	1,083	LF	$ 1.54	$ 1,668		
5.4.2	Geosynthetics Anchor Trench Backfill and Compaction	1,083	LF	$ 4.39	$ 4,754		
5.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	365,108	SF	$ 0.66	$ 240,971		
5.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	124,854	SF	$ 0.57	$ 71,167		
5.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	961,014	SF	$ 0.30	$ 288,304		
5.4.6	Gravel Leak Detection Layer	8,898	CY	$ 58.23	$ 518,131		
5.4.7	Leak Detection Pipes: Installation and Materials	2,403	LF	$ 25.60	$ 61,517		
5.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	365,108	SF	$ 0.81	$ 295,737		
5.4.9	Gravel Leachate Collection Layer	8,898	CY	$ 58.23	$ 518,131		
5.4.10	Leachate Collection Pipes: Installation and Materials	2,403	LF	$ 25.60	$ 61,517		
5.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	124,854	SF	$ 0.57	$ 71,167		
5.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
5.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
5.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 36,476.53	$ 36,477		
5.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
5.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 52,642.73	$ 52,643		
5.5	**Contact Water System Additions**					**$ 35,437**	
5.5.1	Drain Ports	5	EA	$ 4,450.75	$ 22,254		
5.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Notes:

a. Includes pre-construction geotechnical investigation.

b. Includes seismic investigation.

c. Includes pre-construction groundwater investigation to assess water table and background conditions for constituents predicted to be in proposed waste streams.

d. Includes 30%, 60%, 90% and for construction design packages, test pad, methane gas generation study, etc.

Table I2.3. Development and Construction Cost Estimate for Site 3A - Low End Volume Scenario

General Information and Assumptions:

Landfill Operations Area	2,147,825	SF	49.31	AC
Total Centerline Length of Earthfill Dike	4,370	LF		
Average Cross Sectional Area of Earthfill Dike	10,840	SF		
Liner Crest Footprint	823,034	SF	18.89	AC
Liner Base Area	407,875	SF	9.36	AC
Area of Liner on Side Slopes	437,615	SF	10.05	AC
Total Liner Area	845,490	SF	19.41	AC
Total Liner Anchor Trench Length	3,959	LF		
Dike Fill Volume	1,619,059	CY		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Construction Phases:	Year	Percent of Liner Area Constructed		
Phase 1	2014	30%		
Phase 2	2019	25%		
Phase 3	2025	25%		
Phase 4	2031	20%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Planning, Environmental, and Engineering Services	$ 16,179,234	$ 2,426,885	$ -	$ 18,606,119
Phase 1 Construction	$ 83,553,054	$ 12,532,958	$ 25,065,916	$ 121,151,928
Phase 2 Construction	$ 45,473,715	$ 6,821,057	$ 13,642,115	$ 65,936,887
Phase 3 Construction	$ 33,534,186	$ 5,030,128	$ 10,060,256	$ 48,624,570
Phase 4 Construction	$ 26,891,974	$ 4,033,796	$ 8,067,592	$ 38,993,362
TOTAL SITE 3A CAPITAL COST	**$ 205,632,163**	**$ 30,844,824**	**$ 56,835,879**	**$ 293,312,866**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***PLANNING, ENVIRONMENTAL AND ENGINEERING SERVICES***						***$ 16,179,234***
1.1	**NEPA Substantive Requirements Documentation**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.2	**Environmental Site Studies[a]**	**1**	**LS**	**$ 400,000.00**	**$ 400,000**	**$400,000**	
1.3	**Remedial Design Work Plan and Associated Field Work[b]**	**1**	**LS**	**$ 2,219,800.00**	**$ 2,219,800**	**$2,219,800**	
1.4	**Hydrogeological Studies, GW Wells and Monitoring Plan[c]**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.5	**OSWDF Remedial Action Work Plan (1 per Phase)**	**4**	**EA**	**$ 270,700.00**	**$ 1,082,800**	**$1,082,800**	
1.6	**Develop Construction Work Control Documents and Procedures**	**1**	**LS**	**$ 231,595.00**	**$ 231,595**	**$231,595**	
1.7	**Develop Operations Documents**	**1**	**LS**	**$ 635,785.00**	**$ 635,785**	**$635,785**	
1.8	**OSWDF Procurement**	**1**	**LS**	**$ 829,254.00**	**$ 829,254**	**$829,254**	
1.9	**Critical Decision Packages (1 per Phase)**	**4**	**EA**	**$ 560,000.00**	**$ 2,240,000**	**$2,240,000**	
1.10	**OSWDF Design[d]**	**1**	**LS**	**$ 5,420,000.00**	**$ 5,420,000**	**$5,420,000**	
1.11	**Safety Basis Documents**	**1**	**LS**	**$ 440,000.00**	**$ 440,000**	**$440,000**	
1.12	**OSWDF Remedial Action Completion Report (1 per Phase)**	**4**	**EA**	**$ 120,000.00**	**$ 480,000**	**$480,000**	
1.13	**Construction QC Plan, Post-construction Report, O&M Plan (1 per Phase)**	**4**	**EA**	**$ 250,000.00**	**$ 1,000,000**	**$1,000,000**	
2.0	***PHASE 1 CONSTRUCTION***						***$ 83,553,054***
2.1	**General Costs**					**$ 17,786,071**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 65,766,983.00	$ 4,603,689		
2.1.2	Wetlands Replacement Cost	21.4	AC	$ 1,354.50	$ 28,986		
2.1.3	Worker Health and Safety Program	5%	LS	$ 65,766,983.00	$ 3,288,349		
2.1.4	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 65,766,983.00	$ 9,865,047		
2.2	**Site Work and Improvements**					**$ 4,513,660**	
2.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
2.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 41,042.37	$ 41,042		
2.2.3	Additional GW Monitoring Well(s)	14	EA	$ 16,494.00	$ 230,916		
2.2.4	Clearing and Grubbing (Forested Areas)	50	AC	$ 6,856.25	$ 342,813		
2.2.5	Clearing and Grubbing (Semi-open Areas)	40	AC	$ 4,784.50	$ 191,380		
2.2.6	Site Perimeter Run-on Control Berm and Road	10,400	LF	$ 85.80	$ 892,320		
2.2.7	Paved Road Construction	2,000	LF	$ 75.85	$ 151,700		
2.2.8	Graveled Road Construction	5,000	LF	$ 52.76	$ 263,800		
2.2.9	Parking Areas	14,000	LS	$ 6.36	$ 89,040		
2.2.10	Site Perimeter Fence	10,900	LF	$ 41.71	$ 454,639		
2.2.11	Entrance Gate	3	EA	$ 4,272.50	$ 12,818		
2.2.12	Truck Scale	3	EA	$ 75,000.00	$ 225,000		
2.2.13	Outside Lights	1	LS	$ 397,687.80	$ 397,688		
2.2.14	Signs	1	LS	$ 41,186.30	$ 41,186		
2.2.15	Site Topographic Survey	110	AC	$ 4,736.59	$ 521,025		
2.2.16	Site Layout Survey	49	AC	$ 4,736.59	$ 232,093		
2.2.17	Construction Surveying	41	AC	$ 4,736.59	$ 194,200		
2.3	**Buildings, Utilities, and Supplies**					**$ 26,667,206**	
2.3.1	Administrative/Office Building	0	SF	$ 316.64	$ -		
2.3.2	Office Computers, Furniture, Administrative Supplies	1	LS	$ 300,000.00	$ 300,000		
2.3.3	Maintenance Shop	1	EA	$ 744,960.00			
	Pre-engineered Steel Building	4,800	SF	$ 155.20	$ 744,960		
2.3.4	Leachate Treatment Building	1	EA	$ 25,219,885.00			
	Sitework	1	LS	$ 192,760.00	$ 192,760		
	Building Construction	1	LS	$ 1,622,490.00	$ 1,622,490		
	System Equipment	1	LS	$ 20,199,135.00	$ 20,199,135		
	Accessory Equipment and Tanks	1	LS	$ 1,219,850.00	$ 1,219,850		
	Electrical, Monitoring, and Controls	1	LS	$ 1,985,650.00	$ 1,985,650		
2.3.5	Sanitary Treatment System	1	LS	$ 21,840.00	$ 21,840		
2.3.6	Water Supply and Distribution System	1	LS	$ 92,640.00	$ 92,640		
2.3.7	Fire Hydrants and Service Connections	1	LS	$ 27,300.00	$ 27,300		
2.3.8	Telecommunications	1	LS	$ 248,889.00	$ 248,889		
2.3.9	Guard Shacks and Equipment	2	EA	$ 5,846.00	$ 11,692		

Table I2.3. Development and Construction Cost Estimate for Site 3A - Low End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
2.4	**Sitewide Surface Water Improvements**					**$ 454,468**	
2.4.1	Strip and Stockpile Topsoil, Ditch and Pond Areas	8,000	CY	$ 5.49	$ 43,920		
2.4.2	Large Surface Water Ditches with Riprap Armor (incl. Outfall)	4,000	LF	$ 7.77	$ 31,080		
2.4.3	Small Surface Water Ditches with Riprap Armor	4,000	LF	$ 7.77	$ 31,080		
2.4.4	Surface Water Pond Excavation	43,560	CY	$ 4.18	$ 182,081		
2.4.5	Surface Water Pond Overflow	1,000	LF	$ 7.77	$ 7,770		
2.4.6	Surface Water Pumps, Pipes, Fittings, and Ancillary Equipment	1	LS	$ 91,036.50	$ 91,037		
2.4.7	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 67,500.00	$ 67,500		
2.5	**Earthwork for Landfill Operations Area**					**$ 28,921,017**	
2.5.1	Strip and Stockpile Topsoil	11,932	CY	$ 5.49	$ 65,507		
2.5.2	Geologic Buffer: Excavation and Replacement	91,448	CY	$ 35.69	$ 3,263,779		
2.5.3	Place/Compact Earthfill Dike	624,179	CY	$ 39.33	$ 24,548,960		
2.5.4	Liner Subgrade: Compact and Grade Side Slopes	14,587	SY	$ 3.32	$ 48,429		
2.5.5	Liner Subgrade: Compact and Grade Base	13,596	SY	$ 3.32	$ 45,139		
2.5.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	28,183	CY	$ 33.68	$ 949,203		
2.6	**Geosynthetic Liner and Leachate Collection Systems**					**$ 1,470,386**	
2.6.1	Geosynthetics Anchor Trench Preparation	1,188	LF	$ 1.54	$ 1,830		
2.6.2	Geosynthetics Anchor Trench Backfill and Compaction	1,188	LF	$ 4.39	$ 5,215		
2.6.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	253,647	SF	$ 0.66	$ 167,407		
2.6.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	131,285	SF	$ 0.57	$ 74,832		
2.6.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	489,450	SF	$ 0.30	$ 146,835		
2.6.6	Gravel Leak Detection Layer	4,532	CY	$ 58.23	$ 263,898		
2.6.7	Leak Detection Pipes: Installation and Materials	1,224	LF	$ 25.60	$ 31,334		
2.6.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	253,647	SF	$ 0.81	$ 205,454		
2.6.9	Gravel Leachate Collection Layer	4,532	CY	$ 58.23	$ 263,898		
2.6.10	Leachate Collection Pipes: Installation and Materials	1,224	LF	$ 25.60	$ 31,334		
2.6.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	131,285	SF	$ 0.57	$ 74,832		
2.6.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
2.6.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
2.6.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 54,714.80	$ 54,715		
2.6.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
2.6.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 78,964.10	$ 78,964		
2.7	**Leachate Treatment Facility: Hydraulic Structures & Equipment**					**$ 1,540,483**	
2.7.1	Leachate Transmission Pipeline	4,250	LF	$ 61.80	$ 262,650		
2.7.2	Steel Tank Structure	2	EA	$ 150,000.00	$ 300,000		
2.7.3	Steel Tank Secondary Containment	1,070	CY	$ 471.72	$ 504,740		
2.7.4	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.7.5	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.7.6	Overhead Crane	1	LS	$ 6,685.69	$ 6,686		
2.7.7	Post-Treatment Steel Holding Tank	2	EA	$ 150,000.00	$ 300,000		
2.7.8	Analytical Test Facilities and Equipment	1	LS	$ 50,000.00	$ 50,000		
2.8	**Contact Water System: Hydraulic Structures & Equipment**					**$ 2,199,763**	
2.8.1	Contact Water Transmission Pipeline	1,000	LF	$ 61.80	$ 61,800		
2.8.2	Drain Ports	10	EA	$ 4,450.75	$ 44,508		
2.8.3	Lift Station	1	LS	$ 292,567.00	$ 292,567		
2.8.4	Steel Tank Structure	4	EA	$ 150,000.00	$ 600,000		
2.8.5	Steel Tank Secondary Containment	2,140	CY	$ 471.72	$ 1,009,481		
2.8.6	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.8.7	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.8.8	Electrical Equipment, Control Systems	1	LS	$ 75,000.00	$ 75,000		
3.0	***PHASE 2 CONSTRUCTION***						***$ 45,473,715***
3.1	**General Costs**					**$ 9,667,640**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 35,806,075.00	$ 2,506,425		
3.1.2	Worker Health and Safety Program	5%	LS	$ 35,806,075.00	$ 1,790,304		
3.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 35,806,075.00	$ 5,370,911		
3.2	**Site Work**					**$ 10,441,674**	
3.2.1	Relocate Overhead Electrical Power Lines and Towers	1	LS	$ 4,868,653.00	$ 4,868,653		
3.2.2	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
3.2.3	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
3.2.4	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
3.2.5	Small Surface Water Ditches with Riprap Armor	1,000	LF	$ 7.77	$ 7,770		
3.2.6	Graveled Road Construction	2,600	LF	$ 52.76	$ 137,176		
3.2.7	Site Grubbing	7	AC	$ 4,784.50	$ 33,492		
3.2.8	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
3.2.9	Signs	1	LS	$ 41,186.30	$ 41,186		
3.2.10	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
3.2.11	Sanitary Treatment System	1	LS	$ 4,522,000.00	$ 4,522,000		
3.2.12	Construction Surveying	34	AC	$ 4,736.59	$ 161,044		
3.3	**Earthwork for Landfill Operations Area**					**$ 24,100,863**	
3.3.1	Strip and Stockpile Topsoil	9,944	CY	$ 5.49	$ 54,593		
3.3.2	Geologic Buffer: Excavation and Replacement	76,207	CY	$ 35.69	$ 2,719,828		
3.3.3	Place/Compact Earthfill Dike	520,149	CY	$ 39.33	$ 20,457,460		
3.3.4	Liner Subgrade: Compact and Grade Side Slopes	12,156	SY	$ 3.32	$ 40,358		
3.3.5	Liner Subgrade: Compact and Grade Base	11,330	SY	$ 3.32	$ 37,616		
3.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	23,486	CY	$ 33.68	$ 791,008		

Table I2.3. Development and Construction Cost Estimate for Site 3A - Low End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 1,237,003**	
3.4.1	Geosynthetics Anchor Trench Preparation	990	LF	$ 1.54	$ 1,525		
3.4.2	Geosynthetics Anchor Trench Backfill and Compaction	990	LF	$ 4.39	$ 4,346		
3.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	211,373	SF	$ 0.66	$ 139,506		
3.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	109,404	SF	$ 0.57	$ 62,360		
3.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	407,875	SF	$ 0.30	$ 122,363		
3.4.6	Gravel Leak Detection Layer	3,777	CY	$ 58.23	$ 219,935		
3.4.7	Leak Detection Pipes: Installation and Materials	1,020	LF	$ 25.60	$ 26,112		
3.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	211,373	SF	$ 0.81	$ 171,212		
3.4.9	Gravel Leachate Collection Layer	3,777	CY	$ 58.23	$ 219,935		
3.4.10	Leachate Collection Pipes: Installation and Materials	1,020	LF	$ 25.60	$ 26,112		
3.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	109,404	SF	$ 0.57	$ 62,360		
3.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
3.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
3.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
3.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
3.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
3.5	**Contact Water System Additions**					**$ 26,535**	
3.5.1	Drain Ports	3	EA	$ 4,450.75	$ 13,352		
3.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
4.0	***<u>PHASE 3 CONSTRUCTION</u>***						***$ 33,534,186***
4.1	**General Costs**					**$ 7,129,316**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 26,404,870.00	$ 1,848,341		
4.1.2	Worker Health and Safety Program	5%	LS	$ 26,404,870.00	$ 1,320,244		
4.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 26,404,870.00	$ 3,960,731		
4.2	**Site Work**					**$ 1,040,469**	
4.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
4.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
4.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
4.2.4	Small Surface Water Ditches with Riprap Armor	1,000	LF	$ 7.77	$ 7,770		
4.2.5	Graveled Road Construction	2,400	LF	$ 52.76	$ 126,624		
4.2.6	Site Grubbing	7	AC	$ 4,784.50	$ 33,492		
4.2.7	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
4.2.8	Signs	1	LS	$ 41,186.30	$ 41,186		
4.2.9	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
4.2.10	Construction Surveying	34	AC	$ 4,736.59	$ 161,044		
4.3	**Earthwork for Landfill Operations Area**					**$ 24,100,863**	
4.3.1	Strip and Stockpile Topsoil	9,944	CY	$ 5.49	$ 54,593		
4.3.2	Geologic Buffer: Excavation and Replacement	76,207	CY	$ 35.69	$ 2,719,828		
4.3.3	Place/Compact Earthfill Dike	520,149	CY	$ 39.33	$ 20,457,460		
4.3.4	Liner Subgrade: Compact and Grade Side Slopes	12,156	SY	$ 3.32	$ 40,358		
4.3.5	Liner Subgrade: Compact and Grade Base	11,330	SY	$ 3.32	$ 37,616		
4.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	23,486	CY	$ 33.68	$ 791,008		
4.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 1,237,003**	
4.4.1	Geosynthetics Anchor Trench Preparation	990	LF	$ 1.54	$ 1,525		
4.4.2	Geosynthetics Anchor Trench Backfill and Compaction	990	LF	$ 4.39	$ 4,346		
4.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	211,373	SF	$ 0.66	$ 139,506		
4.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	109,404	SF	$ 0.57	$ 62,360		
4.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	407,875	SF	$ 0.30	$ 122,363		
4.4.6	Gravel Leak Detection Layer	3,777	CY	$ 58.23	$ 219,935		
4.4.7	Leak Detection Pipes: Installation and Materials	1,020	LF	$ 25.60	$ 26,112		
4.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	211,373	SF	$ 0.81	$ 171,212		
4.4.9	Gravel Leachate Collection Layer	3,777	CY	$ 58.23	$ 219,935		
4.4.10	Leachate Collection Pipes: Installation and Materials	1,020	LF	$ 25.60	$ 26,112		
4.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	109,404	SF	$ 0.57	$ 62,360		
4.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
4.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
4.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
4.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
4.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
4.5	**Contact Water System Additions**					**$ 26,535**	
4.5.1	Drain Ports	3	EA	$ 4,450.75	$ 13,352		
4.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Table I2.3. Development and Construction Cost Estimate for Site 3A - Low End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
5.0	***PHASE 4 CONSTRUCTION***						***$ 26,891,974***
5.1	**General Costs**					**$ 5,717,191**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 21,174,783.00	$ 1,482,235		
5.1.2	Worker Health and Safety Program	5%	LS	$ 21,174,783.00	$ 1,058,739		
5.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 21,174,783.00	$ 3,176,217		
5.2	**Site Work**					**$ 859,629**	
5.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
5.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 27,361.58	$ 27,362		
5.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
5.2.4	Small Surface Water Ditches with Riprap Armor	1,000	LF	$ 7.77	$ 7,770		
5.2.5	Graveled Road Construction	1,200	LF	$ 52.76	$ 63,312		
5.2.6	Site Grubbing	7	AC	$ 4,784.50	$ 33,492		
5.2.7	Outside Lights	1	LS	$ 265,125.20	$ 265,125		
5.2.8	Signs	1	LS	$ 41,186.30	$ 41,186		
5.2.9	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 45,000.00	$ 45,000		
5.2.10	Construction Surveying	27	AC	$ 4,736.59	$ 127,888		
5.3	**Earthwork for Landfill Operations Area**					**$ 19,280,667**	
5.3.1	Strip and Stockpile Topsoil	7,955	CY	$ 5.49	$ 43,673		
5.3.2	Geologic Buffer: Excavation and Replacement	60,965	CY	$ 35.69	$ 2,175,841		
5.3.3	Place/Compact Earthfill Dike	416,119	CY	$ 39.33	$ 16,365,960		
5.3.4	Liner Subgrade: Compact and Grade Side Slopes	9,725	SY	$ 3.32	$ 32,287		
5.3.5	Liner Subgrade: Compact and Grade Base	9,064	SY	$ 3.32	$ 30,092		
5.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	18,789	CY	$ 33.68	$ 632,814		
5.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 1,003,501**	
5.4.1	Geosynthetics Anchor Trench Preparation	792	LF	$ 1.54	$ 1,220		
5.4.2	Geosynthetics Anchor Trench Backfill and Compaction	792	LF	$ 4.39	$ 3,477		
5.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	169,098	SF	$ 0.66	$ 111,605		
5.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	87,523	SF	$ 0.57	$ 49,888		
5.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	326,300	SF	$ 0.30	$ 97,890		
5.4.6	Gravel Leak Detection Layer	3,021	CY	$ 58.23	$ 175,913		
5.4.7	Leak Detection Pipes: Installation and Materials	816	LF	$ 25.60	$ 20,890		
5.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	169,098	SF	$ 0.81	$ 136,969		
5.4.9	Gravel Leachate Collection Layer	3,021	CY	$ 58.23	$ 175,913		
5.4.10	Leachate Collection Pipes: Installation and Materials	816	LF	$ 25.60	$ 20,890		
5.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	87,523	SF	$ 0.57	$ 49,888		
5.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
5.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
5.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 36,476.53	$ 36,477		
5.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
5.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 52,642.73	$ 52,643		
5.5	**Contact Water System Additions**					**$ 30,986**	
5.5.1	Drain Ports	4	EA	$ 4,450.75	$ 17,803		
5.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Notes:
a. Includes pre-construction geotechnical investigation.
b. Includes seismic investigation.
c. Includes pre-construction groundwater investigation to assess water table and background conditions for constituents predicted to be in proposed waste streams.
d. Includes 30%, 60%, 90% and for construction design packages, test pad, methane gas generation study, etc.

Table I2.4. Development and Construction Cost Estimate for Site 11 - Low End Volume Scenario

General Information and Assumptions:

Landfill Operations Area	2,092,863	SF	48.05	AC
Total Centerline Length of Earthfill Dike	3,963	LF		
Average Cross Sectional Area of Earthfill Dike	10,840	SF		
Liner Crest Footprint	788,543	SF	18.10	AC
Liner Base Area	419,904	SF	9.64	AC
Area of Liner on Side Slopes	388,579	SF	8.92	AC
Total Liner Area	808,483	SF	18.56	AC
Total Liner Anchor Trench Length	3,551	LF		
Dike Fill Volume	1,613,031	CY		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Construction Phases:	Year	Percent of Liner Area Constructed		
Phase 1	2014	30%		
Phase 2	2019	25%		
Phase 3	2025	25%		
Phase 4	2031	20%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Planning, Environmental, and Engineering Services	$ 16,179,234	$ 2,426,885	$ -	$ 18,606,119
Phase 1 Construction	$ 91,754,507	$ 13,763,176	$ 27,526,352	$ 133,044,035
Phase 2 Construction	$ 39,038,091	$ 5,855,714	$ 11,711,427	$ 56,605,232
Phase 3 Construction	$ 33,281,749	$ 4,992,262	$ 9,984,525	$ 48,258,536
Phase 4 Construction	$ 26,688,830	$ 4,003,325	$ 8,006,649	$ 38,698,804
TOTAL SITE 11 CAPITAL COST	**$ 206,942,411**	**$ 31,041,362**	**$ 57,228,953**	**$ 295,212,726**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***PLANNING, ENVIRONMENTAL AND ENGINEERING SERVICES***						*$ 16,179,234*
1.1	**NEPA Substantive Requirements Documentation**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.2	**Environmental Site Studies[a]**	**1**	**LS**	**$ 400,000.00**	**$ 400,000**	**$400,000**	
1.3	**Remedial Design Work Plan and Associated Field Work[b]**	**1**	**LS**	**$ 2,219,800.00**	**$ 2,219,800**	**$2,219,800**	
1.4	**Hydrogeological Studies, GW Wells and Monitoring Plan[c]**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.5	**OSWDF Remedial Action Work Plan (1 per Phase)**	**4**	**EA**	**$ 270,700.00**	**$ 1,082,800**	**$1,082,800**	
1.6	**Develop Construction Work Control Documents and Procedures**	**1**	**LS**	**$ 231,595.00**	**$ 231,595**	**$231,595**	
1.7	**Develop Operations Documents**	**1**	**LS**	**$ 635,785.00**	**$ 635,785**	**$635,785**	
1.8	**OSWDF Procurement**	**1**	**LS**	**$ 829,254.00**	**$ 829,254**	**$829,254**	
1.9	**Critical Decision Packages (1 per Phase)**	**4**	**EA**	**$ 560,000.00**	**$ 2,240,000**	**$2,240,000**	
1.10	**OSWDF Design[d]**	**1**	**LS**	**$ 5,420,000.00**	**$ 5,420,000**	**$5,420,000**	
1.11	**Safety Basis Documents**	**1**	**LS**	**$ 440,000.00**	**$ 440,000**	**$440,000**	
1.12	**OSWDF Remedial Action Completion Report (1 per Phase)**	**4**	**EA**	**$ 120,000.00**	**$ 480,000**	**$480,000**	
1.13	**Construction QC Plan, Post-construction Report, O&M Plan (1 per Phase)**	**4**	**EA**	**$ 250,000.00**	**$ 1,000,000**	**$1,000,000**	
2.0	***PHASE 1 CONSTRUCTION***						*$ 91,754,507*
2.1	**General Costs**					**$ 19,509,860**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 72,244,647.00	$ 5,057,125		
2.1.2	Wetlands Replacement Cost	2.81	AC	$ 1,354.50	$ 3,806		
2.1.3	Worker Health and Safety Program	5%	LS	$ 72,244,647.00	$ 3,612,232		
2.1.5	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 72,244,647.00	$ 10,836,697		
2.2	**Site Work and Improvements**					**$ 10,609,210**	
2.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
2.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 41,042.37	$ 41,042		
2.2.3	Additional GW Monitoring Well(s)	10	EA	$ 16,494.00	$ 164,940		
2.2.4	Clearing and Grubbing (Forested Areas)	40	AC	$ 6,856.25	$ 274,250		
2.2.5	Indiana Bat Habitat Mitigation	40	AC	$ 6,000.00	$ 240,000		
2.2.6	Clearing and Grubbing (Semi-open Areas)	40	AC	$ 4,784.50	$ 191,380		
2.2.7	Re-route Little Bayou Creek	1	LS	$ 20,000.00	$ 20,000		
2.2.8	Site Perimeter Run-on Control Berm and Road	10,000	LF	$ 85.80	$ 858,000		
2.2.9	Paved Road Construction	2,800	LF	$ 75.85	$ 212,380		
2.2.10	Graveled Road Construction	4,600	LF	$ 52.76	$ 242,696		
2.2.11	Haul Road Overpass	1	LS	$ 6,000,000.00	$ 6,000,000		
2.2.12	Parking Areas	14,000	LS	$ 6.36	$ 89,040		
2.2.13	Site Perimeter Fence	10,500	LF	$ 41.71	$ 437,955		
2.2.14	Entrance Gate (secure area)	2	EA	$ 4,272.50	$ 8,545		
2.2.15	Truck Scale (Replacement or Improvements to Existing)	3	EA	$ 75,000.00	$ 225,000		
2.2.16	Outside Lights	1	LS	$ 397,687.80	$ 397,688		
2.2.17	Signs	1	LS	$ 41,186.30	$ 41,186		
2.2.18	Site Topographic Survey	110	AC	$ 4,736.59	$ 521,025		
2.2.19	Site Layout Survey	48	AC	$ 4,736.59	$ 227,356		
2.2.20	Construction Surveying	39	AC	$ 4,736.59	$ 184,727		
2.3	**Buildings, Utilities, and Supplies**					**$ 27,632,102**	
2.3.1	Administrative/Office Building Addition	5,400	SF	$ 316.64	$ 1,709,856		
2.3.2	Office Computers, Furniture, Administrative Supplies	1	LS	$ 300,000.00	$ 300,000		
2.3.3	Maintenance Shop [Existing Shop Will Be Used]	0	EA				
2.3.4	Leachate Treatment Building	1	EA	$ 25,219,885.00			
	Sitework	1	LS	$ 192,760.00	$ 192,760		
	Building Construction	1	LS	$ 1,622,490.00	$ 1,622,490		
	System Equipment	1	LS	$ 20,199,135.00	$ 20,199,135		
	Accessory Equipment and Tanks	1	LS	$ 1,219,850.00	$ 1,219,850		
	Electrical, Monitoring, and Controls	1	LS	$ 1,985,650.00	$ 1,985,650		
2.3.5	Sanitary Treatment System	1	LS	$ 21,840.00	$ 21,840		
2.3.6	Water Supply and Distribution System	1	LS	$ 92,640.00	$ 92,640		
2.3.7	Fire Hydrants and Service Connections	1	LS	$ 27,300.00	$ 27,300		
2.3.8	Telecommunications	1	LS	$ 248,889.00	$ 248,889		
2.3.9	Guard Shacks and Equipment	2	EA	$ 5,846.00	$ 11,692		

