DOE/OR/07-1846/V1&D2
PRIMARY DOCUMENT

Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Volume 1 of 4
Chapters 1–8

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

I-04410-0012

August 2000

CLEARED FOR PUBLIC RELEASE

Department of Energy
Oak Ridge Operations
Paducah Site Office
P.O. Box 1410
Paducah, KY 42001

I-04410-0012

August 21, 2000

Mr. Carl R. Froede Jr., P.G.
United States Environmental Protection Agency
Region IV
DOE Remedial Section
Federal Facilities Branch
Waste Management Division
61 Forsyth Street
Atlanta, Georgia 30303

Mr. Michael V. Welch, P.E.
Manager
Hazardous Waste Branch
Kentucky Department for Environmental Protection
14 Reilly Road, Frankfort Office Park
Frankfort, Kentucky 40601

Dear Mr. Froede and Mr. Welch:

D2 REMEDIAL INVESTIGATION REPORT (VOLUMES 1-4) FOR WASTE AREA GROUPING 28, AT THE PADUCAH GASEOUS DIFFUSION PLANT, PRIMARY DOCUMENT, AUGUST 2000, DOE/OR/07-1846&D2 AND COMMENT RESPONSE TABLE FOR DATA REPORT FOR THE SITE-WIDE REMEDIAL EVALUATION FOR SOURCE AREAS CONTRIBUTING TO OFF-SITE GROUNDWATER CONTAMINATION AT THE PADUCAH GASEOUS DIFFUSION PLANT, SECONDARY DOCUMENT, JANUARY 2000, DOE/OR/07-1845&D1

The D2 Remedial Investigation (RI) Report for Waste Area Grouping (WAG) 28 is enclosed for your approval. The report addresses the findings of the WAG 28 RI, in addition to documenting revisions based on agency comments received in April and June of this year.

The enclosed Comment Response Table for the Data Report for the Site-Wide Remedial Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination at the Paducah Gaseous Diffusion Plant addresses the Environmental Protection Agency's comments on the report. The Commonwealth of Kentucky did not comment on this document. As agreed to between the agencies and DOE, the Comment Response Table is to be considered part of the D1 version of the data report, and a revised D2 edition of the document will not be required.

If you have any questions or require additional information, please call Gary Bodenstein at (270) 441-6831.

Sincerely,

W. D. Seaborg

W. Don Seaborg, Site Manager
Paducah Site Office

Enclosures

cc w/out enclosures:
DMC/Kevil
R. A. Pratt, BJC/Kevil
R. C. Sleeman, EM-92

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M. V. Welch			X		X	
Tennessee Valley Authority						
T. Whitaker				X		X
U.S. Enrichment Corporation						
T. M. Taimi				X		X
U.S. Geological Survey						
T. Mesko			X		X	
West Kentucky Wildlife Management Area						
T. Kreher			X		X	

D0–Bechtel Jacobs Company/DOE internal draft
D1–EPA/KY first draft
D2–EPA/KY final draft (comments incorporated)

CERTIFICATION

Document Identification: **Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/OR/07-1846&D2 Primary Document)**

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 assure 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)
Owner and Operator

W. D. Seaborg

W. Don Seaborg, Paducah Site Manager

8/18/00

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 assure 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.

Bechtel Jacobs Company LLC
Co-Operator

Gordon L. Dover, Paducah Manager of Projects

8/18/00

Date Signed

Response to Comments on the Draft (D1) Waste Area Grouping 28 Remedial Investigation Report
Paducah Gaseous Diffusion Plant, Paducah, Kentucky
U.S. Environmental Protection Agency

No.	Page/ Reference	Comment	Response
General, U. S. Environmental Protection Agency			
1		Several documents were referenced as providing information used in the development of this document. Some of these documents (e.g., *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (Department of Energy [DOE], 1997) and the *Installation Wide Sampling and Analysis Plan (SAP) for the Paducah Gaseous Diffusion Plant (PGDP), Paducah, Kentucky*) have not been reviewed and approved by this Agency. Inconsistencies between EPA/KDEP guidance and DOE methodology outlined in these documents might lead to differences in conclusions. These documents should be reviewed and approved to avoid potential future conflicts over final cleanup decisions.	This comment required no change to the document. The document, *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, KY* (DOE 1997), has been reviewed by KDEP and EPA. Comments were incorporated and the document was revised by providing self-adhesive labels to those parts of the document that required changes. See attached documentation. No references to the document, *Installation Wide Sampling and Analysis Plan (SAP) for the Paducah Gaseous Diffusion Plant (PGDP), Paducah, Kentucky*, were found in the WAG 28 RI.

Response to Comments on the Draft (D1) Waste Area Grouping 28 Remedial Investigation Report
Paducah Gaseous Diffusion Plant, Paducah, Kentucky
U.S. Environmental Protection Agency

No.	Page/ Reference	Comment	Response
2		The discussion of the logic of grouping of Solid Waste Management Units (SWMUs) into Waste Area Groups (WAGs) is beyond the scope of this report and these comments. However, these SWMUs are relatively closely spaced. To treat them as individual units with no understanding or referencing of the potential impact of the neighboring SWMUs or larger PGDP-wide issues does not allow a comprehensive understanding of site conditions. Additionally it does not allow for the proper frame of reference for consideration of remedial options. This is more so an issue for groundwater contamination than soil contamination. How will this link between the SWMUs be addressed? A large scale map showing the topography of the entire PGDP area, the adjacent (offsite) areas, and the locations of the WAGs should be provided. Complete and detailed environmental reviews of any investigative report originating from the PGDP cannot be conducted without such a map. Potentiometric surface maps of the two uppermost aquifers of the entire PGDP, specific WAGs, and SWMUs should be provided.	This comment required no change to the document. The DOE plans to address the cleanup at the PGDP through remedial actions for integrator units. An integrator unit is defined as a medium (e.g., groundwater, surface water, etc.) that receives contamination from various sources. Because these integrator units can serve as migration pathways to off-site receptors, the DOE has given them a very high priority in the remedial action strategy for the PGDP. The DOE plans to address the cleanup of these integrator units through remedial actions at the Groundwater Operable Unit (GWOU), the Surface Soil Operable Unit (SSOU), the Surface Water Operable Unit (SWOU), the Burial Grounds Operable Unit (BGOU), the Decontamination and Decommissioning Operable Unit (DDOU), and the Comprehensive Sitewide Operable Unit (CSOU). The first four operable units (i.e., GWOU, SSOU, SWOU, and BGOU) will address the migration pathways from those SWMUs that have been identified as possible contributors. Note that the PGDP Site Management Plan coordinates the assessment of SWMUs where the SWMUs contribute to several operable units. The DDOU will address contamination that cannot be cleaned up until the unit is closed down and no longer utilized for production activities. The CSOU will evaluate the remedial actions from the GWOU, the SSOU, the GWOU, and the SWOU and ensure that the entire site has been remediated to levels that are protective of current and future human health and the environment. The work plans and reports for each of the operable units will provide the site-wide perspective and analysis of pertinent data to address contamination for each of the operable units. The RGA potentiometric surface is being added to an existing figure (3.20) for the PGDP region.

No.	Page/ Reference	Comment	Response
3		Isopleth/isoconcentration maps for areas in which Technetium-99 (Tc-99) and trichloroethene (TCE) plumes are of a concern should be provided for comparison. The current presentation of individual concentrations at differing elevations and SWMUs is not readily evaluated. These maps should be presented on size and scale sufficient to show topography, structures (i.e., buildings), sample locations, and any other data and/or features to facilitate the environmental review. In particular, the inclusion of analytical results from upgradient monitoring wells would provide a frame of reference by which to assess the impact or contribution of contamination of the individual SWMUs to the regional groundwater quality.	This comment required no change to the document. The sampling locations for WAG 28 were based on the occurrence of TCE in historical samples and the inference of an elongated plume moving northeast. When sampling data were evaluated, it was observed that only a few hits were encountered in the UCRS or RGA and that a TCE source in the WAG 28 SWMUs could not be identified from the current samples. Moreover, the working conceptual model of a Northeast Plume could not be refined given those results.
4		The report does not demonstrate whether the vertical extent of contamination by TCE and Tc-99 have been ascertained. The vertical extent of TCE, TC-99, and any other contaminants associated with WAG 28 should be established and presented in the report.	This comment required no change to the document. Based on the limited contaminants encountered (as described in the response to No. 3, above) no apparent source of TCE contamination appears to be contained within the WAG 28 SWMUs. The occurrences of any contamination in the underlying groundwater based on this investigation would be related to sources outside the SWMU. The PGDP groundwater is currently being addressed under the site-wide GWOU.
5		The report contains sections describing the technical approach and the data collected during surface geophysics and borehole geophysics investigations. There appears to be no discussion of the results of these activities or how they were used to further the understanding of site conditions. For example, the borehole geophysical logs could have been correlated with each other and with reference logs from the PGDP for which regional cross sections could be created to provide a stratigraphic framework. The results from these geophysical surveys and other data collection activities should be discussed in terms of their impact on the understanding of site conditions.	The report has been revised to state: Section 2.1, p. 2-1, introductory paragraph: "*The borehole geophysical logs were run to confirm the lithologic descriptions and were used to correlate boreholes and develop cross sections.*" Section 2.6, p. 2-6, 1st paragraph: "*The surface geophysics were conducted to attempt to locate the buried utilities and septic system, but the presence of the underground tank and leachate system was not indicated.*"

No.	Page/ Reference	Comment	Response
6		The main objectives for this RI were to evaluate the nature and extent of the contamination with each SWMU, to evaluate the risk associated with each SWMU and to collect data necessary to evaluate the appropriate remedial action at each SWMU. A large amount of data was collected and evaluated. Yet there were instances where the contamination was not fully assessed. The soils around the drain pipe area at SWMU 99 were identified as being contaminated but not fully characterized. The soils at SWMU 194 were characterized as being impacted with chromium, but the vertical extent was not defined. In general, throughout this investigation, there was a considerable lateral distance between samples ranging from 75 feet to over 200 feet. This leaves a considerable volume of soil uncharacterized. As for the groundwater, there is only enough data to show that these SWMUs need to be addressed as part of a regional solution, perhaps a groundwater operable unit. Based upon these examples, the first objective of the report was not met.	This comment required no change to the document. The conceptual models for the various SWMUs define the potential contamination as subsurface releases. Even though historical data indicated sporadic low concentrations of inorganic analytes in soil above some reference level, no pattern of contamination has been observed. The overall risk and related nature and extent of contamination in the soils will be evaluated in the future under the SSOU. The sampling was performed in accordance with the approved work plan. A future evaluation for SWMU 99 will be performed under the GWOU after the scrap metal on the pad has been removed. Projections are that this will be handled as a removal action and will include an evaluation of the original floor drains in the concrete pad.
		The second objective was to evaluate the ecological and human health risk associated with each SWMU. There are several comments on the risk assessments included in this report. But, the risk assessment concluded that "response actions may be appropriate" and that satisfies, as a general statement, the second objective. What is not known is how much stronger the case for "response actions" would have been had the data gaps discussed in the previous paragraph been filled prior to the risk assessment.	This comment required no change to the document. Although additional information concerning the extent of contamination may need to be compiled to determine cost for the final remedy, it is believed that enough information existed at the end of the field investigation to characterize the nature of the contamination, complete a satisfactory baseline risk assessment, and select among potential remedies. It is believed that any additional information concerning the extent of contamination can and should be collected as part of the remedial action implementation for WAG 28. Specifically, for the risk assessment, it is believed that additional sampling results would only lead to a lessening of identified levels of risk due to the manner in which summary statistics are compiled for EPA baseline risk assessments. Therefore, additional data would not be useful for determining whether action is needed.

No.	Page/ Reference	Comment	Response
6 (cont.)		This brings us to the third objective. Is the data complete enough to evaluate the remedial response(s)? One would have to say no. The data gaps identified suggest that there should be a Phase II RI or a Feasibility Study with significant additional data collection. As an example, the soils at SWMU 194 should be assessed further to refine the estimated waste volume of 13,383,500 cubic feet. This number is very imprecise and would result in astronomical cost estimates for remedial response.	This comment required no change to the document. To suggest an extensive Phase II RI or data collection during the Feasibility Study is to say that the conceptual model is not valid and that other significant sources of contamination exist. We do not agree that this is the case. We presented those metal data for completeness sake, not to suggest that a pattern or surface soil or subsurface soil contamination has been discovered. As stated previously, the appropriate forum for evaluating the risks from soils will be under the SSOU.
		The nature of this report appears to be that there is enough data to draw some conclusions but not definitive conclusions. Two of the three main objectives of this report are not met. Perhaps the inadequacies of this report are best summarized by referring to the Completeness portion of the Analytical Data Quality Section (2.7.3). This section describes the overall completeness of the RI as being 80%, ten percent shy of the goal of 90% completeness.	Vol. 1, Sect. 2.7.3.1, p. 2-15. The 80% "overall completeness" cited for the WAG 28 RI does not consider all of the factors that are outlined in the discussion preceding the statement of "overall completeness." When comparing the amount of data reported that were judged acceptable for the intended use to the amount of data expected in the base portion of the WAG 28 RI, over 90% completeness was achieved for all parameters in all matrices with the exception of groundwater data for wet chemistry (i.e., water quality indicator) parameters and soil data for VOCs (other than TCE and its degradation products).
Specific, U. S. Environmental Protection Agency			
1	Page 1-4, §1.4	The statement that the clay content of the Levings Member of the McNairy Formation impeded the migration of contaminants, such as TCE, is vague and unsubstantiated. Samples recovered from well 099-035 and well 204-031 yielded analytical results of 350 and 125 micrograms/liter (□g/L) TCE, respectively, from depths of 100 to 110 feet and boring logs and Figure 3.2 and Figure 3.10 (cross sections) indicate that wells set in the McNairy Formation below the Levings Member do detect contaminants. The inclusion of a discussion of possible vertical hydraulic gradients would explain this contaminant migration.	Vol. 1, Sect. 1.4, p. 1-4 The work plan conceptual model indicated that the Levings Member of the McNairy Formation has impeded vertical contaminant migration in the Paducah area. However, the Levings is not a complete barrier, and downward migration of contamination can occur. The Levings Member is usually approximately 50 feet below the RGA/McNairy contact, or about 160 feet bgs in the subject area. Therefore, wells completed at 100–110 feet would be above the Levings Member. A discussion on vertical hydraulic gradient is included in Sect. 3.7.

No.	Page/ Reference	Comment	Response
2	Fig. 1.7	The figure should be presented at a greater scale and the locations of all WAGs should be identified on this figure. See General Comment No. 3.	Figure 1.7 The map has been revised to show WAG 28 SWMUs.
3	Pages 2-14 through 2-22, §2.7.3	This entire section on Analytical Data Quality indicated that there were significant problems with certain segments of the data. While it is understandable that the completeness of soil sample collection may be limited by auger refusal, the rejection of a significant portion of the volatile organic groundwater analytical data is more troubling. The text does state that 3,179 data points were rejected. This causes a data gap in the planned data collection program. The text needs to explain what data gaps were caused by the rejection of this data and other data quality problems and whether those gaps are significant.	Vol. 1, Sect. 2.7.3.1, p. 2-15 The completeness percentage for the VOC samples was over 90%, which met the goal identified in the work plan. This includes both base and contingency samples; consequently, there are no data gaps for VOC groundwater. The 3,179 rejected data points were for VOC soil samples. The completeness goal for these data was not met, but 84% completeness was achieved. Considering that for each rejected fixed-base data result for TCE and its degradation products, a "confirmatory" field screening result is available, the impact of this apparent data gap is not considered significant other than for the identification of other potential VOC contaminant sources.

No.	Page/ Reference	Comment	Response
4	Figs. 3.2 thru 3.10	The figures do not show the potentiometric surface(s) derived from water level data obtained from the various wells/borings. The potentiometric surfaces should be shown on the figures accompanied by the water level data. The gray areas shown on the various wells/borings should be defined. The symbols shown on the plan view figure inserts should be defined. Specific Section 3 Figure comments are as follows: • <u>Figure 3.2</u>. Well/boring 099-035 is not shown on the plan view figure insert. • <u>Figure 3.4</u>. Well/boring H217 is not shown on the plan view figure insert. • <u>Figure 3.7</u>. Well/boring 193-035 is not shown on the cross-section. • <u>Figure 3.9</u>. Well/boring 194-2 is not shown on the cross-section. Seems reasonable to connect the sandy layer all the way across in the lower unit. • <u>Figure 3.10</u>. Well/boring 204-20 is not shown on the cross-section.	In general water level measurements were not obtained from DPT sampling or dual wall drilling. DPT sampling would attempt to obtain a water sample from the deepest saturated sand in the UCRS. In most instances, however, only limited water volumes could be extracted from these semi-saturated horizons. The dual-wall drilling attempted to obtain water samples every 5 ft in the saturated RGA. Neither sampling method allowed water levels to stabilize to record the potentiometric level. Figures changed as noted below: • <u>Figure 3.2</u>: The cross-section had a typo of station -036 to -035. • <u>Figure 3.4</u>: Boring H217 has been added to the plan view map. • <u>Figure 3.7</u>: Boring -035 was a typo on the cross-section. Boring –036 was corrected to –035. Likewise it was not intended to include CPTs -035 and -037 along this transect; however, they will be added to the cross-section B-B'. • <u>Figure 3.9</u>: Boring -002 was not intended to be included in the cross-section. It was mistakenly included on the plan view map. Considering the extensive distance between the sampling locations and knowing this area to have been historically dissected by rivers and streams, these sands have been interpreted as lenses or channel fills. • <u>Figure 3.10</u>: Boring -020 was a historic boring location and at the time of document preparation, no lithologic description was available.
5	Table 4.25	A table should be made for those inorganic materials for which Recommended Dietary Allowances (RDA) exist, if this information is necessary. There is no reason to include a table that presents continuous and unnecessary RDA parameters for inorganic, organic, and radioactive materials for which there are no RDAs. The unnecessary and cumbersome sections of the table should be removed.	This comment required no change to the document. The information provided in the table is relevant and necessary to the report.

No.	Page/ Reference	Comment	Response
6	Figs. 4.2, 4.4, 4.5, 4.6., and 4.7	The Section 4 figures and figure legends show insufficient detail. The figures should be presented in similar fashion as Figures 3.14 thru 3.18 and show general topography, structures (i.e., buildings), potentiometric surfaces, and any other reference data and/or features to facilitate the environmental review. Additionally, elevations of samples are shown on Figure 4-7 while depth and depth ranges of samples are shown in other Section 4 figures mentioned in the above comment. The presentations of like data on like figures should be consistent to facilitate document review and avoid confusion.	Including all the changes suggested in the figures in Section 4 would make the figures illegible. This information was originally added to the figures and subsequently removed. Changes to Figs. 4.2, 4.4, 4.5, 4.6, and 4.7: The elevations for the figures in Sect. 4 have been amended to feet below ground surface (bgs).

Response to Comments on the Draft (D1) Waste Area Grouping 28 Remedial Investigation Report
Ecological Risk Assessment
Paducah Gaseous Diffusion Plant, Paducah, Kentucky
U.S. Environmental Protection Agency

No.	Page/ Reference	Comment	Response
General, Ecological Risk Assessments, U. S. Environmental Protection Agency			
1		Although the most recent EPA guidance is cited in the ecological risk assessment (ERA), the actual procedures that are used to conduct the ERA did not follow current EPA and Region 4 policies and format. The ERA follows the out-dated 1989 RAGS methodology, and it is assumed that it follows Paducah-specific protocol (*Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant*; DOE, 1996). It is recommended that the protocol used in preparing ERAs for Paducah be revised to be more in line with current EPA guidance. If current EPA guidance had been used in preparing the ERA for WAG 28, fewer contaminants would have been carried into the food web model, the food web model would have been calculated using more conservative parameters, and additional contaminant-specific discussion would have been provided as lines-of-evidence in determining whether a contaminant is an ecological contaminant of concern (COC). It is important to note that the conclusions that are reached in this ERA are not significantly different than those that would be reached if current EPA protocol had been followed. However, a cost savings might have been realized in following EPA protocol.	This comment required no change to the document. The regulatory agencies and DOE have initiated discussions concerning future ecological risk assessment activities at the PGDP through the Risk Assessment Working Group. This group will use current EPA guidance as the basis for development of site-specific guidance for completion of future ecological risk assessments at the PGDP. The ecological risk assessment would have been organized differently if current EPA guidance had been followed throughout the WAG 28 project. However, the scoping portion of this project predates the release of the current EPA guidance; hence, this guidance was not available at the time the project was initiated and could not have been followed. It is agreed that the conclusions of the ecological risk assessment in the WAG 28 report would not have differed significantly if the assessment had been rewritten following current EPA guidance; therefore, it is believed that there is no need for a major revision.
2		Sediment/surface water sampling is mentioned in Volume 1, but the data are not evaluated in the risk assessments. It should be noted in the text that there will be surface water/sediment operable unit (OU) risk assessments conducted for the entire Paducah Gaseous Diffusion Plant.	This comment required no change to the document. There were no sediment and surface water data applicable to the ecological risk assessment for WAG 28.

No.	Page/ Reference	Comment	Response
Specific, Ecological Risk Assessments, U. S. Environmental Protection Agency			
1	Vol. 1, Page ES-5, Exec. Summ., ¶4; and Table ES.2	Please add a statement to the text and a footnote to the table indicating that SWMUs 99b and 194 and AOC 204 were not evaluated for risk to ecological receptors because it was previously determined that there were no contaminants of concern (COCs) in surface soil at these sites.	Vol. 1. p. ES-5, final para. Added statement to text in Executive Summary, p. ES-5, and footnote to Table ES-2 indicating that these sites were not evaluated in the ERA because it was previously determined that there were no contaminants of concern in surface soil at these sites. See below: "*Lack of quality habitat in the industrial setting of WAG 28 sites within the fence boundaries limits exposure of ecological receptors at most sites under current conditions (with the exception of the Millwright Shop at SWMU 193). However, an assessment of potential risks in the future, assuming conditions change so that suitable habitat becomes available for ecological receptors, was conducted. Several contaminants in surface soils were found to be at concentrations greater than levels that are protective of future nonhuman receptors. Table ES.2 summarizes these chemicals and radionuclides of potential ecological concern (COPECs). Risk for ecological receptors was not evaluated at SWMUs 99b and 194 or AOC 204 because it was previously determined that surface soil was not a medium of concern at these sites.*" Vol. 1, p. ES-7, Table ES-2 [a] *Surface soil was not a medium of concern at SWMUs 99b and 194 or AOC 204; therefore, ecological risks were not evaluated at those sites.*

Response to Comments on the Draft (D1) Waste Area Grouping 28 Remedial Investigation Report
Ecological Risk Assessment
Paducah Gaseous Diffusion Plant, Paducah, Kentucky
U.S. Environmental Protection Agency

No.	Page/ Reference	Comment	Response
2	Vol. 1, Page 3-6, §3.5.3	It is not clear from the discussion of wetlands in this section whether there are wetlands associated with Waste Area Grouping 28 (WAG 28). In the ERA, it is stated that there are no wetlands associated with this WAG. This information should be added to Section 3.5.3.	Vol. 1, Sect. 3.5.3, p. 3-7, para. 3 There were no wetlands associated with WAG 28. This information has been added to Section 3.5.3 in Vol. 1. See below: *"There are no wetlands associated with WAG 28."*
3	Vol. 1, Page 6-25, §6.3, ¶4	SWMU 99b is not mentioned in Section 6.3. In the detailed ERA in Volume 4, it is stated that SWMU 99b was not evaluated in the ERA because the surface soils were not contaminated. The explanation should be added to Section 6.3.	Vol. 1., Sect. 6.3, p. 6-25, first para. Added statement to text indicating that SWMU 99b was not evaluated in the ERA because surface soil at this site was not contaminated. *"The conceptual model defined in the approved WAG 28 work plan (DOE 1998a) defined the potential sources of contamination in SWMU 194 and AOC 204 as being contained within subsurface soil (i.e., drain fields and buried debris pile). This is also the case for SWMU 99b. Consequently, surface soils were not expected to be impacted and did not require an ecological evaluation to be performed."*
4	Vol. 1, Page 6-25, §6.3, ¶7	The text states that "Potential risks from chromium are largely based on chromium being present as the more toxic Cr(VI) rather than the more likely Cr(III)." To improve the clarity of the statement, it is recommended that the text be revised to read "Potential risks from chromium are largely based on the conservative assumption that chromium is present as the more toxic Cr(VI) rather than the more likely Cr(III)."	Vol. 1, Sect. 6.3, p. 6-25, final para. Text revised as recommended. See below: *"Potential risks from chromium are largely based on the conservative assumption that chromium is present as the more toxic Cr(VI) rather than the more likely Cr(III). However, chromium exceeds benchmarks for plants and soil invertebrates at all four sites with the highest concentrations occurring at SWMUs 99a and 193b."*

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5	Vol. 4, Page 2-1, §2.0	The text states that the ERA follows the general guidance provided in *Guidelines for Ecological Risk Assessment* (EPA, 1998). However, the approach and format are not in line with the EPA guidance issued between 1996 and 1998, but is typical of ERAs conducted according to the 1989 *Risk Assessment Guidance for Superfund.* It is assumed that the ERA for WAG 28 is consistent with procedures described in *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE, 1996). It is preferable that the ERA cite the Paducah-specific guidance rather than incorrectly cite the recent EPA guidance. It should be noted that the use of the older guidance does not alter the report's final conclusions regarding potential risks at WAG 28.	This comment required no change to the document. The regulatory agencies and DOE have initiated discussions concerning future ecological risk assessment activities at the PGDP through the Risk Assessment Working Group. This group will use current EPA guidance as the basis for development of site-specific guidance for completion of future ecological risk assessments at the PGDP. The ecological risk assessment would have been organized differently if current EPA guidance had been followed throughout the WAG 28 project. However, the scoping portion of this project predates the release of the current EPA guidance; hence, this guidance was not available at the time the project was initiated and could not have been followed. The conclusions of the ecological risk assessment in the WAG 28 report would not have differed significantly if the assessment had been rewritten following current EPA guidance; therefore, it is believed that there is no need for a major revision.
6	Vol. 4, Pages 2-3 through 2-4, §2.1.1.2	Please provide some additional information about the procedures that were used to determine that there were no ecological surface soil risks at OU-99b, -194a, -194b, and AOC-204. Alternatively, cite the location of this information in other sections of this RI report.	This comment required no change to the document. As stated in Sect. 2.1.1.2, the conceptual model defined in the approved WAG 28 work plan (DOE 1998a) defined the potential sources of contamination in SWMU 194 and AOC 204 as being contained within subsurface soil. Consequently, surface soils are not impacted and do not require an ecological evaluation to be performed. The source of contamination at SWMU 99b is drain lines that are underneath a gravel-covered parking area; again, no surface soil contamination, and so exposures are not expected.

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7	Vol. 4, Pages 2-3 and 2-4, §2.1.1.2	It is stated that the determination was made in the work plan that there were no ecological risks associated with surface soil in SWMU 194 and AOC 204. It is not stated whether a similar determination was made in the work plan for SWMU 99b. If the determination for SWMU 99b was made in the work plan, it should be stated. If the determination was not made until the ERA was being prepared, additional discussion of this determination should be included in the ERA.	Vol. 4, Sect. 2.1.1.2, p. 2-3, para. 2 During the evaluation, SWMU 99 was subdivided into two units that possessed different conceptual models for potential contaminant releases. While the subject of ecological risk is not specifically discussed in the work plan for SWMU 99b, the model implicitly omits the need for an ecological evaluation. Added text to clarify lack of ecological exposures to contaminated soil at SWMU 99b. See below: "*An estimated 80% of SWMU 99b is covered by gravel and 20% by grass. Surface soil was not a medium of concern at this site because the leach lines were below the surface of a gravel-covered parking lot. No ecological exposures were expected; therefore, the site was eliminated from further evaluation during problem formulation.*"
8	Vol. 4, Page 2-4, §2.1.2.1, ¶5	In the ERA, Reasonable Maximum Exposures (RMEs), in many cases the 95% Upper Confidence Limit (UCL), are used in calculating Hazard Quotients (HQs) for terrestrial wildlife. Although 95% UCLs are routinely used in human health risk assessments, Region 4 has stated that the 95% UCLs should not be used in ERAs. Rather, HQs should be determined using the following parameters: site maximum/no observed adverse effect level (NOAEL); site maximum/lowest observed adverse effect level (LOAEL); Central Tendency/NOAEL; and Central Tendency/LOAEL. This approach gives the risk manager a range of values on which to base management decisions. Revised HQs that are calculated using site maximum rather than 95% UCL values will not change the final assessment of risk as these sites. However, it is recommended that 95% UCLs should not be used to calculate HQ values at Paducah sites in the future.	This comment required no change to the document. Comment noted. Please provide source of Region 4 statement regarding use of 95% UCLs, comparison of maximum detects to NOAELs/LOAELs, and what measure of central tendency is preferred.

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9	Vol. 4, Pages 2-5 through 2-6, §2.1.2.2	Soil data were screened against background. Then, regardless of the result of the background comparison, all constituents were evaluated in food web models. Region 4 policy is that all soil constituents be first screened against Ecological Screening Values, then against background. Only constituents with concentrations that are higher than both ecological screening values and background, or that have the potential to bioaccumulate and are higher than background, are carried into the food web models. The failure to follow these steps results in many more constituents being evaluated in the food web model than EPA Region 4 believes are necessary. This approach does not impact the ERA conclusions. However, it is highly recommended that the current guidance be followed in future submissions.	This comment required no change to the document. Comment noted. However, the KDEP opposes eliminating contaminants based on screening against background. While it is agreed that more contaminants are carried into the food web model than really should be necessary, it is more efficient to conduct a full evaluation the first time.
10	Vol. 4, Pages 2-6 through 2-9, §2.1.3 and §2.1.4	The selection of specific assessment endpoints (i.e., protection of herbivorous mammals) and receptors is done without consideration of the contaminants at the site. It is EPA policy that specific assessment endpoints and receptors be selected so that the receptor guilds and species evaluated are those most sensitive to the contaminants of potential concern (COPC). Specific assessment endpoints and receptors should not be selected until after all contaminants at the site have been screened against contaminant concentrations that EPA believes are sufficiently protective of ecological receptors (Ecological Screening Values).	This comment required no change to the document. It is agreed that it would be convenient to restrict endpoints and receptors, but in practice it is more efficient to evaluate a suite of receptors that includes those trophic groups and representative receptor species expected to receive high exposures and be sensitive to contaminants present. Adding additional receptors (i.e., birds where pesticides are a potential concern) beyond the standard suite for primarily industrial Paducah sites will be done if warranted.

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11	Vol. 4, Page 2-7, §2.1.3, ¶6	No birds are evaluated as receptors because "...exposures for the mammalian receptors, particularly the shrew, are anticipated to be greater than comparable birds..." It is stated that the mammalian wildlife exposure endpoints were agreed upon during the data quality objective process for WAG 28. However, there are some contaminants, such as DDT, that pose a greater threat to birds than mammals. Also, if the food web models were calculated using the most conservative parameters as per current Region 4 guidance (i.e., nonmigratory with all exposure associated with the site), the perceived risk to birds may be greater than for mammals. It is recommended that in the future submissions, exposure endpoints be revised to include vermivorous birds.	This comment required no change to the document. Inclusion of additional endpoints will be considered in future evaluations.
12	Vol. 4, Page 2-9, §2.1.5.1, ¶4	No mention is made of exposure via inhalation. Ingestion and dermal contact are the only exposure routes discussed. Inhalation should be identified as an exposure route for terrestrial wildlife, and a justification for its exclusion, similar to the one provided for dermal contact, should be included in the text.	Vol. 4, Sect. 2.1.5.1, p. 2-9, final bullet Text added to explain exclusion of inhalation exposures for terrestrial wildlife. See below: *"Terrestrial wildlife may also consume contaminated soil by incidental ingestion while feeding and/or burrowing. It is not believed that wildlife receptors receive significant exposure via inhalation or dermal contact. Because such species are fur-covered, little if any direct exposure to dermal surfaces can occur. Exposure could occur through grooming or inhalation of dust, but these exposure routes are accounted for as incidental ingestion of soil. Omitting dermal contact as an exposure route to be quantitatively evaluated is a practice that is widely accepted in the field of ecological risk analysis. Further, exposure parameters and toxicity values for dermal exposure are generally not available. Inhalation of contaminated air contributes minimally to overall exposures at sites such as those in WAG 28 where VOCs are not significant contaminants of surface soils."*

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13	Vol. 4, Pages 2-20 through 2-23, §2.4.1.1 through §2.4.4.2	The text in most of these sections references Table 2.13 as illustrating the analytes that were detected at above background concentrations and toxicological benchmarks. However, Table 2.13 only summarizes the contaminants that were determined to be COCs; it does not provide any quantitative data to support this selection. For plants and earthworms, Table 2.1 (background and toxicological benchmark screen) should be referenced. For terrestrial wildlife, Table 2.1 (background screen) and Table 2.14 (comparison to toxicological benchmarks) should be referenced.	Vol. 4, Sect. 2.4, p. 2-19, para. 6 Text was inserted near the beginning of the risk characterization section indicating that results of benchmark-soil concentration comparisons are provided in Table 2.1 (for plants and invertebrates) and Table 2.14 (terrestrial wildlife). The table call outs have been left as is and refer to the summary tables, focusing on the COCs rather than the raw results in Tables 2.1 and 2.14. See below: "*Toxicological benchmark values derived for contaminants found at PGDP and the Oak Ridge Reservation (Sample et al. 1996; Efroymson et al. 1997a,b) are used in this assessment. Benchmark development is an ongoing process, and although the methods for derivation remain the same, the most current benchmarks are used. Ecological risks posed by contaminants are discussed as they relate to each endpoint population, including multiple pathways of exposure (e.g., food, soil) when applicable. Benchmarks are not available for all chemical/receptor combinations. Results of the comparison of surface soil concentrations to benchmarks for plants and invertebrates are reported in Table 2.1. Results for terrestrial wildlife are in Table 2.14. Table 2.13 provides a summary of benchmark exceedances for those chemicals detected above background levels.*"

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14	Vol. 4, Pages 2-24 through 2-26, §2.5	The ERA should be expanded to include a discussion of the uncertainties associated with the lack of toxicological benchmarks for some contaminants/receptors and the lack of background data for lithium and strontium.	Vol. 4, Sect., 2.5.1, p. 2-25, bullet 1 Discussion of uncertainties associated with lack of benchmarks for some contaminants has been added. Background for lithium and strontium is a moot point because benchmarks are lacking for both. See below: • ***Benchmark availability***—*Toxicity data for derivation of toxicological benchmarks were not available for all chemical–receptor combinations. While it is possible that chemicals without benchmarks could be a concern, there is no way to evaluate possible effects without site-specific toxicity testing. However, benchmarks are available for many priority contaminants.*
15	Vol. 4, Table 2.1	Please add a foot note to Table 2.1 indicating the significance of the bolded Hazard Quotient values.	Vol. 4, Appendix A, Table 2.1, pp. A-427–A-429 Footnote added indicating bolded hazard quotients call attention to chemicals with soil concentrations greater than background (or no background value available) and resulting in hazard quotients >1. See below: [b] *Bolded values indicate results for chemicals for which the surface soil concentration exceeded background (or no background was available) and resulted in a hazard quotient >1.*

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General, Human Health Risk Assessment, U. S. Environmental Protection Agency			
1		The future recreational exposure scenarios were quantified for only the game ingestion pathways. However, incidental ingestion of soil, dermal contact with soil, inhalation of particulates emitted from soil, and external exposure to ionizing radiation in soil are all identified in the text as potential exposure pathways. The rationale for not quantifying exposure from soil pathways is that "repeated contact by recreational users with soil [is] unlikely/exposure time [is] limited." However, the exposure factors used for adult game ingestion include 350 meals per year over an exposure duration of 22 years, which would imply repeated contact with soils over a long period of time. The soil exposure pathway should be added to the recreational scenario, or a more detailed rationale for excluding the soil pathways should be presented in the text.	Exposures in a home setting are usually averaged over a period of one year (365 days minus two weeks vacation); hence, the 350-day exposure frequency. This does not imply that the recreator bags and eats game 350 days per year, but rather that the annual consumption rate is averaged over a year's time. Consider consumption of rabbit by a recreational user. Footnote "c" in Table 1.22 in App. A states that the average daily consumption rate for adults (0.0165) is based on 20 rabbits bagged per year, weighing an average 1.2 kg each, 60% of which is dressed weight. There are 2.5. persons per household. So 20 rabbits × 1.2 kg × 60% / 350 days / 2.5 adults per household = 0.0165 kg/day consumption rate. The 22-year exposure time is a Kentucky-specific (KDEP 1995) number based upon a reasonable maximum exposure rate of length of residence in one home. Note that game may become contaminated via several exposure media, such as contaminated soil, water, and vegetation. Including the soil pathway direct exposure routes for the recreational user would not markedly alter the results and conclusions of the baseline human health risk assessment because the recreational user is assumed to be a local resident who has a home on a WAG 28 site(s). See excerpt from WAG 28 below: Vol. 4, Sect. 1.3.3.1, p. 1-42, para. 3 *"The assessment assumes that residents are the individuals most likely to partake in recreational activities at WAG 28 and near PGDP. That is, in addition to exposure from rural residential activities, a resident may also be exposed during recreational activities."*

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			However, it is recognized that this issue needs additional discussion in the revised WAG 28 document and when revising the Methods Document. Note that the current methods document does not include standard exposure assumptions for direct soil exposures by a recreational user.
2		The human health risk assessment (HHRA) provides discussion regarding the selection of Chemicals of Concern (COCs) at each of the SWMUs investigated. However, the text presents only lists of "priority COCs" whose derivation is only vaguely defined. All of the COCs identified for each SWMU should be identified in the text.	The COCs identified for each site are alphabetically listed in summary exhibits provided in the text (e.g., Exhibit 1.41 lists the COCs for systemic toxicity in soil at sites in WAG 28). Providing an additional list of dozens of chemicals as straight text would result in rather unwieldy reading. The reasoning behind derivation of "priority COCs" will be more fully explained in the text. See below: Vol. 4, Sect. 1.5.7, p. 1-185, para. 1 "*Combining the results from Exhibits 1.41 and 1.43 and considering the magnitude of the chemical-specific HIs and ELCRs, the following COCs can be considered 'priority COCs' (COCs with a chemical-specific HI or ELCR that exceeds 1 or 1E-04, respectively) in soil for the current use and most likely future use scenario (i.e., industrial use):* • *SWMU 99a—beryllium* • *SWMU 99b—surface soil not assessed* • *SWMU 193a—none* • *SWMU 193b—chromium, vanadium, and beryllium* • *SWMU 193c—lead* • *SWMU 194—surface soil not assessed* • *AOC 204—surface soil not assessed*"

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3		The data evaluation conducted in the HHRA is limited and incomplete. Data evaluation is presented in a cursory, generic way in Section 1.2.2. The evaluation of data for risk assessment purposes is an essential portion of the HHRA, which has been neglected in this document. The data evaluation discussion is even more critical for this document, because data concerns have been identified elsewhere. For example, there is a portion of the data that has not been validated, and the completeness of the data is also an issue. A complete discussion of data evaluation should be written and included in the HHRA.	This comment required no change to the document. This BHHRA did not challenge the results of the data evaluation. Inadequacies and/or incompleteness of the data set are discussed in Vol. 1 of the RI. It is assumed in the BHHRA that the data set is representative. Uncertainties associated with the data and data evaluation are assessed and discussed in Sect. 1.6 of the BHHRA.
Specific, Human health Risk Assessment, U. S. Environmental Protection Agency			
1	Vol. 4, Page 1-5, §1.1.1	The text states: "Hazard indices (HIs) for all well categories exceed the de minimus level defined in the Methods Document (i.e., 1) for all well categories under maximum exposure assumptions, but only for the monitoring well category under average exposure assumptions." The term "maximum exposure" may be confused with a "worse case" scenario. The risk assessment calculations used in this risk assessment contain a mix of upper bound and average values for the input parameters. Therefore, the "maximum exposure" should be replaced with "reasonable maximum exposure" for clarity. The sentence does not make sense as written.	This comment required no change to the document. Making this change is inappropriate because the referenced material uses the term "maximum exposure assumptions."