Table I2.4. Development and Construction Cost Estimate for Site 11 - Low End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
2.4	**Sitewide Surface Water Improvements**					**$ 438,928**	
2.4.1	Strip and Stockpile Topsoil, Ditch and Pond Areas	8,000	CY	$ 5.49	$ 43,920		
2.4.2	Large Surface Water Ditches with Riprap Armor (incl. Outfall)	3,000	LF	$ 7.77	$ 23,310		
2.4.3	Small Surface Water Ditches with Riprap Armor	3,000	LF	$ 7.77	$ 23,310		
2.4.4	Surface Water Pond Excavation	43,560	CY	$ 4.18	$ 182,081		
2.4.5	Surface Water Pond Overflow	1,000	LF	$ 7.77	$ 7,770		
2.4.6	Surface Water Pumps, Pipes, Fittings, and Ancillary Equipment	1	LS	$ 91,036.50	$ 91,037		
2.4.7	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 67,500.00	$ 67,500		
2.5	**Earthwork for Landfill Operations Area**					**$ 28,665,814**	
2.5.1	Strip and Stockpile Topsoil	11,627	CY	$ 5.49	$ 63,832		
2.5.2	Geologic Buffer: Excavation and Replacement	87,616	CY	$ 35.69	$ 3,127,015		
2.5.3	Place/Compact Earthfill Dike	622,371	CY	$ 39.33	$ 24,477,851		
2.5.4	Liner Subgrade: Compact and Grade Side Slopes	12,953	SY	$ 3.32	$ 43,004		
2.5.5	Liner Subgrade: Compact and Grade Base	13,997	SY	$ 3.32	$ 46,470		
2.5.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	26,949	CY	$ 33.68	$ 907,642		
2.6	**Geosynthetic Liner and Leachate Collection Systems**					**$ 1,458,347**	
2.6.1	Geosynthetics Anchor Trench Preparation	1,065	LF	$ 1.54	$ 1,640		
2.6.2	Geosynthetics Anchor Trench Backfill and Compaction	1,065	LF	$ 4.39	$ 4,675		
2.6.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	242,545	SF	$ 0.66	$ 160,080		
2.6.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	116,574	SF	$ 0.57	$ 66,447		
2.6.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	503,885	SF	$ 0.30	$ 151,166		
2.6.6	Gravel Leak Detection Layer	4,666	CY	$ 58.23	$ 271,701		
2.6.7	Leak Detection Pipes: Installation and Materials	1,260	LF	$ 25.60	$ 32,256		
2.6.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	242,545	SF	$ 0.81	$ 196,461		
2.6.9	Gravel Leachate Collection Layer	4,666	CY	$ 58.23	$ 271,701		
2.6.10	Leachate Collection Pipes: Installation and Materials	1,260	LF	$ 25.60	$ 32,256		
2.6.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	116,574	SF	$ 0.57	$ 66,447		
2.6.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
2.6.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
2.6.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 54,714.80	$ 54,715		
2.6.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
2.6.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 78,964.10	$ 78,964		
2.7	**Leachate Treatment Facility: Hydraulic Structures & Equipment**					**$ 1,540,483**	
2.7.1	Leachate Transmission Pipeline	4,250	LF	$ 61.80	$ 262,650		
2.7.2	Steel Tank Structure	2	EA	$ 150,000.00	$ 300,000		
2.7.3	Steel Tank Secondary Containment	1,070	CY	$ 471.72	$ 504,740		
2.7.4	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.7.5	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.7.6	Overhead Crane	1	LS	$ 6,685.69	$ 6,686		
2.7.7	Post-Treatment Steel Holding Tank	2	EA	$ 150,000.00	$ 300,000		
2.7.8	Analytical Test Facilities and Equipment	1	LS	$ 50,000.00	$ 50,000		
2.8	**Contact Water System: Hydraulic Structures & Equipment**					**$ 1,899,763**	
2.8.1	Contact Water Transmission Pipeline	1,000	LF	$ 61.80	$ 61,800		
2.8.2	Drain Ports	10	EA	$ 4,450.75	$ 44,508		
2.8.3	Lift Station	1	LS	$ 292,567.00	$ 292,567		
2.8.4	Steel Tank Structure	2	EA	$ 150,000.00	$ 300,000		
2.8.5	Steel Tank Secondary Containment	2,140	CY	$ 471.72	$ 1,009,481		
2.8.6	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.8.7	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.8.8	Electrical Equipment, Control Systems	1	LS	$ 75,000.00	$ 75,000		
3.0	***PHASE 2 CONSTRUCTION***						***$ 39,038,091***
3.1	**General Costs**					**$ 8,299,437**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 30,738,654.00	$ 2,151,706		
3.1.2	Worker Health and Safety Program	5%	LS	$ 30,738,654.00	$ 1,536,933		
3.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 30,738,654.00	$ 4,610,798		
3.2	**Site Work**					**$ 5,597,063**	
3.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
3.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
3.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
3.2.4	Small Surface Water Ditches with Riprap Armor	750	LF	$ 7.77	$ 5,828		
3.2.5	Graveled Road Construction	3,000	LF	$ 52.76	$ 158,280		
3.2.6	Site Grubbing	10	AC	$ 4,784.50	$ 47,845		
3.2.7	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
3.2.8	Signs	1	LS	$ 41,186.30	$ 41,186		
3.2.9	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
3.2.10	Sanitary Treatment System	1	LS	$ 4,522,000.00	$ 4,522,000		
3.2.11	Construction Surveying	32	AC	$ 4,736.59	$ 151,571		
3.3	**Earthwork for Landfill Operations Area**					**$ 23,888,162**	
3.3.1	Strip and Stockpile Topsoil	9,689	CY	$ 5.49	$ 53,193		
3.3.2	Geologic Buffer: Excavation and Replacement	73,013	CY	$ 35.69	$ 2,605,834		
3.3.3	Place/Compact Earthfill Dike	518,642	CY	$ 39.33	$ 20,398,190		
3.3.4	Liner Subgrade: Compact and Grade Side Slopes	10,794	SY	$ 3.32	$ 35,836		
3.3.5	Liner Subgrade: Compact and Grade Base	11,664	SY	$ 3.32	$ 38,724		
3.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	22,458	CY	$ 33.68	$ 756,385		

Table I2.4. Development and Construction Cost Estimate for Site 11 - Low End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 1,226,894**	
3.4.1	Geosynthetics Anchor Trench Preparation	888	LF	$ 1.54	$ 1,368		
3.4.2	Geosynthetics Anchor Trench Backfill and Compaction	888	LF	$ 4.39	$ 3,898		
3.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	202,121	SF	$ 0.66	$ 133,400		
3.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	97,145	SF	$ 0.57	$ 55,373		
3.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	419,904	SF	$ 0.30	$ 125,971		
3.4.6	Gravel Leak Detection Layer	3,888	CY	$ 58.23	$ 226,398		
3.4.7	Leak Detection Pipes: Installation and Materials	1,050	LF	$ 25.60	$ 26,880		
3.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	202,121	SF	$ 0.81	$ 163,718		
3.4.9	Gravel Leachate Collection Layer	3,888	CY	$ 58.23	$ 226,398		
3.4.10	Leachate Collection Pipes: Installation and Materials	1,050	LF	$ 25.60	$ 26,880		
3.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	97,145	SF	$ 0.57	$ 55,373		
3.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
3.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
3.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
3.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
3.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
3.5	**Contact Water System Additions**					**$ 26,535**	
3.5.1	Drain Ports	3	EA	$ 4,450.75	$ 13,352		
3.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
4.0	***PHASE 3 CONSTRUCTION***						***$ 33,281,749***
4.1	**General Costs**					**$ 7,075,647**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 26,206,102.00	$ 1,834,427		
4.1.2	Worker Health and Safety Program	5%	LS	$ 26,206,102.00	$ 1,310,305		
4.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 26,206,102.00	$ 3,930,915		
4.2	**Site Work**					**$ 1,064,511**	
4.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
4.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
4.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
4.2.4	Small Surface Water Ditches with Riprap Armor	750	LF	$ 7.77	$ 5,828		
4.2.5	Graveled Road Construction	2,800	LF	$ 52.76	$ 147,728		
4.2.6	Site Grubbing	10	AC	$ 4,784.50	$ 47,845		
4.2.7	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
4.2.8	Signs	1	LS	$ 41,186.30	$ 41,186		
4.2.9	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
4.2.10	Construction Surveying	32	AC	$ 4,736.59	$ 151,571		
4.3	**Earthwork for Landfill Operations Area**					**$ 23,888,162**	
4.3.1	Strip and Stockpile Topsoil	9,689	CY	$ 5.49	$ 53,193		
4.3.2	Geologic Buffer: Excavation and Replacement	73,013	CY	$ 35.69	$ 2,605,834		
4.3.3	Place/Compact Earthfill Dike	518,642	CY	$ 39.33	$ 20,398,190		
4.3.4	Liner Subgrade: Compact and Grade Side Slopes	10,794	SY	$ 3.32	$ 35,836		
4.3.5	Liner Subgrade: Compact and Grade Base	11,664	SY	$ 3.32	$ 38,724		
4.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	22,458	CY	$ 33.68	$ 756,385		
4.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 1,226,894**	
4.4.1	Geosynthetics Anchor Trench Preparation	888	LF	$ 1.54	$ 1,368		
4.4.2	Geosynthetics Anchor Trench Backfill and Compaction	888	LF	$ 4.39	$ 3,898		
4.4.2	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	202,121	SF	$ 0.66	$ 133,400		
4.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	97,145	SF	$ 0.57	$ 55,373		
4.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	419,904	SF	$ 0.30	$ 125,971		
4.4.6	Gravel Leak Detection Layer	3,888	CY	$ 58.23	$ 226,398		
4.4.7	Leak Detection Pipes: Installation and Materials	1,050	LF	$ 25.60	$ 26,880		
4.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	202,121	SF	$ 0.81	$ 163,718		
4.4.9	Gravel Leachate Collection Layer	3,888	CY	$ 58.23	$ 226,398		
4.4.10	Leachate Collection Pipes: Installation and Materials	1,050	LF	$ 25.60	$ 26,880		
4.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	97,145	SF	$ 0.57	$ 55,373		
4.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
4.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
4.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
4.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
4.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
4.5	**Contact Water System Additions**					**$ 26,535**	
4.5.1	Drain Ports	3	EA	$ 4,450.75	$ 13,352		
4.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Table I2.4. Development and Construction Cost Estimate for Site 11 - Low End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
5.0	***PHASE 4 CONSTRUCTION***						***$ 26,688,830***
5.1	**General Costs**					**$ 5,674,003**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 21,014,827.00	$ 1,471,038		
5.1.2	Worker Health and Safety Program	5%	LS	$ 21,014,827.00	$ 1,050,741		
5.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 21,014,827.00	$ 3,152,224		
5.2	**Site Work**					**$ 877,855**	
5.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
5.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 27,361.58	$ 27,362		
5.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
5.2.4	Small Surface Water Ditches with Riprap Armor	750	LF	$ 7.77	$ 5,828		
5.2.5	Graveled Road Construction	1,400	LF	$ 52.76	$ 73,864		
5.2.6	Site Grubbing	10	AC	$ 4,784.50	$ 47,845		
5.2.7	Outside Lights	1	LS	$ 265,125.20	$ 265,125		
5.2.8	Signs	1	LS	$ 41,186.30	$ 41,186		
5.2.9	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 45,000.00	$ 45,000		
5.2.10	Construction Surveying	26	AC	$ 4,736.59	$ 123,151		
5.3	**Earthwork for Landfill Operations Area**					**$ 19,110,552**	
5.3.1	Strip and Stockpile Topsoil	7,751	CY	$ 5.49	$ 42,553		
5.3.2	Geologic Buffer: Excavation and Replacement	58,411	CY	$ 35.69	$ 2,084,689		
5.3.3	Place/Compact Earthfill Dike	414,914	CY	$ 39.33	$ 16,318,568		
5.3.4	Liner Subgrade: Compact and Grade Side Slopes	8,635	SY	$ 3.32	$ 28,668		
5.3.5	Liner Subgrade: Compact and Grade Base	9,331	SY	$ 3.32	$ 30,979		
5.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	17,966	CY	$ 33.68	$ 605,095		
5.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 995,434**	
5.4.1	Geosynthetics Anchor Trench Preparation	710	LF	$ 1.54	$ 1,093		
5.4.2	Geosynthetics Anchor Trench Backfill and Compaction	710	LF	$ 4.39	$ 3,117		
5.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	161,697	SF	$ 0.66	$ 106,720		
5.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	77,716	SF	$ 0.57	$ 44,298		
5.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	335,923	SF	$ 0.30	$ 100,777		
5.4.6	Gravel Leak Detection Layer	3,110	CY	$ 58.23	$ 181,095		
5.4.7	Leak Detection Pipes: Installation and Materials	840	LF	$ 25.60	$ 21,504		
5.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	161,697	SF	$ 0.81	$ 130,975		
5.4.9	Gravel Leachate Collection Layer	3,110	CY	$ 58.23	$ 181,095		
5.4.10	Leachate Collection Pipes: Installation and Materials	840	LF	$ 25.60	$ 21,504		
5.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	77,716	SF	$ 0.57	$ 44,298		
5.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
5.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
5.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 36,476.53	$ 36,477		
5.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
5.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 52,642.73	$ 52,643		
5.5	**Contact Water System Additions**					**$ 30,986**	
5.5.1	Drain Ports	4	EA	$ 4,450.75	$ 17,803		
5.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Notes:
a. Includes pre-construction geotechnical investigation.
b. Includes seismic investigation.
c. Includes pre-construction groundwater investigation to assess water table and background conditions for constituents predicted to be in proposed waste streams.
d. Includes 30%, 60%, 90% and for construction design packages, test pad, methane gas generation study, etc.

Table I2.5. Development and Construction Cost Estimate for Site 3A - Base Case Volume Scenario

General Information and Assumptions:

Landfill Operations Area	2,826,682	SF	$ 64.89	AC
Total Centerline Length of Earthfill Dike	5,130	LF		
Average Cross Sectional Area of Earthfill Dike	10,840	SF		
Liner Crest Footprint	1,270,561	SF	$ 29.17	AC
Liner Base Area	764,530	SF	$ 17.55	AC
Area of Liner on Side Slopes	533,404	SF	$ 12.25	AC
Total Liner Area	1,297,934	SF	$ 29.80	AC
Total Liner Anchor Trench Length	4,719	LF		
Dike Fill Volume	1,939,198	CY		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Construction Phases:	Year	Percent of Liner Area Constructed		
Phase 1	2014	30%		
Phase 2	2019	25%		
Phase 3	2025	25%		
Phase 4	2031	20%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Planning, Environmental, and Engineering Services	$ 16,179,234	$ 2,426,885	$ -	$ 18,606,119
Phase 1 Construction	$ 102,635,150	$ 15,395,273	$ 30,790,545	$ 148,820,968
Phase 2 Construction	$ 57,605,606	$ 8,640,841	$ 17,281,682	$ 83,528,129
Phase 3 Construction	$ 45,666,076	$ 6,849,911	$ 13,699,823	$ 66,215,810
Phase 4 Construction	$ 36,623,390	$ 5,493,509	$ 10,987,017	$ 53,103,916
TOTAL SITE 3A CAPITAL COST	**$ 258,709,456**	**$ 38,806,419**	**$ 72,759,067**	**$ 370,274,942**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***PLANNING, ENVIRONMENTAL AND ENGINEERING SERVICES***						***$16,179,234***
1.1	**NEPA Substantive Requirements Documentation**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.2	**Environmental Site Studies[a]**	**1**	**LS**	**$ 400,000.00**	**$ 400,000**	**$400,000**	
1.3	**Remedial Design Work Plan and Associated Field Work[b]**	**1**	**LS**	**$ 2,219,800.00**	**$ 2,219,800**	**$2,219,800**	
1.4	**Hydrogeological Studies, GW Wells and Monitoring Plan[c]**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.5	**OSWDF Remedial Action Work Plan (1 per Phase)**	**4**	**EA**	**$ 270,700.00**	**$ 1,082,800**	**$1,082,800**	
1.6	**Develop Construction Work Control Documents and Procedures**	**1**	**LS**	**$ 231,595.00**	**$ 231,595**	**$231,595**	
1.7	**Develop Operations Documents**	**1**	**LS**	**$ 635,785.00**	**$ 635,785**	**$635,785**	
1.8	**OSWDF Procurement**	**1**	**LS**	**$ 829,254.00**	**$ 829,254**	**$829,254**	
1.9	**Critical Decision Packages (1 per Phase)**	**4**	**EA**	**$ 560,000.00**	**$ 2,240,000**	**$2,240,000**	
1.10	**OSWDF Design[d]**	**1**	**LS**	**$ 5,420,000.00**	**$ 5,420,000**	**$5,420,000**	
1.11	**Safety Basis Documents**	**1**	**LS**	**$ 440,000.00**	**$ 440,000**	**$440,000**	
1.12	**OSWDF Remedial Action Completion Report (1 per Phase)**	**4**	**EA**	**$ 120,000.00**	**$ 480,000**	**$480,000**	
1.13	**Construction QC Plan, Post-construction Report, O&M Plan (1 per Phase)**	**4**	**EA**	**$ 250,000.00**	**$ 1,000,000**	**$1,000,000**	
2.0	***PHASE 1 CONSTRUCTION***						***$102,635,150***
2.1	**General Costs**					**$21,842,895**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 80,792,255.00	$ 5,655,458		
2.1.2	Wetlands Replacement Cost	21.4	AC	$ 1,354.50	$ 28,986		
2.1.3	Worker Health and Safety Program	5%	LS	$ 80,792,255.00	$ 4,039,613		
2.1.4	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 80,792,255.00	$ 12,118,838		
2.2	**Site Work and Improvements**					**$5,183,457**	
2.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
2.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 41,042.37	$ 41,042		
2.2.3	Additional GW Monitoring Well(s)	14	EA	$ 16,494.00	$ 230,916		
2.2.4	Clearing and Grubbing (Forested Areas)	50	AC	$ 6,856.25	$ 342,813		
2.2.5	Clearing and Grubbing (Semi-open Areas)	40	AC	$ 4,784.50	$ 191,380		
2.2.6	Site Perimeter Run-on Control Berm and Road	10,400	LF	$ 85.80	$ 892,320		
2.2.7	Paved Road Construction	2,000	LF	$ 75.85	$ 151,700		
2.2.8	Graveled Road Construction	5,000	LF	$ 52.76	$ 263,800		
2.2.9	Parking Areas	14,000	LS	$ 6.36	$ 89,040		
2.2.10	Site Perimeter Fence	10,900	LF	$ 41.71	$ 454,639		
2.2.11	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	5,000	LF	$ 52.61	$ 263,050		
2.2.12	Entrance Gate	3	EA	$ 4,272.50	$ 12,818		
2.2.13	Truck Scale	3	EA	$ 75,000.00	$ 225,000		
2.2.14	Outside Lights	1	LS	$ 397,687.80	$ 397,688		
2.2.15	High Security Area Lighting and Electrical	1	LS	$ 226,756.86	$ 226,757		
2.2.16	Signs	1	LS	$ 41,186.30	$ 41,186		
2.2.17	Site Topographic Survey	110	AC	$ 4,736.59	$ 521,025		
2.2.18	Site Layout Survey	65	AC	$ 4,736.59	$ 307,878		
2.2.19	Construction Surveying	63	AC	$ 4,736.59	$ 298,405		
2.3	**Buildings, Utilities, and Supplies**					**$28,377,062**	
2.3.1	Administrative/Office Building	5,400	SF	$ 316.64	$ 1,709,856		
2.3.2	Office Computers, Furniture, Administrative Supplies	1	LS	$ 300,000.00	$ 300,000		
2.3.3	Maintenance Shop	1	EA	$ 744,960.00			
	Pre-engineered Steel Building	4,800	SF	$ 155.20	$ 744,960		
2.3.4	Leachate Treatment Building	1	EA	$ 25,219,885.00			
	Sitework	1	LS	$ 192,760.00	$ 192,760		
	Building Construction	1	LS	$ 1,622,490.00	$ 1,622,490		
	System Equipment	1	LS	$ 20,199,135.00	$ 20,199,135		
	Accessory Equipment and Tanks	1	LS	$ 1,219,850.00	$ 1,219,850		
	Electrical, Monitoring, and Controls	1	LS	$ 1,985,650.00	$ 1,985,650		
2.3.5	Sanitary Treatment System	1	LS	$ 21,840.00	$ 21,840		
2.3.6	Water Supply and Distribution System	1	LS	$ 92,640.00	$ 92,640		
2.3.7	Fire Hydrants and Service Connections	1	LS	$ 27,300.00	$ 27,300		
2.3.8	Electrical and Telecommunications	1	LS	$ 248,889.00	$ 248,889		
2.3.9	Guard Shacks and Equipment	2	EA	$ 5,846.00	$ 11,692		

Table I2.5. Development and Construction Cost Estimate for Site 3A - Base Case Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
2.4	**Sitewide Surface Water Improvements**					**$535,393**	
2.4.1	Strip and Stockpile Topsoil, Ditch and Pond Areas	8,000	CY	$ 5.49	$ 43,920		
2.4.2	Large Surface Water Ditches with Riprap Armor (incl. Outfall)	4,000	LF	$ 7.77	$ 31,080		
2.4.3	Small Surface Water Ditches with Riprap Armor	4,000	LF	$ 7.77	$ 31,080		
2.4.4	Surface Water Pond Excavation	62,920	CY	$ 4.18	$ 263,006		
2.4.5	Surface Water Pond Overflow	1,000	LF	$ 7.77	$ 7,770		
2.4.6	Surface Water Pumps, Pipes, Fittings, and Ancillary Equipment	1	LS	$ 91,036.50	$ 91,037		
2.4.7	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 67,500.00	$ 67,500		
2.5	**Earthwork for Landfill Operations Area**					**$39,045,229**	
2.5.1	Strip and Stockpile Topsoil	15,704	CY	$ 5.49	$ 86,215		
2.5.2	Geologic Buffer: Excavation and Replacement	141,173	CY	$ 35.69	$ 5,038,464		
2.5.3	Place/Compact Earthfill Dike	821,759	CY	$ 39.33	$ 32,319,781		
2.5.4	Liner Subgrade: Compact and Grade Side Slopes	17,780	SY	$ 3.32	$ 59,030		
2.5.5	Liner Subgrade: Compact and Grade Base	25,484	SY	$ 3.32	$ 84,607		
2.5.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	43,264	CY	$ 33.68	$ 1,457,132		
2.6	**Geosynthetic Liner and Leachate Collection Systems**					**$2,348,738**	
2.6.1	Geosynthetics Anchor Trench Preparation	1,416	LF	$ 1.54	$ 2,181		
2.6.2	Geosynthetics Anchor Trench Backfill and Compaction	1,416	LF	$ 4.39	$ 6,216		
2.6.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	389,380	SF	$ 0.66	$ 256,991		
2.6.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	160,021	SF	$ 0.57	$ 91,212		
2.6.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	917,436	SF	$ 0.30	$ 275,231		
2.6.6	Gravel Leak Detection Layer	8,495	CY	$ 58.23	$ 494,664		
2.6.7	Leak Detection Pipes: Installation and Materials	2,294	LF	$ 25.60	$ 58,726		
2.6.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	389,380	SF	$ 0.81	$ 315,398		
2.6.9	Gravel Leachate Collection Layer	8,495	CY	$ 58.23	$ 494,664		
2.6.10	Leachate Collection Pipes: Installation and Materials	2,294	LF	$ 25.60	$ 58,726		
2.6.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	160,021	SF	$ 0.57	$ 91,212		
2.6.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
2.6.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
2.6.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 54,714.80	$ 54,715		
2.6.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
2.6.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 78,964.10	$ 78,964		
2.7	**Leachate Treatment Facility: Hydraulic Structures & Equipment**					**$2,570,781**	
2.7.1	Leachate Transmission Pipeline	4,625	LF	$ 61.80	$ 285,825		
2.7.2	Steel Tank Structure	2	EA	$ 150,000.00	$ 300,000		
2.7.3	Steel Tank Secondary Containment	3,205	CY	$ 471.72	$ 1,511,863		
2.7.4	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.7.5	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.7.6	Overhead Crane	1	LS	$ 6,685.69	$ 6,686		
2.7.7	Post-Treatment Steel Holding Tank	2	EA	$ 150,000.00	$ 300,000		
2.7.8	Analytical Test Facilities and Equipment	1	LS	$ 50,000.00	$ 50,000		
2.8	**Contact Water System: Hydraulic Structures & Equipment**					**$2,731,595**	
2.8.1	Contact Water Transmission Pipeline	1,000	LF	$ 61.80	$ 61,800		
2.8.2	Drain Ports	11	EA	$ 4,450.75	$ 48,958		
2.8.3	Lift Station	1	LS	$ 292,567.00	$ 292,567		
2.8.4	Steel Tank Structure	4	EA	$ 150,000.00	$ 600,000		
2.8.5	Steel Tank Secondary Containment	3,205	CY	$ 471.72	$ 1,511,863		
2.8.6	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.8.7	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.8.8	Electrical Equipment, Control Systems	1	LS	$ 100,000.00	$ 100,000		
3.0	***PHASE 2 CONSTRUCTION***						***$57,605,606***
3.1	**General Costs**					**$12,246,861**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 45,358,745.00	$ 3,175,112		
3.1.2	Worker Health and Safety Program	5%	LS	$ 45,358,745.00	$ 2,267,937		
3.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 45,358,745.00	$ 6,803,812		
3.2	**Site Work**					**$10,821,117**	
3.2.1	Relocate Overhead Electrical Power Lines and Towers	1	LS	$ 4,868,653.00	$ 4,868,653		
3.2.2	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
3.2.3	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
3.2.4	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
3.2.5	Small Surface Water Ditches with Riprap Armor	1,000	LF	$ 7.77	$ 7,770		
3.2.6	Graveled Road Construction	2,600	LF	$ 52.76	$ 137,176		
3.2.7	Site Grubbing	7	AC	$ 4,784.50	$ 33,492		
3.2.8	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
3.2.9	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
3.2.10	High Security Area Lighting and Electrical	1	LS	$ 188,964.05	$ 188,964		
3.2.11	Signs	1	LS	$ 41,186.30	$ 41,186		
3.2.12	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
3.2.13	Sanitary Treatment System	1	LS	$ 4,522,000.00	$ 4,522,000		
3.2.14	Construction Surveying	52	AC	$ 4,736.59	$ 246,303		
3.3	**Earthwork for Landfill Operations Area**					**$32,537,774**	
3.3.1	Strip and Stockpile Topsoil	13,086	CY	$ 5.49	$ 71,842		
3.3.2	Geologic Buffer: Excavation and Replacement	117,645	CY	$ 35.69	$ 4,198,750		
3.3.3	Place/Compact Earthfill Dike	684,800	CY	$ 39.33	$ 26,933,184		
3.3.4	Liner Subgrade: Compact and Grade Side Slopes	14,817	SY	$ 3.32	$ 49,192		
3.3.5	Liner Subgrade: Compact and Grade Base	21,237	SY	$ 3.32	$ 70,507		
3.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	36,054	CY	$ 33.68	$ 1,214,299		

Table I2.5. Development and Construction Cost Estimate for Site 3A - Base Case Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.4	**Geosynthetic Liner and Leachate Collection Systems**					**$1,968,868**	
3.4.1	Geosynthetics Anchor Trench Preparation	1,180	LF	$ 1.54	$ 1,817		
3.4.2	Geosynthetics Anchor Trench Backfill and Compaction	1,180	LF	$ 4.39	$ 5,180		
3.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	324,484	SF	$ 0.66	$ 214,159		
3.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	133,351	SF	$ 0.57	$ 76,010		
3.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	764,530	SF	$ 0.30	$ 229,359		
3.4.6	Gravel Leak Detection Layer	7,079	CY	$ 58.23	$ 412,210		
3.4.7	Leak Detection Pipes: Installation and Materials	1,911	LF	$ 25.60	$ 48,922		
3.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	324,484	SF	$ 0.81	$ 262,832		
3.4.9	Gravel Leachate Collection Layer	7,079	CY	$ 58.23	$ 412,210		
3.4.10	Leachate Collection Pipes: Installation and Materials	1,911	LF	$ 25.60	$ 48,922		
3.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	133,351	SF	$ 0.57	$ 76,010		
3.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
3.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
3.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
3.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
3.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
3.5	**Contact Water System Additions**					**$30,986**	
3.5.1	Drain Ports	4	EA	$ 4,450.75	$ 17,803		
3.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
4.0	***PHASE 3 CONSTRUCTION***						***$45,666,076***
4.1	**General Costs**					**$9,708,536**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 35,957,540.00	$ 2,517,028		
4.1.2	Worker Health and Safety Program	5%	LS	$ 35,957,540.00	$ 1,797,877		
4.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 35,957,540.00	$ 5,393,631		
4.2	**Site Work**					**$1,419,912**	
4.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
4.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
4.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
4.2.4	Small Surface Water Ditches with Riprap Armor	1,000	LF	$ 7.77	$ 7,770		
4.2.5	Graveled Road Construction	2,400	LF	$ 52.76	$ 126,624		
4.2.6	Site Grubbing	7	AC	$ 4,784.50	$ 33,492		
4.2.7	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
4.2.8	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
4.2.9	High Security Area Lighting and Electrical	1	LS	$ 188,964.05	$ 188,964		
4.2.10	Signs	1	LS	$ 41,186.30	$ 41,186		
4.2.11	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
4.2.12	Construction Surveying	52	AC	$ 4,736.59	$ 246,303		
4.3	**Earthwork for Landfill Operations Area**					**$32,537,774**	
4.3.1	Strip and Stockpile Topsoil	13,086	CY	$ 5.49	$ 71,842		
4.3.2	Geologic Buffer: Excavation and Replacement	117,645	CY	$ 35.69	$ 4,198,750		
4.3.3	Place/Compact Earthfill Dike	684,800	CY	$ 39.33	$ 26,933,184		
4.3.4	Liner Subgrade: Compact and Grade Side Slopes	14,817	SY	$ 3.32	$ 49,192		
4.3.5	Liner Subgrade: Compact and Grade Base	21,237	SY	$ 3.32	$ 70,507		
4.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	36,054	CY	$ 33.68	$ 1,214,299		
4.4	**Geosynthetic Liner and Leachate Collection Systems**					**$1,968,868**	
4.4.1	Geosynthetics Anchor Trench Preparation	1,180	LF	$ 1.54	$ 1,817		
4.4.2	Geosynthetics Anchor Trench Backfill and Compaction	1,180	LF	$ 4.39	$ 5,180		
4.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	324,484	SF	$ 0.66	$ 214,159		
4.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	133,351	SF	$ 0.57	$ 76,010		
4.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	764,530	SF	$ 0.30	$ 229,359		
4.4.6	Gravel Leak Detection Layer	7,079	CY	$ 58.23	$ 412,210		
4.4.7	Leak Detection Pipes: Installation and Materials	1,911	LF	$ 25.60	$ 48,922		
4.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	324,484	SF	$ 0.81	$ 262,832		
4.4.9	Gravel Leachate Collection Layer	7,079	CY	$ 58.23	$ 412,210		
4.4.10	Leachate Collection Pipes: Installation and Materials	1,911	LF	$ 25.60	$ 48,922		
4.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	133,351	SF	$ 0.57	$ 76,010		
4.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
4.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
4.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
4.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
4.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
4.5	**Contact Water System Additions**					**$30,986**	
4.5.1	Drain Ports	4	EA	$ 4,450.75	$ 17,803		
4.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Table I2.5. Development and Construction Cost Estimate for Site 3A - Base Case Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
5.0	***PHASE 4 CONSTRUCTION***						***$36,623,390***
5.1	**General Costs**					**$7,786,075**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 28,837,315.00	$ 2,018,612		
5.1.2	Worker Health and Safety Program	5%	LS	$ 28,837,315.00	$ 1,441,866		
5.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 28,837,315.00	$ 4,325,597		
5.2	**Site Work**					**$1,187,069**	
5.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
5.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 27,361.58	$ 27,362		
5.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
5.2.4	Small Surface Water Ditches with Riprap Armor	1,000	LF	$ 7.77	$ 7,770		
5.2.5	Graveled Road Construction	1,200	LF	$ 52.76	$ 63,312		
5.2.6	Site Grubbing	7	AC	$ 4,784.50	$ 33,492		
5.2.7	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
5.2.8	Outside Lights	1	LS	$ 265,125.20	$ 265,125		
5.2.9	High Security Area Lighting and Electrical	1	LS	$ 151,171.24	$ 151,171		
5.2.10	Signs	1	LS	$ 41,186.30	$ 41,186		
5.2.11	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 45,000.00	$ 45,000		
5.2.12	Construction Surveying	42	AC	$ 4,736.59	$ 198,937		
5.3	**Earthwork for Landfill Operations Area**					**$26,030,213**	
5.3.1	Strip and Stockpile Topsoil	10,469	CY	$ 5.49	$ 57,475		
5.3.2	Geologic Buffer: Excavation and Replacement	94,116	CY	$ 35.69	$ 3,359,000		
5.3.3	Place/Compact Earthfill Dike	547,840	CY	$ 39.33	$ 21,546,547		
5.3.4	Liner Subgrade: Compact and Grade Side Slopes	11,853	SY	$ 3.32	$ 39,352		
5.3.5	Liner Subgrade: Compact and Grade Base	16,990	SY	$ 3.32	$ 56,407		
5.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	28,843	CY	$ 33.68	$ 971,432		
5.4	**Geosynthetic Liner and Leachate Collection Systems**					**$1,589,047**	
5.4.1	Geosynthetics Anchor Trench Preparation	944	LF	$ 1.54	$ 1,454		
5.4.2	Geosynthetics Anchor Trench Backfill and Compaction	944	LF	$ 4.39	$ 4,144		
5.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	259,587	SF	$ 0.66	$ 171,327		
5.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	106,681	SF	$ 0.57	$ 60,808		
5.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	611,624	SF	$ 0.30	$ 183,487		
5.4.6	Gravel Leak Detection Layer	5,663	CY	$ 58.23	$ 329,756		
5.4.7	Leak Detection Pipes: Installation and Materials	1,529	LF	$ 25.60	$ 39,142		
5.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	259,587	SF	$ 0.81	$ 210,265		
5.4.9	Gravel Leachate Collection Layer	5,663	CY	$ 58.23	$ 329,756		
5.4.10	Leachate Collection Pipes: Installation and Materials	1,529	LF	$ 25.60	$ 39,142		
5.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	106,681	SF	$ 0.57	$ 60,808		
5.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
5.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
5.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 36,476.53	$ 36,477		
5.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
5.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 52,642.73	$ 52,643		
5.5	**Contact Water System Additions**					**$30,986**	
5.5.1	Drain Ports	4	EA	$ 4,450.75	$ 17,803		
5.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Notes:
a. Includes pre-construction geotechnical investigation.
b. Includes seismic investigation.
c. Includes pre-construction groundwater investigation to assess water table and background conditions for constituents predicted to be in proposed waste streams.
d. Includes 30%, 60%, 90% and for construction design packages, test pad, methane gas generation study, etc.

Table I2.6. Development and Construction Cost Estimate for Site 11 - Base Case Volume Scenario

General Information and Assumptions:

Landfill Operations Area	2,866,171	SF	$ 65.80	AC
Total Centerline Length of Earthfill Dike	4,971	LF		
Average Cross Sectional Area of Earthfill Dike	10,840	SF		
Liner Crest Footprint	1,251,530	SF	$ 28.73	AC
Liner Base Area	762,501	SF	$ 17.50	AC
Area of Liner on Side Slopes	515,482	SF	$ 11.83	AC
Total Liner Area	1,277,983	SF	$ 29.34	AC
Total Liner Anchor Trench Length	4,560	LF		
Dike Fill Volume	2,046,170	CY		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Construction Phases:	Year	Percent of Liner Area Constructed		
Phase 1	2014	30%		
Phase 2	2019	25%		
Phase 3	2025	25%		
Phase 4	2031	20%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Planning, Environmental, and Engineering Services	$ 16,179,234	$ 2,426,885	$ -	$ 18,606,119
Phase 1 Construction	$ 110,780,048	$ 16,617,007	$ 33,234,014	$ 160,631,069
Phase 2 Construction	$ 52,670,081	$ 7,900,512	$ 15,801,024	$ 76,371,617
Phase 3 Construction	$ 46,913,741	$ 7,037,061	$ 14,074,122	$ 68,024,924
Phase 4 Construction	$ 37,615,462	$ 5,642,319	$ 11,284,639	$ 54,542,420
TOTAL SITE 11 CAPITAL COST	**$ 264,158,566**	**$ 39,623,784**	**$ 74,393,799**	**$ 378,176,149**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***PLANNING, ENVIRONMENTAL AND ENGINEERING SERVICES***						***$ 16,179,234***
1.1	**NEPA Substantive Requirements Documentation**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.2	**Environmental Site Studies[a]**	**1**	**LS**	**$ 400,000.00**	**$ 400,000**	**$400,000**	
1.3	**Remedial Design Work Plan and Associated Field Work[b]**	**1**	**LS**	**$ 2,219,800.00**	**$ 2,219,800**	**$2,219,800**	
1.4	**Hydrogeological Studies, GW Wells and Monitoring Plan[c]**	**1**	**LS**	**$ 600,000.00**	**$ 600,000**	**$600,000**	
1.5	**OSWDF Remedial Action Work Plan (1 per Phase)**	**4**	**EA**	**$ 270,700.00**	**$ 1,082,800**	**$1,082,800**	
1.6	**Develop Construction Work Control Documents and Procedures**	**1**	**LS**	**$ 231,595.00**	**$ 231,595**	**$231,595**	
1.7	**Develop Operations Documents**	**1**	**LS**	**$ 635,785.00**	**$ 635,785**	**$635,785**	
1.8	**OSWDF Procurement**	**1**	**LS**	**$ 829,254.00**	**$ 829,254**	**$829,254**	
1.9	**Critical Decision Packages (1 per Phase)**	**4**	**EA**	**$ 560,000.00**	**$ 2,240,000**	**$2,240,000**	
1.10	**OSWDF Design[d]**	**1**	**LS**	**$ 5,420,000.00**	**$ 5,420,000**	**$5,420,000**	
1.11	**Safety Basis Documents**	**1**	**LS**	**$ 440,000.00**	**$ 440,000**	**$440,000**	
1.12	**OSWDF Remedial Action Completion Report (1 per Phase)**	**4**	**EA**	**$ 120,000.00**	**$ 480,000**	**$480,000**	
1.13	**Construction QC Plan, Post-construction Report, O&M Plan (1 per Phase)**	**4**	**EA**	**$ 250,000.00**	**$ 1,000,000**	**$1,000,000**	
2.0	***PHASE 1 CONSTRUCTION***						***$ 110,780,048***
2.1	**General Costs**					**$ 23,554,660**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 87,225,388.00	$ 6,105,777		
2.1.2	Wetlands Replacement Cost	2.81	AC	$ 1,354.50	$ 3,806		
2.1.3	Worker Health and Safety Program	5%	LS	$ 87,225,388.00	$ 4,361,269		
2.1.4	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 87,225,388.00	$ 13,083,808		
2.2	**Site Work and Improvements**					**$ 11,293,218**	
2.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
2.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 41,042.37	$ 41,042		
2.2.3	Additional GW Monitoring Well(s)	10	EA	$ 16,494.00	$ 164,940		
2.2.4	Clearing and Grubbing (Forested Areas)	40	AC	$ 6,856.25	$ 274,250		
2.2.5	Indiana Bat Habitat Mitigation	40	AC	$ 6,000.00	$ 240,000		
2.2.6	Clearing and Grubbing (Semi-open Areas)	40	AC	$ 4,784.50	$ 191,380		
2.2.7	Re-route Little Bayou Creek	1	LS	$ 20,000.00	$ 20,000		
2.2.8	Site Perimeter Run-on Control Berm and Road	10,000	LF	$ 85.80	$ 858,000		
2.2.9	Paved Road Construction	2,800	LF	$ 75.85	$ 212,380		
2.2.10	Graveled Road Construction	4,600	LF	$ 52.76	$ 242,696		
2.2.11	Haul Road Overpass	1	LS	$ 6,000,000.00	$ 6,000,000		
2.2.12	Parking Areas	14,000	LS	$ 6.36	$ 89,040		
2.2.13	Site Perimeter Fence	10,500	LF	$ 41.71	$ 437,955		
2.2.14	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	5,000	LF	$ 52.61	$ 263,050		
2.2.15	Entrance Gate (secure area)	2	EA	$ 4,272.50	$ 8,545		
2.2.16	Truck Scale (Replacement or Improvements to Existing)	3	EA	$ 75,000.00	$ 225,000		
2.2.17	Outside Lights	1	LS	$ 397,687.80	$ 397,688		
2.2.18	High Security Area Lighting and Electrical	1	LS	$ 226,756.86	$ 226,757		
2.2.19	Signs	1	LS	$ 41,186.30	$ 41,186		
2.2.20	Site Topographic Survey	110	AC	$ 4,736.59	$ 521,025		
2.2.21	Site Layout Survey	66	AC	$ 4,736.59	$ 312,615		
2.2.22	Construction Surveying	62	AC	$ 4,736.59	$ 293,669		
2.3	**Buildings, Utilities, and Supplies**					**$ 27,442,118**	
2.3.1	Administrative/Office Building Addition	4,800	SF	$ 316.64	$ 1,519,872		
2.3.2	Office Computers, Furniture, Administrative Supplies	1	LS	$ 300,000.00	$ 300,000		
2.3.3	Maintenance Shop [Existing Shop Will Be Used]	0	EA				
2.3.4	Leachate Treatment Building	1	EA	$ 25,219,885.00			
	Sitework	1	LS	$ 192,760.00	$ 192,760		
	Building Construction	1	LS	$ 1,622,490.00	$ 1,622,490		
	System Equipment	1	LS	$ 20,199,135.00	$ 20,199,135		
	Accessory Equipment and Tanks	1	LS	$ 1,219,850.00	$ 1,219,850		
	Electrical, Monitoring, and Controls	1	LS	$ 1,985,650.00	$ 1,985,650		
2.3.5	Sanitary Treatment System	1	LS	$ 21,840.00	$ 21,840		
2.3.6	Water Supply and Distribution System	1	LS	$ 92,640.00	$ 92,640		
2.3.7	Fire Hydrants and Service Connections	1	LS	$ 27,300.00	$ 27,300		
2.3.8	Telecommunications	1	LS	$ 248,889.00	$ 248,889		
2.3.9	Guard Shacks and Equipment	2	EA	$ 5,846.00	$ 11,692		

Table I2.6. Development and Construction Cost Estimate for Site 11 - Base Case Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
2.4	**Sitewide Surface Water Improvements**					**$ 519,853**	
2.4.1	Strip and Stockpile Topsoil, Ditch and Pond Areas	8,000	CY	$ 5.49	$ 43,920		
2.4.2	Large Surface Water Ditches with Riprap Armor (incl. Outfall)	3,000	LF	$ 7.77	$ 23,310		
2.4.3	Small Surface Water Ditches with Riprap Armor	3,000	LF	$ 7.77	$ 23,310		
2.4.4	Surface Water Pond Excavation	62,920	CY	$ 4.18	$ 263,006		
2.4.5	Surface Water Pond Overflow	1,000	LF	$ 7.77	$ 7,770		
2.4.6	Surface Water Pumps, Pipes, Fittings, and Ancillary Equipment	1	LS	$ 91,036.50	$ 91,037		
2.4.7	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 67,500.00	$ 67,500		
2.5	**Earthwork for Landfill Operations Area**					**$ 40,208,559**	
2.5.1	Strip and Stockpile Topsoil	15,923	CY	$ 5.49	$ 87,417		
2.5.2	Geologic Buffer: Excavation and Replacement	139,059	CY	$ 35.69	$ 4,963,016		
2.5.3	Place/Compact Earthfill Dike	853,851	CY	$ 39.33	$ 33,581,960		
2.5.4	Liner Subgrade: Compact and Grade Side Slopes	17,183	SY	$ 3.32	$ 57,048		
2.5.5	Liner Subgrade: Compact and Grade Base	25,417	SY	$ 3.32	$ 84,384		
2.5.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	42,599	CY	$ 33.68	$ 1,434,734		
2.6	**Geosynthetic Liner and Leachate Collection Systems**					**$ 2,329,813**	
2.6.1	Geosynthetics Anchor Trench Preparation	1,368	LF	$ 1.54	$ 2,107		
2.6.2	Geosynthetics Anchor Trench Backfill and Compaction	1,368	LF	$ 4.39	$ 6,006		
2.6.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	383395	SF	$ 0.66	$ 253,041		
2.6.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	154,645	SF	$ 0.57	$ 88,148		
2.6.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	915,001	SF	$ 0.30	$ 274,500		
2.6.6	Gravel Leak Detection Layer	8,472	CY	$ 58.23	$ 493,325		
2.6.7	Leak Detection Pipes: Installation and Materials	2,288	LF	$ 25.60	$ 58,573		
2.6.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	383,395	SF	$ 0.81	$ 310,550		
2.6.9	Gravel Leachate Collection Layer	8,472	CY	$ 58.23	$ 493,325		
2.6.10	Leachate Collection Pipes: Installation and Materials	2,288	LF	$ 25.60	$ 58,573		
2.6.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	154,645	SF	$ 0.57	$ 88,148		
2.6.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
2.6.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
2.6.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 54,714.80	$ 54,715		
2.6.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
2.6.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 78,964.10	$ 78,964		
2.7	**Leachate Treatment Facility: Hydraulic Structures & Equipment**					**$ 2,720,781**	
2.7.1	Leachate Transmission Pipeline	4,625	LF	$ 61.80	$ 285,825		
2.7.2	Steel Tank Structure	3	EA	$ 150,000.00	$ 450,000		
2.7.3	Steel Tank Secondary Containment	3,205	CY	$ 471.72	$ 1,511,863		
2.7.4	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.7.5	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.7.6	Overhead Crane	1	LS	$ 6,685.69	$ 6,686		
2.7.7	Post-Treatment Steel Holding Tank	2	EA	$ 150,000.00	$ 300,000		
2.7.8	Analytical Test Facilities and Equipment	1	LS	$ 50,000.00	$ 50,000		
2.8	**Contact Water System: Hydraulic Structures & Equipment**					**$ 2,711,046**	
2.8.1	Contact Water Transmission Pipeline	1,000	LF	$ 61.80	$ 61,800		
2.8.2	Drain Ports	12	EA	$ 4,450.75	$ 53,409		
2.8.3	Lift Station	1	LS	$ 292,567.00	$ 292,567		
2.8.4	Steel Tank Structure	4	EA	$ 150,000.00	$ 600,000		
2.8.5	Steel Tank Secondary Containment	3,205	CY	$ 471.72	$ 1,511,863		
2.8.6	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
2.8.7	Pumps and Motors	1	LS	$ 103,224.00	$ 103,224		
2.8.8	Electrical Equipment, Control Systems	1	LS	$ 75,000.00	$ 75,000		
3.0	***PHASE 2 CONSTRUCTION***						***$ 52,670,081***
3.1	**General Costs**					**$ 11,197,576**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 41,472,505.00	$ 2,903,075		
3.1.2	Worker Health and Safety Program	5%	LS	$ 41,472,505.00	$ 2,073,625		
3.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 41,472,505.00	$ 6,220,876		
3.2	**Site Work**					**$ 5,981,242**	
3.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
3.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
3.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
3.2.4	Small Surface Water Ditches with Riprap Armor	750	LF	$ 7.77	$ 5,828		
3.2.5	Graveled Road Construction	3,000	LF	$ 52.76	$ 158,280		
3.2.6	Site Grubbing	10	AC	$ 4,784.50	$ 47,845		
3.2.7	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
3.2.8	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
3.2.9	High Security Area Lighting and Electrical	1	LS	$ 188,964.05	$ 188,964		
3.2.10	Signs	1	LS	$ 41,186.30	$ 41,186		
3.2.11	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
3.2.12	Sanitary Treatment System	1	LS	$ 4,522,000.00	$ 4,522,000		
3.2.13	Construction Surveying	51	AC	$ 4,736.59	$ 241,566		
3.3	**Earthwork for Landfill Operations Area**					**$ 33,507,162**	
3.3.1	Strip and Stockpile Topsoil	13,269	CY	$ 5.49	$ 72,847		
3.3.2	Geologic Buffer: Excavation and Replacement	115,882	CY	$ 35.69	$ 4,135,829		
3.3.3	Place/Compact Earthfill Dike	711,543	CY	$ 39.33	$ 27,984,986		
3.3.4	Liner Subgrade: Compact and Grade Side Slopes	14,319	SY	$ 3.32	$ 47,539		
3.3.5	Liner Subgrade: Compact and Grade Base	21,181	SY	$ 3.32	$ 70,321		
3.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	35,500	CY	$ 33.68	$ 1,195,640		

Table I2.6. Development and Construction Cost Estimate for Site 11 - Base Case Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 1,953,115**	
3.4.1	Geosynthetics Anchor Trench Preparation	1,140	LF	$ 1.54	$ 1,756		
3.4.2	Geosynthetics Anchor Trench Backfill and Compaction	1,140	LF	$ 4.39	$ 5,005		
3.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	319,496	SF	$ 0.66	$ 210,867		
3.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	128,871	SF	$ 0.57	$ 73,456		
3.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	762,501	SF	$ 0.30	$ 228,750		
3.4.6	Gravel Leak Detection Layer	7,060	CY	$ 58.23	$ 411,104		
3.4.7	Leak Detection Pipes: Installation and Materials	1,906	LF	$ 25.60	$ 48,794		
3.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	319,496	SF	$ 0.81	$ 258,792		
3.4.9	Gravel Leachate Collection Layer	7,060	CY	$ 58.23	$ 411,104		
3.4.10	Leachate Collection Pipes: Installation and Materials	1,906	LF	$ 25.60	$ 48,794		
3.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	128,871	SF	$ 0.57	$ 73,456		
3.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
3.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
3.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
3.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
3.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
3.5	**Contact Water System Additions**					**$ 30,986**	
3.5.1	Drain Ports	4	EA	$ 4,450.75	$ 17,803		
3.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		
4.0	***PHASE 3 CONSTRUCTION***						***$ 46,913,741***
4.1	**General Costs**					**$ 9,973,788**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 36,939,953.00	$ 2,585,797		
4.1.2	Worker Health and Safety Program	5%	LS	$ 36,939,953.00	$ 1,846,998		
4.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 36,939,953.00	$ 5,540,993		
4.2	**Site Work**					**$ 1,448,690**	
4.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
4.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 34,201.98	$ 34,202		
4.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
4.2.4	Small Surface Water Ditches with Riprap Armor	750	LF	$ 7.77	$ 5,828		
4.2.5	Graveled Road Construction	2,800	LF	$ 52.76	$ 147,728		
4.2.6	Site Grubbing	10	AC	$ 4,784.50	$ 47,845		
4.2.7	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
4.2.8	Outside Lights	1	LS	$ 331,406.50	$ 331,407		
4.2.9	High Security Area Lighting and Electrical	1	LS	$ 188,964.05	$ 188,964		
4.2.10	Signs	1	LS	$ 41,186.30	$ 41,186		
4.2.11	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 56,250.00	$ 56,250		
4.2.12	Construction Surveying	51	AC	$ 4,736.59	$ 241,566		
4.3	**Earthwork for Landfill Operations Area**					**$ 33,507,162**	
4.3.1	Strip and Stockpile Topsoil	13,269	CY	$ 5.49	$ 72,847		
4.3.2	Geologic Buffer: Excavation and Replacement	115,882	CY	$ 35.69	$ 4,135,829		
4.3.3	Place/Compact Earthfill Dike	711,543	CY	$ 39.33	$ 27,984,986		
4.3.4	Liner Subgrade: Compact and Grade Side Slopes	14,319	SY	$ 3.32	$ 47,539		
4.3.5	Liner Subgrade: Compact and Grade Base	21,181	SY	$ 3.32	$ 70,321		
4.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	35,500	CY	$ 33.68	$ 1,195,640		
4.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 1,953,115**	
4.4.1	Geosynthetics Anchor Trench Preparation	1,140	LF	$ 1.54	$ 1,756		
4.4.2	Geosynthetics Anchor Trench Backfill and Compaction	1,140	LF	$ 4.39	$ 5,005		
4.4.2	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	319,496	SF	$ 0.66	$ 210,867		
4.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	128,871	SF	$ 0.57	$ 73,456		
4.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	762,501	SF	$ 0.30	$ 228,750		
4.4.6	Gravel Leak Detection Layer	7,060	CY	$ 58.23	$ 411,104		
4.4.7	Leak Detection Pipes: Installation and Materials	1,906	LF	$ 25.60	$ 48,794		
4.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	319,496	SF	$ 0.81	$ 258,792		
4.4.9	Gravel Leachate Collection Layer	7,060	CY	$ 58.23	$ 411,104		
4.4.10	Leachate Collection Pipes: Installation and Materials	1,906	LF	$ 25.60	$ 48,794		
4.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	128,871	SF	$ 0.57	$ 73,456		
4.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
4.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
4.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 45,595.67	$ 45,596		
4.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
4.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 65,803.42	$ 65,803		
4.5	**Contact Water System Additions**					**$ 30,986**	
4.5.1	Drain Ports	4	EA	$ 4,450.75	$ 17,803		
4.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Table I2.6. Development and Construction Cost Estimate for Site 11 - Base Case Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
5.0	***PHASE 4 CONSTRUCTION***						***$ 37,615,462***
5.1	**General Costs**					**$ 7,996,988**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 29,618,474.00	$ 2,073,293		
5.1.2	Worker Health and Safety Program	5%	LS	$ 29,618,474.00	$ 1,480,924		
5.1.3	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 29,618,474.00	$ 4,442,771		
5.2	**Site Work**					**$ 1,205,295**	
5.2.1	Construction Dewatering	1	LS	$ 232,000.00	$ 232,000		
5.2.2	BMPs for Stormwater Management and Sediment	1	LS	$ 27,361.58	$ 27,362		
5.2.3	Additional GW Monitoring Well(s)	1	EA	$ 16,494.00	$ 16,494		
5.2.4	Small Surface Water Ditches with Riprap Armor	750	LF	$ 7.77	$ 5,828		
5.2.5	Graveled Road Construction	1,400	LF	$ 52.76	$ 73,864		
5.2.6	Site Grubbing	10	AC	$ 4,784.50	$ 47,845		
5.2.7	High Security 8-ft Chain Link Fence w/ Barbed Wire Top	2,000	LF	$ 52.61	$ 105,220		
5.2.8	Outside Lights	1	LS	$ 265,125.20	$ 265,125		
5.2.9	High Security Area Lighting and Electrical	1	LS	$ 151,171.24	$ 151,171		
5.2.10	Signs	1	LS	$ 41,186.30	$ 41,186		
5.2.11	Sediment Removal and Pond Maintenance During Construction	1	LS	$ 45,000.00	$ 45,000		
5.2.12	Construction Surveying	41	AC	$ 4,736.59	$ 194,200		
5.3	**Earthwork for Landfill Operations Area**					**$ 26,805,723**	
5.3.1	Strip and Stockpile Topsoil	10,615	CY	$ 5.49	$ 58,276		
5.3.2	Geologic Buffer: Excavation and Replacement	92,706	CY	$ 35.69	$ 3,308,677		
5.3.3	Place/Compact Earthfill Dike	569,234	CY	$ 39.33	$ 22,387,973		
5.3.4	Liner Subgrade: Compact and Grade Side Slopes	11,455	SY	$ 3.32	$ 38,031		
5.3.5	Liner Subgrade: Compact and Grade Base	16,944	SY	$ 3.32	$ 56,254		
5.3.6	Construct Clay Liner: Purchase, Haul, Place, Compact and Grade	28,400	CY	$ 33.68	$ 956,512		
5.4	**Geosynthetic Liner and Leachate Collection Systems**					**$ 1,576,470**	
5.4.1	Geosynthetics Anchor Trench Preparation	912	LF	$ 1.54	$ 1,404		
5.4.2	Geosynthetics Anchor Trench Backfill and Compaction	912	LF	$ 4.39	$ 4,004		
5.4.3	Secondary Liner (60-mil HDPE) Material, including transportation to site, placement, seams/overlaps	255,597	SF	$ 0.66	$ 168,694		
5.4.4	Geocomposite Drainage Net Between Side Slope Liners, including transportation to site, placement, seams/overlaps	103,096	SF	$ 0.57	$ 58,765		
5.4.5	Geotextile (12-oz) Layers (4), including transportation to site, placement, seams/overlaps	610,001	SF	$ 0.30	$ 183,000		
5.4.6	Gravel Leak Detection Layer	5,648	CY	$ 58.23	$ 328,883		
5.4.7	Leak Detection Pipes: Installation and Materials	1,525	LF	$ 25.60	$ 39,040		
5.4.8	Primary Liner (80-mil HDPE) Material, including transportation to site, placement, seams/overlaps	255,597	SF	$ 0.81	$ 207,034		
5.4.9	Gravel Leachate Collection Layer	5,648	CY	$ 58.23	$ 328,883		
5.4.10	Leachate Collection Pipes: Installation and Materials	1,525	LF	$ 25.60	$ 39,040		
5.4.11	Geocomposite Drainage Net Above Side Slope Liners, including transportation to site, placement, seams/overlaps	103,096	SF	$ 0.57	$ 58,765		
5.4.12	Pump and Sump Access Pipes	1,200	LF	$ 44.06	$ 52,872		
5.4.13	Pre-cast Concrete Vaults	2	EA	$ 7,244.46	$ 14,489		
5.4.14	Sump, Perforated Pipes, Fittings, Drain Rock Fill	1	LS	$ 36,476.53	$ 36,477		
5.4.15	Cleanout Access Port	1	EA	$ 2,477.43	$ 2,477		
5.4.16	Electrical, Sensors, Controls, Pumps, Piping, and Fittings	1	LS	$ 52,642.73	$ 52,643		
5.5	**Contact Water System Additions**					**$ 30,986**	
5.5.1	Drain Ports	4	EA	$ 4,450.75	$ 17,803		
5.5.2	Pipes, Valves and Fittings	1	LS	$ 13,182.67	$ 13,183		

Notes:
a. Includes pre-construction geotechnical investigation.
b. Includes seismic investigation.
c. Includes pre-construction groundwater investigation to assess water table and background conditions for constituents predicted to be in proposed waste streams.
d. Includes 30%, 60%, 90% and for construction design packages, test pad, methane gas generation study, etc.