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2	Vol. 4, Page 1-13, §1.2.2	Exhibit 1.6 references the Methods Document (DOE, 1996a) as the source for site-specific risk-based concentrations used to screen COPCs. This document was not available for review. It is requested that additional information regarding the derivation of the screening values be included in the HHRA when it is revised. Similarly, the text references the document *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE, 1997) as the source of the background concentrations used to screen for COPCs. However, the background document has not been reviewed or approved. It is requested that additional information regarding the background data set be included in the HHRA when it is revised. Of interest are the number of samples collected, locations, depths, statistic used as background (i.e, average, UTL, etc.), and other data necessary to evaluate the appropriateness of the comparison.	The equations used to derive the RBCs are located in App. A, and this cross-reference has been added to the text. Reference has also been made to the source of the most current toxicity values. See below: Vol. 4, Sect. 1.2.2, p. 1-13, para. 4 "***Examination of toxicity of detected analytes***—*A comparison of the analyte's maximum detected concentration to that analyte's residential use human health RBC was performed for the data set created for the BHHRA. The human health RBCs used in this comparison are derived according to equations in the Methods Document (see Appendix A, Tables 1.12–1.38, in this volume) using the most recent toxicity values available [http://risk.lsd.ornl.gov/tox/rap_hp.shtml (DOE 1998c)].*" EPA has provided comments on the Methods Document and these comments were incorporated in the risk assessment methods used for WAG 28. *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, KY* (DOE 1997) has been reviewed and approved. Please see the attached letter from DOE to KDEP and EPA and the certification document.

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3	Vol. 4, Page 1-16, §1.2.3.1	The text states, "This program merged toxicity information with the list of COPCs." The text does not identify the sources of the toxicity data imported into the program. Since a risk-based screening was previously performed by an earlier SAS (software) program and risk calculations do not occur in this step, the purpose of importing the toxicity data is not clear. Additional information regarding this step of the SAS programs should be included.	Toxicity values used in this BHHRA are from the Risk Assessment Information System (RAIS) available online at http://risk.ldb.ornl.gov/rap_hp.shtml. Information is taken from IRIS, HEAST, NCEA, etc., and updated monthly. Kentucky-specific values are also provided in this database. This information will be referenced in the text. The sixth SAS program determines COPCs based on the previous screening steps and then merges the chemical-specific information (e.g., toxicity values such as RfD or slope factors, Henry's Law constant, toxicity equivalency factor, soil uptake factor, etc.) necessary to run the forward risk models. This information will be added to the text. See below: Vol. 4, Sect. 1.2.3.1, p. 1-16, para. 5 "***Sixth SAS® Program (Toxicity Values).*** *This program determined the COPCs based on the previous screening steps and then merged the chemical-specific information [e.g., toxicity values (see Sect. 1.4 and http://risk.lsd.ornl.gov/tox/rap_hp.shtml in DOE 1998c)] such as RfDs and slope factors, Henry's Law constant, toxicity equivalency factor, soil uptake factor, etc.] necessary to run the forward risk equations.*"
4	Vol. 4, Page 1-21, §1.2.4.1	The text indicates that a well survey was conducted in the vicinity of PGDP as a result of the discovery of groundwater contamination in private wells in the vicinity of the facility. Some of the findings of the survey are discussed in the text, but it is not clear if the private wells with known contamination are within the vicinity of WAG 28. The distance of these wells from WAG 28 should be presented in the text and indicated on a map.	This comment required no change to the document. The well survey information was included to emphasize that well water is used for drinking water purposes in the vicinity of the PGDP. Additional information about this survey is available in the Methods Document.

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5	Vol. 4, Page 1-42, §1.3.3.1	The text states that the future residents may also be exposed to contaminants through the ingestion of game, but this pathway is not quantified specifically for the residential scenario. However, the text offers the following advice: "To address this issue, the reader may wish to combine the exposure values from the recreational user scenario with those from the rural resident scenario." This appears to be a valuable piece of information for evaluating potential exposure that should not be left to the reader to complete. It is recommended that this simple addition of exposure values be combined in a table for the reader.	This comment required no change to the document. The risk results obtained from using the highly uncertain biota pathway models are not significant enough to affect any remedial decisions at WAG 28 [HI exceeds 1 at only one site (7.21 at SWMU 193c); ELCRs barely exceed 1E-06 at two sites (2.76E-06 at SWMU 99a and 3.6E-06 at SWMU 193a)]. Because the risks for the resident are so high (relatively), adding risks for the recreator would make no difference in terms of remedial decisions. Note also that when considering future land use scenarios at WAG 28 sites, different use scenarios at a single site are not considered to be occurring at the same time. However, it is recognized that this issue needs additional discussion when revising the Methods Document.
6	Vol. 4, Page 1-43, §1.3.3.2	Incidental ingestion of soil, dermal contact with soil, and inhalation of particulates emitted from soil are all identified in the text as potential exposure pathways. However, none of these pathways are included in the site-specific conceptual site models depicted in Figures 1.9 through 1.16. The Conceptual Site Models should be modified to include these potential exposure pathways.	This comment required no change to the document. All the site conceptual models in Sect. 1.3 include surface soil as a secondary release medium and list ingestion, dermal contact, inhalation, and external exposure as exposure routes. The pertinent receptors are noted as well. (See top box of model.)
7	Vol. 4, Appendix A, Table 1.3, SWMU 193c	The table indicates that lead was detected in the McNairy groundwater at a frequency of 1/1. The detected concentration is reported as 2.50E-01. However, the reported arithmetic average is a reported value that is half that concentration, which is obviously incorrect. The table should be reviewed and corrected for other errors. A review should also be conducted to ensure that the average concentration reported in this table was not used in other tables or calculations.	This comment required no change to the document. Examination of the SAS programs revealed a programming glitch that returned one-half the maximum concentration result as the arithmetic average for analytes with a 1/1 detection frequency. This has been corrected and the affected tables will be revised. This erroneous result was not used in any calculations. The values in Table 1.11 in App. A that include the representative concentrations used to calculate chronic daily intakes are correct.

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8	Vol. 4, Appendix A, Table 1.10, SWMU 193c	The table indicates that lead was detected in the McNairy groundwater at a frequency of 1/1. The detected concentration is reported as 2.50E-01. However, the reported arithmetic average is a reported value that is half that concentration, which is obviously incorrect. The table should be reviewed and corrected for other errors. A review should also be conducted to ensure that the average concentration reported in this table was not exported from this table to other calculations.	This comment required no change to the document. This programming error was corrected in every place that it occurred (Tables 1.3, 1.4, and 1.10).
9	Vol. 4, Appendix A, Table 1.32	The exposure duration for the excavation worker is reported as 25 years. This exposure duration is much longer, though more conservative, than that generally used in an excavation scenario. Typically, the exposure factor used is based upon the duration of a hypothetical construction project involving the digging of basements, installation of utilities, or other finite project. A value that is generally used is one year. The value used is more conservative, and no changes to the document are necessary. However, site-specific exposure durations should be considered for future documents. This exposure factor is repeated in Tables 1.33 and 1.34.	This comment required no change to the document. A one-year value for excavator exposure in the Methods Document was changed to 25 years based upon comments from the KDEP. This value has been used in BHHRAs at the PGDP for many years. The full citation for the Methods Document includes "as modified by comments." Note that shorter exposure durations are examined in the uncertainty section.
10	Vol. 4, Appendix D	The appendix is titled, "Complete Toxicity Profiles for COCs." However, the appendix merely lists the Contaminants of Concern (COCs) and references web sites where toxicity data may be located. The Toxicity Assessment contained within the Human Health Risk Assessment (Section 1.4) contains complete toxicity profiles for all of the Contaminants of Potential Concern (COPCs), which includes the subsequent COCs. If toxicity profiles for the COCs are not contained within Appendix D, it is recommended that the appendix be deleted, or the appendix should reference Section 1.4.	This comment required no change to the document. Most of the toxicity profiles in the text are taken from RAIS (web address provided previously). RAIS provides both a "capsule profile," which is presented in Sect. 1.4, and a "long profile," which has been placed in Appendix D for previous PGDP risk assessments, as required per the Methods Document. It was decided not to include the "long" versions in this report, because the complete profiles would have added over 500 pages to the document. Hence the reader is referred to RAIS and other sources. The short profiles are incomplete for several reasons. For example, they do not include uncertainty discussions, while the long profiles do; therefore, it is recommended that the references for the long profiles remain.

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General, State of Kentucky			
1		Chapter 4 of Vol. 1 indicates that several metals including selenium, silver, mercury, antimony and cadmium all had minimum detection limits in soil that were higher than the respective background concentrations for these metals. It is suggested that DOE contract with another lab that can provide lower detection limits for metals. Severn Trent Laboratories based in St. Louis, Missouri, provides analytical services for the Division. This facility can achieve detection limits below PGDP background for selenium, silver, mercury, antimony and cadmium.	This comment required no change to the document. The lower detection limits referred to in this comment may be instrument detection limits as opposed to method detection limits that were referenced in this report. The Paducah Site "core team" will also take this suggestion into consideration.
2		Section 3.6.1.5 of this document described the Upper and Lower Continental Deposits. Nelson et al. (*Geological Society of American Abstracts with Programs*, 31(7), p. A-48, 1999) provide a more recent synopsis of the deposition of the Continental Deposits.	This comment required no change to the document. The Paducah team WAG 28 team will obtain the reference and review it for new information on Continental Deposits to be used in future studies.
3		Section 4.2.1.5, page 4-12 of the document (paragraph 1) describes the filters used to prepare RGA groundwater samples for inorganic analysis. Note that 0.45 µm is an arbitrary (although common) criterion for defining dissolved metal concentrations. Metallic colloids can occur at sizes less than 0.05 µm, and USGS uses 0.10 µm as a cutoff for trace metals.	This comment required no change to the document. Comment noted. This information will be used for future studies at Paducah. However, chapter three of SW-846 defines dissolved metals as "The concentration of metals determined in a sample after the sample is filtered through a 0.45-µm filter (Method 3005)." Because the approved work plan for the WAG 28 RI specified in Section 9.7.1 that "when available and appropriate for the sample matrix, SW-846 methods will be used," this criterion was used.
4		Several citations presented in the text do not appear to contain references in the Chapter 8 reference list. For example, Baes et al. (1984), Baes and Sharp (1984), Looney et al. (1987), SAIC (1996, 1998), and Sheppard and Thibault (1990) don't appear in the reference list. Add these and any other missing references to the Chapter 8 list of references.	These references have been added to the final draft.

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5		Pages 5-19, 5-23, and 5-25 of Chapter 5, Vol. 1 state that for modeling purposes the HU3 and terrace gravels were considered to be partially saturated. Was this actually the case or were these units unsaturated?	This comment required no change to the document. The saturation of the HU3 unit varies over very short lateral distances; consequently, it was considered partially saturated in models used in this study.
6		The uncertainty discussion in the Baseline Risk Assessment is a valuable and essential component of the risk evaluation of WAG 28. The level of detail is appreciated. However, one method of discussing the uncertainty involved calculating risk/hazards without the inclusion of the COPCs that rely upon provisional or withdrawn toxicity values. The benefit of this approach is not clear; the chemicals in question clearly have resulted in toxicity following exposure and the withdrawn or provisional values remain the best estimate of their toxicity and contribution to total risk. Although the facility certainly can include such an analysis, it appears to be of limited benefit in understanding the uncertainty surrounding the risk characterization of the site.	This comment required no change to the document. The methods and presentations used in the WAG 28 BHHRA are consistent with those presented in the Methods Document, as modified by regulatory comments. This document integrates human health risk assessment guidance from EPA and the KDEP and incorporates instructions contained in regulatory agency comments on earlier risk assessments performed at PGDP. The Methods Document received final approval from the Commonwealth of Kentucky for use in environmental investigations and restoration activities at PGDP in February 1998 (KDEP 1998). The consideration of uncertainty associated with the use of provisional or withdrawn toxicity values is one of the many uncertainties required in the Methods Document. The uncertainty regarding the use of withdrawn or provisional values is included in the assessment to let risk managers know if a substantial proportion of the total risk is due to "suspect" information. For example, if a site has a very high HI and the analysis of this uncertainty indicated that virtually all the uncertainty was due to iron (which has a provisional RfD), risk managers may then decide that taking remedial action at the site may not be appropriate.

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Specific, State of Kentucky			
1	V1, Exec. Summary, Page ES-3, ¶1	Although there does not appear to be a source within the confines of AOC 204, the December 1995 report "Final Site Evaluation Report for the Outfall 010, 011 and 012 Areas, Paducah Gaseous Diffusion Plant, Paducah, Kentucky" specifies that sediments contained in a small section of Outfall 011 are contaminated with in excess of 5300 μg/kg TCE. This would appear to be the source of the UCRS TCE groundwater contamination. Removal of this source and subsequent confirmatory sampling should be scheduled to coincide with the removal of sediment and soils from Outfall 011 (SWOU).	This comment required no change to the document. An investigation of Outfall 011 was not within the scope of the AOC 204 investigation. This information in the comment will be forwarded to the surface water and groundwater operable unit team for their use.
2	V1, Exec. Summary, Page ES-6, Table ES.1	It is not clear within the Executive Summary what the letters that follow the SWMU names located at the top of the table specify. Please make this clear within the text of the Executive Summary.	Executive Summary, p. ES-6, Table ES-1 An explanation of the letters has been added in the Executive Summary in the revised document.
3	V1, §1.2, Page 1-3, ¶1	The final sentence in this paragraph indicates that McGraw UST SE sample results are located in Appendix F of Vol. 2 of this report. This data is actually located in Vol. 3 of the report. Modify the text to reflect that the data are located in Vol. 3.	Sect. 1.2, p. 1-3 This change has been made in the revised report.
4	V1, §2.4.1, Page 2-4, Table 2.2	It appears that SWMU 194 has been incorrectly identified in the third line of the table as SWMU 94. Please correct the table.	Section 2.4.1, p. 2-4, Table 2.2 This change has been made in the revised report.
5	V1, §2.5.1, Page 2-5, ¶7	The last sentence in this paragraph states that ". . . the flow rate was adjusted to between 200–250 mL/min." Was this the flow rate used to collect VOA samples or was this rate used only for the other required samples? Section 6.7.2 of the site procedure PTER-2010, Rev. 1, requires that all VOA samples be collected at a flow rate of 100 mL/min or less. If a higher flow rate was used for VOA sample collection, then provide justification as to why this standard procedure was not followed.	Vol. 1, Sect. 2.5.1, p. 2-5, para. 6 The following explanation has been added to the revised report: "*The procedure was followed in the field to try and collect VOA samples at 100 mL/min, or as low a flow rate as the formation would produce. In some instances, however, the pump would cavitate and the flow rate had to be increased in order to get a sample. In all cases the samples were collected at as low a flow rate as possible at each location.*" Additionally, the Paducah site "core team" will consider the recommendation by the Commonwealth of Kentucky to use bladder pumps when possible for future sample collection.

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6	V1, §2.5.2, Page 2-6, Table 2.4	The text in Section 2.5.2 does not indicate that there was a problem with obtaining samples from any of the DPT borings. However, there were only 16 samples obtained from a total of 34 borings. Indicate in the text why a complete set of samples could not be obtained.	This comment required no change to the document. Due to unsaturated conditions within the UCRS, there were several times where the soil did not have enough or any water to collect a sample. In those instances, only soil samples were collected. During the investigation, the DPT water screen would be set at the selected depth and allowed to recharge, but this would not occur. There were instances where temporary well points were installed for up to several days in an attempt to collect sufficient water for a sample. The western Kentucky region was undergoing draught conditions before and during the RI field activities, significantly reducing moisture content in the UCRS.

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7	V1, §2.7.1.7, Page 2-11, Table 2.6	This table lists the reporting limits for each of the parameters of interest. However, it doesn't list the detection limits. Page 9-16 of the WAG 28 D2 Work Plan indicates that the detection limits for VOCs when using SW-846, Method 8021, would be 5.0 µg/L for soil samples. Was this detection limit met? Include the detection limits for all parameters in Table 2.6.	Vol. 1, Sect. 2.7.1.7, p. 2-11, Table 2.6 The WAG 28 D2 Workplan indicates that the detection limit for VOC analyses by the field screening laboratory using SW-846 Method 8021 would be 5.0 µg/kg. This detection limit was not met by the field screening laboratory. Detection limits from actual method detection limit studies conducted by the field laboratories (or accumulated minimum detectable activity data from the project for radiological field laboratory) will be incorporated into Table 2.6. The actual method used for VOC soil analyses for the WAG 28 RI utilized the previously developed and agreed to hexane extraction sample collection/preparatory procedure, as described in Section 2.7.1.2. This preparatory procedure for soil samples differs from the standard SW-846 Method 8021 preparatory protocol for low concentration soil samples at the time of the approval of the WAG 28 D2 Work Plan (SW-846 Method 5030A). The hexane extraction sample collection/preparatory procedure is somewhat similar to one of the current SW-846 Method 5035 high concentration (>200 µg/kg) VOC soil sample preparatory method options. This option provides for field preservation of high concentration soil samples with a water-miscible solvent, such as methanol. The detection limit achievable using either of these similar sample collection/preparatory techniques is roughly two or three orders of magnitude higher than that achievable under ideal conditions using a low-concentration method. The low-concentration methods capture the total VOC mass present in the approximately 5-gram sample, which is purged directly from the sample/preservative matrix and analyzed by GC. Both the hexane and the methanol field preservation/extraction preparatory methods initially transfer the same total VOC mass present in the approximately 5-gram sample to the preservation/extraction solvent. However, only a small aliquot (i.e., a few µL of the total 5 mL) of the extract is directly injected

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7 (cont.)			into the GC for analysis. As stated in Section 2.7.3.6 of the D1 draft report, the hexane extraction and low concentration preparatory methods produce similar (and, in most cases, higher concentration results for the hexane extraction method) data as the concentration of TCE and/or other VOCs increases above the lower concentration limit (200 µg/kg) for the hexane extraction preparatory method. Losses of VOC analytes due to sample handling (i.e., volatilization and escape during collection and storage) and chemical/biological degradation prior to analysis are minimized using the hexane extraction preparatory method. This greatly outweighs the inherent loss of sensitivity for high concentration (>200 µg/kg) VOC soil samples.
8	V1, Chap. 3, Fig. 3.14	Three pipeline bedding samples were proposed in the WAG 28 D2 Work Plan for SWMU 99. These samples do not appear on this map. Were samples collected from along this line? If not, then provide an explanation.	Section 2.1, p. 2-1, introductory para. The geophysical survey did not indicate the presence of the pipeline, so the samples were not collected. This information can be found on p. 4-6 of Sect. 4.2.1.5; a short description of this and a reference has been added to the report.
9	V1, §4.1.1, Page 4-1, ¶6	This paragraph indicates that several metals including selenium, silver, mercury, antimony, and cadmium all had minimum detection limits that were higher than the respective background concentrations for these metals. Provide a table that lists these minimum detection limits alongside the appropriate background numbers.	This information requested has been provided in Table 4-1.
10	V1, §4.1.1, Page 4-2, ¶4	The first sentence in this paragraph indicates that EPA SSLs were used in part to screen soil data. Were the SSLs used to exclude data from the Baseline Risk Assessment? The second paragraph on page 4-3 would seem to indicate that this is the case. If this data was not carried forward, then how were surface and subsurface exposures to soil evaluated for risk?	This comment required no change to the document. Data used in the BHHRA were not screened against EPA SSLs. SSLs were used, in part, to screen soil data for the MEPAS modeling and the RI discussion of nature and extent. The BHHRA used site-specific RBCs based on the most recent toxicity values available. SSLs are not entirely risk-based in that they are developed using MCLs. MCLs are partly risk-based but also take into account technical feasibility.

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11	V1, §4.2.1.5, Page 4-1, ¶3	The paragraph indicates that contaminants did not appear to have reached the collapsed section of drainpipe located at SWMU 99. When did the pipe collapse occur? How long has the plywood been in place? Is there a chance that these contaminants reached Outfall 010?	This comment required no change to the document. The collapsed portion of the drain pipe lies outside the SWMU 99 boundary. An opportunity was taken to sample the contents of the pipe and surrounding soils when road repairs were undertaken. The condition of the pipe and presence of the plywood board were observed during these repairs. No background information is available to supplement the information contained within the report and a separate fact-finding effort was not undertaken to investigate this occurrence outside the SWMU boundary. Surface water contamination will be addressed separately as part of an EE/CA for SWMU 16. The concrete pad is believed to be the source of contamination for Outfall 010, which will also be addressed separately.
12	V1, §4.2.4.6, Page 4-26, ¶1	Although there does not appear to be a source within the confines of AOC 204, the December 1995 report "Final Site Evaluation Report for the Outfall 010, 011 and 012 Areas, Paducah Gaseous Diffusion Plant, Paducah, Kentucky" specifies that sediments contained in a small section of Outfall 011 are contaminated with in excess of 5300 μg/kg TCE. This would appear to be the source of the UCRS TCE groundwater contamination. Removal of this source and subsequent confirmatory sampling should be scheduled to coincide with the removal of sediment and soils from Outfall 011 (SWOU).	This comment required no change to the document. This information will be forwarded to the surface water and groundwater OU teams for use in subsequent actions. This is not within the scope of the AOC 204 Investigation.

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13	V1, Tables 4.3–4.25	These tables contain several errors. For instance, several of the tables that supposedly list inorganics above site background list chromium when it is below background and in certain instances list the incorrect background concentration. Incorrect background numbers appear to be present for other inorganics as well, including beryllium. A background of 19.9 mg/kg is listed for strontium, an inorganic that does not have a calculated site specific background concentration. In other instances, groundwater results are qualified as having exceeded EPA Soil Screening Values. Table 4.16 appears to contain several results for SWMU 193 samples that are mislabeled as SWMU 99 samples. Modify these tables and correct any inadvertent errors.	Tables 4.3 – 4.25 The tables have been modified to correct errors. This information will be forwarded to the surface water and groundwater OU teams for use in subsequent actions. This is not within the scope of the AOC 204 Investigation.
14	V1, §5.2.1.4, Page 5-3, ¶6	Although there does not appear to be a source within the confines of AOC 204, the December 1995 report "Final Site Evaluation Report for the Outfall 010, 011 and 012 Areas, Paducah Gaseous Diffusion Plant, Paducah, Kentucky" specifies that sediments contained in a small section of Outfall 011 are contaminated with in excess of 5300 µg/kg TCE. This would appear to be the source of the UCRS TCE groundwater contamination. Removal of this source and subsequent confirmatory sampling should be scheduled to coincide with the removal of sediment and soils from Outfall 011 (SWOU).	This comment required no change to the document. This information will be forwarded to the surface water and groundwater OU teams. This is not within the scope of AOC 204. This information will be shared with the other teams for use in the removal action.
15	V1, §5.4.2, Page 5-23, ¶3	The paragraph states: "Cobalt was detected above screening levels in one boring, DPT193-036, at a sample depth of 2–5 ft bgs. The source was defined as a rectangular area 240 ft by 260 ft..." Explain how an area 240 ft by 260 ft was chosen based on data from a single borehole.	This comment required no change to the document. The dimensions for the extent of cobalt were based on the distance to the next data point, 193-033, which had levels of cobalt below screening levels. According to the current practice of source area delineation by the MEPAS model, the source area boundary is determined to be the furthest extent to the adjacent sample that has a non-detect or below screening levels value.

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16	V1, §7.2, Page 7-7, ¶1	The last sentence in this paragraph states: "Outfall 011 is currently monitored, and it is unlikely that contaminated fluids are currently infiltrating to the subsurface along this surface drainage." The Division disagrees with this statement (see comments 1, 12, and 14). It does not appear that a sample was collected from within the ditch during the course of the WAG 28 investigation. Sediment sample 011-002, collected during the AOC 204 SE, contained 5343 µg/kg of TCE. Therefore, it is very likely that this TCE is continuing to be released to the subsurface from this small source area.	Section 7.2, p. 7-7 The last sentence in the paragraph has been removed.
17	V1, Page 7-17, Table 7.4	At the bottom of this table under the heading <u>General Conclusions for AOC 204</u> conclusion number three states that "AOC 204 is not a source of contamination to surface water bodies." Although Outfall 011 is not technically a part of AOC 204 it defines its southern border. Several releases of TCE from contaminated ditch sediment occurred in 1995. This conclusion should be revised.	This comment required no change to the document. While Outfall 011 defines the southern boundary to AOC 204, it is not part of the area of concern. The investigation has not confirmed the conceptual model (i.e., that buried debris is a source of contamination). The working hypothesis is that a discreet spill within the outfall is the source of the TCE in the groundwater underneath AOC 204. Consequently the statement that AOC 204 is not a source of contamination to surface water bodies is considered correct.
18	V1, §2.5.2, Page 2-6, ¶2	Specify whether the DPT borings were purged prior to the collection of groundwater samples.	Section 2.5.2, p. 2-6, 1st para. DPT borings are intended to collect in situ groundwater samples and are not purged before sample collection. This statement will be added to the revised report.
19	V1, §3.6.1.5, Page 3-9, ¶6	The first sentence of this paragraph refers to "strong brown chert gravel." What is "strong brown chert gravel"?	Section 3.6.15, p. 3-9, para. 5 The term "strong brown" refers to the Munsel color chart. The phrase "Munsel Color Chart" has been added in parentheses in the text, and the complete reference added in the revised report.

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20	V1, §3.6.1.5, Page 3-10, ¶3 and 5	Paragraph 3 states that the "UCD represents a fining-upward sequence of interbedded clay, silt, sand and gravel ..." while paragraph 5 indicates that "clay content of the UCD increases significantly near the base ..." Explain how the Upper Continental Deposits can be clayey at the bottom and yet be "fining-upward."	Section 3.6.1.5, p. 3-10 The text has been revised as follows: 2nd full paragraph – "*The UCD primarily consists of fine-grained valley-fill deposits that are differentiated from the underlying LCD by grain size. The UCD represents a sequence of interbedded clay, silt, sand, and gravel as shown in the cross sections for the various SWMUs. The layers of clay, silt, sand, and gravel were seen to grade laterally into adjacent units throughout the UCD.*" 4th full paragraph – "*In the basal soils of the UCD, the clay content increases significantly so that the dominant lithology is a silty clay with minor occurrences of lenticular sand and gravels. This silts clay unit acts as a semi-confining layer above the RGA. The contact between the middle and lower zones is dominantly gradational, but it can be locally sharp. The lower zone is present to the east and south of PGDP and consists of approximately 10 ft of yellowish-grayish-brown silty clay with minor sand content. All the UCD units rise and thin as they approach the Porters Creek terrace to the south.*"
21	V1, §3.7.1, Page 3-11, ¶3	Deer Lick and Snake Slough are incorrectly listed as "Snake Creek" and "Slough Creek." These creeks do not drain the northwestern part of the PGDP site—Bayou Creek does. Furthermore, the discussion of stream gaging should cite the original reference (Evaldi and McClain, U.S. Geological Survey Open-File Report 89-582, 1989), not CH2M Hill (1992). CH2M Hill misinterpreted Evaldi and McClain's data in inaccurately characterizing Bayou Creek as a gaining stream. More recent data on outfall discharges and on stream flow can be obtained from Bechtel Jacobs and the USGS, respectively. Modify the text to incorporate these changes.	Text deleted as indicated. This information (cited from previous reports) is included as general background on the PGDP site and is not pertinent to the WAG 28 source unit investigation. The references to the 1989 flow measurements will be deleted unless BJC has a summary of more recent information that can be included.

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22	V1, §3.7.2.4, Page 3-13, ¶4	The RGA has been arbitrarily defined to include Holocene alluvium, which is finer than the gravels in the Lower Continental Deposits. Modify the definition included in this paragraph.	Section 3.7.2.4, p. 3-13 The last sentence in the 1st paragraph has been deleted.
23	V1, §3.6.1.5, Page 3-10, ¶5	This paragraph refers to the HU3 as a semi-confining layer, a statement that is generally well accepted. However, this description is inconsistent with the HU3 descriptions found in Figures 3.2–3.6. These figures refer to the HU3 as "very impermeable." The HU3 should not be referred to as "very impermeable" if it constitutes a semi-confining layer. Remove the description "very impermeable" from Figures 3.2–3.6.	This comment required no change to the document. Disagree. The caption on the figures states, "HU3 clay to silty clay, very impermeable clay that acts as a semi-confining to confining layer." It is not incongruent that the clay is impermeable but non-continuous, thereby acting as a semi-confining layer. The caption is identical to that in the WAG 27 report.
24	V1, Figs. 3.8–3.9	The geologic descriptions given in the two figures lump the terrace sands and gravels with the Porters Creek clay. Explain why this was done.	This comment required no change to the document. This grouping of the terrace sands and gravels with the Porters Creek Clays was done in the figures (colormetrically) because they are of the same hydraulic unit.
25	V1, §4.2.2.6, Page 4-20, ¶2	Beneath SWMU 193, is the maximum TCE concentration in McNairy groundwater 42 µg/L (as stated on p. 4-19) or 23 µg/L (as stated on p. 4-20)? Make the appropriate corrections to the text.	Section 4.2.2.6, p. 4-20 The text on page 4-20 has been corrected to read "42 µg/L."
26	V1, §5.2.2, Page 5-4, ¶5	This paragraph states that the "annual average water balance estimates for WAG 28" are derived from the GeoTrans (1992) model. The Jacobs EM Team modeling reports (1998, 1999) are more up-to-date than GeoTrans (1992). Reference this more recent data in the text.	This comment required no change to the document. The more recent references will be evaluated for incorporation into future reports.
27	V1, §5.2.3.3, Page 5-12, ¶2 and 5	The degradation pathway flowchart listed beneath paragraph 2 appears to indicate vinyl chloride is the same as chloroethane. Vinyl chloride is synonymous with chloroethene, not chloroethane. Also, the last sentence of paragraph 5 makes reference to trichlomethane. What is "trichlomethane"? Correct this text as appropriate.	Section 5.2.3.3, p. 5-12, pathway flowchart and para. 5 The pathway should indicate vinyl chloride or chloroethene, as stated in the comment. This was a typographical error. The reference to "trichlomethene" in paragraph 5 is a similar typographical error. It should have read "trichloromethane," which is synonymous with chloroform. These corrections have been made in the revised report.

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28	V1, §5.3.1, Page 5-16, ¶5	This paragraph attempts to describe factors that affect "the dissolution of COPCs in soils and the rate of contaminant movement through soils." The limitations of assuming a linear sorption isotherm are not discussed (see, for example, Domenico and Schwartz, *Physical and Chemical Hydrogeology*, John Wiley & Sons, 1998). Also, strictly speaking, mineralogy is not a property of a contaminant. Discuss the limitations associated with the linear sorption isotherm assumption and remove mineralogy from the list of contaminant properties.	Section 5.3.1, p. 5-17, 1st para. A discussion on the limitation associated with the linear sorption isotherm assumption was added to the revised report and the term "mineralogy" was not used as a contaminant name. The discussion on assumptions inherent in applying the linear sorption isotherm reads as follows: "*The assumptions, and consequently the limitations, of using this equation above, often referred to as the linear absorption isotherm, are many. Assumptions made are based on homogeneity of the transport medium, steady-state flow of groundwater, reaction rates being faster than transport rates, constant temperature, low or moderate contaminant concentrations, and reversible reactions between the solid porous medium and dissolved phase of contaminant. Because these assumptions are seldom, if ever, completely met in the natural environment, they pose an inherent limitation on the applications in which they are used. Additionally, the effects of biodegradation have not been included in the modeling effort for this remedial investigation.*"
29	V1, §5.3.1, Page 5-17, ¶1	The volumetric water content of the unsaturated zone will be less than or equal to the total porosity (assumed = 0.37). Consequently, the vertical velocity will be greater than or equal to the ratio of recharge rate/porosity. Therefore, 11 in./yr may underestimate the vertical velocity. Modify the text to reflect this reality.	Section 5.3.1, p. 5-17, 2nd para. These parameters are used site-wide in other modeling efforts and are retained here for consistency and comparison. The basis for these numbers can be found in Vol. 4, App. B. A reference to this has been added to Chap. 5.

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30	V1, §5.3.1, Page 5-17, ¶2	No documentation is provided for the statement that "the dominant driving force for chemical migration in the UCRS is diffusion." Provide a reference or references that substantiate this conclusion.	Section 5.3.1, p. 5-17, 3rd para. This paragraph has been revised as follows: *"Vertical migration rates can be increased by advection/ leaching and diffusion. Diffusion along permeable zones of sand can significantly increase the rate of contaminant migration as the chemical moves to counteract concentration gradients. Vertical groundwater gradients are documented for the UCRS in <u>Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III</u> (Clausen et. al. 1992.)"*
31	V1, §5.3.1, Page 5-17, ¶5	Assuming an effective porosity of 0.30 is <u>not</u> conservative; de Marsily (*<u>Quantitative Hydrogeology</u>*, Academic Press, 1986) cites values of about 0.15 to 0.35. Also, how were values of k, I, and n selected for the RGA? Provide some justification for selecting 0.30 as the effective porosity value and indicate the origin of the k, I, and n values.	Section 5.3.1, p. 5-15, 2nd para. These parameters are used site-wide in other modeling efforts and are retained here for consistency and comparison. The basis for these numbers can be found in Vol. 4, App. B. A reference to this will be added to Chap. 5.
32	V1, §5.3.2, Page 5-19, ¶1	The statement that "dispersion generally causes chemicals to migrate from 10 to 20 percent farther than migration caused by advection alone" needs to be referenced. Provide a reference to substantiate this statement.	This is a generic reference and is not applicable to the MEPAS modeling that was performed for WAG 28. This sentence has been removed from the text.
33	V4, App. B, Pages B-12 and B-21, Tables B.1 and B.4	For the unsaturated zone, the volumetric water content equals the total porosity only in the capillary fringe (immediately above the water table).	Vol. 4, App. B, Sect. B.3.1, p. B-9 The text in Appendix B has been changed to the following to clarify the modeling assumptions: *"In cases where model sources were located in a partially saturated layer adjacent to saturated layers (a condition possible in the UCRS due to the presence of perched, discontinuous water zones), the moisture content of the release site soil was assumed to be 100% to simulate saturated conditions at the source."*

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34	Exec. Summary, Page ES-4	It should be noted that what is being termed a "worst case" evaluation is usually described as a "reasonable maximum exposure" (RME). The United States Environmental Protection Agency (USEPA) Risk Assessment Guidance for Superfund: Human Health Evaluation Manual (Part A) (1991) defines the RME as the highest exposure that is reasonably expected to occur at a site. It is estimated by combining the 90–95th percentile values for some but not all (e.g., body weight) of the intake parameters used to calculate risk. The uncertainty inherent in modeling scenarios to represent potential exposures and health effects require the use of conservative estimates such as the 95% upper confidence limit of the arithmetic average of the site data to estimate the exposure concentration. The intake parameters required by USEPA and the Kentucky Department for Environmental Protection (KYDEP) are consistent with the USEPA definition of the RME.	Vol. 1, p. ES-4, para. 1-2 There is concurrence with the commentator's disapproval of the expression "worst case." However, the subject under discussion in this section of the Executive Summary is the strategy employed in the BHHRA to ensure that the risk estimates are sufficiently conservative. This approach encompasses how the data set was put together and the use of "high-end" (and possibly unrealistic) toxicity estimates, in addition to the way in which (RME) concepts were built into the exposure evaluations. Accordingly. the following paragraphs are offered as a replacement for the first two paragraphs of p. ES-4, beginning at the second sentence: "*Such an approach is justified as a means of ensuring that the identification of COPCs and the computed chemical and radiological hazards and risks at WAG 28 do not underestimate the potential threats to human health posed by prevailing levels of contamination at the sites. Other elements of this conservative strategy include (1) the use of provisional and withdrawn reference dose (RfD) values, (2) the use of default dermal absorption factors that may exceed the real value, and (3) the use of default exposure parameters that probably exceed the current rates of exposure at the site.* *In general, many of the sites and sub-sites contain contaminants that, taken together, contribute to risk above de minimis levels, as shown in Table ES-1. However, to view these results in context, also included in the risk assessment is a comprehensive analysis of the influence, both individually and collectively, of the default parameters and values that may have made the hazard and risk determinations overly conservative (Sect. 1.6 of Vol. 4). By including such a comprehensive analysis, a more complete evaluation of the likely impact of site contamination on*

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34 (cont.)			*human health and the environment is provided to the risk managers charged with making decisions about remedial actions at WAG 28. The semiquantitative assessment of uncertainty also permits sensitivity issues to be explicitly addressed.*"
35	§2.3–2.4, Page 2-3	WAG 28 consists of over 125 acres of land, yet only 25 soil samples were taken, and subsurface samples were taken in only 38 different locations. No surface soil samples were taken at SWMU 194, SWMU 99b, or AOC 204 because historical use suggests that surface soils were not impacted. Although this may be true, this must be proven by sampling, particularly for risk-based closures and decision making. As the risk assessment projects hypothetical future uses of the site such as future resident, it depends upon an adequate characterization of the site, including all potentially impacted media.	This comment required no change to the document. The conceptual model and sampling strategy for these source operable units were proposed in the approved WAG 28 work plan. From historical and process knowledge, this model identified the leach fields as the principal source of contamination at SWMU 194. Since there was only a potential subsurface release, no surface samples were deemed necessary. The same type of model (subsurface source) was formulated for SWMU 99b and AOC 204. Should further evaluation be required for site-wide closure decisions, then the Surface Soils Operable Unit is the appropriate forum for those data.
36	§2.7, Pages 2-7–2-26	Although the magnitude of impact on the overall site characterization and risk assessment is uncertain, several problems with the sample analysis and data management were noted that potentially brings into question the ability of the data to represent site conditions.	See response to part a, below.