ATTACHMENT 3

ANNUAL OPERATING AND MONITORING COST ESTIMATES

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Table I3.1. Annual Operating and Monitoring Cost Estimate for All Sites - High End Volume Scenario

General Information and Assumptions:

Management Reserve (MR)	15%	
Operating Periods	Start Year	End Year
Initial Operations	2015	2,019
Landfill Operations During D&D	2019	2,039
Closure Operations	2039	2,044

Cost Summary:

	Cost	MR	Total Cost	
Annual Cost During Initial Operations	$ 8,765,538	$ 1,314,831	$ 10,080,369	Per Year
Annual Cost During D&D	$ 12,634,013	$ 1,895,102	$ 14,529,115	Per Year
Annual Cost During Closure Period	$ 8,763,712	$ 1,314,557	$ 10,078,269	Per Year

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***INITIAL OPERATIONS (FIRST 5 YEARS)***						***$ 8,765,538***
1.1	**General Site Costs**					**$ 216,000**	
1.1.1	Training	1	LS	$ 216,000.00	$ 216,000		
1.2	**On-site Labor**					**$ 4,727,423**	
1.2.1	OSWDF Manager	2,080	HR	$ 245.93	$ 511,534		
1.2.2	Operations/Frontline Manager	4,160	HR	$ 158.92	$ 661,107		
1.2.3	Quality Engineer	2,080	HR	$ 117.47	$ 244,338		
1.2.4	WAC Manager	2,080	HR	$ 131.28	$ 273,062		
1.2.5	Health and Safety Professional	4,160	HR	$ 108.62	$ 451,859		
1.2.6	Radiation Controls Technician	4,160	HR	$ 76.42	$ 317,907		
1.2.7	Heavy Equipment Operator	4,160	HR	$ 76.42	$ 317,907		
1.2.8	A Operator	2,080	HR	$ 76.42	$ 158,954		
1.2.9	B Operator	8,320	HR	$ 76.42	$ 635,814		
1.2.10	Records Administrator	2,080	HR	$ 96.74	$ 201,219		
1.2.11	Scale Operator	2,080	HR	$ 76.42	$ 158,954		
1.2.12	Treatment Plant Operator	8,320	HR	$ 76.42	$ 635,814		
1.2.13	Surveyor	2,080	HR	$ 76.42	$ 158,954		
1.3	**Equipment: Owning, Operating, and Maintenance**					**$ 1,469,670**	
1.3.1	Track Loader (medium-large tractor w/ attachments)	1,560	HR	$ 180.00	$ 280,800		
1.3.2	Waste Compactor	520	HR	$ 150.00	$ 78,000		
1.3.3	Wheel Loader	1,040	HR	$ 160.00	$ 166,400		
1.3.4	Medium Bulldozer	520	HR	$ 140.00	$ 72,800		
1.3.5	Haul Truck	2,080	HR	$ 120.00	$ 249,600		
1.3.6	Motor Grader	520	HR	$ 200.00	$ 104,000		
1.3.7	Water Truck	520	HR	$ 100.00	$ 52,000		
1.3.8	Fixative Sprayer	520	HR	$ 80.00	$ 41,600		
1.3.9	Personnel Vehicles (1 van, 2 pickup trucks, 3 carts)	1	LS	$ 194,470.00	$ 194,470		
1.3.10	Contact Water and Leachate Pumps	1	LS	$ 100,000.00	$ 100,000		
1.3.11	Site Maintenance Equipment	1	LS	$ 100,000.00	$ 100,000		
1.3.12	Boundary Control Station and Associated Equipment	1	LS	$ 20,000.00	$ 20,000		
1.3.13	Shop Equipment	1	LS	$ 10,000.00	$ 10,000		
1.4	**Materials**					**$ 2,147,445**	
1.4.1	General Earth Fill Materials	20,000	CY	$ 37.41	$ 748,200		
1.4.2	Road Mix Gravel	1,000	CY	$ 58.23	$ 58,230		
1.4.3	Security Lighting - Bulb Replacement	1	LS	$ 50,000.00	$ 50,000		
1.4.4	PPE and Anti-C's	52	WK	$ 1,000.00	$ 52,000		
1.4.5	Decontamination Materials and Equipment	52	WK	$ 1,000.00	$ 52,000		
1.4.6	Fixative	52	WK	$ 150.00	$ 7,800		
1.4.7	Pond Flocculent	1	LS	$ 30,000.00	$ 30,000		
1.4.8	Contact Water Hoses and Fittings	1	LS	$ 5,000.00	$ 5,000		
1.4.9	Leachate Treatment System Supplies	1	LS	$ 774,214.50	$ 774,215		
1.4.10	On-site Analytical Laboratory Materials and Supplies	1	LS	$ 10,000.00	$ 10,000		
1.4.11	Revegetation Materials and Supplies	1	LS	$ 10,000.00	$ 10,000		
1.4.12	Supplies for Office and Administration	1	LS	$ 100,000.00	$ 100,000		
1.4.13	Sanitary Treatment Plant Supplies	1	LS	$ 250,000.00	$ 250,000		
1.5	**Environmental Monitoring**					**$ 205,000**	
1.5.1	Groundwater Monitoring, Testing, and Reporting[a]	1	LS	$ 140,000.00	$ 140,000		
1.5.2	Surface Water Monitoring[b]	1	LS	$ 40,000.00	$ 40,000		
1.5.3	Air Monitoring[c]	1	LS	$ 25,000.00	$ 25,000		
2.0	***LANDFILL OPERATIONS DURING PGDP FACILITY D&D (20 YEARS)***						***$ 12,634,013***
2.1	**General Site Costs**					**$ 402,816**	
2.1.1	Training	1	LS	$ 132,000.00	$ 132,000		
2.1.2	Custodian Support	1	LS	$ 270,816.00	$ 270,816		
2.2	**On-site Labor**					**$ 6,866,517**	
2.2.1	OSWDF Manager	2,080	HR	$ 316.95	$ 659,256		
2.2.2	Operations/Frontline Manager	4,160	HR	$ 204.81	$ 852,010		
2.2.3	Quality Engineer	2,080	HR	$ 151.38	$ 314,870		
2.2.4	WAC Manager	2,080	HR	$ 169.20	$ 351,936		
2.2.5	Health and Safety Professional	4,160	HR	$ 139.99	$ 582,358		
2.2.6	Radiation Controls Technician	6,240	HR	$ 98.50	$ 614,640		
2.2.7	Heavy Equipment Operator	4,160	HR	$ 98.50	$ 409,760		
2.2.8	A Operator	4,160	HR	$ 98.50	$ 409,760		
2.2.9	B Operator	12,480	HR	$ 98.50	$ 1,229,280		
2.2.10	Records Administrator	2,080	HR	$ 124.66	$ 259,293		
2.2.11	Scale Operator	2,080	HR	$ 98.50	$ 204,880		
2.2.12	Treatment Plant Operator	8,320	HR	$ 98.50	$ 819,520		
2.2.13	Surveyor	2,080	HR	$ 76.42	$ 158,954		

Table I3.1. Annual Operating and Monitoring Cost Estimate for All Sites - High End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
2.3	**Equipment: Owning, Operating, and Maintenance**					**$ 1,698,270**	
2.3.1	Track Loader (medium-large tractor w/ attachments)	2,080	HR	$ 180.00	$ 374,400		
2.3.2	Waste Compactor	520	HR	$ 150.00	$ 78,000		
2.3.3	Wheel Loader	1,040	HR	$ 160.00	$ 166,400		
2.3.4	Medium Bulldozer	520	HR	$ 140.00	$ 72,800		
2.3.5	Haul Truck	2,080	HR	$ 120.00	$ 249,600		
2.3.6	Motor Grader	520	HR	$ 200.00	$ 104,000		
2.3.7	Water Truck	520	HR	$ 100.00	$ 52,000		
2.3.8	Fixative Sprayer	520	HR	$ 80.00	$ 41,600		
2.3.9	Personnel Vehicles (1 van, 2 pickup trucks, 3 carts)	1	LS	$ 194,470.00	$ 194,470		
2.3.10	Contact Water and Leachate Pumps	1	LS	$ 165,000.00	$ 165,000		
2.3.11	Site Maintenance Equipment	1	LS	$ 165,000.00	$ 165,000		
2.3.12	Boundary Control Station and Associated Equipment	1	LS	$ 20,000.00	$ 20,000		
2.3.13	Shop Equipment	1	LS	$ 15,000.00	$ 15,000		
2.4	**Materials**					**$ 3,386,410**	
2.4.1	General Earth Fill Materials	45,000	CY	$ 37.41	$ 1,683,450		
2.4.2	Road Mix Gravel	1,500	CY	$ 58.23	$ 87,345		
2.4.3	Security Lighting - Bulb Replacement	1	LS	$ 150,000.00	$ 150,000		
2.4.4	PPE and Anti-C's	52	WK	$ 2,000.00	$ 104,000		
2.4.5	Decontamination Materials and Equipment	52	WK	$ 2,000.00	$ 104,000		
2.4.6	Fixative	52	WK	$ 200.00	$ 10,400		
2.4.7	Pond Flocculent	1	LS	$ 30,000.00	$ 30,000		
2.4.8	Contact Water Hoses and Fittings	1	LS	$ 8,000.00	$ 8,000		
2.4.9	Leachate Treatment System Supplies	1	LS	$ 774,214.50	$ 774,215		
2.4.10	On-site Analytical Laboratory Materials and Supplies	1	LS	$ 20,000.00	$ 20,000		
2.4.11	Revegetation Materials and Supplies	1	LS	$ 15,000.00	$ 15,000		
2.4.12	Supplies for Office and Administration	1	LS	$ 150,000.00	$ 150,000		
2.4.13	Sanitary Treatment Plant Supplies	1	LS	$ 250,000.00	$ 250,000		
2.5	**Environmental Monitoring**					**$ 280,000**	
2.5.1	Groundwater Monitoring, Testing, and Reporting[a]	1	LS	$ 190,000.00	$ 190,000		
2.5.2	Well Maintenance and Rehabilitation[d]	1	LS	$ 10,000.00	$ 10,000		
2.5.3	Surface Water Monitoring[b]	1	LS	$ 40,000.00	$ 40,000		
2.5.4	Air Monitoring[c]	1	LS	$ 40,000.00	$ 40,000		
3.0	***OPERATIONS DURING FINAL CLOSURE PERIOD (LAST 5 YEARS)***						***$ 8,763,712***
3.1	**General Site Costs**					**$ 92,000**	
3.1.1	Training	1	LS	$ 92,000.00	$ 92,000		
3.2	**On-site Labor**					**$ 5,462,112**	
3.2.1	OSWDF Manager	2,080	HR	$ 403.50	$ 839,280		
3.2.2	Operations/Frontline Manager	4,160	HR	$ 260.73	$ 1,084,637		
3.2.3	Quality Engineer	1,040	HR	$ 192.70	$ 200,408		
3.2.5	Health and Safety Professional	2,080	HR	$ 178.20	$ 370,656		
3.2.6	Radiation Controls Technician	2,080	HR	$ 125.41	$ 260,853		
3.2.7	Heavy Equipment Operator	2,080	HR	$ 125.41	$ 260,853		
3.2.8	A Operator	1,040	HR	$ 125.41	$ 130,426		
3.2.9	B Operator	4,160	HR	$ 125.41	$ 521,706		
3.2.10	Records Administrator	2,080	HR	$ 158.69	$ 330,075		
3.2.11	Scale Operator	2,080	HR	$ 125.41	$ 260,853		
3.2.12	Treatment Plant Operator	8,320	HR	$ 125.41	$ 1,043,411		
3.2.13	Surveyor	2,080	HR	$ 76.42	$ 158,954		
3.3	**Equipment: Owning, Operating, and Maintenance**					**$ 865,470**	
3.3.1	Track Loader (medium-large tractor w/ attachments)	780	HR	$ 180.00	$ 140,400		
3.3.2	Wheel Loader	520	HR	$ 160.00	$ 83,200		
3.3.3	Drain Ports	520	HR	$ 140.00	$ 72,800		
3.3.4	Haul Truck	1,040	HR	$ 120.00	$ 124,800		
3.3.5	Motor Grader	260	HR	$ 200.00	$ 52,000		
3.3.6	Water Truck	520	HR	$ 100.00	$ 52,000		
3.3.7	Fixative Sprayer	260	HR	$ 80.00	$ 20,800		
3.3.8	Personnel Vehicles (1 van, 2 pickup trucks, 3 carts)	1	LS	$ 194,470.00	$ 194,470		
3.3.9	Contact Water and Leachate Pumps	1	LS	$ 50,000.00	$ 50,000		
3.3.10	Site Maintenance Equipment	1	LS	$ 50,000.00	$ 50,000		
3.3.11	Boundary Control Station and Associated Equipment	1	LS	$ 20,000.00	$ 20,000		
3.3.12	Shop Equipment	1	LS	$ 5,000.00	$ 5,000		
3.4	**Materials**					**$ 2,054,130**	
3.4.1	General Earth Fill Materials	20,000	CY	$ 37.41	$ 748,200		
3.4.2	Road Mix Gravel	500	CY	$ 58.23	$ 29,115		
3.4.3	Security Lighting - Bulb Replacement	1	LS	$ 50,000.00	$ 50,000		
3.4.4	PPE and Anti-C's	52	WK	$ 1,000.00	$ 52,000		
3.4.5	Decontamination Materials and Equipment	52	WK	$ 500.00	$ 26,000		
3.4.6	Fixative	52	WK	$ 50.00	$ 2,600		
3.4.7	Pond Flocculent	1	LS	$ 30,000.00	$ 30,000		
3.4.8	Contact Water Hoses and Fittings	1	LS	$ 2,000.00	$ 2,000		
3.4.9	Leachate Treatment System Supplies	1	LS	$ 774,214.50	$ 774,215		
3.4.10	On-site Analytical Laboratory Materials and Supplies	1	LS	$ 10,000.00	$ 10,000		
3.4.11	Revegetation Materials and Supplies	1	LS	$ 30,000.00	$ 30,000		
3.4.12	Supplies for Office and Administration	1	LS	$ 50,000.00	$ 50,000		
3.4.13	Sanitary Treatment Plant Supplies	1	LS	$ 250,000.00	$ 250,000		
3.5	**Environmental Monitoring**					**$ 290,000**	
3.5.1	Groundwater Monitoring, Testing, and Reporting[a]	1	LS	$ 240,000.00	$ 240,000		
3.5.2	Surface Water Monitoring[b]	1	LS	$ 40,000.00	$ 40,000		
3.5.3	Air Monitoring[c]	1	LS	$ 10,000.00	$ 10,000		

Notes:
a. Includes annual monitoring of assumed four (4) wells associated with the WDF; monitoring requirements will be defined in a subsequent CERCLA document.
b. Includes annual monitoring of assumed four (4) surface water locations; monitoring requirements will be defined in a subsequent CERCLA document.
c. Includes daily air monitoring during active operations; monitoring requirements will be defined in a subsequent CERCLA document.
d. Includes routine survey of well conditions, replacement of protective covers and locks, redevelopment, etc. as needed.

Table I3.2. Annual Operating and Monitoring Cost Estimate for All Sites - Low End Volume Scenario

General Information and Assumptions:

Management Reserve (MR)	15%	
Operating Periods	Start Year	End Year
Initial Operations	2015	2,019
Landfill Operations During D&D	2019	2,039
Closure Operations	2039	2,044

Cost Summary:

	Cost	MR	Total Cost	
Annual Cost During Initial Operations	$ 8,765,538	$ 1,314,831	$ 10,080,369	Per Year
Annual Cost During D&D	$ 10,605,744	$ 1,590,862	$ 12,196,606	Per Year
Annual Cost During Closure Period	$ 8,723,712	$ 1,308,557	$ 10,032,269	Per Year

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***INITIAL OPERATIONS (FIRST 5 YEARS)***						*$ 8,765,538*
1.1	**General Site Costs**					**$ 216,000**	
1.1.1	Training	1	LS	$ 216,000.00	$ 216,000		
1.2	**On-site Labor**					**$ 4,727,423**	
1.2.1	OSWDF Manager	2,080	HR	$ 245.93	$ 511,534		
1.2.2	Operations/Frontline Manager	4,160	HR	$ 158.92	$ 661,107		
1.2.3	Quality Engineer	2,080	HR	$ 117.47	$ 244,338		
1.2.4	WAC Manager	2,080	HR	$ 131.28	$ 273,062		
1.2.5	Health and Safety Professional	4,160	HR	$ 108.62	$ 451,859		
1.2.6	Radiation Controls Technician	4,160	HR	$ 76.42	$ 317,907		
1.2.7	Heavy Equipment Operator	4,160	HR	$ 76.42	$ 317,907		
1.2.8	A Operator	2,080	HR	$ 76.42	$ 158,954		
1.2.9	B Operator	8,320	HR	$ 76.42	$ 635,814		
1.2.10	Records Administrator	2,080	HR	$ 96.74	$ 201,219		
1.2.11	Scale Operator	2,080	HR	$ 76.42	$ 158,954		
1.2.12	Treatment Plant Operator	8,320	HR	$ 76.42	$ 635,814		
1.2.13	Surveyor	2,080	HR	$ 76.42	$ 158,954		
1.3	**Equipment: Owning, Operating, and Maintenance**					**$ 1,469,670**	
1.3.1	Track Loader (medium-large tractor w/ attachments)	1,560	HR	$ 180.00	$ 280,800		
1.3.2	Waste Compactor	520	HR	$ 150.00	$ 78,000		
1.3.3	Wheel Loader	1,040	HR	$ 160.00	$ 166,400		
1.3.4	Medium Bulldozer	520	HR	$ 140.00	$ 72,800		
1.3.5	Haul Truck	2,080	HR	$ 120.00	$ 249,600		
1.3.6	Motor Grader	520	HR	$ 200.00	$ 104,000		
1.3.7	Water Truck	520	HR	$ 100.00	$ 52,000		
1.3.8	Fixative Sprayer	520	HR	$ 80.00	$ 41,600		
1.3.9	Personnel Vehicles (1 van, 2 pickup trucks, 3 carts)	1	LS	$ 194,470.00	$ 194,470		
1.3.10	Contact Water and Leachate Pumps	1	LS	$ 100,000.00	$ 100,000		
1.3.11	Site Maintenance Equipment	1	LS	$ 100,000.00	$ 100,000		
1.3.12	Boundary Control Station and Associated Equipment	1	LS	$ 20,000.00	$ 20,000		
1.3.13	Shop Equipment	1	LS	$ 10,000.00	$ 10,000		
1.4	**Materials**					**$ 2,147,445**	
1.4.1	General Earth Fill Materials	20,000	CY	$ 37.41	$ 748,200		
1.4.2	Road Mix Gravel	1,000	CY	$ 58.23	$ 58,230		
1.4.3	Security Lighting - Bulb Replacement	1	LS	$ 50,000.00	$ 50,000		
1.4.4	PPE and Anti-C's	52	WK	$ 1,000.00	$ 52,000		
1.4.5	Decontamination Materials and Equipment	52	WK	$ 1,000.00	$ 52,000		
1.4.6	Fixative	52	WK	$ 150.00	$ 7,800		
1.4.7	Pond Flocculent	1	LS	$ 30,000.00	$ 30,000		
1.4.8	Contact Water Hoses and Fittings	1	LS	$ 5,000.00	$ 5,000		
1.4.9	Leachate Treatment System Supplies	1	LS	$ 774,214.50	$ 774,215		
1.4.10	On-site Analytical Laboratory Materials and Supplies	1	LS	$ 10,000.00	$ 10,000		
1.4.11	Revegetation Materials and Supplies	1	LS	$ 10,000.00	$ 10,000		
1.4.12	Supplies for Office and Administration	1	LS	$ 100,000.00	$ 100,000		
1.4.13	Sanitary Treatment Plant Supplies	1	LS	$ 250,000.00	$ 250,000		
1.5	**Environmental Monitoring**					**$ 205,000**	
1.5.1	Groundwater Monitoring, Testing, and Reporting[a]	1	LS	$ 140,000.00	$ 140,000		
1.5.2	Surface Water Monitoring[b]	1	LS	$ 40,000.00	$ 40,000		
1.5.3	Air Monitoring[c]	1	LS	$ 25,000.00	$ 25,000		
					$ -		
2.0	***LANDFILL OPERATIONS DURING PGDP FACILITY D&D (20 YEARS)***						*$ 10,605,744*
2.1	**General Site Costs**					**$ 402,816**	
2.1.1	Training	1	LS	$ 132,000.00	$ 132,000		
2.1.2	Custodian Support	1	LS	$ 270,816.00	$ 270,816		
2.2	**On-site Labor**					**$ 5,960,698**	
2.2.1	OSWDF Manager	2,080	HR	$ 316.95	$ 659,256		
2.2.2	Operations/Frontline Manager	4,160	HR	$ 204.81	$ 852,010		
2.2.3	Quality Engineer	2,080	HR	$ 151.38	$ 314,870		
2.2.4	WAC Manager	2,080	HR	$ 169.20	$ 351,936		
2.2.5	Health and Safety Professional	2,080	HR	$ 139.99	$ 291,179		
2.2.6	Radiation Controls Technician	6,240	HR	$ 98.50	$ 614,640		
2.2.7	Heavy Equipment Operator	4,160	HR	$ 98.50	$ 409,760		
2.2.8	A Operator	2,080	HR	$ 98.50	$ 204,880		
2.2.9	B Operator	8,320	HR	$ 98.50	$ 819,520		
2.2.10	Records Administrator	2,080	HR	$ 124.66	$ 259,293		
2.2.11	Scale Operator	2,080	HR	$ 98.50	$ 204,880		
2.2.12	Treatment Plant Operator	8,320	HR	$ 98.50	$ 819,520		
2.2.13	Surveyor	2,080	HR	$ 76.42	$ 158,954		

Table I3.2. Annual Operating and Monitoring Cost Estimate for All Sites - Low End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
2.3	**Equipment: Owning, Operating, and Maintenance**					**$ 1,511,070**	
2.3.1	Track Loader (medium-large tractor w/ attachments)	1,040	HR	$ 180.00	$ 187,200		
2.3.2	Waste Compactor	520	HR	$ 150.00	$ 78,000		
2.3.3	Wheel Loader	1,040	HR	$ 160.00	$ 166,400		
2.3.4	Medium Bulldozer	520	HR	$ 140.00	$ 72,800		
2.3.5	Haul Truck	2,080	HR	$ 120.00	$ 249,600		
2.3.6	Motor Grader	520	HR	$ 200.00	$ 104,000		
2.3.7	Water Truck	520	HR	$ 100.00	$ 52,000		
2.3.8	Fixative Sprayer	520	HR	$ 80.00	$ 41,600		
2.3.9	Personnel Vehicles (1 van, 2 pickup trucks, 3 carts)	1	LS	$ 194,470.00	$ 194,470		
2.3.10	Contact Water and Leachate Pumps	1	LS	$ 165,000.00	$ 165,000		
2.3.11	Site Maintenance Equipment	1	LS	$ 165,000.00	$ 165,000		
2.3.12	Boundary Control Station and Associated Equipment	1	LS	$ 20,000.00	$ 20,000		
2.3.13	Shop Equipment	1	LS	$ 15,000.00	$ 15,000		
2.4	**Materials**					**$ 2,451,160**	
2.4.1	General Earth Fill Materials	20,000	CY	$ 37.41	$ 748,200		
2.4.2	Road Mix Gravel	1,500	CY	$ 58.23	$ 87,345		
2.4.3	Security Lighting - Bulb Replacement	1	LS	$ 150,000.00	$ 150,000		
2.4.4	PPE and Anti-C's	52	WK	$ 2,000.00	$ 104,000		
2.4.5	Decontamination Materials and Equipment	52	WK	$ 2,000.00	$ 104,000		
2.4.6	Fixative	52	WK	$ 200.00	$ 10,400		
2.4.7	Pond Flocculent	1	LS	$ 30,000.00	$ 30,000		
2.4.8	Contact Water Hoses and Fittings	1	LS	$ 8,000.00	$ 8,000		
2.4.9	Leachate Treatment System Supplies	1	LS	$ 774,214.50	$ 774,215		
2.4.10	On-site Analytical Laboratory Materials and Supplies	1	LS	$ 20,000.00	$ 20,000		
2.4.11	Revegetation Materials and Supplies	1	LS	$ 15,000.00	$ 15,000		
2.4.12	Supplies for Office and Administration	1	LS	$ 150,000.00	$ 150,000		
2.4.13	Sanitary Treatment Plant Supplies	1	LS	$ 250,000.00	$ 250,000		
2.5	**Environmental Monitoring**					**$ 280,000**	
2.5.1	Groundwater Monitoring, Testing, and Reporting[a]	1	LS	$ 190,000.00	$ 190,000		
2.5.2	Well Maintenance and Rehabilitation[d]	1	LS	$ 10,000.00	$ 10,000		
2.5.3	Surface Water Monitoring[b]	1	LS	$ 40,000.00	$ 40,000		
2.5.4	Air Monitoring[c]	1	LS	$ 40,000.00	$ 40,000		
3.0	***OPERATIONS DURING FINAL CLOSURE PERIOD (LAST 5 YEARS)***						***$ 8,723,712***
3.1	**General Site Costs**					**$ 92,000**	
3.1.1	Training	1	LS	$ 92,000.00	$ 92,000		
3.2	**On-site Labor**					**$ 5,462,112**	
3.2.1	OSWDF Manager	2,080	HR	$ 403.50	$ 839,280		
3.2.2	Operations/Frontline Manager	4,160	HR	$ 260.73	$ 1,084,637		
3.2.3	Quality Engineer	1,040	HR	$ 192.70	$ 200,408		
3.2.5	Health and Safety Professional	2,080	HR	$ 178.20	$ 370,656		
3.2.6	Radiation Controls Technician	2,080	HR	$ 125.41	$ 260,853		
3.2.7	Heavy Equipment Operator	2,080	HR	$ 125.41	$ 260,853		
3.2.8	A Operator	1,040	HR	$ 125.41	$ 130,426		
3.2.9	B Operator	4,160	HR	$ 125.41	$ 521,706		
3.2.10	Records Administrator	2,080	HR	$ 158.69	$ 330,075		
3.2.11	Scale Operator	2,080	HR	$ 125.41	$ 260,853		
3.2.12	Treatment Plant Operator	8,320	HR	$ 125.41	$ 1,043,411		
3.2.13	Surveyor	2,080	HR	$ 76.42	$ 158,954		
3.3	**Equipment: Owning, Operating, and Maintenance**					**$ 865,470**	
3.3.1	Track Loader (medium-large tractor w/ attachments)	780	HR	$ 180.00	$ 140,400		
3.3.2	Wheel Loader	520	HR	$ 160.00	$ 83,200		
3.3.3	Drain Ports	520	HR	$ 140.00	$ 72,800		
3.3.4	Haul Truck	1,040	HR	$ 120.00	$ 124,800		
3.3.5	Motor Grader	260	HR	$ 200.00	$ 52,000		
3.3.6	Water Truck	520	HR	$ 100.00	$ 52,000		
3.3.7	Fixative Sprayer	260	HR	$ 80.00	$ 20,800		
3.3.8	Personnel Vehicles (1 van, 2 pickup trucks, 3 carts)	1	LS	$ 194,470.00	$ 194,470		
3.3.9	Contact Water and Leachate Pumps	1	LS	$ 50,000.00	$ 50,000		
3.3.10	Site Maintenance Equipment	1	LS	$ 50,000.00	$ 50,000		
3.3.11	Boundary Control Station and Associated Equipment	1	LS	$ 20,000.00	$ 20,000		
3.3.12	Shop Equipment	1	LS	$ 5,000.00	$ 5,000		
3.4	**Materials**					**$ 2,054,130**	
3.4.1	General Earth Fill Materials	20,000	CY	$ 37.41	$ 748,200		
3.4.2	Road Mix Gravel	500	CY	$ 58.23	$ 29,115		
3.4.3	Security Lighting - Bulb Replacement	1	LS	$ 50,000.00	$ 50,000		
3.4.4	PPE and Anti-C's	52	WK	$ 1,000.00	$ 52,000		
3.4.5	Decontamination Materials and Equipment	52	WK	$ 500.00	$ 26,000		
3.4.6	Fixative	52	WK	$ 50.00	$ 2,600		
3.4.7	Pond Flocculent	1	LS	$ 30,000.00	$ 30,000		
3.4.8	Contact Water Hoses and Fittings	1	LS	$ 2,000.00	$ 2,000		
3.4.9	Leachate Treatment System Supplies	1	LS	$ 774,214.50	$ 774,215		
3.4.10	On-site Analytical Laboratory Materials and Supplies	1	LS	$ 10,000.00	$ 10,000		
3.4.11	Revegetation Materials and Supplies	1	LS	$ 30,000.00	$ 30,000		
3.4.12	Supplies for Office and Administration	1	LS	$ 50,000.00	$ 50,000		
3.4.13	Sanitary Treatment Plant Supplies	1	LS	$ 250,000.00	$ 250,000		
3.5	**Environmental Monitoring**					**$ 250,000**	
3.5.1	Groundwater Monitoring, Testing, and Reporting[a]	1	LS	$ 200,000.00	$ 200,000		
3.5.2	Surface Water Monitoring[b]	1	LS	$ 40,000.00	$ 40,000		
3.5.3	Air Monitoring[c]	1	LS	$ 10,000.00	$ 10,000		

Notes:
a. Includes annual monitoring of assumed four (4) wells associated with the WDF; monitoring requirements will be defined in a subsequent CERCLA document.
b. Includes annual monitoring of assumed four (4) surface water locations; monitoring requirements will be defined in a subsequent CERCLA document.
c. Includes daily air monitoring during active operations; monitoring requirements will be defined in a subsequent CERCLA document.
d. Includes routine survey of well conditions, replacement of protective covers and locks, redevelopment, etc. as needed.

Table I3.3. Annual Operating and Monitoring Cost Estimate for All Sites - Base Case Volume Scenario

General Information and Assumptions:

Management Reserve (MR)	15%	
Operating Periods	Start Year	End Year
Initial Operations	2015	2,019
Landfill Operations During D&D	2019	2,039
Closure Operations	2039	2,044

Cost Summary:

	Cost	MR	Total Cost	
Annual Cost During Initial Operations	$ 8,765,538	$ 1,314,831	$ 10,080,369	Per Year
Annual Cost During D&D	$ 11,765,468	$ 1,764,820	$ 13,530,288	Per Year
Annual Cost During Closure Period	$ 8,763,712	$ 1,314,557	$ 10,078,269	Per Year

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***INITIAL OPERATIONS (FIRST 5 YEARS)***						***$ 8,765,538***
1.1	**General Site Costs**					**$ 216,000**	
1.1.1	Training	1	LS	$ 216,000.00	$ 216,000		
1.2	**On-site Labor**					**$ 4,727,423**	
1.2.1	OSWDF Manager	2,080	HR	$ 245.93	$ 511,534		
1.2.2	Operations/Frontline Manager	4,160	HR	$ 158.92	$ 661,107		
1.2.3	Quality Engineer	2,080	HR	$ 117.47	$ 244,338		
1.2.4	WAC Manager	2,080	HR	$ 131.28	$ 273,062		
1.2.5	Health and Safety Professional	4,160	HR	$ 108.62	$ 451,859		
1.2.6	Radiation Controls Technician	4,160	HR	$ 76.42	$ 317,907		
1.2.7	Heavy Equipment Operator	4,160	HR	$ 76.42	$ 317,907		
1.2.8	A Operator	2,080	HR	$ 76.42	$ 158,954		
1.2.9	B Operator	8,320	HR	$ 76.42	$ 635,814		
1.2.10	Records Administrator	2,080	HR	$ 96.74	$ 201,219		
1.2.11	Scale Operator	2,080	HR	$ 76.42	$ 158,954		
1.2.12	Treatment Plant Operator	8,320	HR	$ 76.42	$ 635,814		
1.2.13	Surveyor	2,080	HR	$ 76.42	$ 158,954		
1.3	**Equipment: Owning, Operating, and Maintenance**					**$ 1,469,670**	
1.3.1	Track Loader (medium-large tractor w/ attachments)	1,560	HR	$ 180.00	$ 280,800		
1.3.2	Waste Compactor	520	HR	$ 150.00	$ 78,000		
1.3.3	Wheel Loader	1,040	HR	$ 160.00	$ 166,400		
1.3.4	Medium Bulldozer	520	HR	$ 140.00	$ 72,800		
1.3.5	Haul Truck	2,080	HR	$ 120.00	$ 249,600		
1.3.6	Motor Grader	520	HR	$ 200.00	$ 104,000		
1.3.7	Water Truck	520	HR	$ 100.00	$ 52,000		
1.3.8	Fixative Sprayer	520	HR	$ 80.00	$ 41,600		
1.3.9	Personnel Vehicles (1 van, 2 pickup trucks, 3 carts)	1	LS	$ 194,470.00	$ 194,470		
1.3.10	Contact Water and Leachate Pumps	1	LS	$ 100,000.00	$ 100,000		
1.3.11	Site Maintenance Equipment	1	LS	$ 100,000.00	$ 100,000		
1.3.12	Boundary Control Station and Associated Equipment	1	LS	$ 20,000.00	$ 20,000		
1.3.13	Shop Equipment	1	LS	$ 10,000.00	$ 10,000		
1.4	**Materials**					**$ 2,147,445**	
1.4.1	General Earth Fill Materials	20,000	CY	$ 37.41	$ 748,200		
1.4.2	Road Mix Gravel	1,000	CY	$ 58.23	$ 58,230		
1.4.3	Security Lighting - Bulb Replacement	1	LS	$ 50,000.00	$ 50,000		
1.4.4	PPE and Anti-C's	52	WK	$ 1,000.00	$ 52,000		
1.4.5	Decontamination Materials and Equipment	52	WK	$ 1,000.00	$ 52,000		
1.4.6	Fixative	52	WK	$ 150.00	$ 7,800		
1.4.7	Pond Flocculent	1	LS	$ 30,000.00	$ 30,000		
1.4.8	Contact Water Hoses and Fittings	1	LS	$ 5,000.00	$ 5,000		
1.4.9	Leachate Treatment System Supplies	1	LS	$ 774,214.50	$ 774,215		
1.4.10	On-site Analytical Laboratory Materials and Supplies	1	LS	$ 10,000.00	$ 10,000		
1.4.11	Revegetation Materials and Supplies	1	LS	$ 10,000.00	$ 10,000		
1.4.12	Supplies for Office and Administration	1	LS	$ 100,000.00	$ 100,000		
1.4.13	Sanitary Treatment Plant Supplies	1	LS	$ 250,000.00	$ 250,000		
1.5	**Environmental Monitoring**					**$ 205,000**	
1.5.1	Groundwater Monitoring, Testing, and Reporting[a]	1	LS	$ 140,000.00	$ 140,000		
1.5.2	Surface Water Monitoring[b]	1	LS	$ 40,000.00	$ 40,000		
1.5.3	Air Monitoring[c]	1	LS	$ 25,000.00	$ 25,000		
					$ -		
2.0	***LANDFILL OPERATIONS DURING PGDP FACILITY D&D (20 YEARS)***						***$ 11,765,468***
2.1	**General Site Costs**					**$ 402,816**	
2.1.1	Training	1	LS	$ 132,000.00	$ 132,000		
2.1.2	Custodian Support	1	LS	$ 270,816.00	$ 270,816		
2.2	**On-site Labor**					**$ 6,559,197**	
2.2.1	OSWDF Manager	2,080	HR	$ 316.95	$ 659,256		
2.2.2	Operations/Frontline Manager	4,160	HR	$ 204.81	$ 852,010		
2.2.3	Quality Engineer	2,080	HR	$ 151.38	$ 314,870		
2.2.4	WAC Manager	2,080	HR	$ 169.20	$ 351,936		
2.2.5	Health and Safety Professional	4,160	HR	$ 139.99	$ 582,358		
2.2.6	Radiation Controls Technician	6,240	HR	$ 98.50	$ 614,640		
2.2.7	Heavy Equipment Operator	4,160	HR	$ 98.50	$ 409,760		
2.2.8	A Operator	3,120	HR	$ 98.50	$ 307,320		
2.2.9	B Operator	10,400	HR	$ 98.50	$ 1,024,400		
2.2.10	Records Administrator	2,080	HR	$ 124.66	$ 259,293		
2.2.11	Scale Operator	2,080	HR	$ 98.50	$ 204,880		
2.2.12	Treatment Plant Operator	8,320	HR	$ 98.50	$ 819,520		
2.2.13	Surveyor	2,080	HR	$ 76.42	$ 158,954		

Table I3.3. Annual Operating and Monitoring Cost Estimate for All Sites - Base Case Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
2.3	**Equipment: Owning, Operating, and Maintenance**					**$ 1,604,670**	
2.3.1	Track Loader (medium-large tractor w/ attachments)	1,560	HR	$ 180.00	$ 280,800		
2.3.2	Waste Compactor	520	HR	$ 150.00	$ 78,000		
2.3.3	Wheel Loader	1,040	HR	$ 160.00	$ 166,400		
2.3.4	Medium Bulldozer	520	HR	$ 140.00	$ 72,800		
2.3.5	Haul Truck	2,080	HR	$ 120.00	$ 249,600		
2.3.6	Motor Grader	520	HR	$ 200.00	$ 104,000		
2.3.7	Water Truck	520	HR	$ 100.00	$ 52,000		
2.3.8	Fixative Sprayer	520	HR	$ 80.00	$ 41,600		
2.3.9	Personnel Vehicles (1 van, 2 pickup trucks, 3 carts)	1	LS	$ 194,470.00	$ 194,470		
2.3.10	Contact Water and Leachate Pumps	1	LS	$ 165,000.00	$ 165,000		
2.3.11	Site Maintenance Equipment	1	LS	$ 165,000.00	$ 165,000		
2.3.12	Boundary Control Station and Associated Equipment	1	LS	$ 20,000.00	$ 20,000		
2.3.13	Shop Equipment	1	LS	$ 15,000.00	$ 15,000		
2.4	**Materials**					**$ 2,918,785**	
2.4.1	General Earth Fill Materials	32,500	CY	$ 37.41	$ 1,215,825		
2.4.2	Road Mix Gravel	1,500	CY	$ 58.23	$ 87,345		
2.4.3	Security Lighting - Bulb Replacement	1	LS	$ 150,000.00	$ 150,000		
2.4.4	PPE and Anti-C's	52	WK	$ 2,000.00	$ 104,000		
2.4.5	Decontamination Materials and Equipment	52	WK	$ 2,000.00	$ 104,000		
2.4.6	Fixative	52	WK	$ 200.00	$ 10,400		
2.4.7	Pond Flocculent	1	LS	$ 30,000.00	$ 30,000		
2.4.8	Contact Water Hoses and Fittings	1	LS	$ 8,000.00	$ 8,000		
2.4.9	Leachate Treatment System Supplies	1	LS	$ 774,214.50	$ 774,215		
2.4.10	On-site Analytical Laboratory Materials and Supplies	1	LS	$ 20,000.00	$ 20,000		
2.4.11	Revegetation Materials and Supplies	1	LS	$ 15,000.00	$ 15,000		
2.4.12	Supplies for Office and Administration	1	LS	$ 150,000.00	$ 150,000		
2.4.13	Sanitary Treatment Plant Supplies	1	LS	$ 250,000.00	$ 250,000		
2.5	**Environmental Monitoring**					**$ 280,000**	
2.5.1	Groundwater Monitoring, Testing, and Reporting[a]	1	LS	$ 190,000.00	$ 190,000		
2.5.2	Well Maintenance and Rehabilitation[d]	1	LS	$ 10,000.00	$ 10,000		
2.5.3	Surface Water Monitoring[b]	1	LS	$ 40,000.00	$ 40,000		
2.5.4	Air Monitoring[c]	1	LS	$ 40,000.00	$ 40,000		
3.0	***OPERATIONS DURING FINAL CLOSURE PERIOD (LAST 5 YEARS)***						***$ 8,763,712***
3.1	**General Site Costs**					**$ 92,000**	
3.1.1	Training	1	LS	$ 92,000.00	$ 92,000		
3.2	**On-site Labor**					**$ 5,462,112**	
3.2.1	OSWDF Manager	2,080	HR	$ 403.50	$ 839,280		
3.2.2	Operations/Frontline Manager	4,160	HR	$ 260.73	$ 1,084,637		
3.2.3	Quality Engineer	1,040	HR	$ 192.70	$ 200,408		
3.2.5	Health and Safety Professional	2,080	HR	$ 178.20	$ 370,656		
3.2.6	Radiation Controls Technician	2,080	HR	$ 125.41	$ 260,853		
3.2.7	Heavy Equipment Operator	2,080	HR	$ 125.41	$ 260,853		
3.2.8	A Operator	1,040	HR	$ 125.41	$ 130,426		
3.2.9	B Operator	4,160	HR	$ 125.41	$ 521,706		
3.2.10	Records Administrator	2,080	HR	$ 158.69	$ 330,075		
3.2.11	Scale Operator	2,080	HR	$ 125.41	$ 260,853		
3.2.12	Treatment Plant Operator	8,320	HR	$ 125.41	$ 1,043,411		
3.2.13	Surveyor	2,080	HR	$ 76.42	$ 158,954		
3.3	**Equipment: Owning, Operating, and Maintenance**					**$ 865,470**	
3.3.1	Track Loader (medium-large tractor w/ attachments)	780	HR	$ 180.00	$ 140,400		
3.3.2	Wheel Loader	520	HR	$ 160.00	$ 83,200		
3.3.3	Drain Ports	520	HR	$ 140.00	$ 72,800		
3.3.4	Haul Truck	1,040	HR	$ 120.00	$ 124,800		
3.3.5	Motor Grader	260	HR	$ 200.00	$ 52,000		
3.3.6	Water Truck	520	HR	$ 100.00	$ 52,000		
3.3.7	Fixative Sprayer	260	HR	$ 80.00	$ 20,800		
3.3.8	Personnel Vehicles (1 van, 2 pickup trucks, 3 carts)	1	LS	$ 194,470.00	$ 194,470		
3.3.9	Contact Water and Leachate Pumps	1	LS	$ 50,000.00	$ 50,000		
3.3.10	Site Maintenance Equipment	1	LS	$ 50,000.00	$ 50,000		
3.3.11	Boundary Control Station and Associated Equipment	1	LS	$ 20,000.00	$ 20,000		
3.3.12	Shop Equipment	1	LS	$ 5,000.00	$ 5,000		
3.4	**Materials**					**$ 2,054,130**	
3.4.1	General Earth Fill Materials	20,000	CY	$ 37.41	$ 748,200		
3.4.2	Road Mix Gravel	500	CY	$ 58.23	$ 29,115		
3.4.3	Security Lighting - Bulb Replacement	1	LS	$ 50,000.00	$ 50,000		
3.4.4	PPE and Anti-C's	52	WK	$ 1,000.00	$ 52,000		
3.4.5	Decontamination Materials and Equipment	52	WK	$ 500.00	$ 26,000		
3.4.6	Fixative	52	WK	$ 50.00	$ 2,600		
3.4.7	Pond Flocculent	1	LS	$ 30,000.00	$ 30,000		
3.4.8	Contact Water Hoses and Fittings	1	LS	$ 2,000.00	$ 2,000		
3.4.9	Leachate Treatment System Supplies	1	LS	$ 774,214.50	$ 774,215		
3.4.10	On-site Analytical Laboratory Materials and Supplies	1	LS	$ 10,000.00	$ 10,000		
3.4.11	Revegetation Materials and Supplies	1	LS	$ 30,000.00	$ 30,000		
3.4.12	Supplies for Office and Administration	1	LS	$ 50,000.00	$ 50,000		
3.4.13	Sanitary Treatment Plant Supplies	1	LS	$ 250,000.00	$ 250,000		
3.5	**Environmental Monitoring**					**$ 290,000**	
3.5.1	Groundwater Monitoring, Testing, and Reporting[a]	1	LS	$ 240,000.00	$ 240,000		
3.5.2	Surface Water Monitoring[b]	1	LS	$ 40,000.00	$ 40,000		
3.5.3	Air Monitoring[c]	1	LS	$ 10,000.00	$ 10,000		

Notes:

a. Includes annual monitoring of assumed four (4) wells associated with the WDF; monitoring requirements will be defined in a subsequent CERCLA document.

b. Includes annual monitoring of assumed four (4) surface water locations; monitoring requirements will be defined in a subsequent CERCLA document.

c. Includes daily air monitoring during active operations; monitoring requirements will be defined in a subsequent CERCLA document.

d. Includes routine survey of well conditions, replacement of protective covers and locks, redevelopment, etc. as needed.

ATTACHMENT 4

CLOSURE COST ESTIMATES

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Table I4.1. Closure Cost Estimate for Site 3A - High End Volume Scenario

General Information and Assumptions:

Total Final Cover Area	2,223,542	SF	51.05	AC
Total Liner Anchor Trench Length	6,327	LF		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Closure Areas and Schedule	Year	Percent of Final Cover Installed		
Area 1	2020	20%		
Area 2	2026	25%		
Area 3	2032	25%		
Area 4	2039	25%		
Completion of Final Closure Activities	2044	5%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Area 1 Closure	$ 15,471,298	$ 2,320,695	$ 4,641,389	$ 22,433,382
Area 2 Closure	$ 19,340,259	$ 2,901,039	$ 5,802,078	$ 28,043,376
Area 3 Closure	$ 19,340,259	$ 2,901,039	$ 5,802,078	$ 28,043,376
Area 4 Closure	$ 19,340,259	$ 2,901,039	$ 5,802,078	$ 28,043,376
Final Site Closure Activities	$ 5,452,190	$ 817,829	$ 1,635,657	$ 7,905,676
TOTAL SITE 3A CLOSURE COST	**$ 78,944,265**	**$ 11,841,641**	**$ 23,683,280**	**$ 114,469,186**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***AREA 1 CLOSURE***						***$15,471,298***
1.1	**General Costs**					**$3,065,561**	
1.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 12,405,737.00	$ 868,402		
1.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 12,405,737.00	$ 1,860,861		
1.1.3	Construction Surveying	71	AC	$ 4,736.59	$ 336,298		
1.2	**Earthwork**					**$11,762,303**	
1.2.1	Strip and Stockpile Reusable Topsoil	8,235	CY	$ 5.49	$ 45,210		
1.2.2	Replace Topsoil With Compacted Fill	8,235	CY	$ 13.19	$ 108,620		
1.2.3	Final Cover Subgrade: Compact and Grade Surface	49,412	SY	$ 3.32	$ 164,048		
1.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	49,412	CY	$ 33.68	$ 1,664,196		
1.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	16,471	CY	$ 58.23	$ 959,106		
1.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	49,412	CY	$ 74.71	$ 3,691,571		
1.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	16,471	CY	$ 30.86	$ 508,295		
1.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	123,530	CY	$ 37.41	$ 4,621,257		
1.3	**Geosynthetics**					**$643,434**	
1.3.1	Geosynthetics Anchor Trench Preparation	1,265	LF	$ 1.54	$ 1,948		
1.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,265	LF	$ 4.39	$ 5,553		
1.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	444,708	SF	$ 0.83	$ 369,108		
1.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	889,416	SF	$ 0.30	$ 266,825		
2.0	***AREA 2 CLOSURE***						***$19,340,259***
2.1	**General Costs**					**$3,833,126**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 15,507,133.00	$ 1,085,499		
2.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 15,507,133.00	$ 2,326,070		
2.1.3	Construction Surveying	89	AC	$ 4,736.59	$ 421,557		
2.2	**Earthwork**					**$14,702,835**	
2.2.1	Strip and Stockpile Reusable Topsoil	10,294	CY	$ 5.49	$ 56,514		
2.2.2	Replace Topsoil With Compacted Fill	10,294	CY	$ 13.19	$ 135,778		
2.2.3	Final Cover Subgrade: Compact and Grade Surface	61,765	SY	$ 3.32	$ 205,060		
2.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	61,765	CY	$ 33.68	$ 2,080,245		
2.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	20,588	CY	$ 58.23	$ 1,198,839		
2.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	61,765	CY	$ 74.71	$ 4,614,463		
2.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	20,588	CY	$ 30.86	$ 635,346		
2.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	154,413	CY	$ 37.41	$ 5,776,590		
2.3	**Geosynthetics**					**$804,298**	
2.3.1	Geosynthetics Anchor Trench Preparation	1,582	LF	$ 1.54	$ 2,436		
2.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,582	LF	$ 4.39	$ 6,945		
2.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	555,886	SF	$ 0.83	$ 461,385		
2.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	1,111,772	SF	$ 0.30	$ 333,532		

Table I4.1. Closure Cost Estimate for Site 3A - High End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.0	***AREA 3 CLOSURE***						***$19,340,259***
3.1	**General Costs**					**$3,833,126**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 15,507,133.00	$ 1,085,499		
3.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 15,507,133.00	$ 2,326,070		
3.1.3	Construction Surveying	89	AC	$ 4,736.59	$ 421,557		
3.2	**Earthwork**					**$14,702,835**	
3.2.1	Strip and Stockpile Reusable Topsoil	10,294	CY	$ 5.49	$ 56,514		
3.2.2	Replace Topsoil With Compacted Fill	10,294	CY	$ 13.19	$ 135,778		
3.2.3	Final Cover Subgrade: Compact and Grade Surface	61,765	SY	$ 3.32	$ 205,060		
3.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	61,765	CY	$ 33.68	$ 2,080,245		
3.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	20,588	CY	$ 58.23	$ 1,198,839		
3.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	61,765	CY	$ 74.71	$ 4,614,463		
3.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	20,588	CY	$ 30.86	$ 635,346		
3.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	154,413	CY	$ 37.41	$ 5,776,590		
3.3	**Geosynthetics**					**$804,298**	
3.3.1	Geosynthetics Anchor Trench Preparation	1,582	LF	$ 1.54	$ 2,436		
3.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,582	LF	$ 4.39	$ 6,945		
3.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	555,886	SF	$ 0.83	$ 461,385		
3.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	1,111,772	SF	$ 0.30	$ 333,532		
4.0	***AREA 4 CLOSURE***						***$19,340,259***
4.1	**General Costs**					**$3,833,126**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 15,507,133.00	$ 1,085,499		
4.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 15,507,133.00	$ 2,326,070		
4.1.3	Construction Surveying	89	AC	$ 4,736.59	$ 421,557		
4.2	**Earthwork**					**$14,702,835**	
4.2.1	Strip and Stockpile Reusable Topsoil	10,294	CY	$ 5.49	$ 56,514		
4.2.2	Replace Topsoil With Compacted Fill	10,294	CY	$ 13.19	$ 135,778		
4.2.3	Final Cover Subgrade: Compact and Grade Surface	61,765	SY	$ 3.32	$ 205,060		
4.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	61,765	CY	$ 33.68	$ 2,080,245		
4.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	20,588	CY	$ 58.23	$ 1,198,839		
4.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	61,765	CY	$ 74.71	$ 4,614,463		
4.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	20,588	CY	$ 30.86	$ 635,346		
4.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	154,413	CY	$ 37.41	$ 5,776,590		
4.3	**Geosynthetics**					**$804,298**	
4.3.1	Geosynthetics Anchor Trench Preparation	1,582	LF	$ 1.54	$ 2,436		
4.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,582	LF	$ 4.39	$ 6,945		
4.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	555,886	SF	$ 0.83	$ 461,385		
4.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	1,111,772	SF	$ 0.30	$ 333,532		
5.0	***FINAL SITE CLOSURE ACTIVITIES***						***$5,452,190***
5.1	**General Costs**					**$582,448**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 4,869,742.00	$ 340,882		
5.1.2	Construction Surveying	51	AC	$ 4,736.59	$ 241,566		
5.2	**Final Closure Activities (Separate From Operating Costs)**					**$4,869,742**	
5.2.1	Complete Final Cover	1	LS	$ 3,650,952.00	$ 3,650,952		
5.2.2	Remove Support Buildings and Related Infrastructure	1	LS	$ 527,516.00	$ 527,516		
5.2.3	Remove Contact Water Tanks and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.4	Remove Leachate System Tanks, Facilities, and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.5	Final Site Surface Grading and Reclamation of Disturbed Areas	20	AC	$ 8,381.48	$ 167,630		
5.2.6	Groundwater Well Rehabilitation and Replacement	1	LS	$ 200,000.00	$ 200,000		

* Note: Surface Cover Volume includes an additional 2.5-feet of soil used as final cover, which was calculated using the final cover area of the high-end scenario for Site 3A.