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		a. Eleven percent of the groundwater sampled for volatile organic compounds exceeded holding times and/or experienced calibration failures and were rejected (although Section 2.7.3.4 states that all holding times were met). A total of 7.5% of the groundwater database records for volatiles and inorganics were considered potentially biased due to holding time exceedance.	Section 2.7.3.1, p. 2-15 The reviewer's statement that "over 11% of the affected samples failed to meet the requisite holding time constraints, despite a statement to the contrary in Sect. 2.7.3.4" fails to consider that the referenced section of the report (Sect. 2.7.3.4) describes the holding time performance of the Close Support Laboratories (CSLs) only. The D1 Draft RI report incorrectly identified the VOA samples with grossly exceeded holding times as groundwater samples. A review of the project database revealed this error. The second sentence of the comment also is based on the erroneous information provided in the D1 Draft RI Report, identifying the rejected VOA data as groundwater data. As was distinguishable from this review of the project database, the great majority of the holding times that were exceeded were for fixed-base laboratory VOA SW8260A soil analyses, with 80 (21.4%) of the total WAG 28 VOA soil samples affected and 2800 data points (39.2%) rejected. However, due to the 122% VOA soil sampling completeness (adding in contingency samples to those collected for the base project), an additional 1980 VOA soil data points were collected above the number scheduled for the base project. Therefore, the total amount of usable VOA soil data represents 84% overall completeness compared to that which would have been expected for the base project samples, only 6% shy of the WAG 28 RI overall completeness goal for soil VOA data. This was the only overall completeness goal for soil matrices that was not met for the WAG 28 RI. The D2 RI Report reflects these changes. Note also that a sample for CSL VOA analysis was collected from each location where fixed-base laboratory SW8260A VOA soil samples were collected during the WAG 28 RI. Since no CSL data were rejected, there is "confirmatory" VOA soil data for the rejected fixed-base laboratory SW8260A results for TCE and its degradation products, which are the main groundwater VOA contaminants present at PGDP. Although the detection

No.	Page/ Reference	Comment	Response
36 (cont.)			limit for the CSL VOA analyses for TCE and its degradation products was approximately 140 µg/kg, where CSL data are non-detect for TCE and its degradation products, one can support the absence of a soil source of TCE and its degradation products.
		b. Many of the samples that were sent off-site to a fixed based laboratory [the text states "a minimum of 10 percent of the total number of samples (by matrix) were split..."] showed a significant difference when compared to the field laboratory results. For example, the relative percentage difference (RPD) for the semivolatile analysis for soil samples was 85 percent.	This comment required no change to the document. USEPA CLP guidance for data validation states that "laboratory variability arising from the sub-sampling of non-homogeneous soil samples is a common occurrence." For this reason, the USEPA "may allow the use of less restrictive criteria…to be assessed against duplicate soil samples." Note, however, that this discussion pertains to laboratory duplicate samples, which are prepared from the same exact sample by one person, presumably using the prescribed procedures for homogenization and subsampling of the sample to prepare the duplicate samples used for this QC procedure. In the case of split samples, such as those used for interlaboratory performance comparisons (i.e., water or soil performance evaluation samples), even without the inherent variability of a contaminated natural soil matrix, there is a significant increase in the statistical RPD over single laboratory duplicate measurements. There is also some variability added due to the procedures used by the field sampling team to split the total volume of soil collected from a given interval among several containers for the various analyses requested, and for the two different laboratories. For this reason, Hazardous Waste Remedial Actions Program guidance recommends that for metals analyses, "sample results >5 × CRDL (or the reporting limit), a

No.	Page/ Reference	Comment	Response
36 (cont.)			control limit of ±40 RPD for water (±70 RPD for soil) may be used" for field duplicate samples. In the specific case of semivolatile soil analysis interlaboratory RPD mentioned in the state's comment, the results leading to the high RPD were those where high concentrations of semivolatile PAH analytes were encountered in surface soil samples. These high concentrations required dilutions to be performed to quantitate the results within the range of the calibration standards. This again adds variability to the analytical measurement. Taking all of these factors into consideration, the reported 85% RPD is not at all unusual or excessive, and indicates acceptable interlaboratory agreement.
		c. Chemicals that were detected, yet were thought to have not been used on the site were rejected in the data review process. All detected constituents should be retained for analysis and evaluation; historical records for the activities that have taken place and chemical usage at PGDP are not sufficient to exclude unexpected analytical results.	Page 2-25, 2nd para. Chemicals were not rejected based on non-use. Refer to Sect. 4.1.1 for information of how chemical screening was conducted. The sentence on p. 2-25 that indicated the contrary has been deleted.
37	§4.2.1, Page 4-4	a. Soil and groundwater sampling appear insufficient in SWMU 99 to support the level of site characterization required for risk assessment. For example, only one sample was taken in the interior of the uranium hexafluoride (UF_6) cylinder storage yard. It also appears that historical sampling efforts did not address soils or groundwater in the area; they mainly focused on the boundaries of the site to determine if a release occurred.	This comment required no change to the document. The sampling strategy followed the approved work plan. A number of surface samples were collected from within and surrounding SWMU 99; however, Fig. 4.2 shows only the one hit above the screening levels in the interior of the site. We believe that there are sufficient data to characterize the surface interior of the site.

No.	Page/ Reference	Comment	Response
37 (cont.)		b. Likewise, a collapsed section of Tennessee Avenue near SWMU 99 prompted soil sampling near a section of exposed drainpipe. The analysis indicated radionuclides and PCB contamination, which is thought to be a result of surface water runoff from the Classified Scrap Yard at SWMU 99. Only one sample was taken at this location of the soils surrounding the pipe, and no effort was undertaken to confirm the source of the contamination as the Classified Scrap Yard. Furthermore, although the scrap yard is located on a concrete pad, there is no mention of the integrity of the concrete, no sampling was conducted under the pad, and to date, there has been no sampling of the scrap itself to determine if it is a source of contamination. Outfall 010 receives the drainage from SWMU 99, an outfall that sampling indicates is contributing to impacts in Little Bayou Creek. The vertical and horizontal extent of the contamination at SWMU 99 is unknown. Further delineation of the contamination of soils around and beneath the drainpipe near the collapsed road is recommended, as well as sampling in the interior portions of the site, both in the Classified Scrap Yard and the UF_6 cylinder storage yard.	This comment required no change to the document. The concrete pad and materials within the Classified Scrap Yard are part of SWMU 16 while the soils and groundwater beneath the yard are part of the SWMU 99 investigation. The pad and the soils will be addressed in an upcoming EE/CA for SWMU 99. The sampling strategy identified in the approved work plan was followed during this investigation. Six sample stations were located immediately around the yard (and interior to the SWMU). After removal of the scrap metal, subsequent sampling of the drain holes in the concrete pad is anticipated, potentially as part of a removal action.
		c. Please explain why no groundwater samples were obtained in the vicinity of the leach field. Previous sampling (1998) at boring P4E7 near this area found high levels of trichloroethene in the Regional Gravel Aquifer (RGA).	This comment required no change to the document. The location of the leach field and associated drain pipe could not be determined from available information or identified with subsurface geophysics. DPT samples down to 60 ft below ground surface (within the UCRS) were placed in the general location of these features. Soil samples were collected and an unsuccessful attempt was made to collect a groundwater grab sample. No RGA samples were obtained. The work plan called for the evaluation of the UCRS as a possible source of TCE, not further characterization of the RGA contaminant distribution.

No.	Page/ Reference	Comment	Response
37 (cont.)		d. Please clarify the contradiction between Table 4.34 in the Remedial Investigation Report on page 4-12 and page F-4 in Appendix F in the Baseline Risk Assessment. The table indicates that the concentration of lead in the RGA groundwater averaged 170 µg/L with an observed minimum of 50 µg/L and a maximum of 410 µg/L. However, Table 2 of page F-4 in the Baseline Risk Assessment indicates that concentrations of lead was 81.3 µg/L in the RGA groundwater. It appears that an unknown source of soluble lead is present in site soils.	This comment required no change to the document. The apparent discrepancy referred to by the reviewer arises from the different approaches to data aggregation employed in the risk assessment compared to the RI. While both evaluations employed the same data set (with a minimum value of 50 µg/L, a maximum value of 410 µg/L, and an arithmetic mean of 170 µg/L), the risk assessment also incorporated values for 1/2 the detection limits for each sample in which lead was undetected (23/29 in RGA groundwater at SWMU 99A). This resulted in an arithmetic mean of 63.8 µg/L (see Table 1.3 of the risk assessment), with a reasonable maximum exposure (RME) value of 81.3 µg/L, as listed in Table 1.11. The latter value formed the basis for IEUBK modeling.
38	§4.2.2.4, Page 4-14	It appears that large areas of SWMU 193 were not sampled. The scope of the sampling was limited to three buildings, but the SWMU area encompasses approximately 100 acres and contains more structures than were apparently investigated. The age of the facility and waste handling performance requires a more comprehensive sampling strategy to reduce the uncertainty of contaminant location and increase confidence in the risk assessment. More extensive site characterization is needed for risk assessment purposes.	This comment required no change to the document. The entire surface area of SWMU 193 was not identified as having the potential to be contaminated; therefore, a statistical basis was not employed to characterize the entire area of SWMU. The sampling strategy was defined in the approved work plan and was followed during the WAG 28 investigation. The strategy was to characterize areas that may be potential sources based on historical and process knowledge. As such, a number of sites were sampled in the southern half of the SWMU and two observed groundwater TCE-contaminated areas were extensively sampled in the northern half of the SWMU.

Response to Comments on the Draft (D1) Waste Area Grouping 28 Remedial Investigation Report
Paducah Gaseous Diffusion Plant, Paducah, Kentucky
Kentucky Department for Environmental Protection

No.	Page/ Reference	Comment	Response
39	§4.2.2.5, Page 4-19	Please clarify the contradiction between the text in the Remedial Investigation Report on page 4-19 and page F-4 in Appendix F in the Baseline Risk Assessment. The Remedial Investigation Report states that the McNairy groundwater samples were submitted for inorganic analyses as per the WAG 28 Work Plan. However, Table 2 on page F-4 in the Baseline Risk Assessment indicates high concentrations of lead (250 µg/L) in the McNairy groundwater. If the groundwater data is accurate, it appears that an unknown source of soluble lead is present in site soils.	Vol. 1, Sect. 4.2.2.5, p. 4-19, para. 1 An incorrect statement in the text of the RI report (p. 4-19) accounts for the anomaly identified by the reviewer. The text will be amended to state that "*McNairy groundwater samples at this SWMU were submitted for inorganic analysis....*" In drawing attention to the discrepancy between the presence of a substantial slug of lead in the McNairy formation under SWMU 193c and the comparatively low levels of this element in surface and subsurface soils at this location, the commentator highlights the difficulty of specifying individual cleanup sites as sources of any particular body of groundwater contamination in circumstances where, as here, groundwater contamination is PGDP-wide due to multiple contiguous sources.
40	§4.2.3.3, Page 4-21	Large areas of the southern portion of SWMU 194 were not sampled. As indicated in previous comments, although the most likely source of contamination is associated with the leach fields in this SWMU, a limited number of samples should be placed in locations not previously investigated in order to identify unknown potential sources of contamination. Surface soils as well as subsurface soils should be evaluated. Additionally, groundwater samples should be taken if the soil contamination appears to pose as a potential threat to the groundwater. These "screening" samples should be analyzed for the complete TAL/TCL list of contaminants.	This comment required no change to the document. Based on historical and process knowledge, the surface area of SWMU 194 was not identified as having the potential to be contaminated; therefore, a statistical basis was not employed to characterize the entire area of the SWMU. The sampling strategy was designed to confirm the conceptual model in the approved work plan and was followed during the WAG 28 investigation. The conceptual model only identified a subsurface release from the leach fields as a potential source; therefore, surface samples were not taken.
41	§4.2.4.5, Page 4-24	The sampling plan limited the investigation to volatile organic chemical analysis of subsurface soils and groundwater at this location, based on previous investigations. It is unclear in the text whether previous investigations looked for inorganic or semivolatile contaminants in the surface and subsurface soils in the area.	Section 4.2.4.5, p. 4-24, 1st para. The word "only" will be added to clarify – "*These samples were submitted for VOA and radionuclide analysis **only**.*"
42	§6.0, Page 6-1	The third paragraph states that the tank and leach field connected to the Kellogg Building is approximately 350,000 feet from the building site. This is apparently a typographic error.	Vol. 1, Sect. 6.0, p. 6-1, 3rd para. This error has been corrected.

No.	Page/ Reference	Comment	Response
43	Page 6-3, Table 6.1	The description of AOC 204 indicates adequate habitat for terrestrial ecological receptors. Risk to current and future terrestrial receptors should be evaluated for the area, and indicated in Table 6.1.	This comment required no change to the document. The conceptual model developed in the approved WAG 28 work plan (DOE 1998) defined the potential sources of contamination in SWMUs 99b and 194 and AOC 204 as being contained within subsurface soil (i.e., drain fields and buried debris). Consequently, surface soils are not considered to be impacted and no ecological exposures are expected; therefore, these areas do not require an ecological evaluation to be performed. Should further evaluation be required for site-wide closure decisions, then the Surface Soils Operable Unit is the appropriate forum for those data.
44	V4, §1.3.3.2, Page 1-51	The justification for excluding the ingestion of livestock products by a future rural resident is invalid. A large portion of the WAG 28 site is covered with grass and could potentially support animal agriculture. Furthermore, the document states that the Methods Document requires that these exposure routes are to be evaluated only in the assessment of groundwater and surface water integrator units. Intake via plant uptake is a significant exposure pathway for domestic livestock and ecological receptors. It would also seem appropriate to consider the ingestion of livestock in the surface soil operable unit evaluation. Please modify the Methods Document to reflect this approach, or provide justification why this is not appropriate.	Vol. 4, Sect. 1.3.3.4, p. 1-51, 5th para. The final sentence in this text has been revised as follows: "*The various exposure pathways to be evaluated in BHHRAs for the PGDP will be reevaluated when the Methods Document is revised; however, it may be appropriate to change the Methods Document so that domestic livestock pathways are always assessed for the larger OU investigations. In the current Methods Document, the assessor is directed to quantify these pathways only in assessment of integrator units (i.e., the groundwater, surface water, and surface soil integrator OUs).*"

No.	Page/ Reference	Comment	Response
45	V4, §1.6.1.6, Page 1-196	Although the facility may consider the contamination associated with the collapsed road section in the southwest corner of SWMU 99 "atypical" of the waste management practices and prevailing contamination at the SWMU, the management of the site must be based on total risk, which includes the contribution from this area. Insufficient sampling was conducted in the area to adequately describe the extent of contamination. Therefore, the risk from exposure to soils at SWMU 99a may actually be greater than those estimated.	This comment required no change to the document. It is agreed that assessment of risk must capture all prevailing contamination at a site, including "hot spots." However, the key question under consideration here is whether the measured amounts of chemicals and radionuclides in the collapsed pipeline represent past practices and current levels of contamination at SWMU 99a. Because these peripheral samples were collected from locations that are likely to have been impacted by other SWMUs, most notably by runoff from the concrete pad on which the "classified scrap yard" (SWMU 16) is situated, the levels of detected analytes in samples 082-014 and 082-015 (which were physically located outside the SWMU boundaries) may be atypical of the prevailing contamination at SWMU 99a. The baseline human health risk assessment addressed this uncertainty by calculating the risk and hazard scores for SWMU 99a with and without these "hot spot" samples.
46	V4, §1.7.2, Page 1-212	The routes of exposure for the recreational user should also include exposure to surface soil/sediments and surface water (ingestion, dermal contact, and inhalation of vapors/ particulates). The off-site rural resident should include the above routes of exposure, in addition to exposure to groundwater (ingestion, dermal contact, and inhalation of volatiles).	This comment required no change to the document. Four routes of exposure involving contact by recreational users with contaminated soil were not quantitatively evaluated in the BERA: • incidental ingestion of contaminated surface soil by recreational users, • dermal contact with contaminated surface soil by recreational users, • inhalation of volatiles and particulates emitted from surface soil by recreational users, and • external exposure to ionizing radiation emitted from surface soil by recreational users. The exposure assessment and previous studies indicated that repeated contact by recreational users with soil at the sites in WAG 28 would be unlikely and exposure time would be minimal.

No.	Page/ Reference	Comment	Response
46 (cont.)			Six routes of exposure involving contact with media in open bodies of surface water were not quantitatively evaluated in the BHHRA: • incidental ingestion of surface water while swimming or wading in creeks or ponds, • incidental ingestion of sediment while swimming or wading in creeks or ponds, • dermal contact with surface water while swimming or wading in creeks or ponds, • dermal contact with sediment while swimming or wading in creeks or ponds, • external exposure to sediment while swimming or wading in creeks or ponds, and • ingestion of fish from creeks or ponds containing contaminated surface water. These routes were not quantified because no surface waters or sediments are present at WAG 28 sites; therefore, these are incomplete pathways.

No.	Page/ Reference	Comment	Response
47	V4, App. B, §B.3.2, Page B-10	Iron should not be screened out on the basis of being an essential nutrient (Supplemental Guidance to RAGS: Region 4 Bulletins. Human Health Risk Assessment. November, 1995).	This comment required no change to the document. Iron was not screened out on the basis of being an essential nutrient. The maximum detected concentrations of analytes known to be essential nutrients were compared to their respective RDAs for children to determine if it would be appropriate to remove any essential nutrients from the data set. Generally, analytes whose potential intakes based on the maximum detected concentrations were less than one-fifth of the RDA for children were removed from the data set, as agreed upon by the Commonwealth of Kentucky and EPA in the Methods Document. Seven analytes known to be essential nutrients and known to be toxic only at extremely high concentrations can be removed from the data set on the basis of regulatory guidance (EPA 1995). These analytes are calcium, chloride, iodine, magnesium, potassium, sodium, and phosphorous. Three essential nutrients, chromium, manganese, and zinc, are not screened using this process because of toxic effects seen from exposure to these chemicals at low concentrations.

DOE/OR/07-1846/V1&D2

Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Volume 1 of 4. Chapters 1 through 8

Date Issued—August 2000

Prepared for the
U.S. Department of Energy
Office of Environmental Management

by

BECHTEL JACOBS COMPANY LLC
managing the
Environmental Management Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC05-98OR22700
for the
U.S. DEPARTMENT OF ENERGY

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contributed to the preparation of this document and
should not be considered an eligible contractor for its review.

PREFACE

This integrated Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant (DOE/OR/07-1846/V1–V4&D2) was prepared in accordance with requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Resource Conservation and Recovery Act of 1976 (RCRA).

In accordance with Section IV of the Federal Facility Agreement for the Paducah Gaseous Diffusion Plant, this integrated technical document was developed to satisfy both CERCLA and RCRA corrective action requirements. The phases of the investigation process are referenced by CERCLA terminology within this document to reduce the potential for confusion.

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ACRONYMS

ACO	Administrative Consent Order
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
BRA	baseline risk assessment
CDM	Camp, Dresser, & McKee, Incorporated, Federal Programs Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cm/s	centimeter per second
COC	chemical of concern
COE	U.S. Army Corps of Engineers
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CPT	cone penetrometer
CSL	Close Support Laboratory
DAF	dilution/attenuation factor
DCE	dichloroethene
DNAPL	dense, nonaqueous-phase liquid
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPT	direct push technology
DQO	data quality objective
DWRC	dual wall reverse circulation
ECD	electron capture detector
EDD	electronic data deliverable
ELCD	electrolytic conductivity detector
ELCR	excess lifetime cancer risk
EMEF	Environmental Management and Enrichment Facilities
EPA	U.S. Environmental Protection Agency
ERWM	Environmental Restoration and Waste Management
FFA	Federal Facility Agreement
GC	gas chromatograph
GSA	generator storage area
HASP	health and safety plan
HI	hazard index
HPGe	high purity germanium
HSA	hollow stem auger
HSWA	Hazardous and Solid Waste Amendments of 1984
IATA	International Air and Transportation Association
I.D.	inside diameter
ID	identification
IDW	investigation-derived waste
IEUBK	Integrated Exposure Uptake Biokinetic (model)
KDEP	Kentucky Department for Environmental Protection
KPDES	Kentucky Pollutant Discharge Elimination System
LCD	Lower Continental Deposits

LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LMES	Lockheed Martin Energy Systems, Inc. (also referred to as Energy Systems)
MCA	multichannel analyzer
MDL	method detection limit
MEPAS	Multimedia Environmental Pollutant Assessment System
mgd	million gallons per day
MS	mass spectrometer
MSA	Method of Standard Additions
msl	mean sea level
mS/m	milliSiemens per meter
MS/MSD	matrix spike/matrix spike duplicate
ND	non-detect
O.D.	outside diameter
OOCE	out-of-control event
ORO	Oak Ridge Operations
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
pCi/g	picoCurie per gram
pCi/L	picoCurie per liter
PEMS	Project Environmental Measurements System
PGDP	Paducah Gaseous Diffusion Plant
PID	photoionization detector
POC	pathway of concern
PPE	personal protective equipment
ppm	parts per million
ppt	parts per thousand
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act of 1976
RDA	Recommended Dietary Allowance
RfD	reference dose
RGA	Regional Gravel Aquifer
RI	remedial investigation
RME	reasonable maximum exposure
RPD	relative percent difference
SAA	satellite accumulation area
SE	site evaluation
SI	site investigation
SMO	Sample Management Office
SOP	standard operating procedure
SSL	Soil Screening Level
SVOA	semivolatile organic analyte
SWMU	solid waste management unit
TAL	Target Analyte List
TLD	thermoluminescent dosimeter
TN&A	T N & Associates, Inc.
TOC	total organic carbon
TPH	total petroleum hydrocarbon

TVA	Tennessee Valley Authority
UCD	Upper Continental Deposits
UCRS	Upper Continental Recharge System
UF_6	uranium hexafluoride
μS/cm	microSiemens per centimeter
USEC	United States Enrichment Corporation
USGS	U.S. Geological Survey
UST	underground storage tank
VOA	volatile organic analyte
WAC	waste acceptance criteria
WAG	waste area grouping
WKWMA	West Kentucky Wildlife Management Area

EXECUTIVE SUMMARY

In 1999, the U.S. Department of Energy conducted a Remedial Investigation (RI)/Resource Conservation and Recovery Act Facility Investigation for Waste Area Grouping (WAG) 28. WAG 28 originally included Solid Waste Management Units (SWMUs) 99, 183, 193, and 194 and Area of Concern (AOC) 204 at the Paducah Gaseous Diffusion Plant (PGDP) in Paducah, Kentucky. Upon further evaluation of the records and available data, a determination has been made that SWMU 183 will be removed from WAG 28 and further addressed under the PGDP Underground Storage Tank Program. As a result, the overall purpose of the WAG 28 RI was to determine the presence, nature, and extent of contamination at SWMUs 99, 193, and 194 and AOC 204. Media sampled were generally tested for volatile organic analytes (VOAs), semivolatile organic analytes, polychlorinated biphenyls, metals, and radionuclides. On-site screening of alpha/beta/gamma activities were used to identify samples to be analyzed for selected radionuclides and transuranic elements including americium-241, neptunium-237, plutonium-239, and plutonium-239/240. Of the transuranics, only a single detection of neptunium-237 was identified in any of the WAG 28 samples. The primary focus of the RI was to collect sufficient information about surface soil, subsurface soil, and the shallow groundwater of the Upper Continental Recharge System (UCRS) contamination to support an assessment of risks to human health and the environment and the selection of remedial actions to reduce these risks. In addition, contamination in the Regional Gravel Aquifer (RGA) and McNairy Formation groundwater was characterized to determine if contamination in the sites acted as a secondary source of contamination to groundwater. The sites that were assessed for risk to human health and the environment were SWMUs 99, 193, and 194 and AOC 204.

C-745 Kellogg Building Site (SWMU 99)

The C-745 Kellogg Building Site (SWMU 99) is located along the eastern edge of PGDP. The Kellogg Buildings that occupied the site from 1951 to 1955 were used as temporary support facilities during the construction of the PGDP cascade facilities. The buildings were demolished in 1955, leaving only the concrete pads that are now used to store uranium hexafluoride (UF_6) cylinders and classified scrap materials. A septic tank and a leach field that formerly serviced the Kellogg Buildings have also been identified as part of SWMU 99. These facilities were located approximately 350–400 ft southeast of the site of the former buildings.

Sampling of the soils within SWMU 99 detected a limited suite of metals above screening criteria and isolated occurrences of VOAs in the surface soils. Relatively minor concentrations of trichloroethene were seen in the soils and groundwater of the UCRS. Higher concentrations of trichloroethene reflective of the Northeast Plume were observed in the RGA groundwater samples.

Soil adjacent to a storm drain exposed outside the boundary of SWMU 99 was found to contain elevated levels of polychlorinated biphenyls, technetium-99, uranium, cesium-137, neptunium-237, and thorium-234. Although the origin of the drainpipe is unknown, it may have collected storm water runoff from SWMU 99. The information collected on the drainpipe has been discussed in Chap. 4 of this report, "Nature and Extent of Contamination," and will be utilized in support of remedial alternative selections for SWMU 99 that are currently being developed under the Groundwater Operable Unit Feasibility Study.

McGraw Construction Facilities (SWMU 193)

The McGraw Construction Facilities Area (SWMU 193), located to the south and west of the C-333 Building, was the site of several support facilities used during the construction of PGDP in the 1950s.

The area encompasses approximately 100 acres of mostly flat land, about half of which is currently used to store UF_6 cylinders.

Isolated occurrences of chromium, cobalt, lead, manganese, and cadmium in the surface and subsurface soils at SWMU 193 that were reported from a previous investigation of the site may represent small releases of metals.

Trichloroethene is not present in the soils at SWMU 193. Therefore, the source for the trichloroethene previously identified in the underlying RGA groundwater cannot be attributed to SWMU 193. Within the RGA, a significant decrease in the trichloroethene concentrations beneath the Millwright Shop was observed between sampling conducted in 1994 and sampling conducted during the WAG 28 RI. This change may be attributed to dilution and diffusion of trichloroethene as the contaminant zone migrated to the north-northeast during the intervening 5-year period.

Although trichloroethene is a dense, nonaqueous-phase liquid, downward movement of trichloroethene from the porous RGA sands and gravels into the underlying McNairy clays is not a widespread phenomenon at SWMU 193. The maximum concentration of trichloroethene reported from the McNairy water samples was 42 μg/L, and the deepest penetration of trichloroethene into the McNairy is only to 32 ft below the base of the RGA.

Technetium-99 is the most widespread of the radionuclides in the groundwater at SWMU 193. The distribution and location of the highest technetium-99 activities in the RGA closely mimics the distribution of trichloroethene. Technetium-99 was detected in two McNairy water samples.

McGraw Construction Facilities Leach Fields (SWMU 194)

SWMU 194 is located in the southwestern corner of PGDP and consists of the former locations of the McGraw Construction Facilities Administration Building, cafeteria, security guard headquarters, hospital, purchasing building, paper and stationery warehouse, and boiler house. Also included in the SWMU are two associated leach fields located west of Hobbs Road. All of these facilities were built in the early 1950s and have been demolished. The site now consists of an open, grass-covered area that is mowed regularly as part of PGDP maintenance operations. This SWMU is located outside the main security fence that surrounds the primary plant buildings and structures.

Metals detected in the shallow subsurface at SWMU 194 represent both naturally occurring conditions and possible releases to the subsurface. Aluminum levels detected at the site are considered to represent naturally occurring concentrations. Cadmium, lead, and chromium that have been reported from the site could represent small isolated releases to the subsurface from the leach field.

Area of Concern 204

AOC 204, a heavily vegetated area located on the eastern side of PGDP, is bounded on the east by Dyke Road and on the west by the plant security fence. Kentucky Pollutant Discharge Elimination System Outfalls 010 and 011 define the northern and southern limits of AOC 204, respectively. AOC 204 is thought to have been used as a staging area or construction debris burial ground during the original construction of the plant.

Previous investigations conducted at AOC 204 identified VOAs in the subsurface soils and the possibility of a buried source on site. Sampling conducted for the WAG 28 RI did not confirm the presence of VOAs in the soils but did detect trichloroethene and its by-products in the groundwater. Trichloroethene was noted primarily in the RGA, but not in concentrations that would indicate a nearby source. The lack of significant concentrations of trichloroethene in the shallow subsurface does not support the presence of an on-site source for trichloroethene at AOC 204. Radionuclides were not observed at levels of concern in either the groundwater or soils.

WAG 28 Groundwater Evaluation

As part of the WAG 28 evaluation process, the impact on RGA groundwater from possible contaminant releases was investigated at SWMU 99, SWMU 193, and AOC 204. In general, it is clear that the predominant contaminants in the surface and subsurface soils at WAG 28 are metals. This contrasts with the overwhelming and well-documented contamination in RGA and McNairy groundwater that is characterized by the presence of chlorinated alkenes and radionuclides (predominantly trichloroethene and technetium-99, respectively). These differences in the suites between the soil- and groundwater-borne contaminants suggest that the areas investigated during the WAG 28 RI are not significant sources of the existing groundwater contamination. However, a range of contaminants, including metals, volatile organic compounds, and radionuclides was detected in the soils at WAG 28, some of which appear to have the capacity to migrate to groundwater in the future.

SWMU 99 does not contain significant contaminant concentrations in either the UCRS soils or UCRS groundwater that would suggest that the site is currently or will in the future become a significant contributor of contaminants to the Northeast Plume. However, elevated levels of radionuclides were discovered in shallow soils surrounding a broken drainpipe that drains the SWMU 99 area. This migration pathway, which feeds Outfall 010, may be a contributing source to contamination observed in the Northeast Plume in the underlying RGA.

Sampling of the UCRS soils during the WAG 28 RI indicates that the primary source of the contamination in the RGA groundwater at SWMU 193 does not exist at the former location of the Millwright Shop as originally believed. Moreover, trichloroethene concentrations currently in the RGA groundwater beneath the site have decreased significantly during the last 4 years. This decrease in trichloroethene concentrations in the RGA at the Millwright Shop is best attributed to migration and dispersion of the contaminated groundwater plume.

At AOC 204, relatively minor trichloroethene concentrations (<100 μg/kg) are observed in the near surface soils adjacent to Outfall 011, but higher concentrations are observed at greater depths in the borings located in the interior of the site. This evidence indicates that contaminants detected in the UCRS soils are related to the downward percolation of surface water flow in Outfall 011. This infiltration of contaminants from a losing surface water stream would appear to represent one potential source for the contaminants in the Northeast Plume.

The results of the WAG 28 RI show that widespread contamination is not present in either the UCRS soil or the UCRS groundwater at any of the areas investigated. None of the WAG 28 sites sampled for the RI has been identified as a significant contributor of contaminants to the underlying RGA groundwater. This conclusion is based on the evaluation of the nature, extent, and concentration of contaminants found during the WAG 28 investigation, taking into account the data obtained from both previous and current rounds of sampling.

BASELINE RISK ASSESSMENT

In some instances, contaminant concentrations observed in previous studies could not be confirmed and are therefore not considered representative of current site conditions. This suggests that the prevailing levels of contamination may have become attenuated over time. However, as mandated by *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous*

Diffusion Plant (DOE 1996) and as set forth in the approved work plan (DOE 1998d), the historical data have been aggregated with those from the most recent sampling effort in the accompanying risk assessment (Vol. 4). Such an approach is justified as a means of ensuring that the identification of chemicals of potential concern and the computed chemical and radiological hazards and risks at WAG 28 do not underestimate the potential threats to human health posed by prevailing levels of contaminantion at the sites. Other elements of this conservative strategy include (1) the use of provisional and withdrawn reference dose (RfD) values, (2) the use of default dermal absorption factors that may exceed the real values, and (3) the use of default exposure parameters that probably exceed the current rates of exposure at the site.

In general, many of the sites and sub-sites contain contaminants that, taken together, contribute to risk above de minimis levels, as shown in Table ES.1. However, to view these results in context, also included in this risk assessment is a comprehensive analysis of the influence, both individually and collectively, of the default parameters and values that may have made the hazard and risk determinations overly conservative (Sect. 1.6 of Vol. 4). By including such a comprehensive analysis, a more complete evaluation of the likely impact of site contamination on human health and the environment is provided to risk managers charged with making decisions about remedial actions at WAG 28. The semiquantitative assessment of uncertainty also permits sensitivity issues to be explicitly addressed.

As discussed, the WAG 28 baseline risk assessment utilizes information collected during the recently completed RI of WAG 28 and the results of previous risk assessments for sites in WAG 28 to characterize the baseline risks posed to human health and the environment from contact with contaminants in soil and groundwater. In addition, this baseline risk assessment uses results of fate and transport modeling (Multimedia Environmental Pollutant Assessment System) to estimate the baseline risks posed to human health and the environment through contact with media impacted by contaminants migrating off site from the various sources in WAG 28. Baseline risks are those that may be present now or in the future in the absence of corrective or remedial actions.

Consistent with regulatory guidance and agreements contained in the approved human health risk assessment methods document (DOE 1996), the baseline human health risk assessment evaluates scenarios that encompass current use and several hypothetical future uses of the WAG 28 sites and the areas to which contaminants may migrate. The following scenarios are assessed:

- Current on-site industrial—direct contact with surface soil (0–1 ft bgs)
- Future on-site industrial—direct contact with surface soil and use of groundwater drawn from aquifers below WAG 28
- Future on-site excavation scenario—direct contact with surface and subsurface soil (0–15 ft bgs)
- Future on-site recreational user—ingestion of game exposed to contaminated surface soil
- Future on-site rural resident—direct contact with surface soil, use of groundwater drawn from aquifers below WAG 28, and ingestion of vegetables grown in this area
- Off-site rural resident—use of groundwater drawn from aquifers at the PGDP fence boundary

Also consistent with regulatory guidance and the strategy for the ecological risk assessment of source units (DOE 1993, EPA 1998a), the baseline ecological risk assessment evaluates risks under both current and potential future conditions to several nonhuman receptors that may come into contact with contaminated media at or migrating from sources in WAG 28.

As a measure of the threat of systemic toxicological effects arising through contact with contaminated media at WAG 28, values for hazard indices (HIs) were, for the most part, greater than 1000 when lead was retained as a contaminant of potential concern. However, such high values are related to the use of a provisional RfD, an approach that may overemphasize the potential threat of this contaminant. Accordingly, in this assessment, HIs for all receptor/land use combinations were routinely calculated with lead both included and excluded from the determinations, thereby permitting an evaluation of the overall threat to human health from other contaminants at WAG 28 for sites where lead is present.

For all sites, the cumulative human health excess lifetime cancer risk (ELCR) and systemic toxicity exceed the accepted standards of the Kentucky Department of Environmental Protection and the U.S. Environmental Protection Agency for one or more scenarios when assessed using default exposure parameters. The scenarios for which risk exceeds de minimis levels (i.e., a cumulative ELCR of 1E-6 or a cumulative HI of 1) are summarized in Table ES.1.

The conceptual model defined in the approved WAG 28 Work Plan (DOE 1998d) defined the potential sources of contamination in SWMU 194 and AOC 204 as being contained within subsurface soil (i.e., drainfields and buried debris pile). Consequently, surface soils are not impacted and did not require an ecological evaluation to be performed.

Lack of quality habitat in the industrial setting of WAG 28 sites within the fence boundaries limits exposure of ecological receptors at most sites under current conditions (with the exception of the Millwright Shop at SWMU 193). However, an assessment of potential risks in the future, assuming conditions change so that suitable habitat becomes available for ecological receptors, was conducted. Several contaminants in surface soils were found to be at concentrations greater than levels that are protective of future nonhuman receptors. Table ES.2 summarizes these chemicals and radionuclides of potential ecological concern. Risk for ecological receptors was not evaluated at SWMUs 99b and 194 or AOC 204 because it was previously determined that surface soil was not a medium of concern at these sites.

Table ES.1. Scenarios for which human health risk exceeds de minimis levels

Scenario	Site						
	SWMU 99a*	SWMU 99b*	SWMU 193a*	SWMU 193b*	SWMU 193c*	SWMU 194	AOC 204
Systemic Toxicity[a]							
Current industrial worker							
Exposure to soil	–	NA	–	X[b]	X[c]	NA	NA
Future industrial worker							
Exposure to soil	–	NA	–	X[b]	X[c]	NA	NA
Exposure to RGA groundwater	X[d]	X[b]	X[b]	X[b]	X[b]	NA	X[b]
Exposure to McNairy groundwater	X[b]	NA	X[b]	–	X[d]	NA	NA
Future on-site resident[a]							
Exposure to soil	X[b]	NA	X[b]	X[b]	X[d]	NA	NA
Exposure to RGA groundwater	X[d]	X[b]	X[b]	X[b]	X[b]	NA	X[b]
Exposure to McNairy groundwater	X[b]	NA	X[b]	X[b]	X[d]	NA	NA
Off-site resident							
Exposure to groundwater[e]	X[e]	–	X[e]	–	X[e]	X[e]	X[e]
Future recreational user[a]							
Exposure to soil	–	NA	–	–	X[c]	NA	NA
Future excavation worker							
Exposure to soil	X[d]	–	–	X[b]	X[d]	X[c]	–
Excess lifetime cancer risk							
Current industrial worker							
Exposure to soil	X	NA	X	X	–	NA	NA
Future industrial worker							
Exposure to soil	X	NA	X	X	–	NA	NA
Exposure to RGA groundwater	X	X	X	X	X	NA	X
Exposure to McNairy groundwater	X	NA	X	–	X	NA	NA
Future on-site resident[f]							
Exposure to soil	X	NA	X	X	–	NA	NA
Exposure to RGA groundwater	X	X	X	X	X	NA	X
Exposure to McNairy groundwater	X	NA	X	X	X	NA	NA
Off-site resident							
Exposure to groundwater[e]	–	–	–	–	–	–	X[e]
Future recreational user[f]							
Exposure to soil	X	NA	X	–	–	NA	NA
Future excavation worker							
Exposure to soil	X	X	X	X	X	X	X

Notes: Scenarios where risk exceeded the benchmark levels (HI of 1/ELCR of 1E-6) are marked with an "X."
Scenarios where risk did not exceed a benchmark level are marked with a "–."
"NA" indicates that the scenario/land use combination is not appropriate.
*Letters following SWMU numbers designate subdivisions of SWMUs 99 and 193 based on area and historical use.

[a] For the future recreational user and the future on-site rural resident, the results for a child are presented.

[b] These scenarios are of concern even though lead was undetected.

[c] If contribution from lead is not considered, the total HI falls below 1, and the scenario is not of concern.

[d] Lead is present, and the scenario is of concern whether or not the element is included in the assessment.

[e] Based on the results of contaminant transport modeling, "X" indicates that the location contains a source of unacceptable off-site contamination.

[f] For ELCR regarding the future recreational user and the future on-site rural resident, the values are for lifetime exposure.

Table ES.2. Summary of chemicals with maximum detected or reasonable maximum exposure concentrations resulting in ecological hazard quotients greater than 1 for one or more nonhuman receptor groups

	SWMU[a]			
Receptor group	**99a**	**193a**	**193b**	**193c**
Plants[b]	Barium, Chromium, Zinc, Technetium-99[c]	Chromium	Chromium, Vanadum	Barium, Chromium, Lead, Zinc
Soil invertebrates[b]	Chromium, Zinc, Technetium-99[c]	Chromium	Chromium	Chromium
Terrestrial wildlife[d]	None	none	Vanadium	None

[a] Surface soil was not a medium of concern at SWMUs 99b and 194 or AOC 204; therefore, ecological risks were not evaluated at those sites.

[b] Plant and soil invertebrate results are based on maximum detected concentrations or activities.

[c] See text for discussion of situation resulting in unusually high activity for technetium-99.

[d] Terrestrial wildlife results are based on reasonable maximum exposure concentrations or activities.

1. INTRODUCTION

1.1 PURPOSE OF REPORT

The Paducah Gaseous Diffusion Plant (PGDP), located in western Kentucky, is an active uranium enrichment facility owned by the U.S. Department of Energy (DOE) (Fig. 1.1). On July 1, 1993, DOE leased the plant production operations facilities to the United States Enrichment Corporation (USEC). On April 1, 1998, Bechtel Jacobs Company LLC replaced Lockheed Martin Energy Systems, Inc. (LMES) in implementing the Environmental Management and Enrichment Facilities (EMEF) Program.

DOE and Bechtel Jacobs Company have undertaken to identify, investigate, and remediate, as necessary, all solid waste management units (SWMUs) and areas of concern (AOCs) at PGDP. The regulatory drivers for the remedial investigation (RI) performed at Waste Area Grouping (WAG) 28 are the Resource Conservation and Recovery Act of 1976 (RCRA) permits issued July 16, 1991, as amended by provisions of Hazardous and Solid Waste Amendments of 1984 (HSWA). The Commonwealth of Kentucky issued the basic RCRA permit, which contains provisions to address hazardous waste management, to PGDP. The U.S. Environmental Protection Agency (EPA) issued the corrective action module of the RCRA permit (also known as the HSWA permit) because that portion of the RCRA program had not yet been delegated to Kentucky. The HSWA Permit, combined with the Hazardous Waste Management permit issued by Kentucky, constitutes the RCRA—Part B permit for PGDP. The HSWA provisions require evaluation of hazardous constituent releases and implementation of interim and final corrective measures to address such releases.

In June 1994, PGDP was placed on the National Priorities List under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Both RCRA and CERCLA requirements have been integrated into the Federal Facility Agreement (FFA) that has been negotiated by DOE, EPA, and the Commonwealth of Kentucky. The FFA is intended to satisfy the requirements for an interagency agreement under Section 120 of CERCLA.

To facilitate the EMEF process at PGDP and focus investigations toward the most effective and efficient remedial actions, operable units (OUs) have been defined. These OUs consist of two types: source control units (i.e., units that may contribute contamination to other units) and integrator units (i.e., units that "collect" contamination from source control units—in the specific instance of the PGDP, the groundwater and surface water units). Five integrator OUs exist at PGDP: groundwater, surface water, surface soil, burial grounds, and comprehensive sitewide (DOE 1998a).

This document reports the results of the RI conducted at WAG 28. The WAG 28 area is shown on Fig. 1.2. WAG 28 consists of four sites that were considered potential contributors of the dense, nonaqueous-phase liquid (DNAPL) trichloroethene to groundwater on the east side of PGDP. Each of the SWMUs investigated is defined as a source control unit. The objectives of the RI were to collect data to evaluate the nature and extent of contamination (including migration pathways), determine the human health and ecological risk associated with each SWMU, and collect the data necessary to evaluate and determine the appropriate remedial actions for each SWMU. These data will be incorporated into subsequent studies focusing on remedial action for the groundwater and surface soil OUs.

1.2 WAG 28 BACKGROUND INFORMATION

WAG 28 consists of five sites:

- SWMU 99, C-745 Kellogg Building Site, located in the eastern portion of the plant;
- SWMU 183, McGraw Underground Storage Tank, located in the southeastern portion of the plant;
- SWMU 193, McGraw Construction Facilities, located in the south-central portion of the plant;
- SWMU 194, McGraw Construction Facilities, located in the southern portion of the plant; and
- AOC 204, located on the eastern side of the plant.

Four of these sites are addressed in the WAG 28 RI. A detailed description of each of the four sites in the WAG 28 RI is provided below.

1.2.1 SWMU 99—C-745 Kellogg Building Site

The C-745 Kellogg Buildings (Fig. 1.3) were constructed in 1951 as support facilities during the construction of the PGDP cascade facilities. It is possible that degreasing operations using trichloroethene were conducted within these facilities and may have resulted in releases to the environment. The former building locations are on the eastern side of PGDP and are now occupied by the C-746-D Classified Scrap Yard and the C-745-E uranium hexafluoride (UF_6) Cylinder Storage Yard. SWMU 99 was identified as a possible source area for groundwater contamination during the Groundwater Phase IV Investigation (DOE 1995a) because of the potential that trichloroethene was used at this site. SWMU 99 occupies approximately three acres.

1.2.2 SWMU 193—McGraw Construction Facilities

The McGraw Construction Facilities (Fig. 1.4) are a series of sites located on the southern side of PGDP, east of Patrol Road 5 and west of 16th Street. The area consists of approximately 100 acres of mostly flat land, equally divided between UF_6 cylinder storage yards and open fields. This area was once covered by buildings, some of which were used for metals fabrication, electrical equipment storage, paint storage, cleaning operations, heavy equipment cleaning, waste disposal, refueling, and concrete production. SWMUs 193 and 194 (discussed below) as well as the C-745-G, -F, -K, -L, -D, -Q, -M, -N, and -P Cylinder Storage Yards are located in this area.

1.2.3 SWMU 194—McGraw Construction Facilities

SWMU 194 (Fig. 1.5) encompasses the area that formerly housed the administrative buildings, cafeteria, hospital, and other support facilities for the McGraw Construction Company. This SWMU covers approximately 22 acres of mostly flat land, encompassing an area from west of Hobbs Road to Patrol Road 5, in the southern portion of PGDP. SWMU 194 is located west of SWMU 193.

1.2.4 AOC 204

AOC 204 (Fig. 1.6) consists of approximately 3 acres located between Patrol Road 3 and Dyke Road on the eastern side of PGDP. Very limited historical information is available pertaining to AOC 204, although it is believed that it was used for disposal of construction debris. AOC 204 was extensively investigated in August 1995, and no imminent threat was found that warranted action at that time (DOE 1995b).

1.2.5 SWMU 183 McGraw Underground Storage Tank

Further investigation at the McGraw underground storage tank (UST) (SWMU 183), which was originally proposed as part of WAG 28, was not included in the WAG 28 RI work scope.

The McGraw UST is a 400-gal waste oil tank located south of the C-745-K Cylinder Storage Yard. The currently inactive UST was reportedly used during construction of PGDP. The tank was installed in 1951 and was possibly in operation until 1954. The UST was discovered and filled with either gravel or concrete in the early 1980s during construction of the cylinder yards.

The McGraw UST was investigated during the Site Evaluation (SE) of SWMUs 193 and 194 conducted as part of the Northeast Plume Investigation (DOE 1995a). A geophysical survey using a magnetometer was conducted to determine the UST's approximate location. One soil boring (soil boring 193-4) was near the anomaly identified during the magnetometer survey. Soil and groundwater samples were collected from the soil boring and analyzed for trichloroethene; benzene, toluene, ethylbenzene, and xylenes (also called dimethylbenzene); polychlorinated biphenyls (PCBs); and selected metals. Analytical results of the SE investigation are included in Appendix F of Vol. 3 of this report.

Based on the results of the SWMUs 193 and 194 SE, a recommendation of "no further action" at SWMU 183 was proposed during development of the WAG 28 work plan (DOE 1998b). The justification for this recommendation is outlined below.

- Petroleum USTs that were closed before January 1, 1974, by removing all products and that do not currently contain free product (< 1 in.) are not regulated under 301 Kentucky Administrative Record, Chap. 42, but are subject to Kentucky Superfund Guidelines for nonregulated tanks (under the UST program).
- There have been no documented releases from the McGraw UST.
- Based on the limited time (approximately 4 years) that the tank was in service, it is unlikely that any releases would have occurred as a result of degradation of the tank or its associated piping system.
- There is no potential for continued releases from the tank because it has been filled with gravel or concrete.
- The tank is currently covered by a concrete pad, which serves as a cap to prevent infiltration of surface water.
- No contamination was detected in soil or groundwater samples collected in the immediate vicinity of the tank that would indicate releases to warrant further investigation.

Upon further evaluation of the SWMU 183 records and available data, a determination was made that the site would be removed from WAG 28 and further addressed as part of the PGDP UST program under *Kentucky Revised Statute* 224.60-105 and *Kentucky Administrative Regulations* 401 KAR 42:020 and 42:080. Therefore, SWMU 183 will not be further addressed in the WAG 28 RI.

1.3 PREVIOUS INVESTIGATIONS

Following the discovery of off-site groundwater contamination, DOE and EPA entered into an Administrative Consent Order (ACO) pursuant to CERCLA in November 1988. The primary purpose of the ACO was to formalize requirements for determining the nature and extent of off-site contamination and to ensure that appropriate actions are taken to mitigate immediate risks posed to human health and the environment. As part of the ACO, DOE conducted a two-phase site investigation (SI) from 1989 to 1992. This SI confirmed the widespread presence of groundwater contamination with two large, reasonably distinct contaminant plumes emanating from PGDP. One plume was found leaving PGDP in the northwest corner of the plant (Northwest Plume) and the other plume exits the eastern side of the plant (Northeast Plume) (Fig. 1.7). The Northwest Plume has trichloroethene and technetium-99 as the primary chemicals of concern, and the Northeast Plume has trichloroethene as the primary chemical of concern (COC) (CH2M Hill 1991, 1992).

From 1992 through 1994, two investigations further defined the off-site plumes and showed a third distinct technetium-99 plume located adjacent to the Northwest Plume. The Northwest Plume investigation used drive-point profiling along five transects oriented perpendicular to the plume to better define the three-dimensional distribution of trichloroethene and technetium-99 in the Regional Gravel Aquifer (RGA) (Clausen et al. 1994). The Northeast Plume investigation collected data from four off-site transects as well as several on-site transects to provide the areal and vertical extent of contamination (DOE 1995a). Some of the key findings of these two investigations include significantly elevated concentrations of trichloroethene at the base of the RGA, which is highly suggestive of a DNAPL source at depth. Another key finding is the connection of the Northwest Plume with the site of a former trichloroethene leak near the C-400 Building. Recent investigations conducted at WAG 27 (DOE 1999) have determined that another distinct trichloroethene plume (Southwest Plume) exists in the RGA on the west side of PGDP.

1.4 PROJECT SCOPE

The general scope of this project is to conduct an RI at four locations: three SWMUs and one AOC.

The primary focus of the RI was to collect sufficient information about existing and potential contamination in surface and subsurface soils, the shallow groundwater of the Upper Continental Recharge System (UCRS), and possibly groundwater in the RGA and upper McNairy Formation to support an assessment of risks to human health and the environment and the selection of actions to reduce these risks, if required. If chemicals of potential concern (COPCs) were detected in the UCRS beneath a SWMU, the RGA and McNairy Formation were evaluated as secondary source(s). Based on the geology of the McNairy Formation, it was expected that migration of contaminants through the formation was impeded by the Levings Member, which serves as an aquitard in the PGDP area. Based on this assumption, all of the initial deep soil borings were terminated at the top of the Levings Member of the McNairy Formation (approximately 160 ft).

The list below summarizes the activities that were conducted as part of the RI activities.

1. Collection of surface soil, subsurface soil, surface water, and groundwater samples.

2. Field screening and laboratory analysis of the samples.

3. Numeric modeling of contaminant fate and transport, and estimation of future exposure point concentration at the DOE property boundary.

4. Evaluation of nature and extent of contamination related to each source unit and determination of ecological and human health risks associated with each site.

1.5 REPORT ORGANIZATION

The WAG 28 RI report is organized into eight chapters and eight appendices and is presented in four volumes. The contents of Vol. 1 are described below while Vols. 2 and 3 contain appendix material referenced in this volume. Volume 4 presents the baseline risk assessment. *Figures and large tables that disrupt the flow of the report appear at the end of each chapter in which they are referenced.*

Chapter 1 of this report presents a brief overview of the sites, as well as the rationale for RI field sampling. This section also discusses current and past activities conducted at PGDP.

Chapter 2 describes the investigative methods used to sample the various media, the analytical sampling parameters, health and safety monitoring, decontamination practices, and waste management practices for the investigations.

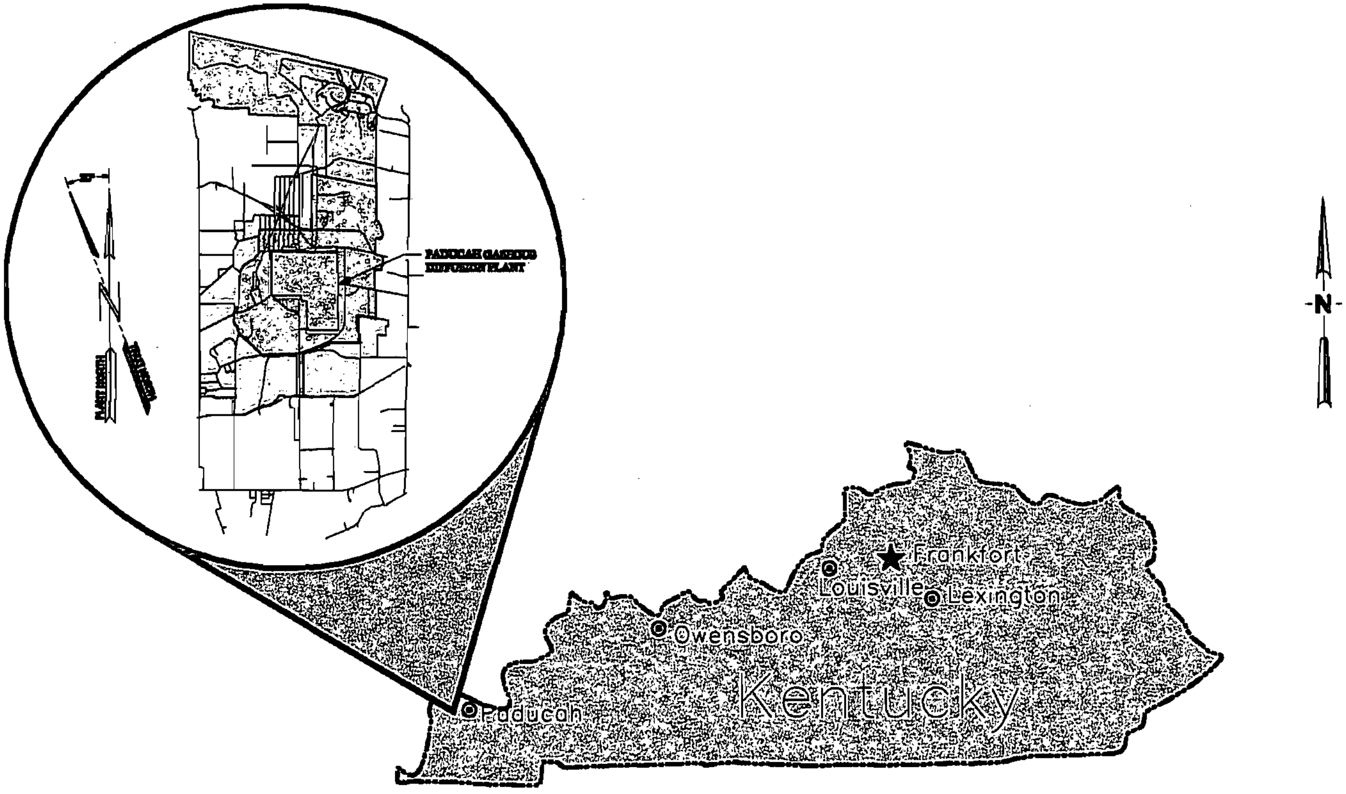
Chapter 3 details the physical characteristics of each SWMU and AOC, including the topography, surface water hydrology, geology, and hydrogeology. In addition, a description of the meteorology, ecology, demography, and land use at PGDP is presented.

Chapter 4 presents a discussion of the nature and extent of the contamination at each site as concluded from analyses of the data collected during the investigation. Contamination as found in previous investigations is also presented.

Chapter 5 presents a discussion of the fate and transport of the contamination at each site. A conceptual site model has been developed in which exposure pathways of potential concern are discussed and contaminant persistence is evaluated. Models of contaminant transport are also presented.

Chapter 6 presents a summary of the baseline risk assessment, which is contained in Vol. 4, including results of previous studies, identification of chemicals of COCs, the exposure assessment, the toxicity assessment, the risk characterization, conclusions, and site-specific remedial action goals.

The final chapters (7 and 8) present the conclusions and references, respectively, of this report.



LEGEND

★ .... STATE CAPITAL

◎ .... CITY

—— .... COMMONWEALTH OF KENTUCKY BOUNDARY

▨ .... PADUCAH GASEOUS DIFFUSION PLANT

▨ .... TVA PROPERY

▨ .... DOE PROPERTY

☐ .... WESTERN KENTUCKY STATE WILDLIFE MANAGEMENT AREA

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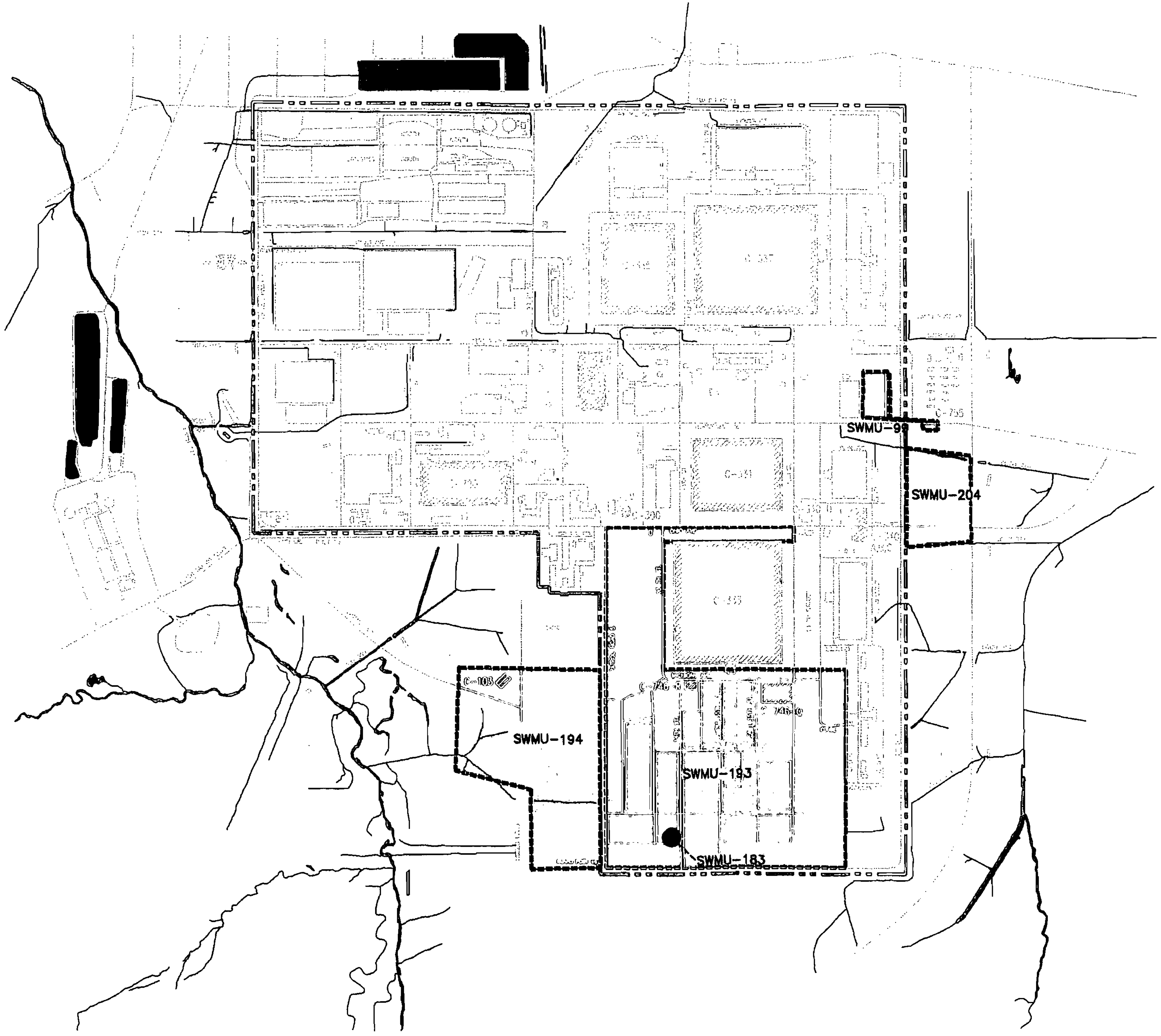
PADUCAH GASEOUS
DIFFUSION PLANT

General Site Location Map
for Paducah Gaseous Diffusion Plant
Paducah, Kentucky

Figure 1.1 August, 2000

DOE/OR/07-1846/D2 & V1



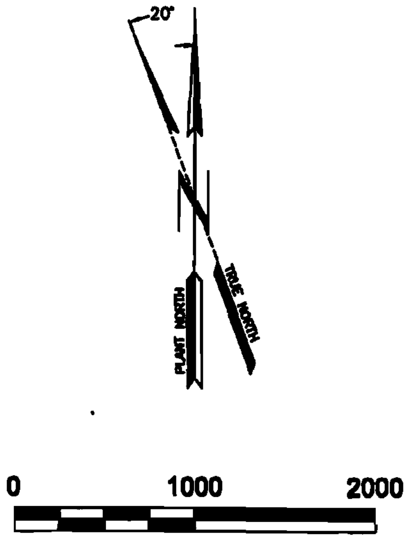
LEGEND

······· SWMU BOUNDARY

······· SECURITY FENCE

NOTES

1.)	C-103	DOE OFFICE FACILITY
	C-300	CENTRAL CONTROL BUILDING
	C-331	PROCESS BUILDING
	C-333	PROCESS BUILDING
	C-335	PROCESS BUILDING
	C-337	PROCESS BUILDING
	C-720	MAINTENANCE AND STORES BLDG.
	C-746-Q	HAZARDOUS AND LLW STORAGE BLDG.
	C-746-R	ORGANIC WASTE STORAGE BLDG.
	C-755	SUB CONTRACTORS STAGING AREA
	C-340 A	POWDER BUILDING
	C-340 B	METALS BUILDING
	C-340 C	SLAG BUILDING
	C-340 D	MAGNESIUM BUILDING



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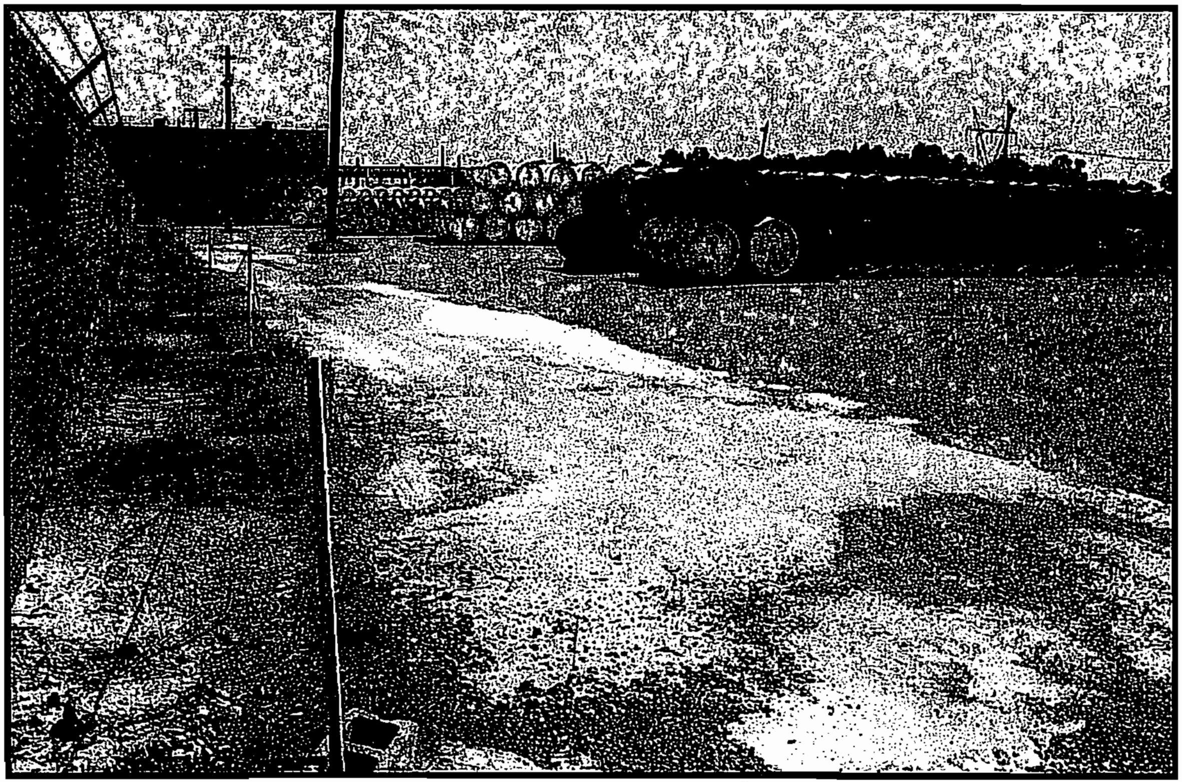
PADUCAH GASEOUS
DIFFUSION PLANT

WAG 28 SWMU LOCATION MAP

Figure 1.2 August, 2000

AutoCAD File: 1999006-8310-B-0002.dwg


SWMU 99 – Looking north across the center of the site. Classified Scrap Yard is to the left behind the fence and the Cylinder Storage Yard is to the right.

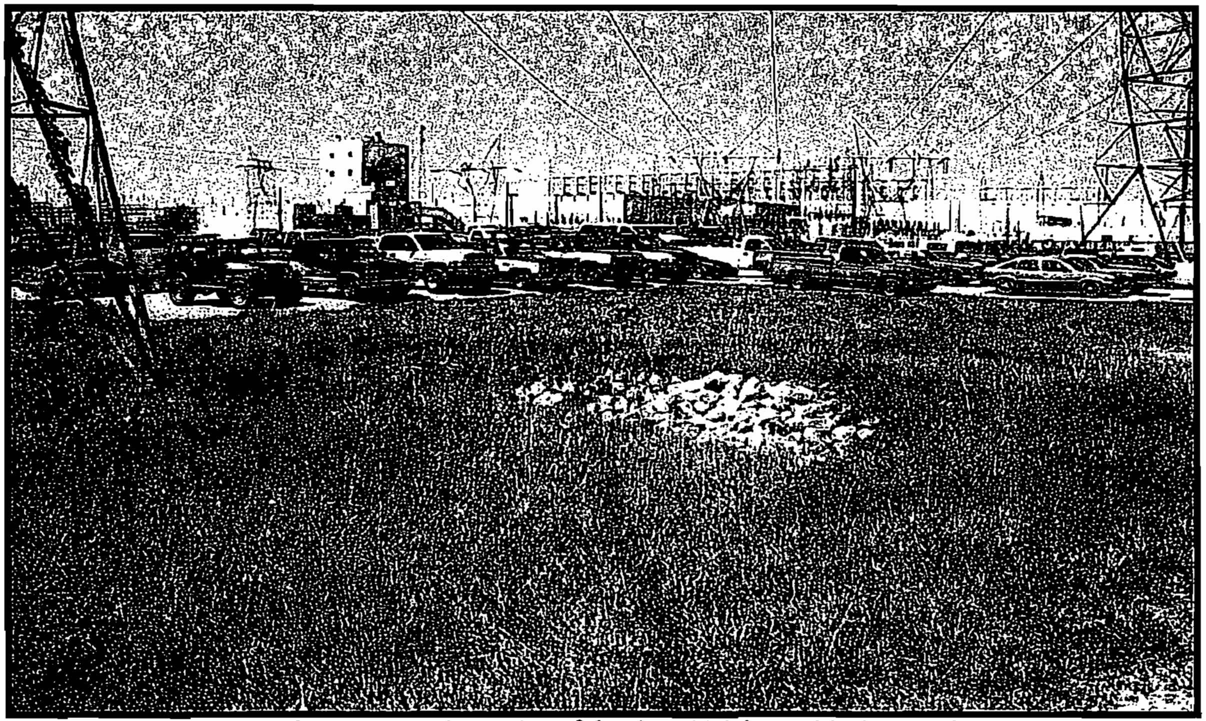
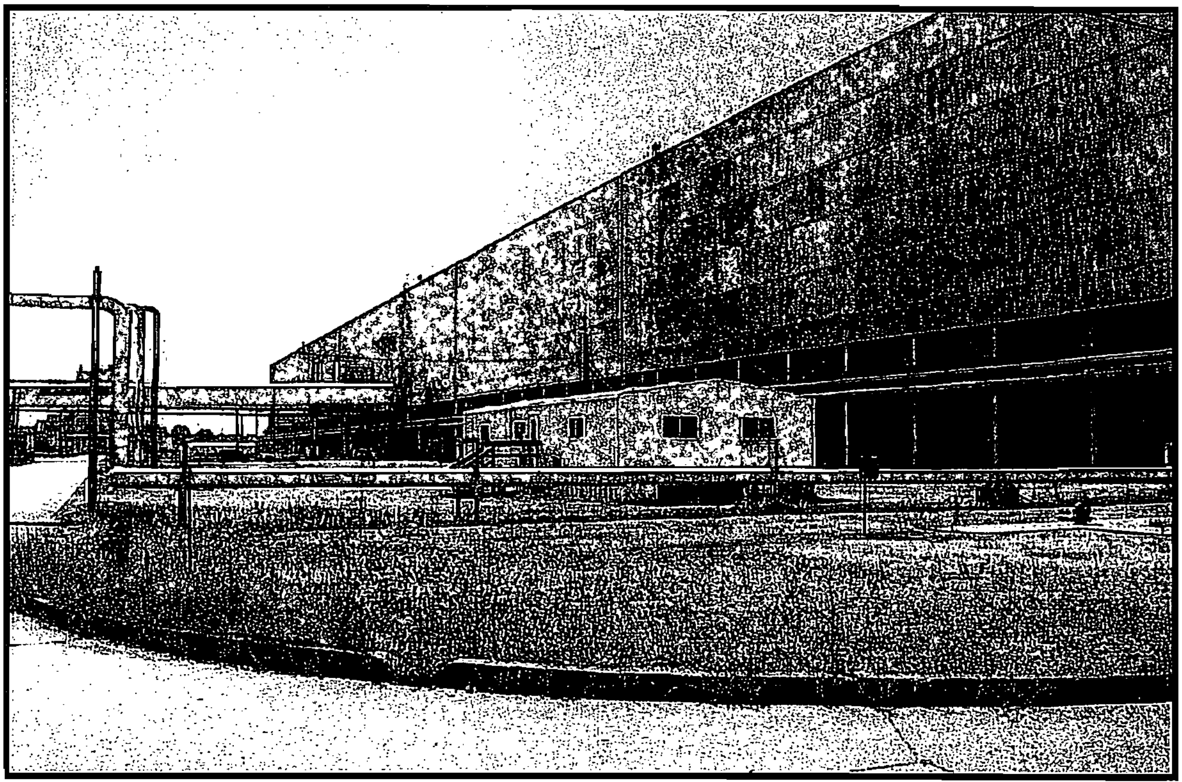

SWMU 99 – Looking southwest across the portion of the site which is outside the security fence - now a gravel parking lot.

Figure 1.3 SWMU 99



SWMU 193 – Looking east across the north end of the C-333 building.

SWMU 193 – Typical cylinder storage yard in southern one-half of SWMU 193.