Table I4.2. Closure Cost Estimate for Site 11 - High End Volume Scenario

General Information and Assumptions:

Total Final Cover Area	2,165,258	SF	49.71	AC
Total Liner Anchor Trench Length	5,935	LF		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Closure Areas and Schedule	Year	Percent of Final Cover Installed		
Area 1	2020	20%		
Area 2	2026	25%		
Area 3	2032	25%		
Area 4	2039	25%		
Completion of Final Closure Activities	2044	5%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Area 1 Closure	$ 15,069,511	$ 2,260,427	$ 4,520,853	$ 21,850,791
Area 2 Closure	$ 18,834,521	$ 2,825,178	$ 5,650,356	$ 27,310,055
Area 3 Closure	$ 18,834,521	$ 2,825,178	$ 5,650,356	$ 27,310,055
Area 4 Closure	$ 18,834,521	$ 2,825,178	$ 5,650,356	$ 27,310,055
Final Site Closure Activities	$ 5,345,319	$ 801,798	$ 1,603,596	$ 7,750,713
TOTAL SITE 11 CLOSURE COST	**$ 76,918,393**	**$ 11,537,759**	**$ 23,075,517**	**$ 111,531,669**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***AREA 1 CLOSURE***						***$ 15,069,511***
1.1	**General Costs**					**$ 2,989,224**	
1.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 12,080,287.00	$ 845,620		
1.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 12,080,287.00	$ 1,812,043		
1.1.3	Construction Surveying	70	AC	$ 4,736.59	$ 331,561		
1.2	**Earthwork**					**$ 11,453,984**	
1.2.1	Strip and Stockpile Reusable Topsoil	8,019	CY	$ 5.49	$ 44,024		
1.2.2	Replace Topsoil With Compacted Fill	8,019	CY	$ 13.19	$ 105,771		
1.2.3	Final Cover Subgrade: Compact and Grade Surface	48,117	SY	$ 3.32	$ 159,748		
1.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	48,117	CY	$ 33.68	$ 1,620,581		
1.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	16,039	CY	$ 58.23	$ 933,951		
1.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	48,117	CY	$ 74.71	$ 3,594,821		
1.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	16,039	CY	$ 30.86	$ 494,964		
1.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	120,292	CY	$ 37.41	$ 4,500,124		
1.3	**Geosynthetics**					**$ 626,303**	
1.3.1	Geosynthetics Anchor Trench Preparation	1,187	LF	$ 1.54	$ 1,828		
1.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,187	LF	$ 4.39	$ 5,211		
1.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	433,052	SF	$ 0.83	$ 359,433		
1.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	866,104	SF	$ 0.30	$ 259,831		
2.0	***AREA 2 CLOSURE***						***$ 18,834,521***
2.1	**General Costs**					**$ 3,734,162**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 15,100,359.00	$ 1,057,025		
2.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 15,100,359.00	$ 2,265,054		
2.1.3	Construction Surveying	87	AC	$ 4,736.59	$ 412,083		
2.2	**Earthwork**					**$ 14,317,479**	
2.2.1	Strip and Stockpile Reusable Topsoil	10,024	CY	$ 5.49	$ 55,032		
2.2.2	Replace Topsoil With Compacted Fill	10,024	CY	$ 13.19	$ 132,217		
2.2.3	Final Cover Subgrade: Compact and Grade Surface	60,146	SY	$ 3.32	$ 199,685		
2.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	60,146	CY	$ 33.68	$ 2,025,717		
2.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	20,049	CY	$ 58.23	$ 1,167,453		
2.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	60,146	CY	$ 74.71	$ 4,493,508		
2.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	20,049	CY	$ 30.86	$ 618,712		
2.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	150,365	CY	$ 37.41	$ 5,625,155		
2.3	**Geosynthetics**					**$ 782,880**	
2.3.1	Geosynthetics Anchor Trench Preparation	1,484	LF	$ 1.54	$ 2,285		
2.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,484	LF	$ 4.39	$ 6,515		
2.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	541,315	SF	$ 0.83	$ 449,291		
2.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	1,082,630	SF	$ 0.30	$ 324,789		

Table I4.2. Closure Cost Estimate for Site 11 - High End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.0	***AREA 3 CLOSURE***						***$ 18,834,521***
3.1	**General Costs**					**$ 3,734,162**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 15,100,359.00	$ 1,057,025		
3.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 15,100,359.00	$ 2,265,054		
3.1.3	Construction Surveying	87	AC	$ 4,736.59	$ 412,083		
3.2	**Earthwork**					**$ 14,317,479**	
3.2.1	Strip and Stockpile Reusable Topsoil	10,024	CY	$ 5.49	$ 55,032		
3.2.2	Replace Topsoil With Compacted Fill	10,024	CY	$ 13.19	$ 132,217		
3.2.3	Final Cover Subgrade: Compact and Grade Surface	60,146	SY	$ 3.32	$ 199,685		
3.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	60,146	CY	$ 33.68	$ 2,025,717		
3.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	20,049	CY	$ 58.23	$ 1,167,453		
3.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	60,146	CY	$ 74.71	$ 4,493,508		
3.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	20,049	CY	$ 30.86	$ 618,712		
3.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	150,365	CY	$ 37.41	$ 5,625,155		
3.3	**Geosynthetics**					**$ 782,880**	
3.3.1	Geosynthetics Anchor Trench Preparation	1,484	LF	$ 1.54	$ 2,285		
3.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,484	LF	$ 4.39	$ 6,515		
3.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	541,315	SF	$ 0.83	$ 449,291		
3.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	1,082,630	SF	$ 0.30	$ 324,789		
4.0	***AREA 4 CLOSURE***						***$ 18,834,521***
4.1	**General Costs**					**$ 3,734,162**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 15,100,359.00	$ 1,057,025		
4.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 15,100,359.00	$ 2,265,054		
4.1.3	Construction Surveying	87	AC	$ 4,736.59	$ 412,083		
4.2	**Earthwork**					**$ 14,317,479**	
4.2.1	Strip and Stockpile Reusable Topsoil	10,024	CY	$ 5.49	$ 55,032		
4.2.2	Replace Topsoil With Compacted Fill	10,024	CY	$ 13.19	$ 132,217		
4.2.3	Final Cover Subgrade: Compact and Grade Surface	60,146	SY	$ 3.32	$ 199,685		
4.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	60,146	CY	$ 33.68	$ 2,025,717		
4.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	20,049	CY	$ 58.23	$ 1,167,453		
4.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	60,146	CY	$ 74.71	$ 4,493,508		
4.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	20,049	CY	$ 30.86	$ 618,712		
4.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	150,365	CY	$ 37.41	$ 5,625,155		
4.3	**Geosynthetics**					**$ 782,880**	
4.3.1	Geosynthetics Anchor Trench Preparation	1,484	LF	$ 1.54	$ 2,285		
4.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,484	LF	$ 4.39	$ 6,515		
4.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	541,315	SF	$ 0.83	$ 449,291		
4.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	1,082,630	SF	$ 0.30	$ 324,789		
5.0	***FINAL SITE CLOSURE ACTIVITIES***						***$ 5,345,319***
5.1	**General Costs**					**$ 571,030**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 4,774,289.00	$ 334,200		
5.1.2	Construction Surveying	50	AC	$ 4,736.59	$ 236,830		
5.2	**Final Closure Activities (Separate From Operating Costs)**					**$ 4,774,289**	
5.2.1	Complete Final Cover	1	LS	$ 3,555,499.20	$ 3,555,499		
5.2.2	Remove Support Buildings and Related Infrastructure	1	LS	$ 527,516.00	$ 527,516		
5.2.3	Remove Contact Water Tanks and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.4	Remove Leachate System Tanks, Facilities, and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.5	Final Site Surface Grading and Reclamation of Disturbed Areas	20	AC	$ 8,381.48	$ 167,630		
5.2.6	Groundwater Well Rehabilitation and Replacement	1	LS	$ 200,000.00	$ 200,000		

* Note: Surface Cover Volume includes an additional 2.5-feet of soil used as final cover, which was calculated using the final cover area of the high-end scenario for Site 11.

Table I4.3. Closure Cost Estimate for Site 3A - Low End Volume Scenario

General Information and Assumptions:

Total Final Cover Area	1,095,779	SF	25.16	AC
Total Liner Anchor Trench Length	4,370	LF		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Closure Areas and Schedule	Year	Percent of Final Cover Installed		
Area 1	2020	20%		
Area 2	2026	25%		
Area 3	2032	25%		
Area 4	2039	25%		
Completion of Final Closure Activities	2044	5%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Area 1 Closure	$ 7,626,303	$ 1,143,945	$ 2,287,891	$ 11,058,139
Area 2 Closure	$ 9,533,936	$ 1,430,090	$ 2,860,181	$ 13,824,207
Area 3 Closure	$ 9,533,936	$ 1,430,090	$ 2,860,181	$ 13,824,207
Area 4 Closure	$ 9,533,936	$ 1,430,090	$ 2,860,181	$ 13,824,207
Final Site Closure Activities	$ 3,348,277	$ 502,242	$ 1,004,483	$ 4,855,002
TOTAL SITE 3A CLOSURE COST	**$ 39,576,388**	**$ 5,936,457**	**$ 11,872,917**	**$ 57,385,762**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***AREA 1 CLOSURE***						***$ 7,626,303***
1.1	**General Costs**					**$ 1,511,121**	
1.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 6,115,182.00	$ 428,063		
1.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 6,115,182.00	$ 917,277		
1.1.3	Construction Surveying	35	AC	$ 4,736.59	$ 165,781		
1.2	**Earthwork**					**$ 5,796,606**	
1.2.1	Strip and Stockpile Reusable Topsoil	4,058	CY	$ 5.49	$ 22,278		
1.2.2	Replace Topsoil With Compacted Fill	4,058	CY	$ 13.19	$ 53,525		
1.2.3	Final Cover Subgrade: Compact and Grade Surface	24,351	SY	$ 3.32	$ 80,845		
1.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	24,351	CY	$ 33.68	$ 820,142		
1.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	8,117	CY	$ 58.23	$ 472,653		
1.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	24,351	CY	$ 74.71	$ 1,819,263		
1.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	8,117	CY	$ 30.86	$ 250,491		
1.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	60,877	CY	$ 37.41	$ 2,277,409		
1.3	**Geosynthetics**					**$ 318,576**	
1.3.1	Geosynthetics Anchor Trench Preparation	874	LF	$ 1.54	$ 1,346		
1.3.2	Geosynthetics Anchor Trench Backfill and Compaction	874	LF	$ 4.39	$ 3,837		
1.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	219,156	SF	$ 0.83	$ 181,899		
1.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	438,312	SF	$ 0.30	$ 131,494		
2.0	***AREA 2 CLOSURE***						***$ 9,533,936***
2.1	**General Costs**					**$ 1,890,062**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 7,643,874.00	$ 535,071		
2.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 7,643,874.00	$ 1,146,581		
2.1.3	Construction Surveying	44	AC	$ 4,736.59	$ 208,410		
2.2	**Earthwork**					**$ 7,245,652**	
2.2.1	Strip and Stockpile Reusable Topsoil	5,073	CY	$ 5.49	$ 27,851		
2.2.2	Replace Topsoil With Compacted Fill	5,073	CY	$ 13.19	$ 66,913		
2.2.3	Final Cover Subgrade: Compact and Grade Surface	30,438	SY	$ 3.32	$ 101,054		
2.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	30,438	CY	$ 33.68	$ 1,025,152		
2.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	10,146	CY	$ 58.23	$ 590,802		
2.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	30,438	CY	$ 74.71	$ 2,274,023		
2.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	10,146	CY	$ 30.86	$ 313,106		
2.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	76,096	CY	$ 37.41	$ 2,846,751		
2.3	**Geosynthetics**					**$ 398,222**	
2.3.1	Geosynthetics Anchor Trench Preparation	1,093	LF	$ 1.54	$ 1,683		
2.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,093	LF	$ 4.39	$ 4,798		
2.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	273,945	SF	$ 0.83	$ 227,374		
2.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	547,890	SF	$ 0.30	$ 164,367		

Table I4.3. Closure Cost Estimate for Site 3A - Low End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.0	***AREA 3 CLOSURE***						***$ 9,533,936***
3.1	**General Costs**					**$ 1,890,062**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 7,643,874.00	$ 535,071		
3.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 7,643,874.00	$ 1,146,581		
3.1.3	Construction Surveying	44	AC	$ 4,736.59	$ 208,410		
3.2	**Earthwork**					**$ 7,245,652**	
3.2.1	Strip and Stockpile Reusable Topsoil	5,073	CY	$ 5.49	$ 27,851		
3.2.2	Replace Topsoil With Compacted Fill	5,073	CY	$ 13.19	$ 66,913		
3.2.3	Final Cover Subgrade: Compact and Grade Surface	30,438	SY	$ 3.32	$ 101,054		
3.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	30,438	CY	$ 33.68	$ 1,025,152		
3.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	10,146	CY	$ 58.23	$ 590,802		
3.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	30,438	CY	$ 74.71	$ 2,274,023		
3.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	10,146	CY	$ 30.86	$ 313,106		
3.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	76,096	CY	$ 37.41	$ 2,846,751		
3.3	**Geosynthetics**					**$ 398,222**	
3.3.1	Geosynthetics Anchor Trench Preparation	1,093	LF	$ 1.54	$ 1,683		
3.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,093	LF	$ 4.39	$ 4,798		
3.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	273,945	SF	$ 0.83	$ 227,374		
3.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	547,890	SF	$ 0.30	$ 164,367		
4.0	***AREA 4 CLOSURE***						***$ 9,533,936***
4.1	**General Costs**					**$ 1,890,062**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 7,643,874.00	$ 535,071		
4.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 7,643,874.00	$ 1,146,581		
4.1.3	Construction Surveying	44	AC	$ 4,736.59	$ 208,410		
4.2	**Earthwork**					**$ 7,245,652**	
4.2.1	Strip and Stockpile Reusable Topsoil	5,073	CY	$ 5.49	$ 27,851		
4.2.2	Replace Topsoil With Compacted Fill	5,073	CY	$ 13.19	$ 66,913		
4.2.3	Final Cover Subgrade: Compact and Grade Surface	30,438	SY	$ 3.32	$ 101,054		
4.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	30,438	CY	$ 33.68	$ 1,025,152		
4.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	10,146	CY	$ 58.23	$ 590,802		
4.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	30,438	CY	$ 74.71	$ 2,274,023		
4.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	10,146	CY	$ 30.86	$ 313,106		
4.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	76,096	CY	$ 37.41	$ 2,846,751		
4.3	**Geosynthetics**					**$ 398,222**	
4.3.1	Geosynthetics Anchor Trench Preparation	1,093	LF	$ 1.54	$ 1,683		
4.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,093	LF	$ 4.39	$ 4,798		
4.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	273,945	SF	$ 0.83	$ 227,374		
4.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	547,890	SF	$ 0.30	$ 164,367		
5.0	***FINAL SITE CLOSURE ACTIVITIES***						***$ 3,348,277***
5.1	**General Costs**					**$ 329,714**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 3,018,563.00	$ 211,299		
5.1.2	Construction Surveying	25	AC	$ 4,736.59	$ 118,415		
5.2	**Final Closure Activities (Separate From Operating Costs)**					**$ 3,018,563**	
5.2.1	Complete Final Cover	1	LS	$ 1,799,773.00	$ 1,799,773		
5.2.2	Remove Support Buildings and Related Infrastructure	1	LS	$ 527,516.00	$ 527,516		
5.2.3	Remove Contact Water Tanks and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.4	Remove Leachate System Tanks, Facilities, and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.5	Final Site Surface Grading and Reclamation of Disturbed Areas	20	AC	$ 8,381.48	$ 167,630		
5.2.6	Groundwater Well Rehabilitation and Replacement	1	LS	$ 200,000.00	$ 200,000		

* Note: Surface Cover Volume includes an additional 2.5-feet of soil used as final cover, which was calculated using the final cover area of the low-end scenario for Site 3A.

Table I4.4. Closure Cost Estimate for Site 11 - Low End Volume Scenario

General Information and Assumptions:

Total Final Cover Area	1,034,646	SF	23.75	AC
Total Liner Anchor Trench Length	3,963	LF		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Closure Areas and Schedule	Year	Percent of Final Cover Installed		
Area 1	2020	20%		
Area 2	2026	25%		
Area 3	2032	25%		
Area 4	2039	25%		
Completion of Final Closure Activities	2044	5%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Area 1 Closure	$ 7,200,271	$ 1,080,041	$ 2,160,081	$ 10,440,393
Area 2 Closure	$ 9,003,890	$ 1,350,584	$ 2,701,167	$ 13,055,641
Area 3 Closure	$ 9,003,890	$ 1,350,584	$ 2,701,167	$ 13,055,641
Area 4 Closure	$ 9,003,890	$ 1,350,584	$ 2,701,167	$ 13,055,641
Final Site Closure Activities	$ 3,236,503	$ 485,475	$ 970,951	$ 4,692,929
TOTAL SITE 11 CLOSURE COST	**$ 37,448,444**	**$ 5,617,268**	**$ 11,234,533**	**$ 54,300,245**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***AREA 1 CLOSURE***						***$ 7,200,271***
1.1	**General Costs**					**$ 1,426,530**	
1.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 5,773,741.00	$ 404,162		
1.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 5,773,741.00	$ 866,061		
1.1.3	Construction Surveying	33	AC	$ 4,736.59	$ 156,307		
1.2	**Earthwork**					**$ 5,473,131**	
1.2.1	Strip and Stockpile Reusable Topsoil	3,832	CY	$ 5.49	$ 21,038		
1.2.2	Replace Topsoil With Compacted Fill	3,832	CY	$ 13.19	$ 50,544		
1.2.3	Final Cover Subgrade: Compact and Grade Surface	22,992	SY	$ 3.32	$ 76,333		
1.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	22,992	CY	$ 33.68	$ 774,371		
1.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	7,664	CY	$ 58.23	$ 446,275		
1.2.6	Bio intrusion Layer: Purchase, Haul, Place, Compact and Grade	22,992	CY	$ 74.71	$ 1,717,732		
1.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	7,664	CY	$ 30.86	$ 236,511		
1.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	57,480	CY	$ 37.41	$ 2,150,327		
1.3	**Geosynthetics**					**$ 300,610**	
1.3.1	Geosynthetics Anchor Trench Preparation	793	LF	$ 1.54	$ 1,221		
1.3.2	Geosynthetics Anchor Trench Backfill and Compaction	793	LF	$ 4.39	$ 3,481		
1.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	206,929	SF	$ 0.83	$ 171,751		
1.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	413,858	SF	$ 0.30	$ 124,157		
2.0	***AREA 2 CLOSURE***						***$ 9,003,890***
2.1	**General Costs**					**$ 1,786,715**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 7,217,175.00	$ 505,202		
2.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 7,217,175.00	$ 1,082,576		
2.1.3	Construction Surveying	42	AC	$ 4,736.59	$ 198,937		
2.2	**Earthwork**					**$ 6,841,413**	
2.2.1	Strip and Stockpile Reusable Topsoil	4,790	CY	$ 5.49	$ 26,297		
2.2.2	Replace Topsoil With Compacted Fill	4,790	CY	$ 13.19	$ 63,180		
2.2.3	Final Cover Subgrade: Compact and Grade Surface	28,740	SY	$ 3.32	$ 95,417		
2.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	28,740	CY	$ 33.68	$ 967,963		
2.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	9,580	CY	$ 58.23	$ 557,843		
2.2.6	Bio intrusion Layer: Purchase, Haul, Place, Compact and Grade	28,740	CY	$ 74.71	$ 2,147,165		
2.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	9,580	CY	$ 30.86	$ 295,639		
2.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	71,850	CY	$ 37.41	$ 2,687,909		
2.3	**Geosynthetics**					**$ 375,762**	
2.3.1	Geosynthetics Anchor Trench Preparation	991	LF	$ 1.54	$ 1,526		
2.3.2	Geosynthetics Anchor Trench Backfill and Compaction	991	LF	$ 4.39	$ 4,350		
2.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	258,662	SF	$ 0.83	$ 214,689		
2.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	517,324	SF	$ 0.30	$ 155,197		

Table I4.4. Closure Cost Estimate for Site 11 - Low End Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.0	***AREA 3 CLOSURE***						***$ 9,003,890***
3.1	**General Costs**					**$ 1,786,715**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 7,217,175.00	$ 505,202		
3.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 7,217,175.00	$ 1,082,576		
3.1.3	Construction Surveying	42	AC	$ 4,736.59	$ 198,937		
3.2	**Earthwork**					**$ 6,841,413**	
3.2.1	Strip and Stockpile Reusable Topsoil	4,790	CY	$ 5.49	$ 26,297		
3.2.2	Replace Topsoil With Compacted Fill	4,790	CY	$ 13.19	$ 63,180		
3.2.3	Final Cover Subgrade: Compact and Grade Surface	28,740	SY	$ 3.32	$ 95,417		
3.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	28,740	CY	$ 33.68	$ 967,963		
3.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	9,580	CY	$ 58.23	$ 557,843		
3.2.6	Bio intrusion Layer: Purchase, Haul, Place, Compact and Grade	28,740	CY	$ 74.71	$ 2,147,165		
3.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	9,580	CY	$ 30.86	$ 295,639		
3.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	71,850	CY	$ 37.41	$ 2,687,909		
3.3	**Geosynthetics**					**$ 375,762**	
3.3.1	Geosynthetics Anchor Trench Preparation	991	LF	$ 1.54	$ 1,526		
3.3.2	Geosynthetics Anchor Trench Backfill and Compaction	991	LF	$ 4.39	$ 4,350		
3.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	258,662	SF	$ 0.83	$ 214,689		
3.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	517,324	SF	$ 0.30	$ 155,197		
4.0	***AREA 4 CLOSURE***						***$ 9,003,890***
4.1	**General Costs**					**$ 1,786,715**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 7,217,175.00	$ 505,202		
4.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 7,217,175.00	$ 1,082,576		
4.1.3	Construction Surveying	42	AC	$ 4,736.59	$ 198,937		
4.2	**Earthwork**					**$ 6,841,413**	
4.2.1	Strip and Stockpile Reusable Topsoil	4,790	CY	$ 5.49	$ 26,297		
4.2.2	Replace Topsoil With Compacted Fill	4,790	CY	$ 13.19	$ 63,180		
4.2.3	Final Cover Subgrade: Compact and Grade Surface	28,740	SY	$ 3.32	$ 95,417		
4.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	28,740	CY	$ 33.68	$ 967,963		
4.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	9,580	CY	$ 58.23	$ 557,843		
4.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	28,740	CY	$ 74.71	$ 2,147,165		
4.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	9,580	CY	$ 30.86	$ 295,639		
4.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	71,850	CY	$ 37.41	$ 2,687,909		
4.3	**Geosynthetics**					**$ 375,762**	
4.3.1	Geosynthetics Anchor Trench Preparation	991	LF	$ 1.54	$ 1,526		
4.3.2	Geosynthetics Anchor Trench Backfill and Compaction	991	LF	$ 4.39	$ 4,350		
4.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	258,662	SF	$ 0.83	$ 214,689		
4.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	517,324	SF	$ 0.30	$ 155,197		
5.0	***FINAL SITE CLOSURE ACTIVITIES***						***$ 3,236,503***
5.1	**General Costs**					**$ 317,975**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 2,918,528.00	$ 204,297		
5.1.2	Construction Surveying	24	AC	$ 4,736.59	$ 113,678		
5.2	**Final Closure Activities (Separate From Operating Costs)**					**$ 2,918,528**	
5.2.1	Complete Final Cover	1	LS	$ 1,699,737.60	$ 1,699,738		
5.2.2	Remove Support Buildings and Related Infrastructure	1	LS	$ 527,516.00	$ 527,516		
5.2.3	Remove Contact Water Tanks and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.4	Remove Leachate System Tanks, Facilities, and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.5	Final Site Surface Grading and Reclamation of Disturbed Areas	20	AC	$ 8,381.48	$ 167,630		
5.2.6	Groundwater Well Rehabilitation and Replacement	1	LS	$ 200,000.00	$ 200,000		

* Note: Surface Volume includes an additional 2.5-feet of soil used as final cover, which was calculated using the final cover area of the low-end scenario for Site 11.

Table I4.5. Closure Cost Estimate for Site 3A - Base Case Volume Scenario

General Information and Assumptions:

Total Final Cover Area	1,593,076	SF	36.57	AC
Total Liner Anchor Trench Length	5,130	LF		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Closure Areas and Schedule	Year	Percent of Final Cover Installed		
Area 1	2020	20%		
Area 2	2026	25%		
Area 3	2032	25%		
Area 4	2039	25%		
Completion of Final Closure Activities	2044	5%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Area 1 Closure	$ 11,086,095	$ 1,662,914	$ 3,325,829	$ 16,074,838
Area 2 Closure	$ 13,858,712	$ 2,078,807	$ 4,157,614	$ 20,095,133
Area 3 Closure	$ 13,858,712	$ 2,078,807	$ 4,157,614	$ 20,095,133
Area 4 Closure	$ 13,858,712	$ 2,078,807	$ 4,157,614	$ 20,095,133
Final Site Closure Activities	$ 4,278,679	$ 641,802	$ 1,283,604	$ 6,204,085
TOTAL SITE 3A CLOSURE COST	**$ 56,940,910**	**$ 8,541,137**	**$ 17,082,275**	**$ 82,564,322**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***AREA 1 CLOSURE***						***$11,086,095***
1.1	**General Costs**					**$2,197,137**	
1.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 8,888,958.00	$ 622,227		
1.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 8,888,958.00	$ 1,333,344		
1.1.3	Construction Surveying	51	AC	$ 4,736.59	$ 241,566		
1.2	**Earthwork**					**$8,427,255**	
1.2.1	Strip and Stockpile Reusable Topsoil	5,900	CY	$ 5.49	$ 32,391		
1.2.2	Replace Topsoil With Compacted Fill	5,900	CY	$ 13.19	$ 77,821		
1.2.3	Final Cover Subgrade: Compact and Grade Surface	35,402	SY	$ 3.32	$ 117,535		
1.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	35,402	CY	$ 33.68	$ 1,192,339		
1.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	11,801	CY	$ 58.23	$ 687,172		
1.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	35,402	CY	$ 74.71	$ 2,644,883		
1.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	11,801	CY	$ 30.86	$ 364,179		
1.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	88,504	CY	$ 37.41	$ 3,310,935		
1.3	**Geosynthetics**					**$461,703**	
1.3.1	Geosynthetics Anchor Trench Preparation	1,026	LF	$ 1.54	$ 1,580		
1.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,026	LF	$ 4.39	$ 4,504		
1.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	318,615	SF	$ 0.83	$ 264,450		
1.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	637,230	SF	$ 0.30	$ 191,169		
2.0	***AREA 2 CLOSURE***						***$13,858,712***
2.1	**General Costs**					**$2,747,589**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 11,111,123.00	$ 777,779		
2.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 11,111,123.00	$ 1,666,668		
2.1.3	Construction Surveying	64	AC	$ 4,736.59	$ 303,142		
2.2	**Earthwork**					**$10,533,991**	
2.2.1	Strip and Stockpile Reusable Topsoil	7,375	CY	$ 5.49	$ 40,489		
2.2.2	Replace Topsoil With Compacted Fill	7,375	CY	$ 13.19	$ 97,276		
2.2.3	Final Cover Subgrade: Compact and Grade Surface	44,252	SY	$ 3.32	$ 146,917		
2.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	44,252	CY	$ 33.68	$ 1,490,407		
2.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	14,751	CY	$ 58.23	$ 858,951		
2.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	44,252	CY	$ 74.71	$ 3,306,067		
2.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	14,751	CY	$ 30.86	$ 455,216		
2.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	110,630	CY	$ 37.41	$ 4,138,668		
2.3	**Geosynthetics**					**$577,132**	
2.3.1	Geosynthetics Anchor Trench Preparation	1,283	LF	$ 1.54	$ 1,976		
2.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,283	LF	$ 4.39	$ 5,632		
2.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	398,269	SF	$ 0.83	$ 330,563		
2.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	796,538	SF	$ 0.30	$ 238,961		

Table I4.5. Closure Cost Estimate for Site 3A - Base Case Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.0	***AREA 3 CLOSURE***						*$13,858,712*
3.1	**General Costs**					**$2,747,589**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 11,111,123.00	$ 777,779		
3.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 11,111,123.00	$ 1,666,668		
3.1.3	Construction Surveying	64	AC	$ 4,736.59	$ 303,142		
3.2	**Earthwork**					**$10,533,991**	
3.2.1	Strip and Stockpile Reusable Topsoil	7,375	CY	$ 5.49	$ 40,489		
3.2.2	Replace Topsoil With Compacted Fill	7,375	CY	$ 13.19	$ 97,276		
3.2.3	Final Cover Subgrade: Compact and Grade Surface	44,252	SY	$ 3.32	$ 146,917		
3.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	44,252	CY	$ 33.68	$ 1,490,407		
3.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	14,751	CY	$ 58.23	$ 858,951		
3.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	44,252	CY	$ 74.71	$ 3,306,067		
3.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	14,751	CY	$ 30.86	$ 455,216		
3.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	110,630	CY	$ 37.41	$ 4,138,668		
3.3	**Geosynthetics**					**$577,132**	
3.3.1	Geosynthetics Anchor Trench Preparation	1,283	LF	$ 1.54	$ 1,976		
3.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,283	LF	$ 4.39	$ 5,632		
3.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	398,269	SF	$ 0.83	$ 330,563		
3.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	796,538	SF	$ 0.30	$ 238,961		
4.0	***AREA 4 CLOSURE***						*$13,858,712*
4.1	**General Costs**					**$2,747,589**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 11,111,123.00	$ 777,779		
4.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 11,111,123.00	$ 1,666,668		
4.1.3	Construction Surveying	64	AC	$ 4,736.59	$ 303,142		
4.2	**Earthwork**					**$10,533,991**	
4.2.1	Strip and Stockpile Reusable Topsoil	7,375	CY	$ 5.49	$ 40,489		
4.2.2	Replace Topsoil With Compacted Fill	7,375	CY	$ 13.19	$ 97,276		
4.2.3	Final Cover Subgrade: Compact and Grade Surface	44,252	SY	$ 3.32	$ 146,917		
4.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	44,252	CY	$ 33.68	$ 1,490,407		
4.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	14,751	CY	$ 58.23	$ 858,951		
4.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	44,252	CY	$ 74.71	$ 3,306,067		
4.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	14,751	CY	$ 30.86	$ 455,216		
4.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	110,630	CY	$ 37.41	$ 4,138,668		
4.3	**Geosynthetics**					**$577,132**	
4.3.1	Geosynthetics Anchor Trench Preparation	1,283	LF	$ 1.54	$ 1,976		
4.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,283	LF	$ 4.39	$ 5,632		
4.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	398,269	SF	$ 0.83	$ 330,563		
4.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	796,538	SF	$ 0.30	$ 238,961		
5.0	***FINAL SITE CLOSURE ACTIVITIES***						*$4,278,679*
5.1	**General Costs**					**$443,702**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 3,834,977.00	$ 268,448		
5.1.2	Construction Surveying	37	AC	$ 4,736.59	$ 175,254		
5.2	**Final Closure Activities (Separate From Operating Costs)**					**$3,834,977**	
5.2.1	Complete Final Cover	1	LS	$ 2,616,186.60	$ 2,616,187		
5.2.2	Remove Support Buildings and Related Infrastructure	1	LS	$ 527,516.00	$ 527,516		
5.2.3	Remove Contact Water Tanks and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.4	Remove Leachate System Tanks, Facilities, and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.5	Final Site Surface Grading and Reclamation of Disturbed Areas	20	AC	$ 8,381.48	$ 167,630		
5.2.6	Groundwater Well Rehabilitation and Replacement	1	LS	$ 200,000.00	$ 200,000		

* Note: Surface Cover Volume includes an additional 2.5-feet of soil used as final cover, which was calculated using the final cover area of the base case scenario for Site 3A.