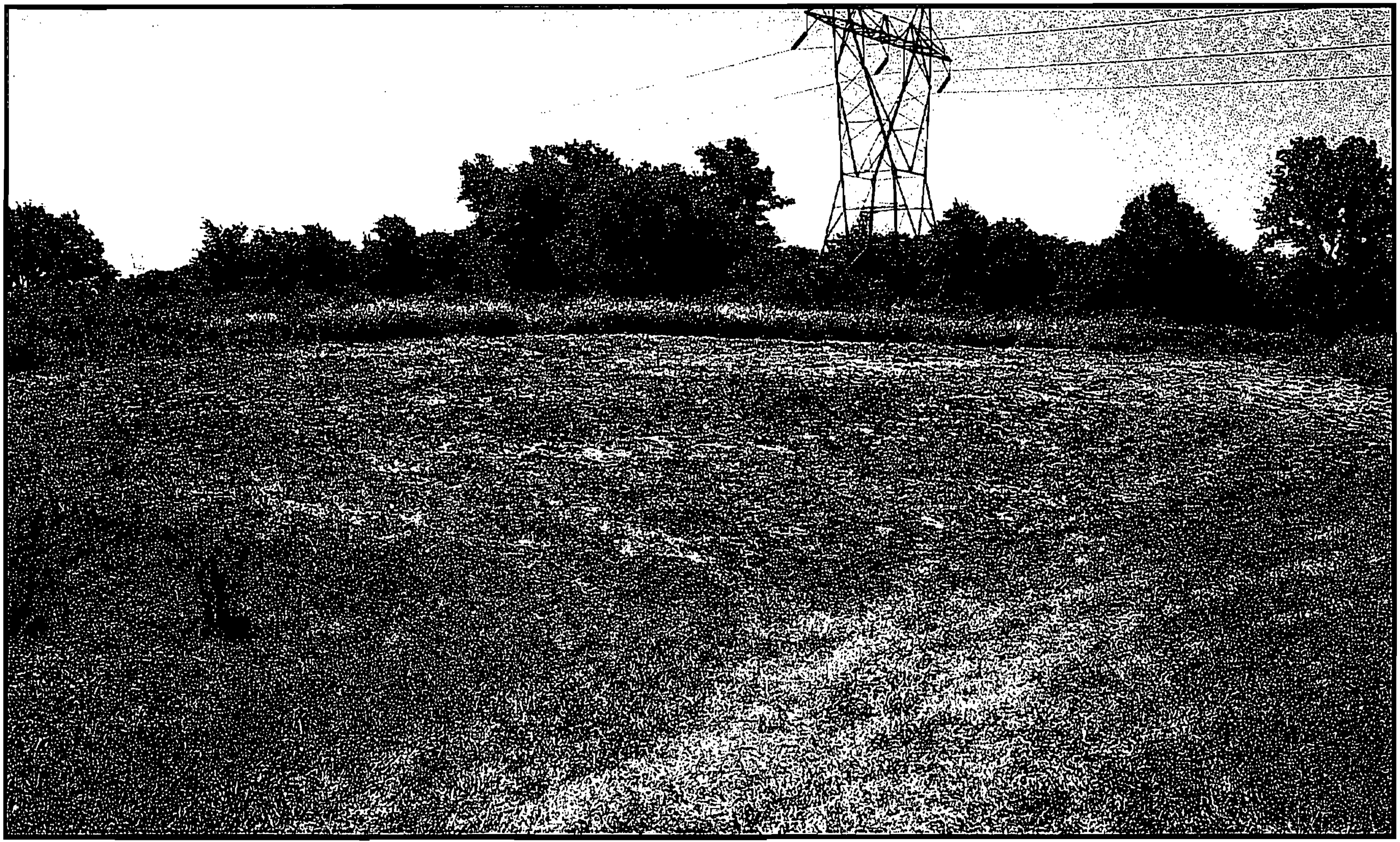
Figure 1.4 SWMU 193


SWMU 193 – East of Building C-333 looking southwest.

Figure 1.4 (continued)

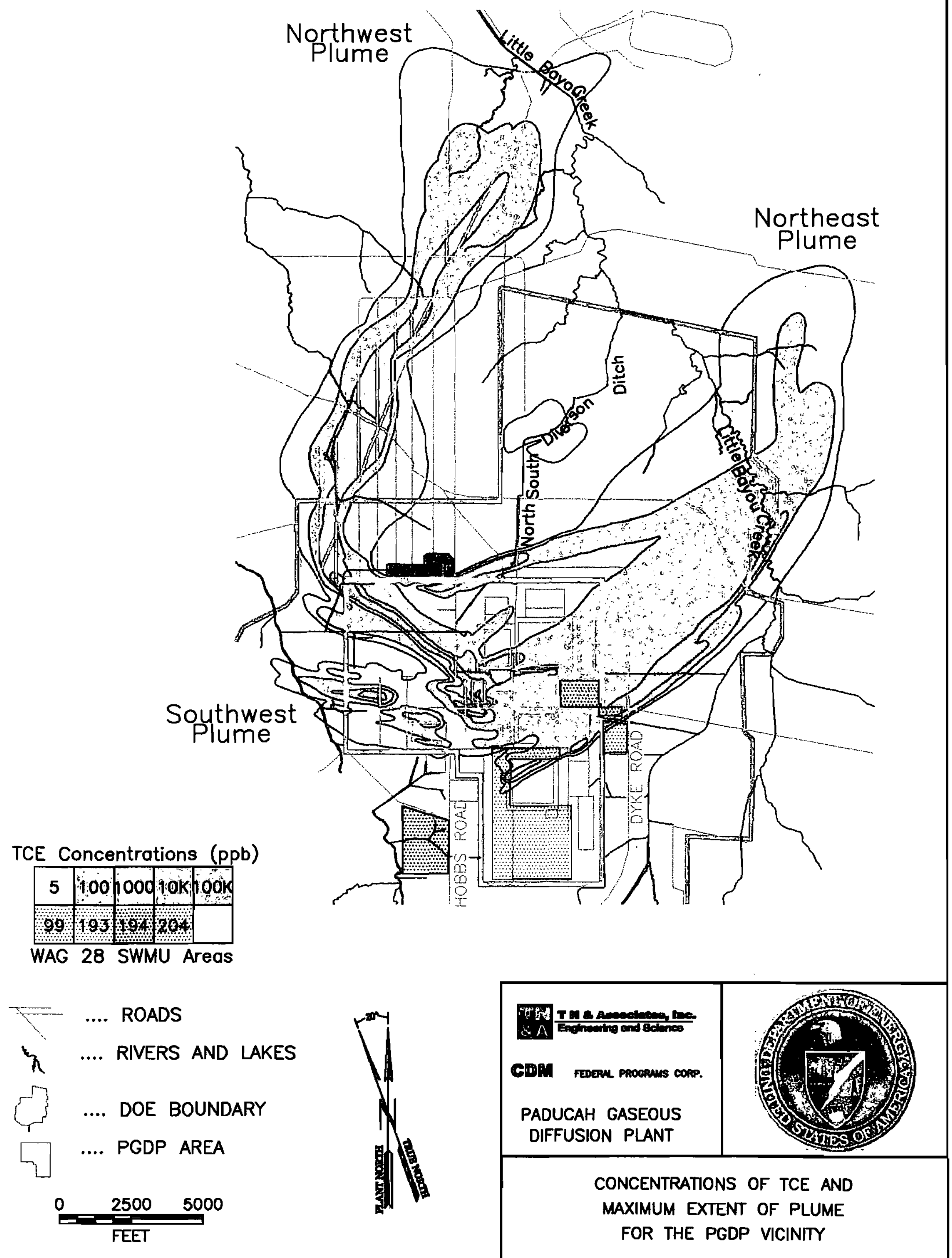
SWMU 194 – Looking north across the site.

Figure 1.5 SWMU 194



AOC 204 – Looking east/southeast across the site.

Figure 1.6 AOC 204



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PADUCAH GASEOUS
DIFFUSION PLANT

CONCENTRATIONS OF TCE AND
MAXIMUM EXTENT OF PLUME
FOR THE PGDP VICINITY

Figure 1.7 August, 2000

AutoCAD File:1999006-8310-A-0042.DWG

2. FIELD INVESTIGATION

This section presents a description of the field investigation activities and methods used during the WAG 28 RI. Major topics include sampling activities, procedures, and equipment, as well as analyses conducted on samples.

All sampling at PGDP was conducted in accordance with the medium-specific procedures set forth in the Paducah EMEF Program Procedures Manual. These procedures are consistent with EPA Region 4 Standard Operating Procedures (EPA 1996a).

2.1 SURFACE GEOPHYSICAL SURVEYS

A surface geophysical survey was performed in SWMU 99 of WAG 28 in March 1999. The area of investigation was a grass-covered field located outside the security fence of the plant near Gate 48. The area is now covered by a gravel parking lot (see Fig. 1.3). The purpose of the investigation was to delineate the locations of a drain line, septic tank, and leaching field that reportedly ran from the southeast corner of a demolished building where the C-745-E UF_6 cylinder storage yard now resides. The surface geophysics were conducted to attempt to locate the buried utilities and septic system, but the presence of the underground tank and leachate system was not indicated.

2.1.1 Methods

A Geonics EM-31 terrain conductivity meter was used to conduct the survey. The EM-31 is an electromagnetic frequency domain instrument primarily used to measure ground conductivity. The EM-31 provides an output of both the quadrature-phase (terrain conductivity) and inphase components of the inducted electromagnetic field, which are recorded simultaneously. The quadrature-phase is a measurement of the conductivity in milliSiemens per meter (mS/M). Terrain conductivity is a function of porosity, degree of saturation, and conductivity of subsurface materials. The absolute values of terrain conductivity are not usually diagnostic, but their spatial variations are important. The ability to identify lateral variations in shallow subsurface materials makes quadrature-phase EM-31 data very useful in the delineation of soil changes and a variety of buried features. While the inphase, in general, is a better detector of metal, the quadrature-phase is more sensitive to linear features (e.g., utilities, pipelines) which are, at least partially, in electrical contact with the ground.

The inphase component of the EM-31 data is primarily used in searching for buried metal and is measured in units of relative parts per thousand (ppt) of the magnetic field. A negative instrument response is generally expected over areas containing shallow buried metal (both ferrous and nonferrous).

2.1.2 Quality Assurance/Quality Control

A calibration check of the EM-31 was performed away from the possible influence of culture (e.g., high voltage power lines) using the manufacturer's standard procedure prior to data collection each day. All readings were within specification. Additionally, a standard evaluation of consistency was conducted by the operator with the EM-31 by repeating several survey lines.

2.1.3 Survey Design

A grid of east-west traverses was established across an approximate 1.5-acre site at 5-ft intervals. EM-31 data were then collected at a 5-ft station spacing along these traverses. All cultural features evident within the survey area were mapped and tied to local grid coordinates. Labeled wooden stakes were set at grid coordinates 1000N+730E, 1080N+730E, 1180N+1000E, and 1230N+660E for grid reacquisition. The surface geophysical surveys are included in Appendix A.

2.2 CONE PENETROMETER TESTS

2.2.1 Cone Penetrometer System

Fugro Geosciences, Inc., of Houston, Texas, employed a 24-ton mobile electronic cone penetrometer (CPT) system to determine hydrogeologic characterization of the overburden lithology at selected sites. The CPT was used in the selection of sample intervals at corresponding subsurface soil and water locations. A total of 10 sites were surveyed with 6 in SWMU 99 and 4 in SWMU 193 (Table 2.1). During the WAG 28 investigation, the conductivity/piezocone was utilized to provide a digital signal for in situ inference of permeability, conductivity, and soil type. The entire system is mounted in a dual-axle truck containing all system components including recording, processing and printing devices, power take-off hydraulic rams, and down hole equipment (samplers, rods, and drive tips). For each location, the CPT was pushed using the dual hydraulic system (45,000 lb of downward force and 53,000 lb of pulling force) until refusal or the predetermined depth.

The CPT provides electrical readouts of cone-point resistance and sleeve friction of subsurface materials to aid in the identification of soil types. In addition, electrical conductivity was measured for pore water calculations. These values were recorded at a constant rate of 2 centimeters per second (cm/s). A fourth measurement, rod inclination, was recorded during each downhole survey. Although not used for the direct inference of the soil lithology, the inclination of the boring was used to correct the tip stress measurement and guide the operator in keeping the rods in a vertical position. The data were transmitted via a cable inside the rod string as an analog signal to the on-board processor and archived for later use. Upon completion of the CPT survey at each location, the hole [less than 2 in. inside diameter (I.D.)] was grouted from the bottom up using a pressure grouting technique with tremmie pipe.

Table 2.1 Cone penetrometer surveys

Site	Locations	Total depth
SWMU 99	6	60 ft each
SWMU 193	4	28 ft, 28 ft, 40 ft, 60 ft
SWMU194	0	—
AOC 204	0	—
TOTAL	**10**	**516 ft**

2.2.2 Stratigraphy Determination

From the recorded corrected tip stress/resistance (q_c) and sleeve friction (f_s), the friction ratio (f_r) provides the greatest interpretive tool to determine the relative amounts of clay, silt, sand, and gravel. The unit is equally capable of determining mixtures of these four basic soil types as well. In general, as the tip resistance decreases, the effective clay content increases. Between the two f_r endpoints, soils are mixtures of clayey-sands to silty-clays relative to the calculated f_r value. From the numerous surveys, the UCRS is generally comprised of silty-sandy clays with silty sand lenses. There is also a fairly compact sandy gravel layer, which appeared at about 15–20 ft bgs. When encountered, the cone was unable to penetrate the top of the terrace (gravel zone). CPT logs are included in Appendix B.

2.3 SURFACE SOIL SAMPLING

Twenty-five surface soil samples were collected in WAG 28. In accordance with PGDP EMEF Procedure PTSA-4201, *Surface Soil Sampling*, the uppermost 12 in. of soil was sampled as follows: first, the surface vegetation was removed from the sampling location, and then a stainless steel hand auger (3 in. I.D.) was utilized to obtain the required amount of sample material. Hand augers are designed to collect surface and shallow subsurface soil samples and are applicable to a variety of soil conditions including sand, silt, and clay.

Volatile organic analyte (VOA) samples were collected from approximately 6 in. bgs. VOA collections required a precleaned 10-cc syringe. The tip was removed from the syringe and pressed into the bottom of the boring, which resulted in soil being forced into the syringe. Then the syringe was withdrawn from the hole and approximately 4 cc of soil were extruded into two 40-mL vials containing equal amounts of deionized water and hexane. A second VOA sample was collected for the off-site laboratory from the same immediate sample section. The soil was placed directly into an unpreserved 4-oz septum top wide-mouth jar. The jar was filled to the top and packed tightly to ensure no headspace. The remaining sample material was placed in a clean stainless steel bowl; homogenized, and prepared in accordance with PGDP EMEF Procedure PTSA-4204 IAD, *Composite Sample Preparation*. Upon completion of sampling, the hole was backfilled with grout.

2.4 SUBSURFACE SOIL SAMPLING METHODS

Subsurface soil samples were collected in accordance with PGDP EMEF Field Operating Procedure PTSA-4202-IAD, *Subsurface Soil Sampling*. Prior to the collection of the samples, each site was prepared by covering the ground under the entire drilling truck and the sample preparation area with a 6-mil plastic sheet. Exclusion and construction zones were installed at the perimeter of the plastic cover.

Soil samples were placed in prelabeled containers and sealed. The outer surface of the container was cleaned, scanned, and affixed with a radiological label to identify the outer radioactivity level of the container. The containers were secured with a custody seal and inserted into Ziploc™ bags before being packed in an insulated cooler. The cooler contained ice to maintain a 4°C (±2 C) temperature.

The first samples collected were for VOAs. Approximately 4 cc of soil were placed into each 40-mL vial, which contained an equal amount of deionized water and hexane. In addition, a second VOA sample was collected and placed into an unpreserved 4-oz septum top wide-mouth jar. The remaining sample material was placed into a clean stainless steel bowl, homogenized, and prepared in accordance with PGDP EMEF Procedure PTSA-4204 IAD, *Composite Sample Preparation*. Lithologic interpretation was completed concurrently with sample preparation following PGDP EMEF Procedure PTSA-1203, *Lithologic Logging*.

2.4.1 Direct Push Technology

UCRS subsurface soil samples were collected using direct push technology (DPT). The DPT allows a discrete interval of soil to be obtained and a water sample to be extracted from a specific depth. DPT sampling produces a minimal amount of investigation-derived waste (IDW) compared to other methods. Samples obtained by this method are noted throughout this report with the prefix "DPT."

The DPT equipment for WAG 28 was a truck-mounted unit. Samples were extracted from the subsurface by a 30- by 1.5-in. I.D. sampler with a removable acetate liner. Table 2.2 details the DPT sampling conducted in WAG 28. The sampler was comprised of a stainless steel outer barrel with cutting edge, drive-tip piston assembly, drive-tip sleeve, and removable liner. The sampler was pushed into the ground with the piston assembly in the locked position. At the desired depth interval, the piston assembly spring would be released, and the sample push continued. The piston assembly would move up inside the liner and outer barrel with the liner being filled with soil. Once the sampler was filled, it was extracted from the boring, and the liner containing the sample was removed.

Table 2.2 Direct push technology soil sampling

Site	Number of locations	Number of soil samples
SWMU 99	19	130
SWMU 193	11	55
SWMU 194	4	21
AOC 204	0	0
TOTAL	34	206

2.4.2 Hollow Stem Auger

The hollow stem auger (HSA) was utilized to retrieve soil samples for chemical and geotechnical analyses (Table 2.3). The HSA provides a fast means of advancing a borehole through many types of soil while still collecting samples. Samples obtained by this method are noted throughout this report with the prefix "HSA." For soil borings, a 4.5-in. I.D. auger (5-ft lengths) was advanced with a center drag bit. When the specified depth was reached, the center bit/rods were removed, and a sample was collected using a 3- by 30-in. split spoon with a plastic liner. The spoon was advanced using a 140-lb hammer with a 30-in. drop. Upon retrieval of the split spoon, the sample was field screened for total beta and volatiles. The liner was split, and the VOA samples were removed. The remaining samples were homogenized and packed in accordance with PGDP EMEF Procedure PTSA-4204 IAD, *Composite Sample Preparation*. Upon completion of the last sample, the bit and rods were removed and 1-in. polyvinyl chloride (PVC) tremmie pipe lowered for grouting. The grout was a high-suspended solids (30 percent) bentonite matrix mixed to achieve a weight of between 10-11 lb/gal.

Table 2.3 Hollow stem auger soil sampling

Site	Number of locations	Number of soil samples
SWMU 99	2	2
SWMU 193	0	0
SWMU 194	0	0
AOC 204	2	29
TOTAL	4	31

2.5 GROUNDWATER SAMPLES

Eighty-eight groundwater grab samples were collected by two methods during the WAG 28 RI. For the collection of deeper samples (RGA and McNairy), dual-wall reverse circulation (DWRC) drilling was utilized. The majority of shallow UCRS groundwater samples were obtained by DPT; however, a limited number of UCRS samples were acquired via DWRC drilling. For RGA, grab samples were attempted at 5-ft intervals throughout its entire thickness. Also, grab samples were usually attempted at two intervals in the UCRS and one interval in the upper part of the McNairy Formation. The purpose of these samples was to obtain a vertical profile of groundwater contamination. A single groundwater sample was collected for each DPT borehole usually at terminal depth.

2.5.1 DWRC Drilling and Groundwater Sampling

DWRC drilling was used to drill 11 borings during the WAG 28 investigation. The total depth of the borings ranged from 100 to 160 ft. Groundwater samples were collected from multiple water-bearing zones during the drilling of each borehole. Samples obtained by this method are noted throughout this report with the prefix "SB."

Reverse circulation drilling uses dual-wall pipe, top drive rotation, and a side inlet for injecting air in a closed, recirculating system. The drilling fluid (air) is injected through the side inlet swivel and down between the outer pipe and inner pipe of the dual tube drill system. The air and cuttings are directed to the center of the drill bit and then forced to the surface through the inner pipe at a very high velocity. The cuttings are discharged into a sampling cyclone where air is removed and velocity dampened. The cuttings are then collected and described by the rig geologist.

A Schramm T450W Rotadrill truck-mounted drill rig was used for the DWRC borehole drilling. The dimensions of the rods and bit were 1.75-in. I.D. for the inner rod, 4-in. I.D. for the outer rod, and a 5.25-in. tricone roller bit. The borings were advanced using 20-ft and 5-ft lengths of pipe. Soil cuttings were shoveled from the discharge tub (where they were collected after being discharged through the cyclone separator) into 55-gal drums. Water was pumped from the trough into a 1200-gal tank at the end of each day, or as needed during the day. The IDW (soil and water) was then transported to the waste management facility.

Upon achieving total depth, the borehole was logged (gamma ray and neutron) in both the descending and ascending directions (see Sect. 2.6). The borehole was then grouted to surface using a high solids grout (Pure Gold—30 percent solids) with a weight between 10–11 lb/gal.

The primary purpose for drilling the boreholes was to collect groundwater samples. A casing was continuously advanced during DWRC drilling leaving only the bottommost portion of the formation open. Cuttings and formation fluids were then flushed up the drill string to a cyclone separator at the surface. This type of drilling reduces the potential for cross-contamination because samples are acquired from a limited portion of the aquifer and drilling discharges do not contact the annulus as they exit the borehole.

Once a sampling zone was identified, a pump was lowered to the bottom of the hole. Purging and sampling were completed using a QED Well Wizard™ bladder pump. The use of these pumps allowed low-flow-rate purging and sampling, which significantly reduces the turbidity of the sample. Selected water quality parameters including pH, temperature, and specific conductivity were monitored during purging and sampling using a Hydac™ or Horiba™ water quality meter. Purging was discontinued when (1) pH stabilized to within 0.50 unit, (2) specific conductivity stabilized to within 10 percent (μmhos/cm), and (3) temperature stabilized to within 1°C. The procedure was followed in the field to try and collect VOA samples at 100 mL/min, or as low a flow rate at the formation would produce. In some instances, however, he pump would cavitate and the flow rate had to be increased to get a sample. In all cases the samples were collected at as low a flow rate as possible at each location.

All samples were collected directly from the pump discharge line into appropriate containers. For intervals with very slow recharge rates, purging could not be completed. After the groundwater samples were containerized, a site safety professional scanned the container in the field using a direct-measure radioactivity meter, wiped the container, and compared the readings against the free release criteria. A label was secured with tape, and the container was placed in a zippered plastic bag. The bags were then packed in ice within coolers and kept at a temperature of 4°C ± 2°C.

2.5.2 DPT Groundwater Sampling

A DPT rig was used to collect 16 UCRS groundwater samples for the WAG 28 RI (Table 2.4). Samples were collected in accordance with PGDP EMEF Field Operating Procedure PTSA-4303-IAD, *Groundwater Sampling*. The sampling tool dimensions were 30-in. by 0.5-in. outside diameter (O.D.) with 0.004-in. vertically slotted screen. Water samples were collected with a stainless steel bailer capable of collecting approximately 200 mL. These samples are collected without purging the DPT boring.

In most instances, a groundwater sample was obtained at the terminal depth of the DPT boring after all soil samples had been collected and the boring has achieved a static water level. Grab samples would be attempted in the lower portion of the UCRS (greater than 35 ft bgs) if a saturated coarse sand was observed in the soil sample. If no sand was present at terminal depth, a 5-ft .010 slotted PVC screen and riser (1.25-in. O.D.) was set to allow later sampling. Sampling of these well points was normally within 48–72 hours. Temporary well points were not constructed with sand pack, bentonite seals, or grout.

Table 2.4 Direct push technology water sampling

Site	Number of locations	Number of water samples
SWMU 99	19	12
SWMU 193	11	2
SWMU 194	4	2
AOC 204	0	0
TOTAL	34	16

Because of unsaturated conditions within the UCRS, several times there was no water in the soil or not enough water to collect a sample. In those instances, only soil samples were collected. During the investigation, the DPT water screen was set at the selected depth and allowed to recharge, but this would not occur. There were instances where temporary well points were installed for up to several days in an attempt to collect sufficient water for a sample. The western Kentucky region was undergoing drought conditions before and during the RI field activities, significantly reducing moisture content in the UCRS.

All sample bottles were cleaned and dried, surface scanned for radioactivity, custody sealed, affixed with a radioactivity screening label, placed in individual zippered baggies, and placed in an ice-filled cooler for temporary storage after collection of the sample as described.

2.6 BOREHOLE GEOPHYSICAL LOGGING

Borehole geophysical logs, consisting of natural gamma and compensated neutron, were run in each borehole through the drill pipe or temporary casing. The logs were run in both down-hole and up-hole directions for quality assurance. The borehole geophysical logs were run to confirm the lithologic descriptions and were used to correlate boreholes and develop cross sections.

2.6.1 Natural Gamma Radiation

Gamma logging of a borehole is a passive measure of the natural radiation of rocks and soils. The down-hole gamma-ray measurement allows the differentiation between clay and other lithologies by using the natural occurrence of potassium-40, uranium-238, and thorium-232 in the shales. A clay or clayey sand can be distinguished from a clean sand because of the higher gamma-ray emissions of those radioisotopes in the shale component. Measurements are usually made with a Geiger-Muller Counter, and the results depend on:

- Radioactivity of surrounding formation
- Borehole diameter
- Type of drilling fluids
- Type and thickness of casing
- Position of probe in hole (centered)

The interpretation of the results is on a qualitative basis and is primarily used to aid in the determination of where sand, as opposed to clay, is the dominant constituent.

2.6.2 Neutron Logging

Neutron logging is utilized for the determination of soil or rock porosity and water content. It is also used to provide a water level measure. A neutron probe contains a radioactive source and a detector. Neutrons emitted from the source are slowed and scattered by the collision with hydrogen nuclei. Once slowed neutrons are captured by the nuclei. Because hydrogen atoms exist in the soils and rock predominantly as moisture or free water in open pore spaces, an increase in the amount of water is correlated to an increase in the number of neutrons that have been captured by the hydrogen atoms. Rocks with a higher saturated porosity will have a lower neutron count than low-porosity soils/rocks. When logged above the water table, results are indicative of lower soil moisture, not saturated porosity.

2.7 ANALYTICAL METHODS

During the analytical program for the WAG 28 RI, the following laboratories were used:

- Close Support Laboratory (CSL) located on site equipped with five gas chromatographs (GCs), one each for screening soil and groundwater samples for trichloroethene and its degradation products (VOAs), one for screening soil and groundwater samples for semivolatile organics analytes (SVOAs), and one for screening soil and groundwater samples for PCBs (On-Site Laboratories, Freemont, California).

- CSL located on site equipped with a gas proportional radioactivity counter for gross alpha and gross beta screening of soil and water samples, a gamma spectrometer for gamma screening of soil, and a liquid scintillation counter for technetium-99 screening of water (Paragon Laboratories, Ft. Collins, Colorado)

- Fixed-base laboratories for soil and groundwater samples (USEC, Portsmouth, Ohio, laboratory and USEC C-710 PGDP laboratory and IT-Middlebrook, Knoxville, Tennessee, laboratory)

- Fixed-base laboratory for geotechnical samples (Southwest Research Institute, San Antonio, Texas).

COPCs associated with various SWMUs investigated in the WAG 28 RI were compiled in the WAG 28 work plan (DOE 1998b) based on the result of previous investigations. The process by which previous sampling results were used to develop the list of COPCs at each SWMU is outlined in Section 6.1.6.1 of the WAG 28 work plan. Narrative discussions and/or tabulated results of previous sampling, method detection limits (MDLs), and applicable screening parameters used during the screening process for each WAG 28 SWMU or AOC are provided in Sects. 6.1, 6.2, 6.3, 6.4, and 6.5 of the WAG 28 work plan. CSL screening techniques permitted quantitative measurement of contaminant levels with near fixed-base sensitivity, while reducing turnaround time to help guide the field sampling effort and also reducing the overall cost of field and analytical services for the WAG 28 RI. In particular, field screening was relied upon to assess the presence of trichloroethene and its degradation products, SVOAs, radionuclides, and PCBs. Two on-site GCs, using modified versions of the current SW-846 8021 method for VOAs (SW8021B), were used to perform field screening for trichloroethene and its degradation products. Soil samples were analyzed using a hexane extraction preparation method, followed by direct injection of the hexane extract into a GC with electrolytic conductivity and photoionization detection in sequence. Water samples were analyzed on a separate GC, using standard purge and trap sample introduction, and sequential electrolytic conductivity and photoionization detection, as specified by the SW-846 8021 method. An on-site GC equipped with a mass spectrometer (MS) detector using a modified version of the SW-846 8270 method for SVOAs (SW8270C) was used to perform field screening for SVOAs.

An on-site GC, using a modified version of the SW-846 8082 method for PCB analysis (SW8082), was used to perform field screening for PCBs. A low-background gas-flow proportional analyzer was used to perform field screening for gross alpha and beta activities. A liquid nitrogen-cooled, high-purity germanium (HPGe) detector and multichannel analyzer was used to perform field screening for gamma activity. A liquid scintillation counter was used to perform field screening for technetium-99 activity.

Results of field laboratory radiological screening were used to implement the radiological analysis procedures found in Sect. 5.10 of the WAG 28 work plan (DOE 1998b). These procedures represented a radiological screening process for soils and water developed by DOE with input and concurrence from the regulatory agencies involved at PGDP. The procedures called for field laboratory screening of soil samples with activities greater than 2 × background and all water samples to determine the gross alpha to gross beta ratio. If the ratio of alpha to beta activity was less than 3:1, further fixed-base speciation analysis was not required, and samples collected for this purpose were not to be analyzed. In addition, a gross beta activity threshold for fixed-base analysis of 50 pCi/L for water samples was established. Samples with gross beta activity in excess of 50 pCi/L, as determined by the field laboratory screening samples, were to be further analyzed by fixed-base analyses for technetium-99. However, as the project progressed, few samples exhibited a gross alpha to beta ratio in excess of 3:1, even while having significantly high gross alpha and/or beta activity. As a result, it was decided to capture additional speciation data on these samples with significant activity, particularly water samples with exceedances of the Kentucky Department of Environmental Conservation (KDEP) criteria for speciation analysis of groundwaters due to alpha activity (15 pCi/L). Therefore, speciation analysis thresholds of 15 pCi/L gross alpha activity in groundwater samples and 50 pCi/g gross alpha or beta activity in soil samples were established and used for the remainder of the project. For all samples that exceeded any of these established thresholds, fixed-base laboratory speciation analyses were also conducted.

In addition, a minimum of 10 percent of the total number of samples (by matrix) were split and submitted to an off-site fixed-base laboratory for analysis. These samples provided definitive data to confirm the results from the CSL screens. A separate sample aliquot was collected from each sample interval scheduled for off-site fixed-base laboratory analysis. This sample aliquot was analyzed at the CSL radiochemistry laboratory, where it underwent radiation screening to facilitate proper U.S. Department of Transportation (DOT) shipment to the off-site laboratories. A wipe sample also was collected from the exterior of each sample container in the field. The WAG 28 RI sample shipping team determined whether the samples could be shipped off site for analysis based on field wipe sample results and radiological screening sample results compared to DOT-, International Air and Transportation Association- (IATA), and DOE-specified limits. The project DOT shipping specialist also prepared the shipment in accordance with DOT and IATA regulations for shipment of dangerous goods, if warranted.

2.7.1 CSL Methods

Two CSLs were mobilized to analyze soil and groundwater samples. The samples were analyzed for:

- VOAs
- SVOAs
- PCBs
- Gross alpha and gross beta activity
- Gamma activity (soils only)
- Technetium-99 (water only)

2.7.1.1 Methods and equipment

Table 2.5 indicates the types of analyses performed by the CSLs.

Table 2.5 Close support laboratory analyses

Analysis	Parameters	Prep. method (matrix)	Analytical method
VOA	TCE and TCE degradation products	SW-846 5030B (water)	Modified SW-846 8021B
VOA	TCE and TCE degradation products	Hexane extraction (soil)	Modified SW-846 8021B
SVOA	CLP semivolatile TCL analytes	SW-846 3510C (water)	Modified SW-846 8270C
SVOA	CLP semivolatile TCL analytes	SW-846 3550B (soil)	Modified SW-846 8270C
PCB	Seven PCB Aroclors	SW-846 3510C (water)	Modified SW-846 8082
PCB	Seven PCB Aroclors	SW-846 3550B (soil)	Modified SW-846 8082
Tc-99	Technetium-99 activity	Empore™ RLS Disk (water)	Modified EPA 906.0
Gross a,b	Gross alpha & beta activity	Empore™ RLS Disk (water)	Modified SW-846 9310
Gross a,b	Gross alpha & beta activity	Empore™ RLS Disk (soil)	Modified SW-846 9310
Gamma	Am-241, Cs-137, Co-60, U-235, Th-234, Pa-234m	Empore™ RLS Disk (soil)	Modified EPA 901.0

TCE = trichloroethene
CLP = Contract Laboratory Program
TCL = Target Compound List

2.7.1.2 CSL VOA analysis for soil samples (hexane extraction)

One photoionization detector (PID)/electrolytic conductivity detector (ELCD)-equipped Hewlett-Packard HP5890 Series II GC was used to analyze VOAs in soil samples. A modification of the current version of the SW-846 8021 method (SW8021B) was used for these analyses. Decontaminated, non-sterile syringes (with ends cut off) were used to transfer an approximately 5-g aliquot of undisturbed soil from the sampling sleeve (soil core) to a 40-mL vial containing 5 mL deionized water and 5 mL hexane. The hexane extracts the VOAs from the soil/water solution. In the laboratory, surrogate-spiking solution was added to the hexane layer, and a syringe was used to sample the hexane layer in the vial. The hexane, along with the VOAs dissolved in it, was directly injected into the GC for analysis.

2.7.1.3 CSL VOA analysis for water samples

One PID/ELCD-equipped Hewlett-Packard HP5890 Series II GC was used to analyze VOAs in water samples. An OI Analytical Discrete Purging Multisampler (Model DPM-16) was used to conduct purge and trap sample introduction of aqueous samples for VOA analyses. A modification of the current version of the SW-846 8021 method (SW8021B) was used for these analyses. The method utilizes the purge and trap process as a sample introduction technique (SW5030B) for water samples. The purge was performed with a flow of helium through samples of water, followed by collection of the halogenated volatile organics in a multiple-phase sorbent trap at ambient temperature. After the purge cycle was completed, the trap was heated and backflushed, desorbing all trapped compounds into a GC column. GC analysis allows separation of these compounds from either the hexane extract or the desorbed trap, and detection with the ELCD and the PID. Quantitative analysis was achieved by comparison of sample values with standard values.

2.7.1.4 CSL SVOA analysis for water and soil samples

One Hewlett-Packard HP5890 Series II GC was equipped with a Hewlett-Packard HP5972 MS detector and used to assess levels of SVOAs in water and soil samples. A measured volume of aqueous sample, usually 1 L, at a specified pH (acidic or basic), was serially extracted with methylene chloride by using a separatory funnel. The extract was dried, concentrated and, as necessary, exchanged into a solvent compatible with the cleanup or determinative step to be used. For soil samples, a 30-g sample was mixed with anhydrous sodium sulfate to form a free-flowing powder. The solvent was extracted using sonication. The extract was separated from the sample by vacuum filtration or centrifugation. The extract was then ready for cleanup and/or analysis following concentration. The analytes were then introduced into the GC/MS system by injecting the extract onto a narrow bore fused silica capillary column. The GC was temperature programmed to separate the compounds prior to detection by an MS, which was used to provide both qualitative and quantitative information. Quantitation was achieved by comparing the response of a major (quantitation) ion relative to an internal standard using a five-point calibration curve.

2.7.1.5 CSL PCB analysis for water and soil samples

Two Hewlett-Packard HP5890 Series II GCs were equipped with halogen-sensitive electron capture detectors (ECDs) and used to assess levels of PCB contamination in soil and water samples. One instrument served as a qualitative confirmation instrument, with a different column than the primary instrument used for quantitation. Water and soil samples were prepared similarly as for SVOA analysis, except that hexane was used for the extraction solvent. The samples were then introduced into the GC/ECD system by injecting the extract onto a narrow bore fused silica capillary column. The GC was temperature programmed to separate the compounds prior to detection by the ECD, which is used to provide both qualitative and quantitative information. Quantitation is achieved by comparing the response of the ECD on the column to a five-point curve response. A second instrument with a different column is used to analyze all positive result extracts for qualititative confirmation of Aroclor species.

2.7.1.6 CSL radiological analysis procedures

When appropriate for the sample matrix, SW-846 methods were used. When SW-846 methods were not available or not appropriate, other nationally recognized methods such as EPA, DOE, and American

Society for Testing and Materials (ASTM) methods were used. The following procedure manuals were used as references for radiological analysis:

- *Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA-600/4-80-032 (EPA 1980)

- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846 (EPA 1986)

- Eastern Environmental Radiation Facility, *Radiochemistry Procedures Manual*, EPA 520/5-84-006, (EPA 1984)

- *Environmental Measurements Laboratory Procedures Manual*, HASL-300 (DOE 1982)

Gross alpha and gross beta assessments were performed using a Tennelec Series 5 Low Background Gas Proportional Counter.

Gamma activity was assessed in soils using a liquid-nitrogen cooled HPGe detector linked to an analog to digital converter and stored in a multichannel analyzer (MCA). The stored MCA data are interpreted by a complex software program, generating results in units of radioactivity per unit sample volume.

Technetium-99 activity was assessed in water samples by filtering the water through 3M Empore Technetium Rad disks, then rinsing with deionized water to eliminate possible tritium presence, and counting on a liquid scintillation counter using a window determined by analysis of standards.

CSL data qualifiers are defined here:

A. Organic Analyses

U	Indicated compound was analyzed for but not detected.
J	Indicates a sample concentration value less than the reporting limit, but above the MDL.
E	Identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis.
D	Identifies all compounds in a reanalysis previously identified in an analysis at a lower dilution factor.

B. Radiological Analyses

U or A	Indicated compound was analyzed for but not detected.

2.7.1.7 Sample requirements

Table 2.6 indicates the analytical methods and sample requirements for CSL analysis.

Table 2.6. Analytical methods and sample requirements for CSL screening samples

Parameter	Matrix	Holding time	Reporting limit	Detection limit*	Container	Preservative
VOA	Water	14 days	1 μg/L	0.05 μg/L	Two 40-mL clear glass vials with Teflon™ septa	HCl; cool to 4°C
VOA	Solid	14 days	500 μg/kg	140 μg/kg	One 40-mL glass vial with Teflon™-lined lid	Cool to 4°C, 5-mL deionized water, 5-mL hexane
SVOA	Water	7 days	10 μg/L	7.1 μg/L	Two 1-L amber glass	Cool to 4°C
SVOA	Solid	14 days	500 μg/kg	4.3 μg/kg	4-oz. Widemouth glass jar with Teflon™-lined lid	Cool to 4°C
PCBs	Water	7 days	100 μg/L	0.4 μg/L	Two 1-L amber glass	Cool to 4°C
PCBs	Solid	14 days	500 μg/kg	44 μg/kg	4-oz. Widemouth glass jar with Teflon™-lined lid	Cool to 4°C
Gross alpha and gross beta	Water	6 months	5 pCi/L	4 pCi/L 3 pCi/L	One 1-L plastic jar	None
Gross alpha and gross beta	Solid	6 months	55 pCi/g	7 pCi/g 6 pCi/g	8-oz. PP Lermer Jar	None
Technetium-99	Water	6 months	17 pCi/L	15 pCi/L	One 1-L plastic jar	None
Gamma activity	Solid	6 months	55 pCi/g	5 pCi/g	8-oz. PP Lermer Jar	None

*Avg of individual method analyte MDLs for multiple analyte methods. Table DL values derived from actual MDL studies performed during the project (organic CSL) or project database data (radiological CSL)

μg/L = micrograms per liter
μg/kg = micrograms per kilogram
pCi/L = picoCuries per liter
pCi/g = picoCuries per gram
HCl = hydrogen chloride

2.7.2 Fixed-Base Laboratory Methods

USEC Portsmouth laboratory; IT-Middlebrook, Knoxville, Tennessee, laboratory; and the USEC C-710 laboratory performed fixed-base laboratory analyses of soil and groundwater samples. These laboratories were contracted through the DOE Oak Ridge Operations (ORO) Sample Management Office (SMO) and are DOE-approved, Nuclear Regulatory Commission-licensed laboratories. SW-846 methods were used for all samples, except those parameters for which other methods are necessary. The analysis followed SW-846 protocols, and "Forms Only" data packages were provided along with electronic data deliverables (EDDs). Table 2.7 summarizes the analytical methods and sample requirements of the fixed-base laboratories. Fixed-base laboratory data qualifiers are defined here:

A. Inorganic Analysis

B	This flag is used when the analyte is found in the associated blank as well as in the sample.
U	The analyte was analyzed for but not detected.
J	Indicates an estimated value.

Table 2.7 Analytical methods, preservation, and container type for all samples analyzed by fixed-base laboratories

Analysis	Analytical method	Container type	Preservative
		Soil	
TCL metals	SW-846 6010A SW-846 7060 SW-846 7471 SW-846 7740	2- or 4-oz widemouth HDPE	None
Hexavalent chromium	SW-846 7196	2- or 4-oz widemouth HDPE	None
Cyanide	SW-846 9014-Total	4-oz widemouth HDPE	None
PCBs	SW-846 8082	4-oz widemouth amber glass	4°C
Radiological	RL-7111 EPA 901.1 HASL-300 SW-846 9310 RL-7116	4 or 8-oz widemouth HDPE	None
TCL SVOA	SW-846 3550/8270	4-oz widemouth amber glass	4°C
TCL VOA	SW-846 8260A or Modified SW-846 8021B	2-oz widemouth glass with Teflon™-septa or one 40-mL glass vial with Teflon™-lined lid	4°C
PH	SW-846 9045	2-oz widemouth HDPE	None
Geotechnical analyses	ASTM D422 ASTM D954	Shelby Tube	None
Percent moisture	ASTM D2218 (percent moisture)	8-oz widemouth HDPE or	None
Bulk density	ASTM D854-92 (bulk density)	Ziploc Bag	
TOC	SW-846 9060	4-oz widemouth amber glass	
		Groundwater	
Major ion analysis	EPA 310.2	250-mL HDPE	Cool to 4°C
	SW-846 9056	125-mL HDPE	
	EPA 376.1		
	EPA 340.2		
TCL metals	6010 7060 7130 7420 7470 7740 7840	(3) 1-L Plastic Two bottles filtered (0.45 and 5 μm) and one unfiltered	Cool to 4°C, HNO_3, pH < 2
Hexavalent chromium	SW-846 7196	250-mL HDPE	Cool to 4°C
Cyanide	SW-846 9010B	1-L HDPE	Cool to 4°C, NaOH to pH >12
PCBs	SW-846 8082	1-L amber glass bottle with Teflon™-lined lid	Cool to 4°C
Radiological	RL-7122 (EPA 900.0)	1-L HDPE	HNO_3, pH < 2
	RL 7100	1-L HDPE	
	RL-7124	500-mL Boston Round HDPE	
	TIMS-3	500-mL Boston Round HDPE	

Table 2.7 (continued)

Analysis	Analytical method	Container type	Preservative
TCL SVOA	SW-846 3510/8270	1-L amber glass bottle with Teflon™-lined lid	Cool to 4°C
TCL VOA	SW-846 8260A	Three 40-mL glass vials with Teflon™-septa	Cool to 4°C, HCl, pH < 2
TOC	SW-846 9060	250-ml amber glass	Cool to 4°C, H_2SO_4, pH < 2
Silica	EPA 370.1	250-mL HDPE	Cool to 4°C
Redox potential	ASTM 2580B	250-mL HDPE	Cool to 4°C
COD	EPA 410.4	250-ml amber glass	Cool to 4°C, H_2SO_4, pH < 2
Total suspended solids	EPA 160.1	1-L HDPE	Cool to 4°C
Total suspended solids	EPA 160.2		
Oil and grease	EPA 413.1	1-L amber glass	Cool to 4°C, H_2SO_4, pH < 2

TOC = total organic carbon
COD = chemical oxygen demand
HDPE = high density polythylene
HNO_3 = nitric acid
NaOH = sodium hydroxide
H_2SO_4 = sulfuric acid

E The reported value is estimated because of the presence of interference. An explanatory note must be included under comments on the cover page (if the problem applies to all samples) or on the specific form I-in (if it is an isolated problem).

M Duplicate injection precision was not met.

N Spiked sample recovery was not within control limits.

S The reported value was determined by the Method of Standard Additions (MSA).

W Postdigestion spike for furnace atomic absorption analysis is out of control limits (85 percent–115 percent), while sample absorbance is less than 50 percent of spike absorbance.

X Other specific flags may be required to properly define the results.

* Duplicate analysis was not within control limits.

\+ Correlation coefficient for the MSA is less than 0.995.

B. Organic Analysis

U Indicated compound was analyzed for but not detected.

J Indicates an estimated value. This flag is used under the following circumstances: (1) when estimating a concentration for tentatively identified compounds where a 1:1 response is assumed and (2) when the mass spectral and retention time data indicate the presence of a compound that meets the pesticide/Aroclor identification criteria and the result is less than the contract-required quantitation limit but greater than zero.

P	This flag is used for a pesticide/Aroclor target analyte when there is greater than 25 percent difference for detected concentrations between the two GC columns.
C	This flag applies to pesticide results where the identification has been confirmed by GC/MS.
B	This flag is used when the analyte is found in the associated blank as well as in the sample.
E	This flag identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis.
D	This flag identifies all compounds identified in an analysis at a secondary dilution factor.
X	Other specific flags may be required to properly define the results.
Y	Indicates MS/MSD recovery and/or relative percent difference (RPD) failed to meet acceptance criteria.

2.7.3 Analytical Data Quality

2.7.3.1 Precision, accuracy, representativeness, completeness, and comparability

Precision, accuracy, and completeness objectives for fixed-base laboratory measurements during the WAG 28 RI are presented in Table 9.2 of the WAG 28 work plan (DOE 1998b). CSL laboratory precision and accuracy objectives are presented in each individual CSL analytical method standard operating procedure (SOP). An assessment of the precision, accuracy, representativeness, completeness, and comparability of field laboratory data measurements and fixed-base laboratory analytical data was performed. The results of this assessment are discussed in the following paragraphs.

Precision. "Precision" is defined as the degree of agreement between repeated (replicate or duplicate) measurements of one property using the same method or technique. Field duplicate samples are collected as a measure of precision of the sample collection and analytical process. In addition, laboratory duplicates, laboratory control samples (LCSs)/ laboratory control sample duplicates (LCSDs) and/or matrix spikes (MSs)/ matrix spike duplicates (MSDs) can be used to measure analytical precision. The RPD between the duplicate sample results is calculated and compared to the appropriate quality assurance (QA) objective. For this field program, field duplicate samples were collected for all media at a frequency of 5 percent. The organic CSL objectives for precision were usually met, with the exception of some very infrequent high RPDs on some semivolatile MS/MSD results. The radiological CSL objectives for precision were always met; however, precision calculations were not performed for duplicate samples with less than 3 times the minimum detectable activity. Table 2.8 contains summary information on the WAG 28 CSL data precision, including average observed RPD information and the CSL RPD limit for each monitored analyte in both water and soil matrices.

Accuracy. "Accuracy" is defined as the degree of agreement of a measurement with an accepted reference or true value. Accuracy of laboratory analyses is estimated through the analysis of blank spikes, matrix spikes, or surrogate spikes. These laboratory quality control (QC) samples are analyzed as required by the appropriate analytical method. The recovery of each spiked analyte is calculated and compared to the appropriate QA objective. The organic CSL objectives for accuracy were usually met, with very few exceptions, mostly on heavily contaminated samples and/or where matrix interference was clearly indicated. The radiological CSL objectives for accuracy were always met. Table 2.8 contains summary information on the WAG 28 CSL data accuracy, including average observed spike recovery information and the CSL control limits for each spiked analyte in both water and soil matrices.

Representativeness. "Representativeness" is defined as the degree to which data accurately and precisely represent the nature and extent of contamination. The data collected during the RI were both accurate and precise. As indicated in Sect. 2.8.3, the samples required in the WAG 28 work plan (DOE 1998b) to define the nature and extent of contamination were collected using standardized procedures designed to provide a true representation of the location sampled. Standardized, accepted analytical methods or modified standard methods, using National Institute of Standards and Technology traceable standards, were used to ensure that accurate, reproducible data were generated. Based on these criteria, the data from the WAG 28 RI were deemed representative.

Completeness. "Completeness" is defined as a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained. In this RI, "overall completeness" refers to the percentage of valid measurements versus the total measurements planned. Table 9.2 of the WAG 28 work plan (DOE 1998b) specified an "overall completeness" objective of 90 percent for all analyses performed for both soil and groundwater matrices. Overall completeness includes both sampling completeness and laboratory analytical data completeness. Sampling completeness refers to the percentage of samples collected versus the total samples planned. Laboratory analytical data completeness refers to the percentage of non-rejected (i.e., results that can be used for decision-making purposes without supplemental data) analytical results reported by the laboratories versus the total number of results expected.

This RI report includes data from base project samples, which were expected to be collected if possible, and from contingency samples, which were collected only at the direction of the Bechtel Jacobs Company LLC. In the planning stage of the project, these potential contingency samples were "planned" to the extent possible by populating the Project Environmental Measurements System (PEMS) database with all possible contingency sample identifications and analysis parameters for each SWMU based on the WAG 28 work plan. Completeness for these samples cannot be discussed in the same manner as the base project samples. Also, for both base project and contingency samples, samples were collected for fixed-base laboratory radiological speciation analyses, which were not analyzed unless preliminary field laboratory screening data indicated an exceedance of the threshold criteria discussed in Sect. 2.7. These samples were "planned" similarly to the potential contingency samples in the project PEMS database and must be considered when assessing overall completeness.

Overall, for all analyses and matrices, the WAG 28 RI achieved sampling completeness of 80 percent for the base project when contingency samples were included. The laboratory analytical data completeness for the base project was 89 percent. These figures do not consider the fixed-base laboratory radiological speciation analyses, which were "planned" but almost all of which were not conducted because the field laboratory screening threshold criteria were very rarely exceeded.

Sampling completeness for soil was 86 percent for the base project. However, soil sampling completeness for VOAs and gross alpha/beta was 91 percent and 93 percent, respectively, above the project completeness objective of 90 percent. Technetium-99 soil sampling completeness was the lowest at 71 percent, below the project completeness objective of 90 percent. In any case, with contingency sampling locations included in the base sampling completeness calculation, all project overall completeness objectives for soil were met, except for VOAs, which had an overall completeness value of 84 percent. The overall soil sampling completeness was mostly affected by sampling difficulties

Table 2.8 Average spike recovery and duplicate relative percent difference (RPD) for the close support laboratories

Parameter	**Water**				**Soil**			
VOA	**%R (MS/MSD)**	**Control limits (%)**	**RPD (%)**	**RPD limit (%)**	**%R (MS/MSD)**	**Control limits (%)**	**RPD (%)**	**RPD limit (%)**
Vinyl chloride	96/98	50–150	4.9	30	80/75	50–150	8.8	30
1,1-Dichloroethene	100/100	50–150	5.1	30	90/85	50–150	8.5	30
Cis-1,2-Dichloroethene	109/112	50–150	4.2	30	92/89	50–150	8.7	30
Trans-1,2-Dichloroethene	92/92	50–150	4.2	30	92/89	50–150	8.8	30
TCE	119/121	50–150	4.2	30	99/97	50–150	8.0	30
PCBs	**%R (LCS/LCSD)**	**Control limits (%)**	**RPD (%)**	**RPD limit (%)**	**%R (MS/MSD)**	**Control limits (%)**	**RPD (%)**	**RPD limit (%)**
Aroclor-1254	107/113	50–150	5.9	30	93/94	50–150	4.9	30
SVOA	**%R (LCS/LCSD)**	**Control limits (%)**	**RPD (%)**	**RPD limit (%)**	**%R (MS/MSD)**	**Control limits (%)**	**RPD (%)**	**RPD limit (%)**
Phenol	26/20	12–110	13.9	42	64/62	26–90	8.5	35
2-Chlorophenol	63/53	27–123	16.3	40	68/65	25–120	9.9	50
1,4-Dichlorobenzene	64/58	36–97	12.1	28	55/53	28–104	8.6	27
N-Nitroso-di-n-propylamine	78/70	41–116	13.3	38	66/61	41–126	8.7	38
1,2,4-Trichlorobenzene	62/56	39–98	13.3	28	55/52	38–107	8.1	23
4-Chloro-3-methylphenol	59/52	23–97	17.7	42	60/60	26–103	11.6	33
Acenaphthene	86/77	46–118	10.2	31	90/76	31–137	10.4	19
4-Nitrophenol	16/17	10–80	23.3	50	54/57	11–114	10.3	50
2,4-Dinitrotoluene	88/78	24–96	21.4	38	69/70	28–89	11.7	47
Pentachlorophenol	34/30	9–103	17.2	50	28/31	17–109	12.6	47
Pyrene	73/72	26–127	9.2	31	128/94	35–142	9.3	36
Technetium-99	**%R (LCS/MS)**	**Control limits (%)**	**RPD Dup(%)**	**RPD limit (%)**	**%R**	**Control limits (%)**	**RPD Dup(%)**	**RPD limit (%)**
^{99}Tc	102/99	50–150	6.0	50	NA	NA	NA	NA
Gamma spectroscopy	**%R**	**Control limits (%)**	**RPD Dup(%)**	**RPD limit (%)**	**%R (LCS)**	**Control limits (%)**	**RPD Dup(%)**	**RPD limit (%)**
Gamma activity (^{241}Am)	NA	NA	NA	NA	95	50–150	NC	50
Gamma activity (^{137}Cs)	NA	NA	NA	NA	105	50–150	40.9	50
Gamma activity (^{60}Co)	NA	NA	NA	NA	99	50–150	NC	50
Gross alpha/beta	**%R (LCS)**	**Control limits (%)**	**RPD Dup(%)**	**RPD limit (%)**	**%R (LCS)**	**Control limits (%)**	**RPD Dup(%)**	**RPD limit (%)**
Gross alpha	109	50–150	10.6	50	111	50–150	16.1	50
Gross beta	101	50–150	10.9	50	101	50–150	11.5	50

NA=Not analyzed by the CSL in this matrix
NC=Not calculated due to insufficient data

(i.e., early refusal during DPT drilling operations); however, most of the VOA soil sampling completeness was lost because of laboratory analytical failures (i.e., grossly exceeded holding times). All of the rejected laboratory analytical data were from the fixed-base laboratories, and the majority of the rejected laboratory data (94 percent of the total 7.9 percent rejected) were VOA soil data rejected because of gross holding time exceedances and/or calibration failures.

Sampling completeness for groundwater was 57 percent for the base project. However, with contingency sampling locations included in the base project sampling completeness calculation, project overall completeness objectives for groundwater were met for all organic analyses, gross alpha and beta analyses, metals, and technetium-99 analyses. The only groundwater overall completeness objectives that were not met were for wet chemistry analyses. Groundwater overall completeness was mostly affected by sampling difficulties (i.e., no groundwater encountered during DPT drilling operations).

Comparability. "Comparability" is defined as the degree of confidence with which one data set can be compared to another. Data collected for this investigation were generally collected according to the WAG 28 work plan (DOE 1998b) and its quality assurance project plan, and all field changes were approved by Bechtel Jacobs Company. The overall comparability of the data collected in the WAG 28 RI to historical data is good.

The organic CSL screening data generated for the WAG 28 RI, particularly for PCBs, was comparable, although of higher quality than previous organic CSL screening data. This increase in quality is based mainly on the use of surrogates, second source LCSs, and MS/MSDs for all WAG 28 RI organic CSL methods. WAG 28 RI CSL PCB analyses were performed using a GC with ECD detection, providing Arochlor speciation data not obtainable by immunoassay test kits previously used for CSL PCB analyses, and much lower detection limits, in addition to the above-mentioned QC checks.

The use of different gross beta (i.e., strontium-90 versus technetium-99) and gross alpha (i.e., americium-241 versus uranium-238) standards in the radiological CSL for the WAG 28 RI may have had some impact on comparability, both with historical radiological CSL data and with current and historical fixed-base confirmation data. Differences in the sample preparation techniques used by the WAG 28 RI radiological CSL and the radiological CSL and fixed-base laboratories used for the WAG 28 RI and previous investigations may also have had an impact on current radiological CSL data comparability with both historical radiological CSL data and with current and historical fixed-base radiological confirmation data.

Because the fixed-base laboratories used for the WAG 28 RI were for the most part the same as used in previous projects, using similar analytical methodology, there should be an extremely high degree of confidence in the comparability of the current and historical fixed-base definitive data.

2.7.3.2 Surveillances

DOE, Bechtel Jacobs Company, and T N & Associates, Inc./CDM Federal Programs Corporation (TN&A/CDM) conducted surveillances of field activities and the CSLs during the WAG 28 RI. Surveillances covered CSL activities, sample management activities, log keeping and chain-of-custody documentation, equipment decontamination, waste management activities, sampling activities, implementation of quality-assured data policies, and well installation and development. TN&A/CDM provided responses and/or proposed corrective actions for the findings from each surveillance and then implemented proposed corrective actions immediately. The ORO-SMO conducted laboratory surveillances of the fixed-base laboratories.

2.7.3.3 Data quality objectives

Data quality objectives (DQOs) are qualitative and quantitative criteria used to establish requirements for sample collection and analysis and are based on the intended uses of the data. The overall intent of DQOs is to generate data of appropriate quality to support the assessment of risks to human health and the environment and the selection of remedial actions. DQOs were documented in the approved WAG 28 RI work plan (DOE 1998b) and were implemented as documented in the field sampling plan and quality assurance project plan.

The DQO process was used to focus the sampling strategy on SWMU-specific media contamination and migration pathways. In addition, this process was used to identify the data requirements for the potential remedial action alternatives.

Decisions to be made during the RI process include a determination of whether releases have occurred and whether remediation of the site will be required. Using risk-based analysis of data generated during the WAG 28 investigation, a determination was made for each of the sites according to the following rules:

1. Where no contamination or contamination not presenting unacceptable risk to human health or the environment are found at the site, a determination for no further action will be made.

2. Where contamination presenting imminent, immediate, unacceptable risks to human health and the environment is found, a determination for implementing interim remedial actions will be considered. The interim measures may include institutional controls or temporary stabilization to prevent further contaminant migration and/or degradation.

3. Where contamination presenting unacceptable risks to human health and the environment is found but the risks are not imminent or immediate, a subsequent feasibility study will be performed.

The results of the DQO process and decision rules analysis are presented in Chap. 7.

2.7.3.4 CSL performance

All data generated at the CSLs were of sufficient quality to support the project decision-making process. Detection limits are method- and matrix-specific. CSL reporting packages included sample results, summary information and/or chromatograms/raw instrument output for all QC samples and/or calibrations, chain-of-custody information, sample preparation and run logs, and other supporting documentation and data summaries. Reporting of SVOA conformed to standard SW-846 documentation for each analytical batch by date.

Included in the documentation were initial and continuing instrument calibration, performance results, determination of MDLs, identification and quantification of compounds and analytes detected, and laboratory QC samples. Selected data were conveyed to the data coordinator for direct download into the project database. The lead chemist reviewed results before the data were input to the project database. The following criteria were reviewed to determine acceptability:

- Holding times—All holding times were met.

- Initial calibration—All initial calibrations met acceptance criteria. If initial calibration criteria were not met, the instrument was recalibrated prior to use.

- Continuing calibration checks—Most continuing calibration checks met acceptance criteria. If continuing calibration criteria were not met, the failure was noted in the case narrative and/or in Out-of-Control Event (OOCE) Sheets in each data package, and in some cases, the affected samples were reanalyzed.
- Method blanks—If target compounds were found in the blank above the reporting limit and also in the associated samples, the samples were reprepared and reanalyzed.
- Laboratory duplicates and/or MSs/MSDs—Most laboratory duplicates and/or MS/MSDs were within the acceptance criteria. If not, the problem was noted in the case narrative and/or OOCE Sheets with each data package.
- Laboratory control samples—An LCS was analyzed with every batch. LCSs very rarely failed to meet acceptance criteria. For some SVOA analyses, one or two of the target LCS analytes may have failed, but if these were not detected in the associated samples, no action other than notation in the case narrative and generation of an OOCE Sheet was taken.
- Surrogate Standards—All organic CSL methods utilized surrogates with QC acceptance criteria. Samples were routinely reprepared and/or reanalyzed if surrogate recoveries were outside of QC acceptance criteria. Surrogate failures were infrequent, with the majority coming during the analysis of high-suspended solids water samples for SVOAs and PCBs.

In general, all CSL data were assessed as usable for their intended purpose (field screening). During the course of the project, the CSLs were audited internally by the TN&A/CDM team, as well as externally by DOE and Bechtel Jacobs Company, against criteria normally used for fixed-base definitive data laboratories. With the exception of fixed-control limits versus statistically derived control limits from project QC sample data, most of the field analyses were conducted with very little deviation from the definitive data methods upon which the field laboratories' SOPs were based. For VOA parameters, average soil spike recoveries ranged from 77 percent to 98 percent, and average water spike recoveries ranged from 92 percent to 120 percent. For volatile spike/spike duplicate results, the average RPD ranged from 4.2 percent to 5.1 percent for water and from 8.0 percent to 8.8 percent for soil. For PCB analyses (spiked with Aroclor-1254), spike recoveries averaged 110 percent for water and 94 percent for soil, and RPDs averaged 5.9 percent for water and 4.9 percent for soil. For the 11 spiked SVOA parameters, average spike recoveries ranged from 23 percent to 83 percent for water and from 29 percent to 111 percent for soil. Average RPDs for SVOA spiked parameters ranged from 10.2 percent to 23.3 percent for water and from 8.1 percent to 12.6 percent for soil. Radiological spike analyses were performed on both water and soil matrices for gross alpha, gross beta, technetium-99, and three gamma spec parameters (americium-241, cesium-137, and cobalt-60). Average control spike recoveries for these parameters ranged from 95 percent to 111 percent recovery. Table 2.8 presents the average precision and accuracy numbers for spiked parameters analyzed at the CSLs.

Field laboratory results were confirmed by sending 10 percent of field laboratory samples to fixed-base laboratories for analysis. The agreement between field and fixed-base laboratory results was assessed by calculating RPDs for each parameter analyzed at both laboratories. The average RPD was 131 percent between results from samples split between the field and fixed-base (USEC, PGDP) laboratories for all parameters in both water and soil samples. However, this preliminary calculation was based on **all** split samples with at least one positive result from either the field screening laboratory or the fixed-base laboratory, some of which may have included results below the detection limit for either the fixed-base or the field laboratory. When the RPD calculations were performed only on split samples with above detection limit results from both the field screening and fixed-base laboratories, the results were significantly better. The RPD for gross beta analyses, where the results were not correctable for method differences between the field and fixed-base laboratories (in either soil or water samples) due to the lack of background data, was highest at 138 percent. For the remaining parameters, the highest RPD was 85 percent for SVOA analyses (all soil results). Only one gamma spectroscopy sample had above detection limit results for both field and fixed-base laboratories, and the RPD between the results was 61 percent (a soil sample). The RPD for gross alpha analyses (using results corrected, as discussed above, for soil analyses for quantifiable differences due to the differences in the methods used by the field and fixed-base laboratories) was 36 percent (predominantly soil results). The RPD for VOA analyses was 30 percent (all water results). Technetium-99 analyses showed the best agreement when only considering detections above the field laboratory MDL of 17 pCi/L at 18 percent.

2.7.3.5 Fixed-base laboratory performance

Fixed-base laboratory performance was based on the results of laboratory QC samples, MS/MSD analysis, and adherence to laboratory procedures through data validation. The laboratories are audited annually by ORO-SMO and are contracted to follow the Analytical Master Specification documents for various analytical chemistry protocols mandated by ORO-SMO.

Some holding time problems were reported for VOA analyses by the fixed-base laboratories used during this investigation. For the most part, these holding time exceedances were the most serious deficiencies resulting in qualification or rejection of data. Initial calibration and continuing calibration deficiencies also led to laboratory qualification of some VOA data and rejection of some data during data validation as discussed in Sect. 2.7.3.7. Specific laboratory problems with the data were addressed and resolved during the data assessment phase.

2.7.3.6 Comparison of trichloroethene results in soils analyzed using hexane extraction versus conventional methods

The WAG 28 RI is another major investigation at PGDP that has used hexane extraction for analysis of chlorinated solvents in soils. The methodology had been refined on smaller projects, most notably in support of the LASAGNA™ Technology demonstration, and incorporated in the PGDP subsurface soil sampling procedure. The method is still relatively new, and most fixed-base laboratories are not equipped to use it. In a recent study, samples were analyzed at a CSL using hexane extraction, and a section of sample sleeve was sent to the fixed-base laboratory for more conventional analysis. As results were received from the fixed-base laboratory and compared with the CSL results, it became obvious that the results of the two methods were not directly comparable. The CSL always returned higher values than the fixed-base laboratory. On average, the CSL reported trichloroethene values nearly 500 times greater than those reported by the fixed-base laboratory. In general, as trichloroethene concentrations increased, the difference in the two results decreased and there was generally good agreement between the two sets of results, although slight differences were attributed to the differences in analytical equipment.

The comparison demonstrated the effectiveness of using hexane extraction for chlorinated solvents in soil. The method, however, does have some disadvantages: (1) MDLs for target VOA analytes (trichloroethene and its degradation products) are approximately 140 µg/kg or 0.14 ppm and (2) the hexane peak masks some VOA target analytes on some detectors (i.e., the PID used in method SW8021).

2.7.3.7 Data validation

Data validation is a process performed for a data set by a qualified individual independent from sampling, laboratory, project management, and other decision-making personnel for the project. In the data validation process, the laboratory adherence to analytical method requirements is evaluated. The TN&A/CDM Team validated definitive data collected for this RI according to the following procedures:

- EMEF Intersite Procedure Environmental Restoration and Waste Management (ERWM)/Environmental Restoration (ER)-P2209, *Radiochemical Data Verification and Validation*, Rev. 0
- EMEF Intersite Procedure ERWM/ER-P2210, *Volatile and Semivolatile Data Verification and Validation*, Rev. 0
- EMEF Intersite Procedure ERWM/ER-P2211, *Pesticide and PCB Data Verification and Validation*, Rev. 0
- EMEF Intersite Procedure ERWM/ER-P2212, *Inorganic Data Verification and Validation*, Rev. 0

As part of the data review process, findings were qualified as necessary to reflect data validation results. The following qualifiers were assigned by the data validators:

U	The material was analyzed for, but was not detected. The associated numerical value is the quantitation limit.
J	Estimated value, either because QC criteria were not met or because the amount detected is below the documented quantitation limit.
UJ	Undetected, but the number reported as the quantitation limit is an estimated value.
NJ	Presumptively present at an estimated quantity.
R	Rejected, so data are of "information only" quality and should be supplemented with additional data for decision-making.
=	Data were validated; however, no qualifier was added.
X	Data were not validated.

Data generated by the fixed-base laboratories were independently validated on a frequency of 10 percent. Actual data records indicate that 12 percent (15,198 data points) of the overall analytical data were validated.

Data packages from SWMUs 193 and 99 (base sample set) were validated for parameters including VOAs, metals, cyanide, PCBs, SVOAs, and radiological analyses. Of the 40,178 total data points, 15,198 were validated. A review of the data validation summary reports indicates that the majority of data quality parameters, including MS/MSD recovery and RPD criteria, for the validated data packages were within established method-specific limits. Grossly exceeded holding times affected significant portions of the VOA soil data in some packages. Other quality problems for individual samples and/or analytes were identified in each of the validated packages; in particular, there were repeated instances of laboratory blank and field QC contamination affecting VOA analytes, such as acetone and methylene chloride, and problems with continuing and initial calibrations for some of the same VOA analytes. Of the overall analytical data, 3179 data points (7.9 percent) were rejected with 3003 (94 percent) of these being VOA data points rejected due to holding time exceedances.

2.7.4 Data Management

The WAG 28 PEMS was used to manage field-generated data; import laboratory-generated data; add data qualifiers based on data verification, validation, and assessment; and transfer data to Paducah's Oak Ridge Environmental Information System. PEMS included a tracking system to identify, track, and monitor each sample and associated data from point of collection through final data reporting. The system included field measurements, chain-of-custody information, and a tracking system for tracking hard-copy data packages and EDDs. PEMS also included information for field planning and data evaluation.

All data packages and EDDs received from the laboratory were tracked, reviewed, and maintained in a secure environment. When first received, data packages were assigned a document control number and then logged into a tracking system. The following information was tracked: sample delivery group numbers, date received, document control number, number of samples, sample analyses, receipt of EDDs, and comments.

The data verification processes for laboratory data were implemented for both hard-copy data and EDDs. The data packages were reviewed to confirm that all samples had been analyzed for the requested parameters. Discrepancies were reported to the laboratory and the data validators. As part of a series of internal integrity checks within PEMS, a check was run to identify which of the requested samples and analyses were not received in an EDD. Hard copy data packages were checked to confirm agreement with the associated EDD. Integrity checks in PEMS were also used to check the list of compounds generated by the laboratory to confirm that data were provided for all requested analytes. Discrepancies were reported to the laboratories for responses and/or correction and to the data validators.

Data verification within PEMS included standardization of analytical methods, chemical names and units, as well as checks for holding time violations and detections above background values.

Validation qualifiers from the TN&A/CDM data validators were manually input into PEMS.

PEMS system requirements included backups, security, change control, and interfacing with other data management systems. PEMS was housed on the Paducah EMEF network. System backups were performed nightly following standard Paducah EMEF network protocol. Updates made to the files were copied to a computer backup tape each night, and an entire backup was performed each week.

Security of PEMS and data used for the data management effort was considered essential to the success of the project. The security protocol followed by the data management team was consistent with that of the Paducah EMEF network. Access to the network is password-protected. Access to PEMS was limited, on an as-needed basis, to the data management personnel. Read-write, graded access to PEMS was limited to the data management team, which consisted of the PEMS Coordinator and the supporting data entry staff. The data management staff assisted other project members with data needs from PEMS by running requested queries.

Each sampling location and sample collected during the WAG 28 RI was assigned a discrete identification number, which consisted of a four-part alpha/numeric sequence. For example:

193-018-WA-095

Each segment of the sequence is used to designate information concerning the location from which a sample was collected, the medium from which it was collected, the nature of the sample, and the depth from which the sample was collected. The first three-digit code is a location definition corresponding to the SWMU or AOC from which the sample was collected. For example, "193" would indicate

SWMU 193. This code is followed by another three-digit code used to define the boring or location within the SWMU (or area) from which the sample was collected. For example, "018" would indicate the 18th boring drilled in that area. The two-letter sequence is used to indicate the nature of the sample. The first letter identifies the matrix of the sample. Examples of the letters used to identify specific matrices include S, W, and L to identify soil, water, and sludge matrices, respectively. The second letter identifies the sequence of multiple samples collected from the same location or the type of QC sample for field QC samples collected. For example, "A" designates an original field sample, "B" or "C" designates a second or third sample collected during another sampling event at the same location (i.e., a resampling). The letter "D" is used to designate a field duplicate sample. "E" designates an equipment rinsate sample, "F" designates a field blank sample, "R" designates refrigerator storage blank for VOAs, and "T" designates a trip blank sample. A "Q" was used for source water samples from the potable water and deionized water used during the project. The predetermined three-digit field is used to designate the approximate depth from which the sample was to have been collected. For example, "095" would mean the sample was to have been collected at 95 ft. In conclusion, for the example above, the sample identification code reads: *within SWMU 193, from boring location 18, a water sample was collected at approximately 95 ft bgs.*

2.7.5 Data Assessment

A large volume of data was generated during the WAG 28 RI. With up to five field teams using four different drilling methods to collect samples and six laboratories involved in sample analysis, the opportunities for problems, inconsistencies, and errors were significant. To confirm that the data set could be used in the decision-making process, the RI team performed various checks and reviews during and after the fieldwork to maintain data consistency and identify problem areas. These checks and reviews included electronic verification and manual assessments by the RI team, as well as independent validation of fixed-base laboratory data. More than 40,178 records were reviewed during the data assessment.

2.7.5.1 Field data

Field data consist of data generated by the on-site CSL and measurements taken in the field during a sampling event. For example, measurements taken in the field during a groundwater sampling event included water temperature, specific conductivity, dissolved oxygen, and pH. The CSLs measured concentrations of trichloroethene and its degradation products in soil and groundwater, SVOAs in soil and groundwater, PCBs in soil and groundwater, gross alpha and beta activity in soil and groundwater, gamma activity in soil, and technetium-99 activity in water.

The field preliminary CSL data underwent daily reviews by the lead chemist, and data management personnel reviewed final CSL data as a means of identifying data entry errors, missing data, and inconsistencies. The data management personnel used numerous queries in ACCESS to provide checks of the PEMS database and identify problems. The PEMS Coordinator and other data management staff reviewed all queries, reporting results to the lead chemist and other project key personnel. Based on these reviews, questions and problems were noted and submitted to the CSL laboratory managers for resolution and correction. The types of problems found included missing or incorrect sample depths, missing or incorrect data qualifiers, and miskeyed data. An additional review was also performed, comparing data against expected conditions to assess whether the results "made sense" within the context of the investigation during data assessment.

2.7.5.2 Fixed-base data

The fixed-base data consist of data generated by the off-site laboratories contracted for the project. These laboratories provided analyses of VOAs, SVOAs, PCBs, dioxins/furans, metals, radioisotopes, feasibility study parameters, and soil properties. Ten percent of the fixed-base data was submitted to

WAG 28 team validators for independent validation of the data quality. The validation included (but was not limited to) review of sample holding times, minimum detection limits, analytical blanks, matrix spikes, laboratory duplicates, surrogates, and instrument calibrations. When appropriate, a qualifier was added to the data. The team validators submitted a report on each data package when the package was returned to the RI team. The results of the validation were then included in the data set. Questions and problems with fixed-base data were noted during data assessment and submitted to the Bechtel Jacobs Company SMO representative for laboratory responses, resolution, and correction, as appropriate.

2.7.5.3 Final review

After each data package was received from the fixed-base laboratory and loaded into the PEMS database, a final review and assessment of all the data was completed. This effort included electronic verification, database queries targeting known problem areas, and manual assessment. For manageability, the data packages were divided by SWMU or AOC.

Electronic verification was used to compare the data set against various reference values, specifically holding time exceedances for all analyses and background exceedances for metals and radioisotopes in soils. Data records for all samples that exceeded holding times were flagged with a "T" in the verification field. Data records for all metals and radioisotopes in soils that exceeded established background levels for the site were flagged with an "I" in the verification field.

In conjunction with electronic verification, a set of data assessment queries was developed. These queries were designed to check the internal consistency of the database and to identify all analytes detected, the concentration and distribution of the analytes detected within the volume of soil and groundwater investigated, and the samples that might have been impacted by various problems that are inevitable during the course of a major investigation. The underlying data assessment questions consistently asked were "Does this number make sense, and what does it mean?"

QC samples were reviewed as a part of the data assessment process. These included equipment rinsate samples, trip blanks, refrigerator blanks, field blanks, and a comparison of field duplicate results. During the assessment of these samples, no problem areas were identified. In each case where analytes were detected in a QC sample, either there were no detections of the analytes in the associated field samples, or the field sample result(s) were greater than 10 times the concentration of the analytes detected in the associated QC sample.

Holding time exceedances were a problem, particularly for some VOA analyses. All holding time exceedances were identified during the verification process. During the assessment process, the impact of those exceedances was evaluated. Analyses for organics and certain metals are particularly sensitive to holding times, whereas analyses for most metals and for radioisotopes are less sensitive. Both the analyses to be performed and the length of the holding time exceedances were evaluated to assess the potential impact. Records for those samples judged to be significantly impacted were assigned an assessment flag of "BL-T" meaning that the result may be biased low due to holding time exceedance. A total of 3010 out of 40178 (7.5 percent) records in the database were assigned the "BL-T" flag.

The "R" assessment flag was used to reject data that did not pass the review process. An example of rejected data would be if the dissolved concentration of a metal in groundwater exceeded the total concentration of the metal in the same sample. If the detected dissolved concentration was greater than 10 percent, the dissolved metal result was considered questionable. Also included as rejected data were samples with gross holding time exceedances. A portion of the VOA analyses conducted by the fixed-base laboratories had such exceedances. A total of 3179 out of 40178 records (7.9 percent) in the database were assigned the "R" flag. Only these data were excluded from use in the evaluation of contaminant nature and extent or fate and transport.