Table I4.6. Closure Cost Estimate for Site 11 - Base Case Volume Scenario

General Information and Assumptions:

Total Final Cover Area	1,563,637	SF	35.90	AC
Total Liner Anchor Trench Length	4,971	LF		
Management Reserve (MR)	15%			
Contingency	30%			
Landfill Closure Areas and Schedule	Year	Percent of Final Cover Installed		
Area 1	2020	20%		
Area 2	2026	25%		
Area 3	2032	25%		
Area 4	2039	25%		
Completion of Final Closure Activities	2044	5%		

Cost Summary:

	Cost	MR	Contingency	Total Cost
Area 1 Closure	$ 10,880,680	$ 1,632,102	$ 3,264,204	$ 15,776,986
Area 2 Closure	$ 13,603,302	$ 2,040,495	$ 4,080,991	$ 19,724,788
Area 3 Closure	$ 13,603,302	$ 2,040,495	$ 4,080,991	$ 19,724,788
Area 4 Closure	$ 13,603,302	$ 2,040,495	$ 4,080,991	$ 19,724,788
Final Site Closure Activities	$ 4,222,362	$ 633,354	$ 1,266,709	$ 6,122,425
TOTAL SITE 11 CLOSURE COST	**$ 55,912,948**	**$ 8,386,941**	**$ 16,773,886**	**$ 81,073,775**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***AREA 1 CLOSURE***						***$ 10,880,680***
1.1	**General Costs**					**$ 2,156,213**	
1.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 8,724,467.00	$ 610,713		
1.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 8,724,467.00	$ 1,308,670		
1.1.3	Construction Surveying	50	AC	$ 4,736.59	$ 236,830		
1.2	**Earthwork**					**$ 8,271,373**	
1.2.1	Strip and Stockpile Reusable Topsoil	5,791	CY	$ 5.49	$ 31,793		
1.2.2	Replace Topsoil With Compacted Fill	5,791	CY	$ 13.19	$ 76,383		
1.2.3	Final Cover Subgrade: Compact and Grade Surface	34,747	SY	$ 3.32	$ 115,360		
1.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	34,747	CY	$ 33.68	$ 1,170,279		
1.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	11,582	CY	$ 58.23	$ 674,420		
1.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	34,747	CY	$ 74.71	$ 2,595,948		
1.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	11,582	CY	$ 30.86	$ 357,421		
1.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	86,869	CY	$ 37.41	$ 3,249,769		
1.3	**Geosynthetics**					**$ 453,094**	
1.3.1	Geosynthetics Anchor Trench Preparation	994	LF	$ 1.54	$ 1,531		
1.3.2	Geosynthetics Anchor Trench Backfill and Compaction	994	LF	$ 4.39	$ 4,364		
1.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	312,727	SF	$ 0.83	$ 259,563		
1.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	625,454	SF	$ 0.30	$ 187,636		
2.0	***AREA 2 CLOSURE***						***$ 13,603,302***
2.1	**General Costs**					**$ 2,697,649**	
2.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 10,905,653.00	$ 763,396		
2.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 10,905,653.00	$ 1,635,848		
2.1.3	Construction Surveying	63	AC	$ 4,736.59	$ 298,405		
2.2	**Earthwork**					**$ 10,339,283**	
2.2.1	Strip and Stockpile Reusable Topsoil	7,239	CY	$ 5.49	$ 39,742		
2.2.2	Replace Topsoil With Compacted Fill	7,239	CY	$ 13.19	$ 95,482		
2.2.3	Final Cover Subgrade: Compact and Grade Surface	43,434	SY	$ 3.32	$ 144,201		
2.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	43,434	CY	$ 33.68	$ 1,462,857		
2.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	14,478	CY	$ 58.23	$ 843,054		
2.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	43,434	CY	$ 74.71	$ 3,244,954		
2.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	14,478	CY	$ 30.86	$ 446,791		
2.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	108,586	CY	$ 37.41	$ 4,062,202		
2.3	**Geosynthetics**					**$ 566,370**	
2.3.1	Geosynthetics Anchor Trench Preparation	1,243	LF	$ 1.54	$ 1,914		
2.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,243	LF	$ 4.39	$ 5,457		
2.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	390,909	SF	$ 0.83	$ 324,454		
2.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	781,818	SF	$ 0.30	$ 234,545		

Table I4.6. Closure Cost Estimate for Site 11 - Base Case Volume Scenario

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
3.0	***AREA 3 CLOSURE***						***$ 13,603,302***
3.1	**General Costs**					**$ 2,697,649**	
3.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 10,905,653.00	$ 763,396		
3.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 10,905,653.00	$ 1,635,848		
3.1.3	Construction Surveying	63	AC	$ 4,736.59	$ 298,405		
3.2	**Earthwork**					**$ 10,339,283**	
3.2.1	Strip and Stockpile Reusable Topsoil	7,239	CY	$ 5.49	$ 39,742		
3.2.2	Replace Topsoil With Compacted Fill	7,239	CY	$ 13.19	$ 95,482		
3.2.3	Final Cover Subgrade: Compact and Grade Surface	43,434	SY	$ 3.32	$ 144,201		
3.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	43,434	CY	$ 33.68	$ 1,462,857		
3.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	14,478	CY	$ 58.23	$ 843,054		
3.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	43,434	CY	$ 74.71	$ 3,244,954		
3.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	14,478	CY	$ 30.86	$ 446,791		
3.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	108,586	CY	$ 37.41	$ 4,062,202		
3.3	**Geosynthetics**					**$ 566,370**	
3.3.1	Geosynthetics Anchor Trench Preparation	1,243	LF	$ 1.54	$ 1,914		
3.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,243	LF	$ 4.39	$ 5,457		
3.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	390,909	SF	$ 0.83	$ 324,454		
3.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	781,818	SF	$ 0.30	$ 234,545		
4.0	***AREA 4 CLOSURE***						***$ 13,603,302***
4.1	**General Costs**					**$ 2,697,649**	
4.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 10,905,653.00	$ 763,396		
4.1.2	Mobilization, De-mobilization, Bonding, Insurance	15%	LS	$ 10,905,653.00	$ 1,635,848		
4.1.3	Construction Surveying	63	AC	$ 4,736.59	$ 298,405		
4.2	**Earthwork**					**$ 10,339,283**	
4.2.1	Strip and Stockpile Reusable Topsoil	7,239	CY	$ 5.49	$ 39,742		
4.2.2	Replace Topsoil With Compacted Fill	7,239	CY	$ 13.19	$ 95,482		
4.2.3	Final Cover Subgrade: Compact and Grade Surface	43,434	SY	$ 3.32	$ 144,201		
4.2.4	Clay Layer: Purchase, Haul, Place, Compact and Grade	43,434	CY	$ 33.68	$ 1,462,857		
4.2.5	Drainage Layer: Purchase, Haul, Place, Compact and Grade	14,478	CY	$ 58.23	$ 843,054		
4.2.6	Biointrusion Layer: Purchase, Haul, Place, Compact and Grade	43,434	CY	$ 74.71	$ 3,244,954		
4.2.7	Filter Layer: Purchase, Haul, Place, Compact and Grade	14,478	CY	$ 30.86	$ 446,791		
4.2.8	Surface Cover: Purchase, Haul, Place, Compact and Grade*	108,586	CY	$ 37.41	$ 4,062,202		
4.3	**Geosynthetics**					**$ 566,370**	
4.3.1	Geosynthetics Anchor Trench Preparation	1,243	LF	$ 1.54	$ 1,914		
4.3.2	Geosynthetics Anchor Trench Backfill and Compaction	1,243	LF	$ 4.39	$ 5,457		
4.3.3	Flexible Geomembrane Material, including transportation to site, placement, seams/overlaps	390,909	SF	$ 0.83	$ 324,454		
4.3.4	Geotextile (12-oz) Layers (2), including transportation to site, placement, seams/overlaps	781,818	SF	$ 0.30	$ 234,545		
5.0	***FINAL SITE CLOSURE ACTIVITIES***						***$ 4,222,362***
5.1	**General Costs**					**$ 435,591**	
5.1.1	Engineering, Testing, and Quality Assurance	7%	LS	$ 3,786,771.00	$ 265,074		
5.1.2	Construction Surveying	36	AC	$ 4,736.59	$ 170,517		
5.2	**Final Closure Activities (Separate From Operating Costs)**					**$ 3,786,771**	
5.2.1	Complete Final Cover	1	LS	$ 2,567,981.20	$ 2,567,981		
5.2.2	Remove Support Buildings and Related Infrastructure	1	LS	$ 527,516.00	$ 527,516		
5.2.3	Remove Contact Water Tanks and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.4	Remove Leachate System Tanks, Facilities, and Related Infrastructure	1	LS	$ 161,822.00	$ 161,822		
5.2.5	Final Site Surface Grading and Reclamation of Disturbed Areas	20	AC	$ 8,381.48	$ 167,630		
5.2.6	Groundwater Well Rehabilitation and Replacement	1	LS	$ 200,000.00	$ 200,000		

* Note: Surface Cover Volume includes an additional 2.5-feet of soil used as final cover, which was calculated using the final cover area of the base case scenario for Site 11.

ATTACHMENT 5

POST CLOSURE COST ESTIMATES

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Table I5.1. Post Closure (1,000-yr Institutional) Period Cost Estimate for All Sites - High End Volume Scenario

General Information and Assumptions:

Management Reserve (MR)	15%		
Beginning of 1,000-yr Institutional Period	Year	2044	
End of 1,000-yr Institutional Period	Year	3044	
	Cost	**MR**	**Total Cost**
ANNUAL COST DURING POST-CLOSURE	**$ 1,020,584**	**$ 153,088**	**$ 1,173,672**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***ANNUAL SURVEILLANCE MONITORING AND MAINTENANCE***						***$ 1,020,584***
1.1	**General Costs**					**$ 55,000**	
1.1.1	Engineering Inspections and Reporting	1	LS	$ 10,000.00	$ 10,000		
1.1.2	Management and Administration	1	LS	$ 25,000.00	$ 25,000		
1.1.3	Environmental Compliance Documentation	1	LS	$ 20,000.00	$ 20,000		
1.2	**Landfill and Site Maintenance**					**$ 859,000**	
1.2.1	Access Controls (Fences, Gates, Other Barriers)	1	LS	$ 5,000.00	$ 5,000		
1.2.2	Signs	1	LS	$ 1,000.00	$ 1,000		
1.2.3	Sediment and Erosion Controls (inc. periodic pond dredging)	1	LS	$ 17,000.00	$ 17,000		
1.2.4	Well Maintenance, Rehabilitation, and Replacement[a]	1	LS	$ 6,000.00	$ 6,000		
1.2.5	Landfill Final Cover[b]	1	LS	$ 24,000.00	$ 24,000		
1.2.6	General Site Maintenance (Weed Management, Revegetation, etc.)	1	LS	$ 6,000.00	$ 6,000		
1.2.7	Leachate Management	1	LS	$ 800,000.00	$ 800,000		
1.3	**Quarterly Environmental Monitoring**					**$ 106,584**	
1.3.1	Groundwater Monitoring[c]	1	LS	$ 53,292.00	$ 53,292		
1.3.2	Surface Water Monitoring[d]	1	LS	$ 53,292.00	$ 53,292		

Notes:

a. Includes routine survey of well conditions, replacement of protective covers and locks, redevelopment, etc. as needed.

b. Includes routine observation of the cover soils with erosion and settlement repair and revegetation as needed.

c. Includes routine monitoring of assumed four (4) wells associated with the WDF; monitoring requirements will be defined in a subsequent CERCLA document.

d. Includes routine monitoring of assumed four (4) surface water locations; monitoring requirements will be defined in a subsequent CERCLA document.

Table I5.2. Post Closure (1,000-yr Institutional) Period Cost Estimate for All Sites - Low End Volume Scenario

General Information and Assumptions:

Management Reserve (MR)	15%		
Beginning of 1,000-yr Institutional Period	Year	2044	
End of 1,000-yr Institutional Period	Year	3044	
	Cost	**MR**	**Total Cost**
ANNUAL COST DURING POST-CLOSURE	**$ 498,584**	**$ 74,788**	**$ 573,372**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***ANNUAL SURVEILLANCE MONITORING AND MAINTENANCE***						***$ 498,584***
1.1	**General Costs**					**$ 55,000**	
1.1.1	Engineering Inspections and Reporting	1	LS	$ 10,000.00	$ 10,000		
1.1.2	Management and Administration	1	LS	$ 25,000.00	$ 25,000		
1.1.3	Environmental Compliance Documentation	1	LS	$ 20,000.00	$ 20,000		
1.2	**Landfill and Site Maintenance**					**$ 337,000**	
1.2.1	Access Controls (Fences, Gates, Other Barriers)	1	LS	$ 5,000.00	$ 5,000		
1.2.2	Signs	1	LS	$ 1,000.00	$ 1,000		
1.2.3	Sediment and Erosion Controls (inc. periodic pond dredging)	1	LS	$ 10,000.00	$ 10,000		
1.2.4	Well Maintenance, Rehabilitation, and Replacement [a]	1	LS	$ 6,000.00	$ 6,000		
1.2.5	Landfill Final Cover [b]	1	LS	$ 10,000.00	$ 10,000		
1.2.6	General Site Maintenance (Weed Management, Revegetation, etc.)	1	LS	$ 5,000.00	$ 5,000		
1.2.7	Leachate Management	1	LS	$ 300,000.00	$ 300,000		
1.3	**Quarterly Environmental Monitoring**					**$ 106,584**	
1.3.1	Groundwater Monitoring [c]	1	LS	$ 53,292.00	$ 53,292		
1.3.2	Surface Water Monitoring [d]	1	LS	$ 53,292.00	$ 53,292		

Notes:
a. Includes routine survey of well conditions, replacement of protective covers and locks, redevelopment, etc. as needed.
b. Includes routine observation of the cover soils with erosion and settlement repair and revegetation as needed.
c. Includes routine monitoring of assumed four (4) wells associated with the WDF; monitoring requirements will be defined in a subsequent CERCLA document.
d. Includes routine monitoring of assumed four (4) surface water locations; monitoring requirements will be defined in a subsequent CERCLA document.

Table I5.3. Post Closure (1,000-yr Institutional) Period Cost Estimate for All Sites - Base Case Volume Scenario

General Information and Assumptions:

Management Reserve (MR)	15%		
Beginning of 1,000-yr Institutional Period	Year	2044	
End of 1,000-yr Institutional Period	Year	3044	
	Cost	**MR**	**Total Cost**
ANNUAL COST DURING POST-CLOSURE	**$ 759,584**	**$ 113,938**	**$ 873,522**

Item	Activity	Quantity	Unit	Unit Cost	Cost	Subtotal	Total
1.0	***ANNUAL SURVEILLANCE MONITORING AND MAINTENANCE***						***$ 759,584***
1.1	**General Costs**					**$ 55,000**	
1.1.1	Engineering Inspections and Reporting	1	LS	$ 10,000.00	$ 10,000		
1.1.2	Management and Administration	1	LS	$ 25,000.00	$ 25,000		
1.1.3	Environmental Compliance Documentation	1	LS	$ 20,000.00	$ 20,000		
1.2	**Landfill and Site Maintenance**					**$ 598,000**	
1.2.1	Access Controls (Fences, Gates, Other Barriers)	1	LS	$ 5,000.00	$ 5,000		
1.2.2	Signs	1	LS	$ 1,000.00	$ 1,000		
1.2.3	Sediment and Erosion Controls (inc. periodic pond dredging)	1	LS	$ 13,500.00	$ 13,500		
1.2.4	Well Maintenance, Rehabilitation, and Replacement[a]	1	LS	$ 6,000.00	$ 6,000		
1.2.5	Landfill Final Cover[b]	1	LS	$ 17,000.00	$ 17,000		
1.2.6	General Site Maintenance (Weed Management, Revegetation, etc.)	1	LS	$ 5,500.00	$ 5,500		
1.2.7	Leachate Management	1	LS	$ 550,000.00	$ 550,000		
1.3	**Quarterly Environmental Monitoring**					**$ 106,584**	
1.3.1	Groundwater Monitoring[c]	1	LS	$ 53,292.00	$ 53,292		
1.3.2	Surface Water Monitoring[d]	1	LS	$ 53,292.00	$ 53,292		

Notes:
a. Includes routine survey of well conditions, replacement of protective covers and locks, redevelopment, etc. as needed.
b. Includes routine observation of the cover soils with erosion and settlement repair and revegetation as needed.
c. Includes routine monitoring of assumed four (4) wells associated with the WDF; monitoring requirements will be defined in a subsequent CERCLA document.
d. Includes routine monitoring of assumed four (4) surface water locations; monitoring requirements will be defined in a subsequent CERCLA document.

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ATTACHMENT 6

UNIT COSTS

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Table I6.1. Unit Costs for All Sites

Unit Costs	Cost Basis (RS MEANS)	Quantity (Basis)	Unit	Unit Cost
Excavation/Loading/Purchase Costs				
Excavate General Fill Materials	31 23 16.42 0260	50,000	cu yd	$ 2.01
Load Loose or Stockpiled Materials	31 23 16.42 0305	50,000	cu yd	$ 1.58
Purchase 3/4" Minus Washed Gravel	31 23 23.16 0100	50,000	cu yd	$ 45.22
Purchase General Fill Material	31 23 23.15 4000	50,000	cu yd	$ 24.40
Purchase Clay Borrow Material	31 23 23.15 6045	50,000	cu yd	$ 17.85
Purchase Biointrusion Barrier (riprap) Borrow Material	31 37 13.10 0300	50,000	cu yd	$ 61.70
Purchase Filter Layer (Dead/Bank Sand) Borrow Material	31 23 23.16 0200	50,000	cu yd	$ 17.85
Purchase Surface Cover (soil-rock mix) Borrow (Weed free Top Soil)	31 23 23.15 4000	50,000	cu yd	$ 24.40
Earth Materials Haul Costs				
500 ft	User Defined	50,000	cu yd	$ 1.31
0.25 mile Haul/ 1/2 mile cycle (20 MPH 8 CY truck)	31 23 23.20 0026	50,000	cu yd	$ 2.64
2 mile Haul/ 4 mile Cycle (20 mph 8 cy Truck)	31 23 23.20 0030	50,000	cu yd	$ 3.69
10 mile Haul/20 Mile Cycle (40 mph 8 CY truck)	31 23 23.20 1078	50,000	cu yd	$ 9.26
25 mile Haul/50 mile cycle (40 MPH 8 CY truck)	31 23 23.20 1084	50,000	cu yd	$ 18.55
Earthwork				
Clearing and Grubbing (Forested Areas trees up to 12 inch dia.)	31 11 10.10 0200	50	acre	$ 6,856.25
Clearing and Grubbing (Semi-open Areas)	31 11 10.10 0020	50	acre	$ 4,784.50
Perimeter Road Construction				$ 59.69
Base Course Drainage Layers, Prepare and roll sub-base, Large areas over 2500 S.Y.	32 11 23.23 8000	10,000	ln ft	$ 2.48
Finish Grading, Grade subgrade for base course, roadways	31 22 16.10 0200	10,000	ln ft	$ 1.40
Base Course Drainage Layers, For roadways and large areas, Crushed 1-1/2" stone base, compacted to 12" deep	32 11 23.23 0304	10,000	ln ft	$ 55.27
Compaction, Water, 3000 gal. truck, 3 mile haul	31 23 23.23 9000	10,000	ln ft	$ -
Finish Grading, Finish grading slopes, gentle	31 22 16.10 3300	10,000	ln ft	$ 0.54
General Purpose Gravel Road Construction				$ 26.65
Roads and Sidewalks Temporary, Roads, gravel fill, no surfacing, 4" gravel depth	01 55 23.50 0050	10,000	ln ft	$ 26.11
Compaction, Water, 3000 gal. truck, 3 mile haul	31 23 23.23 9000	10,000	ln ft	$ -
Finish Grading, Finish grading slopes, gentle	31 22 16.10 3300	10,000	ln ft	$ 0.54
Road Surfacing - road mix gravel and blading	01 55 23.50 0050	10,000	ln ft	$ 26.11
Paved Road Construction (2 1/2 AC on 6 " Base Course) 24' Wide				$ 75.85
Base Course Drainage Layers, For roadways and large areas, Crushed 1-1/2" stone base, compacted to 6" deep	32 11 23.23 0100	10,000	ln ft (24 Ft Wide)	$ 27.30
Sidewalks, Driveways and Patios No base, Asphaltic concrete, 2-1/2" thick	32 06 10.10 0100	10,000	ln ft (24 Ft Wide)	$ 41.01
Hauling, 18 C.Y., 8 wheels, 15 min. wait/Ld./Uld., 50 MPH ave, cycle 50 miles	31 23 23.20 9114	10,000	ln ft (24 Ft Wide)	$ 7.54
Earth Material Unloading, Spread or Stockpile	31 23 23.17 0020	50,000	cu yd	$ 2.17
General Fill Compaction w/ Moisture/Density Control				$ 1.92
Backfill, Structural, From existing stockpile, no compaction, 300 H.P., 50' haul, sand & gravel	31 23 23.14 5000	50,000	cu yd	$ 0.90
Compaction, Towed, Vibrating roller, 12" lifts, 4 passes	31 23 23.23 6270	50,000	cu yd	$ 1.02
Clay Liner Processing and Compaction w/ Moisture/Density Control				$ 2.82
Backfill, Structural, From existing stockpile, no compaction, 200 H.P., 50' haul, clay	31 23 23.14 4040	50,000	cu yd	$ 1.12
Compaction, Riding, Sheepsfoot or wobbly wheel roller, 6" lifts, 4 passes	31 23 23.23 5640	50,000	cu yd	$ 1.70
Gravel Spreading and Grading	31 23 23.20 2300	50,000	cu yd	$ 2.17
Surface Grading	31 23 23.20 2300	50,000	sq yd	$ 2.17
Scarify and Recompact Upper 6" of Subgrade				$ 1.15
Base Course Drainage Layers, Prepare and roll sub-base, Large areas over 2500 S.Y.	32 11 23.23 8000	50,000	sq yd	$ 0.93
Ripping, Till, boulder clay/hardpan, soft, Grader rear ripper, 180 H.P. ideal conditions	31 23 16.32 2815	50,000	sq yd	$ 0.22
General Earthmoving (medium dozer)	01 54 33.20 4260	1,000	hr	$ 156.34
Site Improvements				
8-ft Chain Link Fence	32 31 13.20 0920	10,000	ln ft	$ 41.71
High Security 8-ft Chain Link Fence w/ Barbed Wire Top				$ 52.61
Fence, Chain Link Industrial, 8'H, 6 ga. Wire, 2-1/2" line post, Aluminized steel, in concrete	32 31 13.20 0940	10,000	ln ft	$ 48.85
Razor wire	32 31 13.40 1650	5,000	ln ft	$ 3.76
Fence, Chain Link Industrial, Double swing gates, incl. posts & hardware, in concrete, 8' high, 12' opening, in concrete	32 31 13.20 5080	1	each	$ 1,984.70
Automated Entrance Gate	32 31 13.20 3100	1	each	$ 4,272.50
Large Surface Water Ditch with Riprap Armor				$ 7.77
Dewatering Systems, Excavate drainage trench, 2' wide, 3' deep, with backhoe loader	31 23 19.20 0100	10,000	ln ft	$ 2.57
Riprap and rock lining, Machine placed for slope protection	31 37 13.10 0100	10,000	ln ft	$ 5.20
Small Surface Water Ditch with Riprap Armor				$ 7.77
Dewatering Systems, Excavate drainage trench, 2' wide, 3' deep, with backhoe loader	31 23 19.20 0100	10,000	ln ft	$ 2.57
Riprap and rock lining, Machine placed for slope protection	31 37 13.10 0100	10,000	ln ft	$ 5.20

Table I6.1. Unit Costs for All Sites

Unit Costs	Cost Basis (RS MEANS)	Quantity (Basis)	Unit	Unit Cost
Buildings and Structures				
Administrative/Office	Vendor Quote	5,400	sq ft	$ 316.64
Maintenance Shop	Vendor Quote	4,800	sq ft	$ 155.20
Leachate Treatment Building	Vendor Quote	4,800	sq ft	$ 155.20
Steel Tank Structure, Set in Place, 100,000 gal capacity	$1.50/gallon	1	each	$ 150,000.00
Geosynthetic Materials (including delivery and installation)				
8-oz Nonwoven Geotextile	2011 Vendor Quote	500,000	sq ft	$ 0.30
12-oz Nonwoven Geotextile	2011 Vendor Quote	500,000	sq ft	$ 0.30
Geocomposite Drainage Net	2011 Vendor Quote	500,000	sq ft	$ 0.57
60-mil HDPE Liner	2011 Vendor Quote	500,000	sq ft	$ 0.66
80-mil HDPE Liner	2011 Vendor Quote	500,000	sq ft	$ 0.81
45-mil RPP Liner	2011 Vendor Quote	500,000	sq ft	$ 0.83
Geosynthetic Materials Anchorage				
Anchor Trench Excavation and Preparation	31 23 16.13 0050	2,000	ln ft	$ 1.54
Anchor Trench Backfill and Compaction	31 23 23.13 0300	2,000	ln ft	$ 4.39
Piping and Appurtenances				
Shallow Trenching for 6" Drain Pipe	31 23 16.13 0050	5,000	ln ft	$ 1.54
6" HDPE Corrugated Perforated Pipe	33 46 16.25 2020	5,000	ln ft	$ 18.46
Pipe Bedding for 6" Pipe (Sand)	31 23 23.16 0200	5,000	ln ft	$ 5.60
Dual Containment HDPE Pipe (6" inside 10")				$ 57.37
Water Supply, HDPE, Butt fusion joints, SDR 21, 40' lengths not including excavation or backfill, 10" diameter	33 11 13.35 0400	5,000	ln ft	$ 35.01
Water Supply, HDPE, Butt fusion joints, SDR 21, 40' lengths not including excavation or backfill, 6" diameter	33 11 13.35 0200	5,000	ln ft	$ 22.36
Excavation and Backfill for Dual Contained Pipe (3 ft cover)	31 23 16.13 0050	5,000	ln ft	$ 4.43
16" HDPE Pipe	User Defined	5,000	ln ft	$ 39.05
Excavation and Backfill for 16" HDPE Pipe (3 ft cover)	31 23 16.13 0050	5,000	ln ft	$ 5.01
Valves for 16" Pipe	33 12 16.10 3824	1	each	$ 6,520.95
Pipes, Valves and Fittings				$ 13,182.67
6" HDPE, SDR 21 Pipe	33 11 13.35 0200	400	ln ft	$ 8,944.32
Check Valves	33 12 16.10 3714	6	each	$ 1,293.17
Gate Valves	33 12 16.10 3814	6	each	$ 1,156.32
Fittings	20% of Pipe Costs	400	ln ft	$ 1,788.86
Pump and Motor	22 11 23.10 3240	1	each	$ 103,224.00
Concrete				
Concrete: delivered ready-mix (3,500 PSI)	03 31 05.35 0200	100	cu yd	$ 118.41
Concrete: formwork, steel reinforcement, and labor	03 30 53.40 4050	100	cu yd	$ 353.31
Pre-Fabricated Metal Building Demolition				
3,500 to 7,500 sq ft	13 05 05.15 0550		sf flr	$ 2.93
Concrete lab demo	02 41 16.17 0440			$ 9.34
Pre-Cast Concrete Vaults				
6" ID, 8' deep	33 49 13.10 1210		each	$ 5,913.30
Slab top 8" thick, 6' dia.	33 49 13.10 1500		each	$ 1,023.39
7 cast iron steps, 12" x 10.5"	33 49 13.10 3928		each	$ 307.77
Parking Lot				
6" stone base, 4" binder course, 2" topping	32 12 16.14 0035		sq ft	$ 4.25
Hauling material 6.05 Cyper inch per MSF, 10 mile haul	32 12 16.14 0018		sq ft	$ 0.67
Final Site Grading and Reclamation of Disturbed Areas				
Base Course Drainage Layers, Prepare and roll sub-base, Large areas over 2500 S.Y.	32 11 23.23 8000		acre	$ 4,497.33
Finish Grading, Finish grading slopes, gentle	31 22 16.10 3300		acre	$ 972.36
Wildflower seeding, hydro, mulch and fertilizer	32 92 19.14 5800		acre	$ 2,911.79
Crane				$ 6,685.69
Running Track Crane	41 22 13.10 0210	80	ln ft	$ 3,561.94
Electric Hoist 3-ton	41 22 23.10 2200	1	each	$ 3,123.75
Lift Station	33 32 13.13 2500	1	each	$ 292,567.00
Construction Dewatering				$ 20,116.10
Dewatering Trench	31 23 19.10 0020	12,800	ln ft	$ 3,975.68
Pumping	31 23 19.20 0600	64	days	$ 16,140.42
Septic System and Drainfield	True-Up 1.6.3.1	1	LS	$ 21,840.00
Water Supply and Distribution System	True-Up 1.6.3.1	1	LS	$ 92,640.00
Fire Hydrants and Service Connections	True-Up 1.6.3.1	1	LS	$ 27,300.00
Electrical and Telecommunications	True-Up 1.6.3.1	1	LS	$ 248,889.00
Parking Area	User Defined	14,000	sq ft	$ 6.36