2.7.6 Field QC Procedures

EPA, DOE, the Commonwealth of Kentucky, and PGDP procedures require that field QC samples be collected to assess data quality. The QC samples collected and analyzed included:

- Equipment rinsates
- Source blanks (water supply samples)
- Trip blanks
- Field blanks
- Duplicate samples
- Refrigerator blanks

2.7.6.1 Equipment rinsates

Equipment rinsates were scheduled to be collected at a frequency of 1 in 20 samples. Appendix C provides the data from the equipment rinsate samples. A total of 14 equipment rinsates were collected during the project. Equipment rinsate samples were designated as XXX-XXX-WE-XXX samples in Appendix C.

2.7.6.2 Water supply samples

Source blanks of deionized water and potable water used for equipment decontamination were collected two times during the project. Four water supply samples were collected during the project. Water supply samples (source blanks) are designated as PO (potable water) X-XXX-WQ-XXX samples and DI (deionized water) X-XXX-WQ-XXX samples in Appendix C.

2.7.6.3 Trip blanks

Trip blanks were collected at a frequency established by the direction of the Bechtel Jacobs Company. A total of 50 trip blanks were analyzed during the project. Appendix C provides the results of the trip blank samples. Trip blank samples are designated as XXX-XXX-WT-XXX samples in Appendix C.

2.7.6.4 Field blanks

Field blanks were scheduled to be collected at a frequency of 1 in 20 samples. Appendix C provides the data from the field blanks. A total of 14 field blanks were collected during the project. Field blank samples are designated as XXX-XXX-WF-XXX samples in Appendix C.

2.7.6.5 Duplicate samples

Field duplicates were collected and sent to the CSLs and fixed-base laboratories for analysis. Field duplicates were scheduled to be collected at a frequency of 10 percent of the total number of field samples collected by matrix. Eleven soil and 10 water duplicate samples were collected during the project. Appendix C provides the results of the duplicate samples. Field duplicate samples are designated as XXX-XXX-WD-XXX for water field duplicates and XXX-XXX-SD-XXX for soil field duplicates.

2.7.6.6 Refrigerator blanks

Refrigerator blanks were collected and analyzed every two weeks during the project. Because the WAG 28 field investigation was conducted simultaneously with both the Data Gaps and the WAG 8 SE field investigation, these refrigerator blanks were divided among all three projects for which samples were being collected and stored prior to analysis. Four refrigerator blanks were assigned to the WAG 28 project. Refrigerator blank samples are designated as XXX-XXX-WR-XXX samples in Appendix C.

2.8 CIVIL SURVEY

Upon completion of the activities associated with the sampling points, soil borings, monitoring wells, and Piezometers, a final survey of the location and elevation was conducted. The surveying was conducted in accordance with the Paducah EMEF engineering specifications. The civil survey was performed by a state registered and licensed surveyor of the Commonwealth of Kentucky. Site locations were surveyed on the Kentucky State Plan Coordinate System and the PGDP Plane Coordinate System. Benchmarks and reference points were supplied by the Bechtel Jacobs Company Civil Engineering Department. Grid coordinates were measured to an accuracy of plus or minus 0.01 ft and tied to the U.S. Geological Survey (USGS) National Geodetic Vertical Datum of 1929 or the North American Datum of 1983. Elevations were measured to a hundredth (0.01) of a foot. Surveying field activities were documented in field logbooks for archiving. The civil survey data are included in Appendix D.

2.9 HEALTH AND SAFETY MONITORING

To protect the health and safety of personnel during field activities, site safety professionals were assigned to observe, monitor, direct, and document each activity. In addition, a Radiation Protection Program was implemented to assure adherence to PGDP and DOE regulations. Eleven of the site safety professionals were trained and accredited as radiation control technicians prior to the start of site monitoring activities.

Two major categories of monitoring were performed, work area monitoring and employee bioassay monitoring.

2.9.1 Work Area Monitoring

Several of the drilling and sampling locations for the WAG 28 RI were within the boundaries of known areas of surface radiation contamination. Before field activities began, an initial site radiation survey was performed covering a 60- by 60-ft area around the point of sampling or drilling. The purpose of the survey was to assure that the members of the sampling crew and the equipment were properly protected and to assure that surface contamination, if present, was properly managed.

All radiation abnormalities were reported immediately to the EMEF Health Physics Department and the project construction engineer.

Once the site had been thoroughly scanned for radiation and proper actions had been taken to protect workers from site hazards, equipment was moved in and work zones (with barriers) were established. These zones included an outer construction zone and an inner exclusion zone. The exclusion zone was a strictly controlled area. Every person or item that passed into this zone was considered contaminated and could not be removed until fully scanned for radiation. This was accomplished by discrete measurements with the Ludlum 2224 and smear counting using the Ludlum 2929.

Once the ground surface was broken at a work site, air was continuously monitored with direct read instruments until field activities were completed. Tools and equipment in direct contact with soil were presumed to be contaminated until they were measured and were therefore smeared before they were cleared. If levels were above the release limits, the material was bagged and properly tagged. The bagged material was then surveyed again to confirm that levels were below the release limits. The material was then moved to a designated area until it could be properly decontaminated. Instrument readings were recorded in the field geologist logbook. Typically, readings were recorded from soil cuttings created during the drilling operations, air space monitoring at the drilling location, smears and direct measurements, and readings that met or exceeded the project action levels specified in the Health and Safety Plan (HASP).

The work area was also monitored to prevent overexposure to temperature extremes. On-site ambient temperature was measured and discussed on a daily basis. Cold and heat stress monitoring of personnel was conducted in the work area by a site safety professional. This monitoring included close scrutiny of personnel behavior, obvious signs of overexertion, and heart rates of exposed personnel. Heart rate checks were performed periodically during each exposure period.

Excessive noise was surveyed at each source of elevated noise. These included drill rigs, pressure washing equipment, generators, and other items equipped with combustion engines. Sound level monitoring data were recorded on a Sound Level Survey Form. Sound level surveys were performed with a Quest Model 2700 sound level meter at each source of elevated noise. Working conditions in the vicinity of this equipment were checked at regular intervals to confirm that the site was properly delineated with hearing conservation signs and to reassess the use of proper personal protective equipment (PPE). Hearing protection was required at any levels equal to or above 85 decibels.

2.9.2 Employee Biological Monitoring

All personnel who were required to enter a zone of potential contamination were required to participate in the Bechtel Jacobs Company Biological Monitoring Program. As part of this program, personnel wore thermoluminescent dosimeter (TLD) badges to track possible radiation exposure; in addition; monthly urinalysis was conducted to document radiological ion uptake. The 29 *Code of Federal Regulations* 1910.120 requirements were used for training and biological monitoring of WAG 28 field employees, including a physical examination consisting of blood analysis, audiometric testing, respiratory testing, and cardiopulmonary testing.

Upon arrival at the project site and before any participation in site work, employees were issued a TLD by Bechtel Jacobs Company Health Physics Department personnel, and each person provided a urine sample to establish a baseline. The TLDs were exchanged and analyzed on a quarterly basis. The internal dose evaluation was performed each month and at the end of project participation.

2.10 WASTE HANDLING PRACTICES

A variety of potentially contaminated and noncontaminated wastes was generated during the RI activities. All wastes generated as a result of field-related investigative activities had the potential to contain contaminants related to past work activities. The drilling and sampling investigative activities resulted in the generation of IDW. This required the subcontractor to write a waste generation plan that concurs with the requirements stated in the BJC/PAD-11, Revision 2 Waste Acceptance Criteria (WAC) document. The Waste Generation Plan included waste minimization, segregation, waste generation forecast, proper containerization, labeling/marking, characterization, handling, storage, transportation, and disposal.

2.10.1 IDW Drilling Solids

IDW solids were generated by DPT, HSA, hand-surface sampling, one DWRC drilling, and drilling operation. All IDW solids were placed in appropriately labeled pails and drums according to applicable regulations and PGDP procedures.

DPT sampling generated minimal IDW waste. The majority of solid waste generated by the DPT method was PPE and plastic sheeting used as groundcover under the rig and sampling area.

The DWRC and HSA drilling techniques generate significant quantities of IDW solids and liquids. This mixture was separated at the drill site: the solids were placed into 55-gal drums, and the liquids into 375–1200-gal poly tanks and transported to the C-752-C decontamination pad for final separation. Any remaining IDW liquids that separated from the solids in the 55-gal drums were decanted out of the drum, and the remaining solids were dumped into roll-off bins. The liquid mixture of mud, silt, clay, and water was separated by natural gravity settling, by the addition of flocculation chemicals, and by processing the water through a filter press. The filter press removed the sand, silt, and clay-size particles from the water matrix. The solids were placed into properly labeled roll-off bins along with the drum solids.

One hundred forty of 370 drums of IDW that were generated during the WAG 28 RI have been placed into roll-off boxes (1036 yd^3) for landfill disposal. The roll-off boxes were labeled, and all associated forms and requirements were completed and submitted for landfill disposal. The remaining 180 drums are scheduled to be placed into roll-off boxes in the near future. No IDW from WAG 28 RI has been transferred to Bechtel Jacobs Company for disposal as hazardous waste.

IDW liquids associated with solids were captured by processing soils through the filter press and placing the liquid into 1000-gal mobile poly tanks. This water was then transferred into 21,000-gal frac tanks prior to testing and discharge into Outfall 001.

2.10.2 Well IDW Water, Well Development Water, Decontamination Rinsate, and Purge Water

Water generated during the WAG 28 RI was placed into 375- and 1200-gal poly tanks and transported to the C-752-C Decontamination Pad. If the water had field analysis that showed the water free of contamination, the water was pumped through the filter press to remove all visual solid particles. Clear water from the filter press was captured into 1000-gal mobile poly tanks and transferred into 21,000-gal frac tanks located at C-612-A Clamshell Area.

To date, a total of over 75,000 gal of IDW, well development, decontamination, and purged water has been generated. A total of 63,000 gal of water has passed all PGDP, local, state, and federal discharge limits and has been released into Outfall 001.

Decontamination water was generated from the cleaning of drilling and sampling equipment. All water was collected into Sumps 1–4 located at C-752-C Decontamination Pad. Water from all sumps was cross-referenced with all field and waste sampling laboratory sampling data results, and all water that was deemed noncontaminated was pumped through the filter press and transferred into the frac tanks at C-612-A Clamshell Area. Solids that were not pumped with the water was collected and placed into the solid roll-off bins.

Wastewater generated from the laboratories was collected and temporarily stored at generator storage area (GSA)/satellite accumulation areas (SAAs) located outside of each laboratory. Each container was sampled and, if found noncontaminated, was mixed with other clear water and pumped through the filter press.

All water generated by this project was sampled and analyzed for PCBs, radionuclides, VOA, and SVOAs required by Kentucky Pollutant Discharge Elimination System (KPDES) Outfall Permits. No wastewater from the drilling, sampling, laboratory, or decontamination operations has exceeded applicable concentrations; therefore, it has not been necessary to transfer IDW liquids into storage for later disposal.

2.10.3 PPE and Plastic Sheeting

Modified Level D was the highest level of PPE worn, as required by the WAG 28 HASP. All used PPE was considered IDW waste. Laboratory analyses for each of the borings was cross-referenced to IDW samples. The PPE and sampling refuse were classified the same as the IDW. All noncontaminated PPE and refuse were bagged per each boring, labeled, and dated. The bags were placed into roll-off bins for disposal in the PGDP sanitary landfill.

In accordance with field screening and laboratory data results, PPE and plastic determined to be contaminated was placed in appropriately labeled drums and managed according to applicable regulations and PGDP protocol. To date, seven drums of PPE and plastic have been transferred into storage. Twenty-five cubic yards of clean, noncontaminated PPE and plastic have been placed into three roll-off bins and properly labeled and submitted for landfill disposal.

2.10.4 Laboratory Waste

Used sample containers, PPE, residual soil, and wastewater were generated by laboratory operations. Soil, water, and PPE were combined with the associated waste streams for each boring and processed according to PGDP protocol. At present, no waste has been determined to be RCRA-, Toxic Substances Control Act-, or low-level (radioactive) waste and transferred into storage.

2.10.5 IDW Forms

Request for Disposal forms and Waste Container Log Sheets were completed as the waste was generated at the work site. PGDP supplied all required forms as needed. Completed forms were delivered to the PGDP EMEF Waste Disposal Coordinator for approval.

2.10.6 IDW Labeling

IDW containers were carefully labeled or marked per PGDP's WAC requirements.

2.10.7 IDW Storage

GSAs and SAAs were established as needed. The GSA and SAA were set up and inspected in accordance with PGDP WAC procedures. Each month inspection forms were submitted as required.

2.10.8 Types of Containers

Solid IDW that was generated at each boring location was containerized in 55-gal open top drums with a minimum rating of DOT 1A2/X400/S and lined with a 15-mil-thick plastic liner and an absorbent pad. IDW liquids were stored in 375-, 1200- and 21,000-gal tanks located at C-752-C Decontamination Pad and C-612-A Clamshell Area.

2.10.9 IDW Characterization, Sampling, and Analysis

Waste analyses were performed using EPA-approved procedures as applicable. Analysis required for hazardous waste classification was performed in accordance with EPA SW-846 (1986). Wastewater analysis was performed in accordance with the Clean Water Act of 1972 and/or Safe Drinking Water Act of 1974 procedures.

2.11 DECONTAMINATION PRACTICES

All drilling rigs and drilling-related equipment such as drill rods, casing, liners, and bits were steam-cleaned at C-755, C-416, and C752-C Decontamination Pads. Decontamination of drill and sampling equipment was conducted in accordance with PGDP EMEF Procedure PTSA-5001-IAD, *Decontamination of Drilling-Related Equipment.*

The drilling equipment was thoroughly steam-cleaned and rinsed and then allowed to air dry. The drill string was then wrapped in plastic and placed on the drilling rig and transported to the next boring site. The decontamination water was collected in sumps and processed through the filter press in conjunction with IDW liquids for the removal of suspended solids. The clear water was transported and transferred into a 21,000-gal frac tank.

Sampling equipment such as bowls, spoons, knives, and spatulas, including all stainless steel field sampling equipment, was decontaminated in accordance with PGDP EMEF Procedure PTSA-5002-IAD, *Decontamination of Field Equipment.* The decontamination process occurred in the following order:

- Rinsed with potable water
- Washed and scrubbed with phosphate-free detergent and water
- Rinsed with clean tap water
- Rinsed with deionized water
- Rinsed with isopropanol
- Rinsed with deionized water
- Air dried
- Wrapped in aluminum foil

3. PHYSICAL CHARACTERISTICS OF WAG 28

The on-site physical characteristics of PGDP have been detailed in previous investigations by Clausen et al. (1992a), CH2M Hill (1992), CDM (1992), and EDGe (1989). Miller and Douthitt (1993), TCT-St. Louis (1991), EDGe (1989), and Wehran (1981) have addressed the off-site physical characteristics. For this report, previous investigations of the geology and hydrogeology were used to describe the regional physical characteristics of western Kentucky and summarize the physical characteristic data compiled for the PGDP area during the WAG 28 RI.

3.1 REGIONAL TOPOGRAPHY AND SURFACE WATER

PGDP lies in the Jackson Purchase Region of western Kentucky between the Tennessee and Mississippi Rivers, bounded on the north by the Ohio River. The confluence of the Ohio and Mississippi Rivers is approximately 20 miles downstream (southwest) from the site. The confluence of the Ohio and Tennessee Rivers is approximately 15 miles upstream (east) from the site. The western Kentucky region has gently rolling terrain between 330 and 500 ft above mean sea level (msl). Tributaries of the Ohio, Tennessee, and Mississippi Rivers dissect the region.

The average pool elevation of the Ohio River is 290 ft amsl, and the high water elevation is 342 ft amsl. Approximately 100 small lakes and ponds exist on DOE property. Seven settling basins and 17 gravel pits are also located within the boundary. A wetland area covering 165 acres exists immediately south of the confluence of Bayou Creek and Little Bayou Creek (TCT-St. Louis 1991).

All creeks that drain the site flow northward toward the Ohio River. Specific details of regional hydrology are presented in Sect. 3.7.

Local elevations range from 290 ft amsl along the Ohio River to 450 ft amsl in the southwestern portion of PGDP near Bethel Church Road. Generally, the topography in the PGDP area slopes toward the Ohio River at an approximate gradient of 27 ft per mile (CH2M Hill 1992). Within the 960 acres of the plant boundaries, ground surface elevations vary from 360 to 390 ft amsl. Primary land uses at PGDP include industry and wildlife management; secondary uses include agriculture and fishing.

3.2 METEOROLOGY

The region in which PGDP is located has a humid-continental climate characterized by extremes of both temperature and precipitation. Table 3.1 summarizes average monthly precipitation and temperature for the region between 1984 and 1996, based on data generated at Barkley Field Airport, located southeast of PGDP. The 13-year average monthly precipitation is 3.96 in., varying from an average of 2.59 in. in August to an average of 4.72 in. in February. The 13-year average monthly temperature is 57.9°F, varying from 34.5°F in January to 79.5°F in July.

Recent information on wind direction and speed was obtained from Barkley Field Airport for 1996. Figure 3.1 illustrates average wind speed and direction. The average prevailing wind has a speed of 7.9 mph and blows dominantly from south to southwest. Generally, stronger winds are recorded when the winds are from the southwest.

Table 3.1. Thirteen-year average for precipitation and temperature, Barkley Regional Airport, Paducah, Kentucky

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Precipitation (inches)													
1984	1.21	4.74	5.83	8.45	6.50	1.58	5.44	3.96	6.80	5.88	4.75	9.99	**65.13**
1985	1.82	3.70	3.67	6.85	4.13	4.85	0.85	5.89	9.23	7.26	4.29	1.34	**53.88**
1986	1.44	3.73	3.16	1.55	8.51	1.50	7.07	4.33	3.69	4.45	3.59	3.11	**46.13**
1987	0.99	3.93	1.93	2.30	1.43	4.03	2.58	1.31	2.80	1.58	4.29	9.19	**36.36**
1988	3.5	5.15	4.6	2.13	3.14	0.41	3.08	1.05	3.49	3.81	9.56	3.05	**42.97**
1989	5.31	13.33	5.36	2.55	2.33	9.20	7.07	1.80	2.64	3.48	2.59	1.78	**57.44**
1990	5.38	9.05	3.69	4.76	7.49	2.14	4.03	1.34	2.38	4.45	2.33	9.59	**56.63**
1991	3.77	4.07	3.55	3.81	4.29	1.47	3.23	2.42	3.25	3.57	2.17	3.84	**39.44**
1992	2.13	2.68	3.38	2.07	2.08	3.57	6.90	3.47	5.81	3.51	3.45	1.79	**40.84**
1993	3.79	3.99	2.99	5.14	2.59	5.51	0.56	2.89	6.00	3.82	6.45	3.57	**47.30**
1994	4.06	2.70	3.55	7.39	0.71	2.34	2.40	1.73	3.43	2.93	3.55	3.72	**38.51**
1995	4.20	3.26	1.78	4.34	5.68	4.19	3.28	3.52	1.47	2.30	2.72	1.89	**38.63**
1996	3.38	1.09	3.25	4.62	5.22	7.81	6.11	0.11	7.26	4.13	8.89	4.90	**56.77**
POR=13 years	3.15	4.72	3.60	4.30	4.16	3.74	3.98	2.59	4.44	3.92	4.47	4.44	**47.51**

Table 3.1. (continued)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Average Temperature (°F)													
1984	29.2	42.1	43.6	56.7	64.6	78.6	76.7	76.9	68.5	63.1	45.0	45.2	57.5
1985	23.9	32.0	51.3	60.9	66.8	73.3	78.4	74.8	68.8	62.4	52.5	31.3	56.4
1986	35.5	40.3	49.7	60.6	68.7	77.4	81.7	73.8	73.8	60.1	45.1	36.9	58.6
1987	33.5	40.9	50.2	57.4	73.0	78.2	79.5	79.8	71.6	53.4	50.9	41.1	59.1
1988	32.2	35.1	47.5	57.4	67.3	75.8	80.4	80.9	70.8	52.8	48.4	38.2	57.2
1989	41.4	32.8	48.1	57.3	64.6	73.6	78.3	77.7	69.3	59.9	48.6	27.1	56.6
1990	43.8	45.7	51.5	55.9	63.9	76.4	78.8	75.9	72.1	56.8	53.5	39.9	59.5
1991	34.2	41.9	51.4	62.3	72.5	78.0	80.9	78.4	71.1	61.1	45.4	41.9	59.9
1992	38.1	45.6	49.7	59.2	66.0	73.6	79.7	74.0	69.0	58.5	48.2	38.7	58.4
1993	38.3	36.9	46.6	55.9	67.3	76.5	84.3	78.7	67.3	56.1	45.6	38.5	57.7
1994	29.1	39.6	47.6	60.4	64.1	78.2	78.1	75.0	67.5	59.8	52.4	42.5	57.9
1995	37.0	37.5	51.4	59.7	67.5	75.3	79.5	80.8	66.9	58.9	42.0	36.6	57.8
1996	32.7	37.9	41.0	53.9	69.7	75.3	75.9	76.6	67.8	58.3	43.0	40.2	56.0
POR=13 years	34.5	39.2	48.6	58.2	67.5	76.2	79.5	77.1	69.7	58.5	47.8	38.3	57.9

3.3 SOIL

The general soil map for Ballard and McCracken Counties indicates that three soil associations are present within the vicinity of PGDP (USDA 1976): the Rosebloom-Wheeling-Dubbs association, the Grenada-Calloway association, and the Calloway-Henry association. The predominant soil association in the vicinity of PGDP is the Calloway-Henry association, which consists of nearly level, somewhat poorly drained to poorly drained, medium-textured soils on upland positions. Several other soil groups also occur in limited areas of the region, including the Grenada, Falaya-Collins, Waverly, Vicksburg, and Loring.

The Henry and Calloway soil series are classified as fragiaqualfs and fragiudalfs, respectively. The fragipan horizon within these soils is a dense silty or loamy layer, which may be cemented by noncrystalline material. This diagnostic subsurface horizon greatly retards the vertical movement of water in the soil and is typically responsible for causing seasonal high water tables in these soils. The lateral continuity and integrity of this layer may have been reduced due to construction activities (CH2M Hill 1991). The soil over the majority of PGDP is the Henry silt loam with a transition to Calloway, Falaya-Collins, and Vicksburg away from the site.

The soils in the vicinity of PGDP tend to have a low buffering capacity, with a pH ranging from 4.5 to 5.5. Low pH values are often associated with high cation exchange capacities, so these factors may alter the mobility of soil contaminants (particularly metals) (Birge et al. 1990). The cation exchange capacities measured during the recently completed WAG 6 RI range from 8.92 to 69.8 milliequivalents per liter (DOE 1999).

Although the soil over most of PGDP may be Henry silt loam with a transition to Calloway, Falaya-Collins, and Vicksburg away from the site, many of the characteristics of the original soil have been lost due to industrial activity that has occurred over the past 45 years. Activities that have disrupted the original soil classifications include filling, mixing, and grading.

3.4 POPULATION AND LAND USE

The West Kentucky Wildlife Management Area (WKWMA) and sparsely populated agricultural lands surround PGDP. The closest communities to the plant are Heath, Grahamville, and Kevil, all of which are located within 5 miles of DOE reservation boundaries. The closest municipalities are Paducah, Kentucky, located 15 miles east of the facility; Cape Girardeau, Missouri, which is approximately 40 miles west of the plant; and the cities of Metropolis and Joppa, Illinois, which are located across the Ohio River from PGDP.

Historically, the economy of western Kentucky has been based on agriculture, although there has been increased industrial development in recent years. PGDP employs approximately 2500 people, and the Tennessee Valley Authority (TVA) Shawnee Steam Plant employs 500 people (Oakes et al. 1987). Total population within a 50-mile radius of PGDP is approximately 500,000; approximately 50,000 people live within 10 miles of the plant. The population of McCracken County is approximately 62,879 (verbal communication, Paducah Chamber of Commerce, Dec. 7, 1998).

In addition to the residential population surrounding the plant, WKWMA draws thousands of visitors each year for recreational purposes. Visitors use the area primarily for hunting and fishing; other activities include horseback riding, hiking, sanctioned field trials for hunting dogs, and bird watching. According to WKWMA management, an estimated 5000 anglers visit the area each year.

3.5 ECOLOGY

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

3.5.1 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 communities range from an oak and hickory forest in areas that have been undisturbed to managed fence rows and agricultural lands in the more developed areas. The main crops in the PGDP area include soybean, corn, tobacco, and various grain crops such as millet.

Old field grasslands constitute approximately 2000 acres of WKWMA. Much of this herbaceous community is dominated by members of the *Compositae* family and various grasses. Woody species, such as red maple, are also occasionally present. Some of this area includes remnant prairie, as indicated by the presence of eastern gama and Indian grasses. The shrub community represents a more diverse habitat, including both herbaceous and woody species. Within WKWMA, approximately 800 acres consist of scrub-shrub habitat. Dominant trees include cherry, persimmon, sumac, young hickory, and three species of oak, as well as scattered growths of sweetgum and hackberry. Forest and shrub tracts alternate with fence rows and transitional edge habitats along roads and power transmission-line corridors. Elm, locust, oak, and maple, with an understory of sumac, honeysuckle, blackberry, poison ivy, and grape, dominate fencerow communities. Herbaceous growth in these areas includes clover, plantain, and numerous grasses.

Mice, rabbits, and a variety of other small mammals frequent open herbaceous areas. Birds identified in the area include red-winged blackbirds, quail, sparrows, and predators such as hawks and owls. In transitional areas, including fence rows, low shrub, and young forests, a variety of wildlife is present, including opossum, vole, mole, raccoon, and deer. Birds typically found in the transitional areas include red-winged blackbirds, shrikes, mourning doves, quail, turkeys, cardinals, and meadowlarks. Several groups of coyotes also reside in areas around PGDP. In addition to the larger mammals, mature forests contain squirrels, songbirds, and great horned owls. Muskrat and beaver are found in the aquatic habitats of the PGDP area. Many species of waterfowl also use these areas, including wood ducks, geese, herons, and various other migratory birds. Various reptiles, amphibians, and terrestrial invertebrates (e.g., insects and spiders) are present in all areas. Domestic livestock is abundant in surrounding farmlands.

3.5.2 Aquatic Systems

The aquatic communities in and around the PGDP area that could be impacted by plant discharges include two perennial streams, Bayou Creek and Little Bayou Creek; the North-South Diversion Ditch; a marsh located at the confluence of Bayou Creek and Little Bayou Creek; and other smaller drainage areas. The dominant taxa in the surface water include several species of sunfish, especially bluegill and green sunfish, as well as bass and catfish. Bluegills, green and longear sunfish, and stonerollers dominate shallow streams, characteristic of the two area creeks.

3.5.3 Wetlands and Floodplains

Wetlands were identified during the 1994 U.S. Army Corps of Engineers (COE) (now known as USACE) environmental investigation of 11,719 acres surrounding PGDP. In that investigation, 1083 separate wetland areas were identified and grouped into 16 vegetation cover types (COE 1994). Wetlands inside the plant security fence are confined to portions of drainage ditches traversing the site (CDM 1994). Functions and values of these areas as wetlands are low to moderate (Jacobs 1995); these areas provide some groundwater recharge, floodwater retention, and sediment/toxicant retention. While the opportunity for these functions and values is high, the effectiveness is low due to water exiting the area quickly via the drainage system. Other functions and values (e.g., wildlife benefits, recreation) are very low.

At PGDP, three bodies of water cause most area flooding: the Ohio River, Bayou Creek, and Little Bayou Creek. A floodplain analysis performed by COE (1994) indicated that much of the built-up portions of the plant lie outside the 100- and 500-year floodplains of these streams. In addition, this analysis indicated that ditches within the plant area can contain the expected 100-and 500-year discharges.

There are no wetlands associated with WAG 28.

3.5.4 WAG 28 Surface Features

PGDP is drained by Bayou Creek, Little Bayou Creek, their tributaries, and man-made drainage ditches that flow into the two creeks. Most of the WAG 28 SWMUs are drained by ditches that discharge into KPDES outfalls and Little Bayou Creek west of the plant.

SWMU 99 has been divided into two separate areas: Subunit A at the C-745-E area and Subunit B outside the fence. Subunit A is comprised of a cylinder storage yard with a surface of packed, crushed stone and the Classified Scrap Yard, which consists of a concrete pad covered with obsolete equipment. A concrete road lies between the two areas, and minimal topographic change occurs over the entire subunit. French drains are located throughout the cylinder yard. Soil and grass-covered areas surround the Classified Scrap Yard..

The Subunit B portion incorporates the area outside the security fence. It is bordered by Outfall 010, Dyke Road, and Tennessee Avenue. A shallow ditch drains the C-755 area and runs through the center of the site. There are also two large highpower transmission towers in the area. The area is now covered with crushed stone and a landscape fabric liner so it can be used as a parking area. The drainage ditch remains intact.

SWMU 193 is the largest operational unit investigated and is also divided into subunits. Subunit A comprises the area west of Building C-333 to Patrol Road 5. It is predominantly an open grass area with a crushed stone road that cuts diagonally through the area. The southern portion of Subunit A is dominated by a large mound of construction debris. Subunit B is the area north of C-333 and south of Ohio Ave. This area has a gravel and asphalt surface and considerable overhead pipework. To the east is a residual foundation/concrete slab from a former metal works shop. Subunit C is the entire area south of C-333, east of Patrol Road 5 and west of 18 Street. This area is being used for a cylinder storage yard and is constructed of crushed stone with subsurface drains.

SWMU 194 is a flat, open field area outside the security fence near the main plant entrance. This SWMU is covered in grasses over most of its extent with a stand of trees to the west. There are no facilities or related development on the site.

AOC 204 is situated between Outfall 010 to the north and Outfall 011 to the south. To the east is Dyke Road, and the plant fence bounds the western side. AOC 204 is an open, nondeveloped area that has primary forest growth of small hardwoods, scrub brush, and grasses. Topographically, with the exception of the adjacent ditches, the area is slightly rolling with local elevation changes of less than 5 ft.

3.6 GEOLOGY

The scope of the WAG 28 RI focuses on the surface soil/loess/fill, the Continental Deposits, and the McNairy Formation. The lithologic units observed during WAG 28 sampling activities consist of unconsolidated strata at depths above 160 ft bgs (maximum depth sampled). Generalized lithologic descriptions of each unit are provided in Sects. 3.8.2.1–3.8.2.4. SWMU-specific lithologic interpretation and cross-sections are provided in the following sections and figures (see Figs. 3.2 –3.10). An idealized lithologic cross-section through the entire site is presented in Fig. 3.11.

3.6.1 Geologic Setting

PGDP is located in the Jackson Purchase Region of western Kentucky, which represents the northern tip of the Mississippi Embayment portion of the Coastal Plain Province (Fig. 3.12). The Jackson Purchase Region is an area of land that includes all of Kentucky west of the Tennessee River. The stratigraphic sequence in the region consists of Cretaceous, Tertiary, and Quaternary sediments unconformably overlying Paleozoic bedrock. A lithostratigraphic column of the Jackson Purchase Region is shown in Fig. 3.13.

Within the Jackson Purchase Region, strata deposited above the Precambrian basement rock attain a maximum thickness of 12,000–15,000 ft. Exposed strata in the region range in age from Devonian to Holocene. The Devonian stratum crops out along the western shore of Kentucky Lake. Mississippian carbonates form the nearest outcrop of bedrock and are exposed approximately 9 miles northwest of PGDP in southern Illinois (Clausen et al. 1992b). The Coastal Plain deposits unconformably overlie Mississippian carbonate bedrock and consist of the following: the Tuscaloosa Formation, the sand and clays of the Clayton/McNairy Formations, the Porters Creek Clay, and the Eocene sand and clay deposits (undivided Jackson, Claiborne, and Wilcox Formations). Continental deposits uncomformably overlie the Coastal Plain deposits, which are in turn covered by loess and/or alluvium. Sections 3.6.1.1–3.6.1.6 discuss the strata.

The focus of the WAG 28 RI is the near surface geologic strata ranging in age from Cretaceous to Holocene. Borings advanced during WAG 28 ranged in depths from surface to 160 ft bgs. Figure 1.2 depicts WAG 28 RI SWMU locations and Figs. 3.14 –3.18 depict the sampling locations within each SWMU. Boring logs used for the lithologic interpretation and cross-section construction are located in Appendix E. The geology at WAG 28 has been determined based on information obtained during the WAG 28 RI and on existing borings and monitoring well logs from previous studies. A total of 26 borings were advanced within SWMU 99. These borings were primarily shallow DPT holes pushed to a maximum depth of 60 ft. SWMU 193, the largest unit, had 22 locations sampled by DPT, CPT, or DWRC. There were 10 locations in the western region of SWMU 193, 5 in the northern, and 7 in the southern. At AOC 204, four borings were to the following depths: 60 ft (HSA 204-028), 160 ft (SB204-029), 80 ft (HSA 204-030), and 110 ft (SB204-031). Boring SB204-031 was drilled into the upper RGA. There were no DPT or CPT sampling/advances completed in AOC 204. SWMU 194 had four DPT soil sampling locations (DPT194-008 through -011) and no others. Each was advanced to a maximum depth of 30 ft.

3.6.1.1 Bedrock

The entire PGDP area is underlain by Mississippian carbonates. The bedrock consists of dark gray limestone with some interbedded chert and shale. Regionally the Mississippi strata dips gently to the south. Bedrock was not encountered during the WAG 28 RI.

3.6.1.2 Rubble Zone

The rubble zone consists of angular to subangular chert and silicified limestone fragments (Olive 1980). Prior to deposition of the Upper Cretaceous sediments, a long period of weathering occurred. During this time, erosion removed strata of the Upper Mississippian System (bedrock) and the Pennsylvanian System. Permian through Early Cretaceous age strata are absent from the area due to non-deposition. Remnants of this weathering form the rubble zone. The rubble zone was not encountered during the WAG 28 RI.

3.6.1.3 McNairy Formation

In the Late Cretaceous, a sea encroached northward, leading to deposition of the McNairy Formation (Clausen et al. 1992a). In the southeastern part of the Jackson Purchase Region, the McNairy Formation consists of mostly sand. Farther north, including PGDP, the McNairy Formation consists of light gray to dark gray clay with lenses of fine to coarse sand that weathers to moderate yellow to reddish-brown. It is interbedded with varying amounts of gravel and dark gray silt. The middle portion of the McNairy is tentatively correlated to the Levings Member of Illinois. It is described as a lignitic silt in Illinois but as a series of silty, clayey sands extending from 135 to 270 ft bgs in Kentucky. It serves as an aquitard in the middle of the McNairy Formation, separating the upper and lower units.

The Clayton Formation is Paleocene in age but is difficult to differentiate from the underlying McNairy Formation. The two formations are discussed as one geologic unit (the McNairy Formation) in this report because of the lithologic similarity and uncertainty associated with placement of the contact.

The Upper Cretaceous McNairy Formation was the oldest unit investigated during the WAG 28 RI. Borings in SWMUs 99 and 193 and AOC 204 encountered the McNairy Formation. At each location, the boring was terminated after water samples were collected within the McNairy. The top of the McNairy Formation ranges between 320 ft msl at SWMU 193 to 280 ft msl at SWMU 99. The top of the McNairy Formation gradually increases from east to west. Local elevation differences at the top of the McNairy can be attributed to differential erosion caused by streams that flowed over this unconformable surface during Pleistocene glacial episodes (Clausen et al. 1992b).

The dominant lithology of the McNairy Formation is a dark gray to bluish-gray, micaceous, often pyritic or lignitic clay with interbedded silt and fine- to medium-grained sand. In several borings, a silty sand facies of the McNairy was encountered immediately below RGA. At other locations, the sand content in the McNairy was observed to increase with depth.

3.6.1.4 Porters Creek Clay, Porters Creek Terrace, and Eocene Sands

The Porters Creek Clay consists of dark gray to black clay with varying amounts of silt and fine-grained, micaceous, glauconitic sand. This is indicative of marine and brackish-water sediments deposited in a sea that occupied most of the Mississippi Embayment (Olive 1980). Eocene sediments consisting of interbedded and interlensing sand, silt, and clay overlie the Porters Creek Clay in the southern portion of the DOE property. Abrupt change from fine-grained deposition of the Porters Creek Clay to coarser-grained sedimentation during the Eocene probably resulted from regional uplift.

Post-Eocene erosion into the Paleocene Porters Creek Clay resulted in an important feature known as the Porters Creek Terrace. The terrace lies immediately south, southeast, and southwest of PGDP, and it slopes northward toward the southern boundary of the PGDP fenced security area. Regionally, the Porters Creek Terrace is hydrogeologically important because it marks the southern extent of the Lower Continental Deposits (LCDs) and therefore the southern extent of RGA. It also serves as the aquitard below RGA where RGA laps onto the terrace slope

3.6.1.5 Continental Deposits

Pleistocene Continental Deposits unconformably overlie the Cretaceous through Eocene strata throughout the area. Ancestral rivers bordered the Jackson Purchase Region in approximately the same position as the present Tennessee, Ohio, and Mississippi Rivers. Increased flow in the ancestral Tennessee River, combined with large sediment loads, resulted in the formation of an alluvial fan in the area of the confluence of the Ohio and Tennessee Rivers (Olive 1980). The Continental Deposits resemble a large low-gradient alluvial fan that covered much of the region and eventually buried the erosional topography.