Table I6.1. Unit Costs for All Sites

Unit Costs	Cost Basis (RS MEANS)	Quantity (Basis)	Unit	Unit Cost
Vaults	33 49 13.10 1210, 33 49 13.10 1500, 33 49 13.10 3928		each	$ 7,244.46
Drain Ports	G3030 210 1920	1	LS	$ 4,450.75
Cleanout Access Port				$ 2,477.43
Clean out Tee	22 05 76.20 5130	1	each	$ 73.90
Manhole	33 49 13.10 1130	1	each	$ 2,403.53
Sump, Perforated Pipes, Fittings, Drain Rock Fill				$ 182,382.67
Pipes	See Pipes, Valves and Fittings	1	each	$ 13,182.67
Sump construction including gravel	31 23 19.20 1600	60,000	cu ft	$ 2.82
Surface Water Pumps, Pipes, Fittings, and Ancillary Equipment				$ 91,036.50
Pipes	31 23 16.13 0050, 31 23 23.16 0200, 33 11 13.35 0200	1,000	ln ft	$ 29.50
Pumps	22 11 23.10 3190	2	each	$ 30,768.25
BMPs for Stormwater Management and Sediment				$ 136,807.90
Silt Fence	31 25 14.16 1000	11,000	ln ft	$ 1.30
Hay Bales, Staked	31 25 14.16 1250	11,000	ln ft	$ 8.49
Seeding	32 92 19.14 5800	10	acre	$ 2,911.79
Surface Water Pond Overflow	See Large Surface Water Ditch with Riprap Armor	1000	ln ft	$ 7.77
Signs				$ 41,186.30
Signs, 24"x24"	10 14 53.20 0012	200	each	$ 135.21
Signs, 30"x30"	10 14 53.20 0300	10	each	$ 233.39
Sign Posts	10 14 53.20 1500	210	each	$ 56.24
Electrical, Sensors, Controls, Pumps, Piping, and Fittings				$ 263,213.67
Flow Meter (turbine, 6" diameter, to 1,800 GPM)	22 11 19.38 7360	0	each	$ 4,778.00
6" HDPE, SDR 21 Pipe	33 11 13.35 0200	400	ln ft	$ 8,944.32
Check Valves	33 12 16.10 3714	8	each	$ 3,235.67
Gate Valves	33 12 16.10 3814	8	each	$ 3,098.82
Fittings	20% of Pipe Costs	400	ln ft	$ 1,788.86
Pumps	22 11 23.10 3190	8	each	$ 30,768.25
Outside Lights				$ 1,325,626.00
Roadway Area Luminaire, High Pressure Sodium, 400 watt	26 56 19.20 2780	23,600	ln ft	$ 993.05
Floodlights - pole mounted metal halide, 400 watt	26 56 36.20 2400	10,400	ln ft	$ 772.90
Lighting Poles, Aluminum pole, 20 ft high	26 56 13.10 3000	340	each	$ 1,797.91
Bracket Arms, 1 arms	26 56 13.10 3800	340	each	$ 242.18
Concrete Foundations	33 71 16.20 0960	340	each	$ 933.10
High Security Area Lighting and Electrical				$ 755,856.20
Floodlights - pole mounted high pressure sodium, 400 watt	26 56 36.20 2400	2,000	ln ft	$ 772.90
Lighting Poles, Aluminum pole, 20 ft high	26 56 13.10 3000	20	each	$ 1,797.91
Bracket Arms, 3 arms	26 56 13.10 4200	20	each	$ 592.80
Concrete Foundations	33 71 16.20 0960	20	each	$ 933.10
Electrical Conduit, Rigid Galvanized Steel , 4@2" diameter	33 71 19.17 6400	2000	ln ft	$ 46.90
Conduit Fittings		20% of Conduit Costs		$ 18,760.00
Conduit Trenching	31 23 16.13 0050	300	bulk cu yd	$ 16.62
Non-Metallic Sheathed Cable, 600 volt, #14, 3 conductor	26 05 19.55 1600	2,000	ln ft	$ 262.73
Guard Shacks and Equipment	True-Up Exhibit 36	1	each	$ 5,846.00
Sanitary Treatment System				$ 4,522,000.00
Sanitary Treatment System Equipment	46 07 53.10 1200	50000	gal	$ 2,261,000.00
Sanitary Treatment System Installation	100% of Equipment Cost	100%		$ 2,261,000.00
Surveying	02 21 13.09 0100		acre	$ 4,736.59

Notes:
Quantities are shown to present an "order-of-magnitude" basis for the estimated unit costs.
Actual costs may vary from the above depending on site conditions, economic factors, etc.
Costs obtained from RS Means have been updated to include Fee (12%), Overhead (7%), and Fringe (66%) as appropriate.

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ATTACHMENT 7

LABOR COSTS

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Table I7.1. Labor Costs for All Sites

Annual Wage Increase: **2.0%** **Increase assumed to be independent from inflation index; merit raises only.**
Wages Include: **Base Rate, Fringe (benefits, taxes, etc.), and Fee (12%)**
Note: **Overhead costs are covered as other operating costs, not tied to labor rates.**

YEAR	PCC Manager	Operations Manager	Quality Engineer	WAC Manager	Health & Safety Professional	Rad Con Technician	Heavy Equip. Operator	A Operator	B Operator	Records Administrator	Scale Operator
2014	$236.28	$152.69	$112.86	$126.14	$104.36	$73.42	$73.42	$73.42	$73.42	$92.95	$73.42
2015	$241.01	$155.74	$115.12	$128.66	$106.45	$74.89	$74.89	$74.89	$74.89	$94.81	$74.89
2016	$245.83	$158.85	$117.42	$131.23	$108.58	$76.39	$76.39	$76.39	$76.39	$96.71	$76.39
2017	$250.75	$162.03	$119.77	$133.85	$110.75	$77.92	$77.92	$77.92	$77.92	$98.64	$77.92
2018	$255.77	$165.27	$122.17	$136.53	$112.97	$79.48	$79.48	$79.48	$79.48	$100.61	$79.48
First 5-yr Average	**$245.93**	**$158.92**	**$117.47**	**$131.28**	**$108.62**	**$76.42**	**$76.42**	**$76.42**	**$76.42**	**$96.74**	**$76.42**
2019	$260.89	$168.58	$124.61	$139.26	$115.23	$81.07	$81.07	$81.07	$81.07	$102.62	$81.07
2020	$266.11	$171.95	$127.10	$142.05	$117.53	$82.69	$82.69	$82.69	$82.69	$104.67	$82.69
2021	$271.43	$175.39	$129.64	$144.89	$119.88	$84.34	$84.34	$84.34	$84.34	$106.76	$84.34
2022	$276.86	$178.90	$132.23	$147.79	$122.28	$86.03	$86.03	$86.03	$86.03	$108.90	$86.03
2023	$282.40	$182.48	$134.87	$150.75	$124.73	$87.75	$87.75	$87.75	$87.75	$111.08	$87.75
2024	$288.05	$186.13	$137.57	$153.77	$127.22	$89.51	$89.51	$89.51	$89.51	$113.30	$89.51
2025	$293.81	$189.85	$140.32	$156.85	$129.76	$91.30	$91.30	$91.30	$91.30	$115.57	$91.30
2026	$299.69	$193.65	$143.13	$159.99	$132.36	$93.13	$93.13	$93.13	$93.13	$117.88	$93.13
2027	$305.68	$197.52	$145.99	$163.19	$135.01	$94.99	$94.99	$94.99	$94.99	$120.24	$94.99
2028	$311.79	$201.47	$148.91	$166.45	$137.71	$96.89	$96.89	$96.89	$96.89	$122.64	$96.89
2029	$318.03	$205.50	$151.89	$169.78	$140.46	$98.83	$98.83	$98.83	$98.83	$125.09	$98.83
2030	$324.39	$209.61	$154.93	$173.18	$143.27	$100.81	$100.81	$100.81	$100.81	$127.59	$100.81
2031	$330.88	$213.80	$158.03	$176.64	$146.14	$102.83	$102.83	$102.83	$102.83	$130.14	$102.83
2032	$337.50	$218.08	$161.19	$180.17	$149.06	$104.89	$104.89	$104.89	$104.89	$132.74	$104.89
2033	$344.25	$222.44	$164.41	$183.77	$152.04	$106.99	$106.99	$106.99	$106.99	$135.39	$106.99
2034	$351.14	$226.89	$167.70	$187.45	$155.08	$109.13	$109.13	$109.13	$109.13	$138.10	$109.13
2035	$358.16	$231.43	$171.05	$191.20	$158.18	$111.31	$111.31	$111.31	$111.31	$140.86	$111.31
2036	$365.32	$236.06	$174.47	$195.02	$161.34	$113.54	$113.54	$113.54	$113.54	$143.68	$113.54
2037	$372.63	$240.78	$177.96	$198.92	$164.57	$115.81	$115.81	$115.81	$115.81	$146.55	$115.81
2038	$380.08	$245.60	$181.52	$202.90	$167.86	$118.13	$118.13	$118.13	$118.13	$149.48	$118.13
20-yr Average	**$316.95**	**$204.81**	**$151.38**	**$169.20**	**$139.99**	**$98.50**	**$98.50**	**$98.50**	**$98.50**	**$124.66**	**$98.50**
2039	$387.68	$250.51	$185.15	$206.96	$171.22	$120.49	$120.49	$120.49	$120.49	$152.47	$120.49
2040	$395.43	$255.52	$188.85	$211.10	$174.64	$122.90	$122.90	$122.90	$122.90	$155.52	$122.90
2041	$403.34	$260.63	$192.63	$215.32	$178.13	$125.36	$125.36	$125.36	$125.36	$158.63	$125.36
2042	$411.41	$265.84	$196.48	$219.63	$181.69	$127.87	$127.87	$127.87	$127.87	$161.80	$127.87
2043	$419.64	$271.16	$200.41	$224.02	$185.32	$130.43	$130.43	$130.43	$130.43	$165.04	$130.43
Last 5-yr Average	**$403.50**	**$260.73**	**$192.70**	**$215.41**	**$178.20**	**$125.41**	**$125.41**	**$125.41**	**$125.41**	**$158.69**	**$125.41**

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ATTACHMENT 8

ECONOMIC ANALYSIS FOR 5% OF WASTE NOT MEETING WAC CRITERIA

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Table I8.1. Economic Analysis for 5% of Waste Not Meeting WAC Criteria - High End Volume Scenario for Off-Site Disposal From 2014 - 2039

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular No. A-94, Appendix C)
	High End Volume for 2014 to 2039	200,000	Cubic Yards
	Average Yearly Disposal Rate	7,692	Cubic Yards per Year

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039)

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*	Volume (CY)	Estimated Rate ($/CY)
Year 2014	$ 5,568,962	$ 5,201,967	5.0%	7,692	676
Year 2015	$ 5,568,962	$ 5,085,019	4.9%	7,692	661
Year 2016	$ 5,568,962	$ 4,970,299	4.8%	7,692	646
Year 2017	$ 5,568,962	$ 4,858,919	4.7%	7,692	632
Year 2018	$ 5,568,962	$ 4,749,211	4.6%	7,692	617
Year 2019	$ 5,568,962	$ 4,642,844	4.5%	7,692	604
Year 2020	$ 5,568,962	$ 4,538,147	4.4%	7,692	590
Year 2021	$ 5,568,962	$ 4,436,235	4.3%	7,692	577
Year 2022	$ 5,568,962	$ 4,336,551	4.2%	7,692	564
Year 2023	$ 5,568,962	$ 4,239,094	4.1%	7,692	551
Year 2024	$ 5,568,962	$ 4,143,865	4.0%	7,692	539
Year 2025	$ 5,568,962	$ 4,050,306	3.9%	7,692	527
Year 2026	$ 5,568,962	$ 3,959,532	3.8%	7,692	515
Year 2027	$ 5,568,962	$ 3,870,429	3.7%	7,692	503
Year 2028	$ 5,568,962	$ 3,783,553	3.7%	7,692	492
Year 2029	$ 5,568,962	$ 3,698,348	3.6%	7,692	481
Year 2030	$ 5,568,962	$ 3,615,370	3.5%	7,692	470
Year 2031	$ 5,568,962	$ 3,534,063	3.4%	7,692	459
Year 2032	$ 5,568,962	$ 3,454,427	3.3%	7,692	449
Year 2033	$ 5,568,962	$ 3,377,019	3.3%	7,692	439
Year 2034	$ 5,568,962	$ 3,300,724	3.2%	7,692	429
Year 2035	$ 5,568,962	$ 3,226,657	3.1%	7,692	419
Year 2036	$ 5,568,962	$ 3,154,260	3.1%	7,692	410
Year 2037	$ 5,568,962	$ 3,082,977	3.0%	7,692	401
Year 2038	$ 5,568,962	$ 3,013,922	2.9%	7,692	392
Year 2039	$ 5,568,962	$ 2,945,981	2.9%	7,692	383
Total:	$ 144,793,012				
	TOTAL PRESENT VALUE COST	$ 103,269,719	100.0%	199,992	check, total volume (CY)
	Average Cost per Cubic Yard	$ 516.00	*present value basis		

Table I8.2. Economic Analysis for 5% of Waste Not Meeting WAC Criteria - Low End Volume Scenario for Off-Site Disposal From 2014 - 2039

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular No. A-94, Appendix C)
	Low End Volume for 2014 to 2039	75,000	Cubic Yards
	Average Yearly Disposal Rate	2,885	Cubic Yards per Year

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039)

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*	Volume (CY)	Estimated Rate ($/CY)
Year 2014	$ 1,945,389	$ 1,817,188	5.0%	2,885	630
Year 2015	$ 1,945,377	$ 1,776,324	4.9%	2,885	616
Year 2016	$ 1,945,377	$ 1,736,249	4.8%	2,885	602
Year 2017	$ 1,945,377	$ 1,697,341	4.7%	2,885	588
Year 2018	$ 1,945,377	$ 1,659,018	4.6%	2,885	575
Year 2019	$ 1,945,377	$ 1,621,861	4.5%	2,885	562
Year 2020	$ 1,945,377	$ 1,585,288	4.4%	2,885	549
Year 2021	$ 1,945,377	$ 1,549,687	4.3%	2,885	537
Year 2022	$ 1,945,377	$ 1,514,865	4.2%	2,885	525
Year 2023	$ 1,945,377	$ 1,480,821	4.1%	2,885	513
Year 2024	$ 1,945,377	$ 1,447,555	4.0%	2,885	502
Year 2025	$ 1,945,377	$ 1,414,873	3.9%	2,885	490
Year 2026	$ 1,945,377	$ 1,383,163	3.8%	2,885	479
Year 2027	$ 1,945,377	$ 1,352,037	3.7%	2,885	469
Year 2028	$ 1,945,377	$ 1,321,689	3.7%	2,885	458
Year 2029	$ 1,945,377	$ 1,291,925	3.6%	2,885	448
Year 2030	$ 1,945,377	$ 1,262,939	3.5%	2,885	438
Year 2031	$ 1,945,377	$ 1,234,536	3.4%	2,885	428
Year 2032	$ 1,945,377	$ 1,206,717	3.3%	2,885	418
Year 2033	$ 1,945,377	$ 1,179,677	3.3%	2,885	409
Year 2034	$ 1,945,377	$ 1,153,025	3.2%	2,885	400
Year 2035	$ 1,945,377	$ 1,127,151	3.1%	2,885	391
Year 2036	$ 1,945,377	$ 1,101,862	3.1%	2,885	382
Year 2037	$ 1,945,377	$ 1,076,961	3.0%	2,885	373
Year 2038	$ 1,945,377	$ 1,052,838	2.9%	2,885	365
Year 2039	$ 1,945,377	$ 1,029,104	2.9%	2,885	357
Total:	$ 50,579,814				
	TOTAL PRESENT VALUE COST	$ 36,074,694	100.0%	75,010	check, total volume (CY)
	Average Cost per Cubic Yard	$ 481	*present value basis		

Table I8.3. Economic Analysis for 5% of Waste Not Meeting WAC Criteria - Base Case Volume Scenario for Off-Site Disposal From 2014 - 2039

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular No. A-94, Appendix C)
	Base Case Volume for 2014 to 2039	125,000	Cubic Yards
	Average Yearly Disposal Rate	4,808	Cubic Yards per Year
Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.9131	4	Single Payment Present Worth: from 2015 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2016 to 2011
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2017 to 2011
(P/F, i, n)	0.8528	7	Single Payment Present Worth: from 2018 to 2011
(P/F, i, n)	0.8337	8	Single Payment Present Worth: from 2019 to 2011
(P/F, i, n)	0.8149	9	Single Payment Present Worth: from 2020 to 2011
(P/F, i, n)	0.7966	10	Single Payment Present Worth: from 2021 to 2011
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2022 to 2011
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2023 to 2011
(P/F, i, n)	0.7441	13	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.7273	14	Single Payment Present Worth: from 2025 to 2011
(P/F, i, n)	0.7110	15	Single Payment Present Worth: from 2026 to 2011
(P/F, i, n)	0.6950	16	Single Payment Present Worth: from 2027 to 2011
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2028 to 2011
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2029 to 2011
(P/F, i, n)	0.6492	19	Single Payment Present Worth: from 2030 to 2011
(P/F, i, n)	0.6346	20	Single Payment Present Worth: from 2031 to 2011
(P/F, i, n)	0.6203	21	Single Payment Present Worth: from 2032 to 2011
(P/F, i, n)	0.6064	22	Single Payment Present Worth: from 2033 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2034 to 2011
(P/F, i, n)	0.5794	24	Single Payment Present Worth: from 2035 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2036 to 2011
(P/F, i, n)	0.5536	26	Single Payment Present Worth: from 2037 to 2011
(P/F, i, n)	0.5412	27	Single Payment Present Worth: from 2038 to 2011
(P/F, i, n)	0.5290	28	Single Payment Present Worth: from 2039 to 2011

OFF-SITE DISPOSAL (FROM 2014 TO 2039)

Year	Estimated Cost	Present Value Cost	Percent of Total Cost*	Volume (CY)	Estimated Rate ($/CY)
Year 2014	$ 3,332,654	$ 3,113,032	5.0%	4,808	647
Year 2015	$ 3,332,654	$ 3,043,046	4.9%	4,808	633
Year 2016	$ 3,332,654	$ 2,974,394	4.8%	4,808	619
Year 2017	$ 3,332,654	$ 2,907,741	4.7%	4,808	605
Year 2018	$ 3,332,654	$ 2,842,087	4.6%	4,808	591
Year 2019	$ 3,332,654	$ 2,778,434	4.5%	4,808	578
Year 2020	$ 3,332,654	$ 2,715,780	4.4%	4,808	565
Year 2021	$ 3,332,654	$ 2,654,792	4.3%	4,808	552
Year 2022	$ 3,332,654	$ 2,595,138	4.2%	4,808	540
Year 2023	$ 3,332,654	$ 2,536,816	4.1%	4,808	528
Year 2024	$ 3,332,654	$ 2,479,828	4.0%	4,808	516
Year 2025	$ 3,332,654	$ 2,423,839	3.9%	4,808	504
Year 2026	$ 3,332,654	$ 2,369,517	3.8%	4,808	493
Year 2027	$ 3,332,654	$ 2,316,195	3.7%	4,808	482
Year 2028	$ 3,332,654	$ 2,264,205	3.7%	4,808	471
Year 2029	$ 3,332,654	$ 2,213,216	3.6%	4,808	460
Year 2030	$ 3,332,654	$ 2,163,559	3.5%	4,808	450
Year 2031	$ 3,332,654	$ 2,114,902	3.4%	4,808	440
Year 2032	$ 3,332,654	$ 2,067,245	3.3%	4,808	430
Year 2033	$ 3,332,654	$ 2,020,921	3.3%	4,808	420
Year 2034	$ 3,332,654	$ 1,975,264	3.2%	4,808	411
Year 2035	$ 3,332,654	$ 1,930,940	3.1%	4,808	402
Year 2036	$ 3,332,654	$ 1,887,615	3.1%	4,808	393
Year 2037	$ 3,332,654	$ 1,844,957	3.0%	4,808	384
Year 2038	$ 3,332,654	$ 1,803,632	2.9%	4,808	375
Year 2039	$ 3,332,654	$ 1,762,974	2.9%	4,808	367
Total:	$ 86,649,004				
	TOTAL PRESENT VALUE COST	$ 61,800,069	100.0%	125,008	check, total volume (CY)
	Average Cost per Cubic Yard	$ 494	*present value basis		

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ATTACHMENT 9

ECONOMIC ANALYSIS FOR C-746-U LANDFILL CONSTRUCTION, OPERATIONS, AND CLOSURE & WASTE MINIMIZATION CONSTRUCTION AND OPERATIONS

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Table I9.1. Economic Analysis for C-746-U Landfill Construction, Operations, and Closure

Assumptions:	Discount Rate	2.3%	APR (Based on OMB Circular No. A-94, Appendix C)
	Disposal Waste Volume (2014-2039)	1,100,000	Cubic Yards

Note: Closure and post-closure costs are as reported in the 1994 U Landfill closure plan; the discount rate above is used to convert 1994 dollars to 2010 dollars.

Economic Factors:	Factor Value	No. Years	Explanation
(F/P, i, n)	1.4719	17	Single Payment Future Worth: from 1994 to 2011
	1.1204	5	Single Payment Future Worth: from 2006 to 2011
(P/F, i, n)	0.9775	1	Single Payment Present Worth: from 2010 to 2011
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.8925	5	Single Payment Present Worth: from 2019 to 2014
(P/F, i, n)	0.8725	6	Single Payment Present Worth: from 2020 to 2014
(P/F, i, n)	0.7787	11	Single Payment Present Worth: from 2025 to 2014
(P/F, i, n)	0.7612	12	Single Payment Present Worth: from 2026 to 2014
(P/F, i, n)	0.6794	17	Single Payment Present Worth: from 2031 to 2014
(P/F, i, n)	0.6641	18	Single Payment Present Worth: from 2032 to 2014
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2039 to 2014
(P/F, i, n)	0.5055	30	Single Payment Present Worth: from 2044 to 2014
(P/A, i, n)	20.9940	29	Uniform Series Present Worth: Annual from 2011 to 2040
(P/A, i, n)	4.6727	5	Uniform Series Present Worth: Annual from 2014 to 2019
(P/A, i, n)	18.8530	25	Uniform Series Present Worth: Annual from 2014 to 2039
(P/A, i, n)	15.8878	20	Uniform Series Present Worth: Annual from 2019 to 2039
(P/A, i, n)	4.6727	5	Uniform Series Present Worth: Annual from 2039 to 2044
(P/A, i, n)	20.3829	30	Uniform Series Present Worth: Annual from 2039 to 2069
(P/A, i, n)	39.0041	100	Uniform Series Present Worth: Annual from 2044 to 2144

U-Landfill 2014-2039

Activity	**Type / Year(s) Cost is Incurred**	**Estimated Cost**	**Present Value Cost**	**Percent of Total Cost***
Phases 12-15 Construction	2019	$ 10,056,133	$ 8,383,640	11.2%
Phases 16-19 Construction	2025	$ 10,056,133	$ 7,314,667	9.8%
Phases 20-23 Construction	2031	$ 10,056,133	$ 6,381,899	8.5%
Operations	Annual, 2014 to 2039	$ 1,265,000	$ 22,277,393	29.7%
Closure of Phases 1-23	2039	$ 41,229,939	$ 24,440,068	32.6%
Post-Closure Care (30 years)	Annual, 2039 to 2069	$ 573,372	$ 6,183,282	8.2%
		TOTAL PRESENT WORTH COST	$ 74,980,949	100.0%
		Cost per Cubic Yard	$ 68	*present value basis

Notes:
Costs for Phases 12-23 Construction and Closure of Phases 1-23 include 15% Management Reserve and 25% Contingency.
Costs for Operations and Post Closure Care include 15% Management Reserve.
Operations costs under Estimated Cost are annual costs; Present Value Cost is for the period 2014 through 2039.
Post-closure costs assumed to be those used for the On-Site Disposal Alternative (Low End Volume Scenario).
Annual operating costs assume that soil fill at a 1:1 soil to waste ratio will be sufficient.

Table I9.2. Present Value Costs
(Waste Minimization)

LIFE CYCLE COST ANALYSIS
Engineer's Cost Estimate for
Waste Minimization Construction and Operations

Economic Analysis of Alternatives

Assumptions: Discount Rate 2.3% APR (Based on OMB Circular No. A-94, Appendix C)

Economic Factors:	Factor Value	No. Years	Explanation
(P/F, i, n)	1.0000	0	Single Payment Present Worth: from 2011 to 2011
(P/F, i, n)	0.9341	3	Single Payment Present Worth: from 2014 to 2011
(P/F, i, n)	0.5927	23	Single Payment Present Worth: from 2024 to 2011
(P/F, i, n)	0.5664	25	Single Payment Present Worth: from 2039 to 2014
(P/F, i, n)	0.5055	30	Single Payment Present Worth: from 2044 to 2014
(P/A, i, n)	4.6727	5	Uniform Series Present Worth: Annual from 2014 to 2019
(P/A, i, n)	18.8530	25	Uniform Series Present Worth: Annual from 2014 to 2039
(P/A, i, n)	12.5655	15	Uniform Series Present Worth: Annual from 2024 to 2039

Waste Minimization

Activity	Type / Year(s) Cost is Incurred	Estimated Cost	Present Value Cost	Percent of Total Cost
Construction - Concrete	2024	$ 13,901,875	$ 8,239,641	1.4%
Construction - Metal	2024	$ 574,807,188	$ 340,688,220	59.8%
Concrete Operations - During Site D&D	Annual, 2024 to 2039	$ 5,767,681	$ 42,955,219	7.5%
Metal Operations - During Site D&D	Annual, 2024 to 2039	$ 23,870,946	$ 177,780,585	31.2%
		TOTAL PRESENT WORTH COST	$ 569,663,665	100.0%

Metal Values Based on Recent Market Values

Material	Type / Year(s) Value is Realized	Estimated Value	Present Value	Percent of Value
Steel - Clean	Annual, 2024 to 2039	$ 3,366,261	$ 25,070,471	10.7%
Steel	Annual, 2024 to 2039	$ 12,185,766	$ 90,754,368	38.6%
Copper	Annual, 2024 to 2039	$ 3,252,217	$ 24,221,120	10.3%
Aluminum	Annual, 2024 to 2039	$ 1,135,859	$ 8,459,392	3.6%
Nickel	Annual, 2024 to 2039	$ 11,634,444	$ 86,648,358	36.8%
		TOTAL PRESENT WORTH COST	$ 235,153,709	89.3%

Metal Values Based on 20-Year Historical Market Value Average

Material	Type / Year(s) Value is Realized	Estimated Value	Present Value	Percent of Value
Steel - Clean	Annual, 2024 to 2039	$ 2,099,587	$ 15,636,825	10.0%
Steel	Annual, 2024 to 2039	$ 7,600,443	$ 56,604,845	36.1%
Copper	Annual, 2024 to 2039	$ 1,602,353	$ 11,933,639	7.6%
Aluminum	Annual, 2024 to 2039	$ 970,961	$ 7,231,302	4.6%
Nickel	Annual, 2024 to 2039	$ 8,801,509	$ 65,549,871	41.8%
		TOTAL PRESENT WORTH COST	$ 156,956,482	90.0%

Notes:
Metal tonnages for recycling are assumed to be 75% of total estimated metal tonnage.
Construction-Concrete and Construction-Metal costs include 30% contingency and 15% management reserve.
Operations costs include 15% management reserve.