Erosion and reworking of alluvial fan deposits have resulted in the present thickness and distribution of the Continental Deposits. The thicker sequences of Continental Deposits represent valley fill deposits and can be informally divided into a lower unit (gravel facies) and an upper unit (clay facies). The two distinct facies are as follows:

- **Lower Continental Deposits.** The LCD are found throughout the plant area and to the north, but pinch out to the south, southeast, and southwest along the slope of the Porters Creek Terrace. The LCD are gravel facies consisting of chert gravel in a matrix of poorly sorted sand and silt that rests on an erosional surface representing the beginning of the valley fill sequence. The LCD was deposited on an irregular east-west trending erosional surface exhibiting steps or terraces. Alluvial terraces are former floodplains corresponding to different glacial events. The gravel deposit averages approximately 30 ft thick, but some thicker deposits (as much as 50 ft) are found in deeper scour channels.

  The Pleistocene age LCD is a prominent fluvial gravel facies beneath PGDP and is considered to be the lower part of RGA. These coarser-grained sediments unconformably overlie the finer-grained Cretaceous McNairy Formation as a Pleistocene erosional surface. The top of this erosional surface rises to the east and south of PGDP. LCD is primarily distinguished from the overlying Upper Continental Deposits (UCD) by a coarser grain size.

  The dominant lithology of LCD is a poorly sorted, brownish-yellow to strong brown (Munsel Color Chart—Kollmargen 1994) chert gravel with occasional sand and silt. Immediately above the gravel facies, a fine- to medium-grained pale yellow to brownish-yellow silty sand was present over most of the investigative area. This sand was encountered at a depth of 60–80 ft beneath SWMUs 99 and 193 and AOC 204 and is approximately 10–15 ft thick. The sand thins towards the southeast and is absent in SWMU 194. Due to the complex nature of the depositional environment in which the LCD and UCD were deposited, the contact separating the two is locally gradational. This makes it more difficult to determine the units' boundaries and thicknesses.

  The top of the gravel facies often mirrors the top of the lower McNairy Formation as it was deposited above an unconformable surface. The gravel facies outcrops between 280 ft msl at SWMU 99 and 320 ft msl in southern portions of SWMU 193. The LCD thickness was observed to vary significantly between sites. On the western side of SWMU 193, LCD was between 70 and 80 ft thick.

In the area of SWMU 193, SWMU 194, and AOC 204, the LCD is known to pinch out against the Porters Creek Terrace Slope.

- **Upper Continental Deposits.** The UCD are primarily a fine-grained, clastic facies varying in thickness from 15 to 55 ft that consist of clayey silt with lenses of sand and occasional gravel. The UCD represent sediments deposited in a fluvial and lacustrine environment (Finch 1967, Frye et al. 1972). Widespread lacustrine sedimentation occurred along the present Ohio River and Tennessee River valleys when they became choked from draining glaciated areas. The sediment dammed valleys of tributaries, creating slackwater lakes that resulted in deposition of fine-grained sediments of the UCD. Depending on stages of glaciation, periods of lacustrine deposition were followed by periods of erosion. As aggradation of the fluvial system continued, stream gradients in the ancestral Tennessee River and tributaries lessened. Lower gradients likely favored a transition from a braided environment to a meandering environment. A very gravelly lower sequence becoming sandier upwards identifies the transition in the subsurface.

  The UCD primarily consists of fine-grained valley-fill deposits that are differentiated from the underlying LCD by grain size. The UCD represents a sequence of interbedded clay, silt, sand, and gravel as shown in the cross sections for the various SWMUs. The layers of clay, silt, sand, and gravel were seen to grade laterally into adjacent units throughout the UCD.

  The UCD is comprised of three zones. The uppermost zone consists of silty clay to clayey silt to a depth of 15–20 ft in the north. At AOC 204, this zone thickens to approximately 40 ft. The middle zone consists of poorly sorted, dark yellowish-brown to yellow-brown silty sands and gravels that are interbedded with silts and clays. The middle zone differs from the upper zone by the presence of sand/gravel lenses and an increase in silt content. These coarser-grained sediments are prevalent between 20 and 40 ft bgs.

  In the basal soils of the UCD, the clay content increases significantly so that the dominant lithology is a silty clay with minor occurrences of lenticular sand and gravels. This silts/clay unit acts as a semi-confining layer above the RGA. The contact between the middle and lower zones is dominantly gradational, but it can be locally sharp. The lower zone is present to the east and south of PGDP and consists of approximately 10 ft of yellowish-grayish brown silty clay with minor sand content. All the UCD units rise and thin as they approach the Porters Creek terrace to the south.

3.6.1.6 Surface soil, loess, and fill

The surface deposits found in the vicinity of PGDP are Pleistocene to recent in age and consist of loess and alluvium. Both units are composed of clayey silt or silty clay and range in color from yellowish-brown to brownish-gray or tan, making field differentiation difficult.

The eolian loess deposits overlie the UCD throughout the PGDP area. Only the most recent (Illinoisan- and Wisconsinan-aged) deposits are represented in the sedimentary sequence.

Loess deposits overlie UCDs throughout the WAG 28 area. Loess was encountered in all borings from the surface (below the construction fill material) to a depth of 5–10 ft. The developed areas had fill material comprised of a crushed stone with silts, sands, and clay up to a depth of 5 ft. The loess predominantly consists of clayey silt and silty clay with occasional traces of fine sand and gravel.

As discussed in Sect. 3.3, the predominant soil association in the vicinity of PGDP is the Calloway-Henry association (USDA 1976). The fragipan subsurface horizon within this soil is a densified silty or loamy layer, which may be cemented by amorphous material. Excavation and construction activities at PGDP over the past 45 years have reduced the continuity of the fragipan layer and increased vertical drainage throughout the plant area (CH2M Hill 1992).

3.7 HYDROGEOLOGY

3.7.1 Surface Water

Information presented herein regarding the surface water setting at PGDP was derived from *Results of the Site Investigation, Phase II, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992). PGDP is located in the western portion of the Ohio River drainage basin. The plant is within the drainage areas of Bayou Creek and Little Bayou Creek and is situated on the divide between the two creeks (Fig. 3.19).

Bayou Creek is a perennial stream with drainage area of approximately 18.6 square miles that flows generally northward from approximately 2.5 miles south of the plant site to the Ohio River and extends along the western boundary of the plant. Little Bayou Creek, also a perennial stream, originates within WKWMA, flows northward to the Ohio River, and extends along the eastern boundary of the plant. The approximate drainage area of Little Bayou Creek is 8.5 square miles (CH2M Hill 1992). The confluence of the two creeks is approximately 3 miles north of the plant site, just upstream of the location at which the creeks discharge into the Ohio River. The drainage areas for both creeks are generally rural; however, they receive surface drainage from numerous swales that drain residential and commercial properties, including WKWMA, PGDP, and the TVA Shawnee Steam Plant. A major portion of the flow in both creeks north of PGDP is effluent water from the plant, discharged through KPDES-permitted outfalls.

Man-made drainages receive stormwater and effluent from PGDP. The plant monitors 17 outfalls, which have a combined average daily flow of approximately 4.9 million gallons per day (mgd) (Clausen et al. 1992b). Water flow in these ditches is intermittent based on seasonal rainfall. The plant ditches are generally considered to be located in areas where the local groundwater table is below the bottoms of the ditch channels. Therefore, the ditches probably function as influent (losing) streams most of the time, resulting in some discharge to the subsurface.

Surface water bodies in the vicinity of PGDP include the Ohio River, Metropolis Lake (located east of the Shawnee Steam Plant), and small ponds, clay and gravel pits, and settling basins scattered throughout the area. There is 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.

3.7.2 Groundwater

The Jackson Purchase Region is characterized by several hundred feet of unconsolidated Cretaceous through Holocene sediments deposited on an erosionally truncated Paleozoic surface. The local groundwater flow system in the vicinity of PGDP exists primarily within unconsolidated sediments. Information presented herein regarding the groundwater setting at PGDP was derived from the *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III* (Clausen et al. 1992a). The regional hydrogeology discussion is intended to provide a general overview of the groundwater flow regime for PGDP.

The regional groundwater flow system occurs within the Mississippian Bedrock, Cretaceous McNairy Formation, Eocene Sands, Pliocene Terrace Gravel, Pleistocene LCD, and UCD. Terms used to describe the hydrogeologic flow system are the McNairy Flow System, Eocene Sands, Pliocene Terrace

Gravel, RGA, and UCRS. Specific components have been identified for the regional groundwater flow system and are defined in the following paragraphs.

3.7.2.1 Paleozoic bedrock aquifer

Limestone, believed to be the Mississippian-aged Warsaw Limestone, subcrops beneath PGDP. Groundwater production from the bedrock aquifers comes from fissures and fractures and from the weathered rubble zone near the top of the bedrock. The bedrock aquifer was not encountered during the WAG 28 RI.

3.7.2.2 McNairy flow system

Formerly termed the "deep groundwater system," this component consists of the interbedded and interlensing sand, silt, and clay of the Cretaceous McNairy Formation. Regionally, the sand in the McNairy Formation is an excellent aquifer in the southeastern part of the Jackson Purchase Region. The McNairy Formation grades from mostly sand in those areas to containing significant amounts of silt and clay near PGDP (Clausen et al. 1992b). Regionally, the McNairy recharges along areas of outcrop in the eastern part of the region, near Kentucky Lake and Lake Barkley (Davis et al. 1973). Water movement is north and northwest toward discharge areas in Missouri and along the Ohio River.

The McNairy Formation subcrops beneath the plant at depths ranging from approximately 70 to 100 ft. Sand facies account for 40–50 percent of the total formation thickness of approximately 225 ft. In areas where the RGA overlies the McNairy Flow System and where the RGA is in direct hydraulic connection with coarser-grained sediments of the McNairy Formation, the McNairy flow is coincident with that of the RGA. The presence of McNairy Formation sands immediately below RGA would promote potential downward flow of groundwater. Because the sands below RGA are of limited extent, substantial downward flow of groundwater does not occur. Groundwater flow in the McNairy is considered coincidental with the RGA having a lateral component to the north-northwest.

Clay is the dominant lithology of the upper McNairy Formation in the WAG 28 area. Laboratory geotechnical analysis from the WAG 6 RI indicates an average hydraulic conductivity of the McNairy Flow System of 2.9E-4 cm/s. Comparison of the hydraulic conductivity measurements taken from nearby SWMUs for the RI of WAG 27 (DOE 1999) also demonstrates similar findings with the clay lithology of the McNairy being much less permeable than the coarser sediments of RGA.

Davis et al. (1973) reported values of hydraulic conductivity for the McNairy Flow System ranging from 1.4×10^{-8} to 4.7×10^{-2} cm/s. During the WAG 6 RI, values of hydraulic conductivity were measured from 8.2×10^{-8} to 1.1×10^{-3} cm/s (DOE 1999). The range of five orders of magnitude difference is due to depositional heterogeneity within the McNairy Formation.

3.7.2.3 Pliocene Terrace Gravel and Eocene Sands

Pliocene-aged gravel deposits and Eocene-aged reworked sand and gravel locally overlie the Paleocene Porters Creek Clay in the southern portion of PGDP. Pliocene Terrace Gravel or Eocene Sands may have been encountered in borings installed at SWMU 194.

3.7.2.4 Regional Gravel Aquifer

RGA consists of the gravel facies of the LCD. RGA is the most prominent gravel facies beneath PGDP and is the primary local aquifer. RGA consists of a Pleistocene gravel deposit overlying an erosional surface. RGA is found throughout the plant area and to the north, but pinches out to the south, southeast, and southwest along the slope of the Porters Creek Terrace.

RGA is the dominant aquifer within the local flow system. Figure 3.20 shows the components of the flow system in the vicinity of PGDP (Davis et al. 1973). Toward the southern part of PGDP, RGA terminates against the Porters Creek Terrace. The restriction results in a high gradient and probably causes groundwater discharge to adjoining streams. In the north-central portion of the plant site, the lower gradients are a result of the thickened Pleistocene sequence containing higher fractions of coarse sand and gravel. Northward, near the Ohio River, the hydraulic gradient increases as a result of either a thinner section of RGA or low-permeability bottom sediments in the Ohio River.

Regional groundwater flow within RGA trends north-northeast toward base level represented by the Ohio River. The hydraulic gradient varies spatially but is on the order of 1.0×10^{-4} to 1.0×10^{-3} ft/ft (Clausen et al. 1992a). Clausen et al. (1992a) reports hydraulic conductivities for RGA ranging from 1.0×10^{-4} to 1 cm/s. During the WAG 6 RI, values of hydraulic conductivity were measured from 1.8×10^{-7} to 9.4 cm/s (DOE 1999). The range of eight orders of magnitude is due to depositional heterogeneities within the silt, sand, and gravel of the RGA.

In the WAG 28 investigation area, sand constitutes up to 30 percent of RGA lithology in discontinuous lens at various intervals and impedes groundwater flow where encountered. RGA is recharged by infiltration from UCRS and some underflow from the terrace gravels that are in the southern portion of WAG 28 (SWMUs 193 and 194).

3.7.2.5 Upper Continental Recharge System

UCRS consists of the surface loess and UCD. The UCRS consists of clayey silt with lenses of sand and occasional gravel. The UCRS has been divided into three general horizons:

- Hydrologic Unit 1 (HU1)—loess and alluvium,
- HU2—an intervening sand and gravel interval, and
- HU3—a lower silt and clay interval.

These horizons are highly subjective, but each exhibits clear features that stand out throughout the investigation area. "UCRS" generally refers to the sand and gravel lithofacies of HU2, but also the silty clays of HU3 that confine the uppermost water-saturated units. The HU2 permeable units are only seasonally saturated and may be considered perched groundwater aquifers. UCRS groundwater flows downward into RGA, hence the term "recharge system."

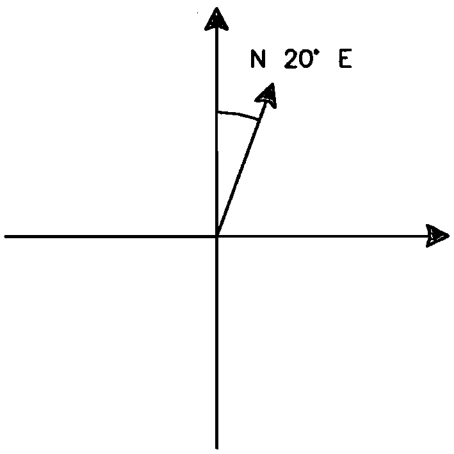
Strong vertical gradients exist between UCRS and RGA, which display hydraulic head differences of as much as 30 ft. Head differences between RGA and UCRS indicate a primarily downward gradient from UCRS to RGA. Horizontal flow in UCRS may exist nearer to the Porters Creek Terrace and further south as HU3 increases in grain size to a sandy clay in the area of SWMU 194.

When the HU2 layer is saturated, historical data show that hydraulic conductivity values range from 3.7×10^{-6} to 3.97×10^{-5} cm and storage coefficients range from 7.43×10^{-3} to 5.9×10^{-2} (DOE 1999). As discussed previously, this lower clay unit serves as an aquitard. Perched groundwater has been measured to 20 ft bgs.

Regionally, the UCRS thickness ranges from 0 ft to 50 ft. In a study by Clausen et al. (1992b), UCRS hydraulic conductivity values ranged from 1×10^{-8} to 1×10^{-2} cm/s. During the WAG 6 RI, values of hydraulic conductivity ranged from 3.2 to 1.7×10^{-8} cm/s (DOE 1999).

DOE/OR/07-1846/D2 & V1

PARAMETER	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	YEAR AVG.
RESULT. SPEED (MPH)	1.2	2.7	1.9	3.0	3.8	2.0	0.9	0.6	0.6	1.3	0.7	1.4	1.0
RES. DIR. (TENS OF DEGS.)	27	27	32	23	20	22	34	35	06	26	07	25	25
MEAN SPEED (MPH)	9.8	9.3	8.9	9.6	7.7	5.4	4.9	3.8	4.5	6.0	7.5	7.9	7.1
PREVAIL. DIR. (TENS OF DEGS.)	20	20	32	20	20	20	21	03	23	20	02	21	20



PREVAILING WIND DIRECTION

T N & Associates, Inc.
Engineering and Science

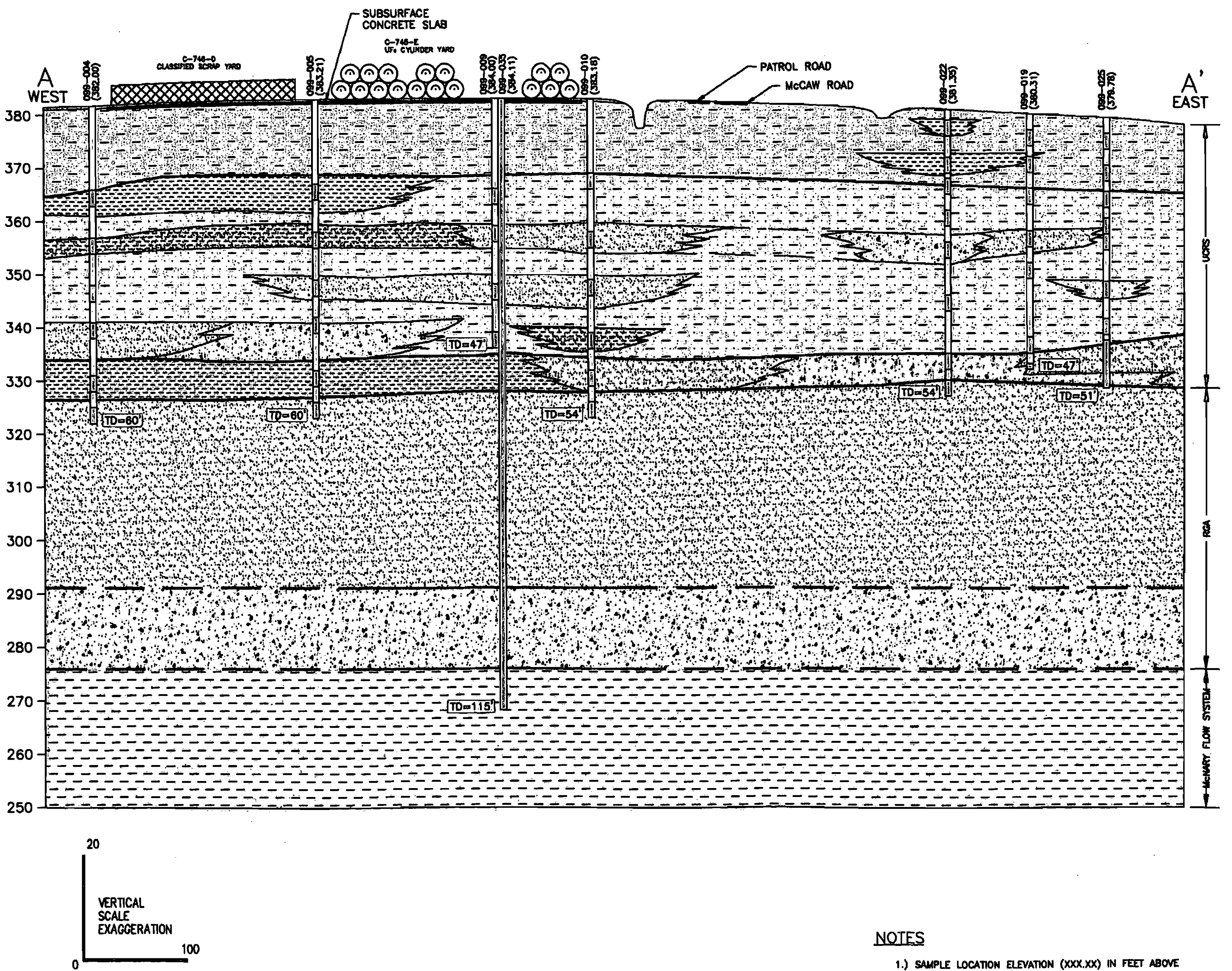
CDM FEDERAL PROGRAMS CORP.

PADUCAH GASEOUS
DIFFUSION PLANT

Wind Speed and Direction
Monthly and Cumulative Averages
Berkley Regional airport

Figure 3.1 August, 2000

AutoCAD File: 19990006-8310-A-0040.dwg



NOTES

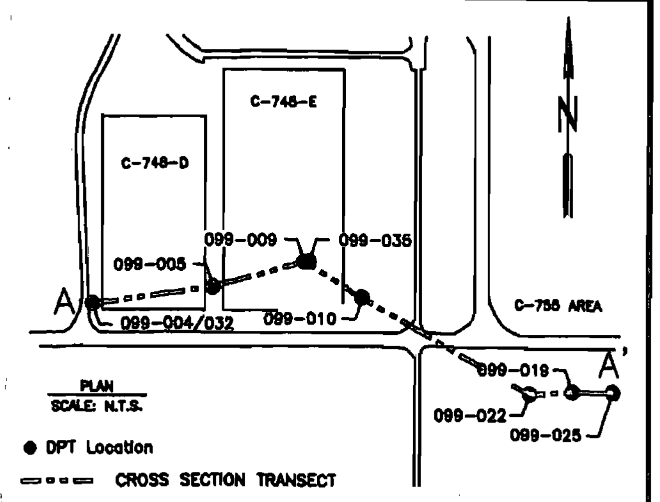
1.) SAMPLE LOCATION ELEVATION (XXX.XX) IN FEET ABOVE MEAN SEA LEVEL (MSL)

LITHOLOGIC UNITS

- ▨ .... FILL MATERIAL CONSISTING OF CRUSHED STONE WITH SAND AND CLAY MIXTURE.
- .... SILTY CLAYS AND CLAYEY SILTS
- .... CLAY TO SILTY CLAY
- .... SAND TO SILTY SAND, FINE TO MEDIUM GRAINSIZE. SUB-ROUNDED TO SUB-ANGULAR.
- .... GRAVEL, >2MM TO 2" FRAGMENTS, SUB-ROUNDED TO SUB-ANGULAR.

HYDRAULIC UNITS

- .... CONSTRUCTION FILL OR SURFICIAL LOESS
- .... HU1 – THE UPPER FLUVIAL/ALLUVIAL SILTY CLAYS RUST BROWN TO GREY BROWN; PLEISTOCENE AGE.
- .... HU2 – LOESS, CLAYEY SILTY SAND TO SANDY SILT, SAND LENSES ARE DISCONTINUOUS BUT CORRELATABLE, RUST BROWN TO YELLOW BROWN; PLEISTOCENE AGE.
- .... HU3 – CLAY TO SILTY CLAY, VERY IMPERMEABLE CLAY THAT ACTS AS A SEMICONFINING TO CONFINING LAYER, PRIMARY CONSTITUENT OF THE UPPER CONTINENTAL DEPOSITS; LOWER PLEISTOCENE AGE.
- .... HU4 – SAND WITH GRAVEL AND SILT, CONSIDERED THE UPPER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.
- .... HU5 – GRAVEL WITH SAND AND SILT, CONSIDERED THE LOWER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.
- .... MCNAIRY FORMATION – GREYISH WHITE TO DARK MICACEOUS CLAY, OFTEN SILTY, INTERBEDDED WITH LIGHT GREY TO YELLOW-BROWN VERY FINE SAND. CRETACEOUS AGE.
- .... SOIL BORING SAMPLE INTERVAL



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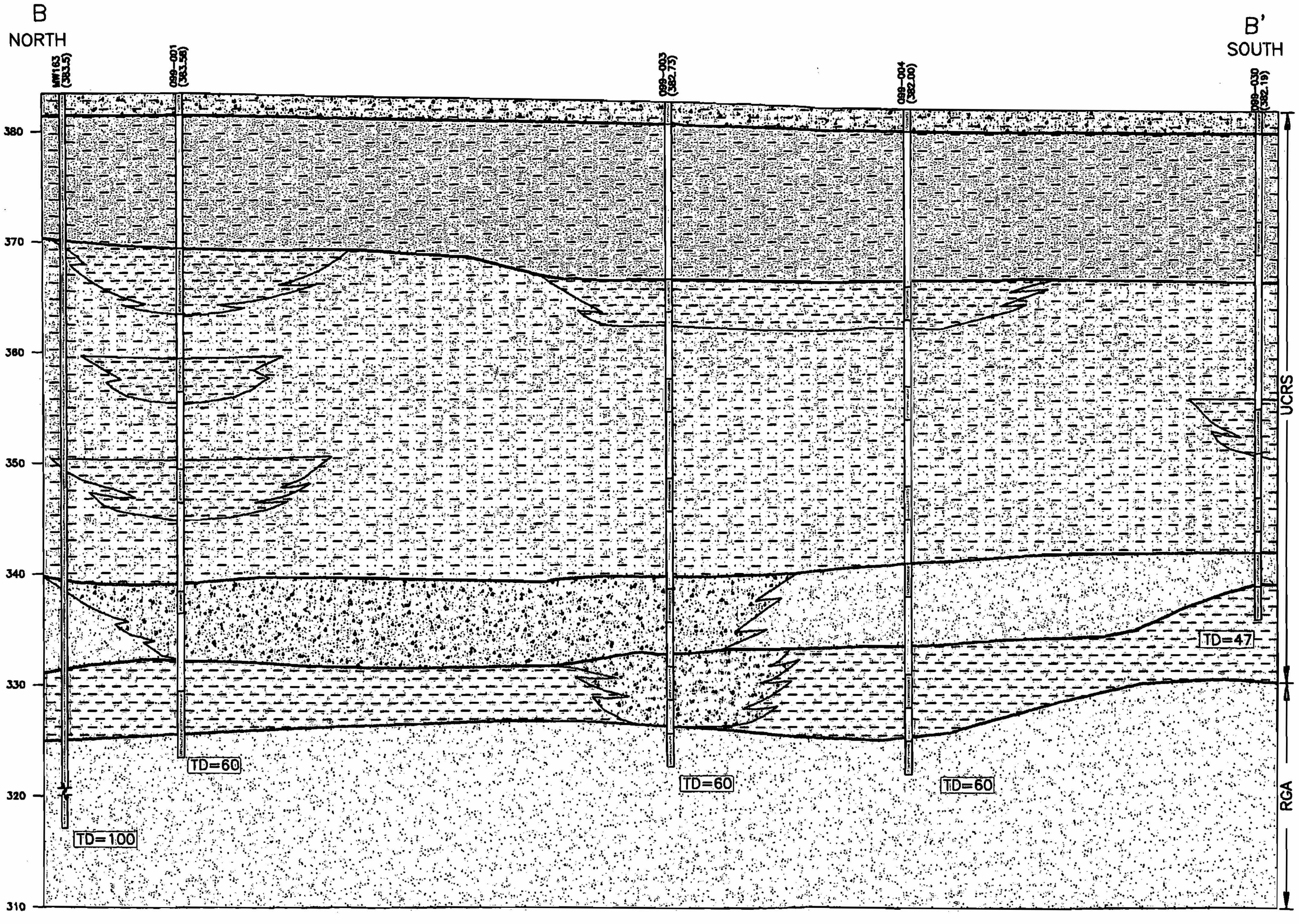
PADUCAH GASEOUS DIFFUSION PLANT

WAG 28 – SWMU 99
LITHOLOGIC CROSS-SECTION A-A'

Figure 3.2 August, 2000

AutoCAD File: 1999006-8310-B-0011.DWG



LITHOLOGIC UNITS

▨ ······· FILL MATERIAL CONSISTING OF CRUSHED STONE WITH SAND AND CLAY MIXTURE.

▨ ······· SILTY CLAYS AND CLAYEY SILTS

▨ ······· CLAY TO SILTY CLAY

▨ ······· SAND TO SILTY SAND, FINE TO MEDIUM GRAINSIZE, SUB-ROUNDED TO SUB-ANGULAR.

▨ ······· GRAVEL, >2MM TO 2" FRAGMENTS, SUB-ROUNDED TO SUB-ANGULAR.

HYDRAULIC UNITS

▨ ······· CONSTRUCTION FILL OR SURFICIAL LOESS

▨ ······· HU1 – THE UPPER FLUVIAL/ALLUVIAL SILTY CLAYS RUST BROWN TO GREY BROWN; PLEISTOCENE AGE.

▨ ······· HU2 – LOESS, CLAYEY SILTY SAND TO SANDY SILT, SAND LENSES ARE DISCONTINUOUS BUT CORRELATABLE, RUST BROWN TO YELLOW BROWN; PLEISTOCENE AGE.

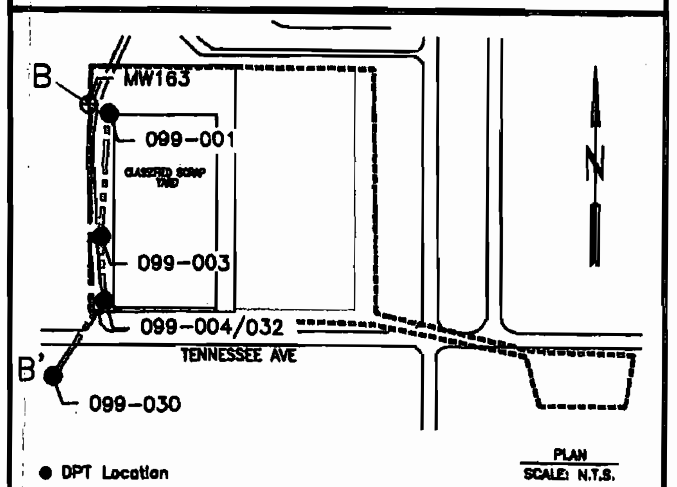
▨ ······· HU3 – CLAY TO SILTY CLAY, VERY IMPERMEABLE CLAY THAT ACTS AS A SEMICONFINING TO CONFINING LAYER, PRIMARY CONSTITUENT OF THE UPPER CONTINENTAL DEPOSITS; LOWER PLEISTOCENE AGE.

▨ ······· HU4 – SAND WITH GRAVEL AND SILT, CONSIDERED THE UPPER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.

▨ ······· HU5 – GRAVEL WITH SAND AND SILT, CONSIDERED THE LOWER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.

▨ ······· MCNAIRY FORMATION – GREYISH WHITE TO DARK MICACEOUS CLAY, OFTEN SILTY, INTERBEDDED WITH LIGHT GREY TO YELLOW-BROWN VERY FINE SAND. CRETACEOUS AGE.

▯ ······· SOIL BORING SAMPLE INTERVAL



● DPT Location
⊕ MONITORING WELL

PLAN
SCALE: N.T.S.

▬ ▪ ▪ ▬ ······· CROSS SECTION TRANSECT

NOTES

1.) SAMPLE LOCATION ELEVATION (XXX.XX) IN FEET ABOVE MEAN SEA LEVEL (MSL)

2.) MW 163 TOTAL DEPTH IS 100 FT BGS, BECAUSE OF DRAWING CONSTRAINTS AND WANTING TO SHOW THE GREATEST DETAIL THIS BORING HAS BEEN TRUNCATED.

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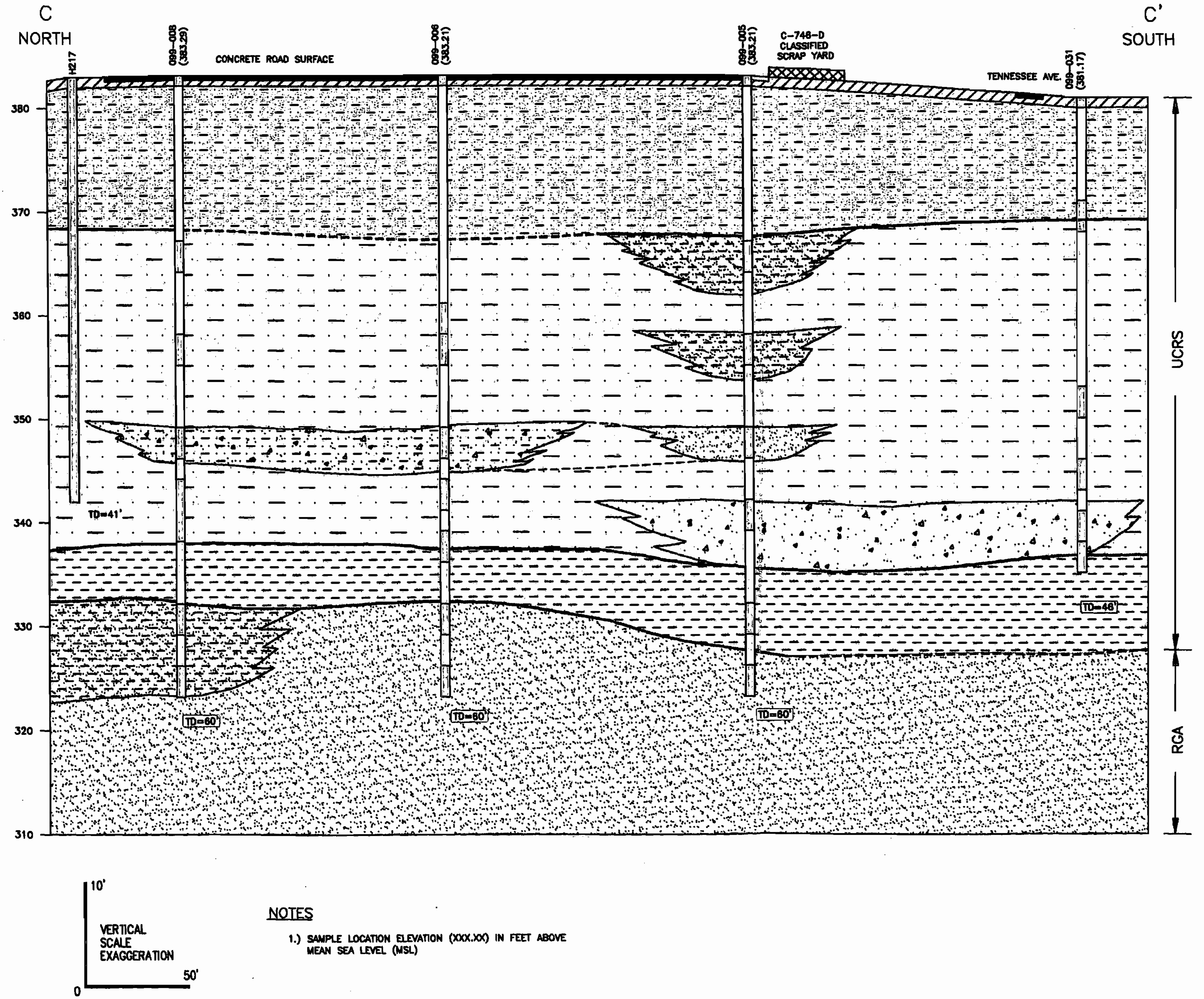
PADUCAH GASEOUS
DIFFUSION PLANT

WAG 28 – SWMU 99
LITHOLOGIC CROSS-SECTION B-B'

Figure 3.3 August, 2000

AutoCAD File: 1999006-8310-B-0012.DWG



NOTES

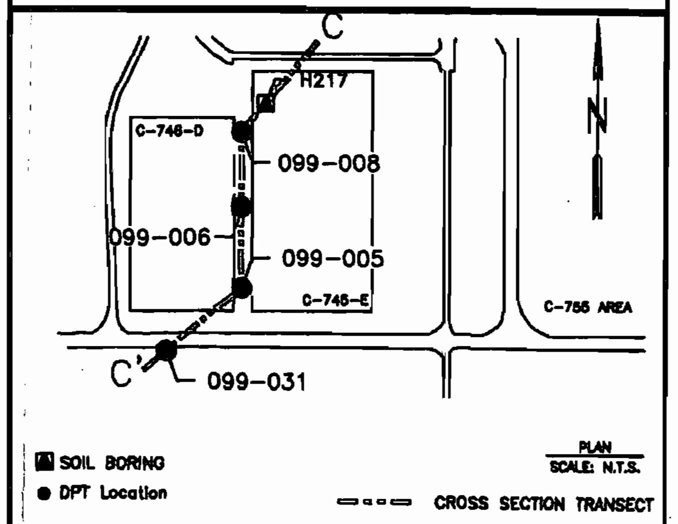
1.) SAMPLE LOCATION ELEVATION (XXX.XX) IN FEET ABOVE MEAN SEA LEVEL (MSL)

LITHOLOGIC UNITS

▨ ······· FILL MATERIAL CONSISTING OF CRUSHED STONE WITH SAND AND CLAY MIXTURE.
▤ ······· SILTY CLAYS AND CLAYEY SILTS
▤ ······· CLAY TO SILTY CLAY
▩ ······· SAND TO SILTY SAND, FINE TO MEDIUM GRAINSIZE, SUB-ROUNDED TO SUB-ANGULAR.
▩ ······· GRAVEL, >2MM TO 2" FRAGMENTS, SUB-ROUNDED TO SUB-ANGULAR.

HYDRAULIC UNITS

☐ ······· CONSTRUCTION FILL OR SURFICIAL LOESS
☐ ······· HU1 – THE UPPER FLUVIAL/ALLUVIAL SILTY CLAYS RUST BROWN TO GREY BROWN; PLEISTOCENE AGE.
☐ ······· HU2 – LOESS, CLAYEY SILTY SAND TO SANDY SILT, SAND LENSES ARE DISCONTINUOUS BUT CORRELATABLE, RUST BROWN TO YELLOW BROWN; PLEISTOCENE AGE.
☐ ······· HU3 – CLAY TO SILTY CLAY, VERY IMPERMEABLE CLAY THAT ACTS AS A SEMICONFINING TO CONFINING LAYER, PRIMARY CONSTITUENT OF THE UPPER CONTINENTAL DEPOSITS; LOWER PLEISTOCENE AGE.
☐ ······· HU4 – SAND WITH GRAVEL AND SILT, CONSIDERED THE UPPER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.
☐ ······· HU5 – GRAVEL WITH SAND AND SILT, CONSIDERED THE LOWER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.
▯ ······· SOIL BORING SAMPLE INTERVAL



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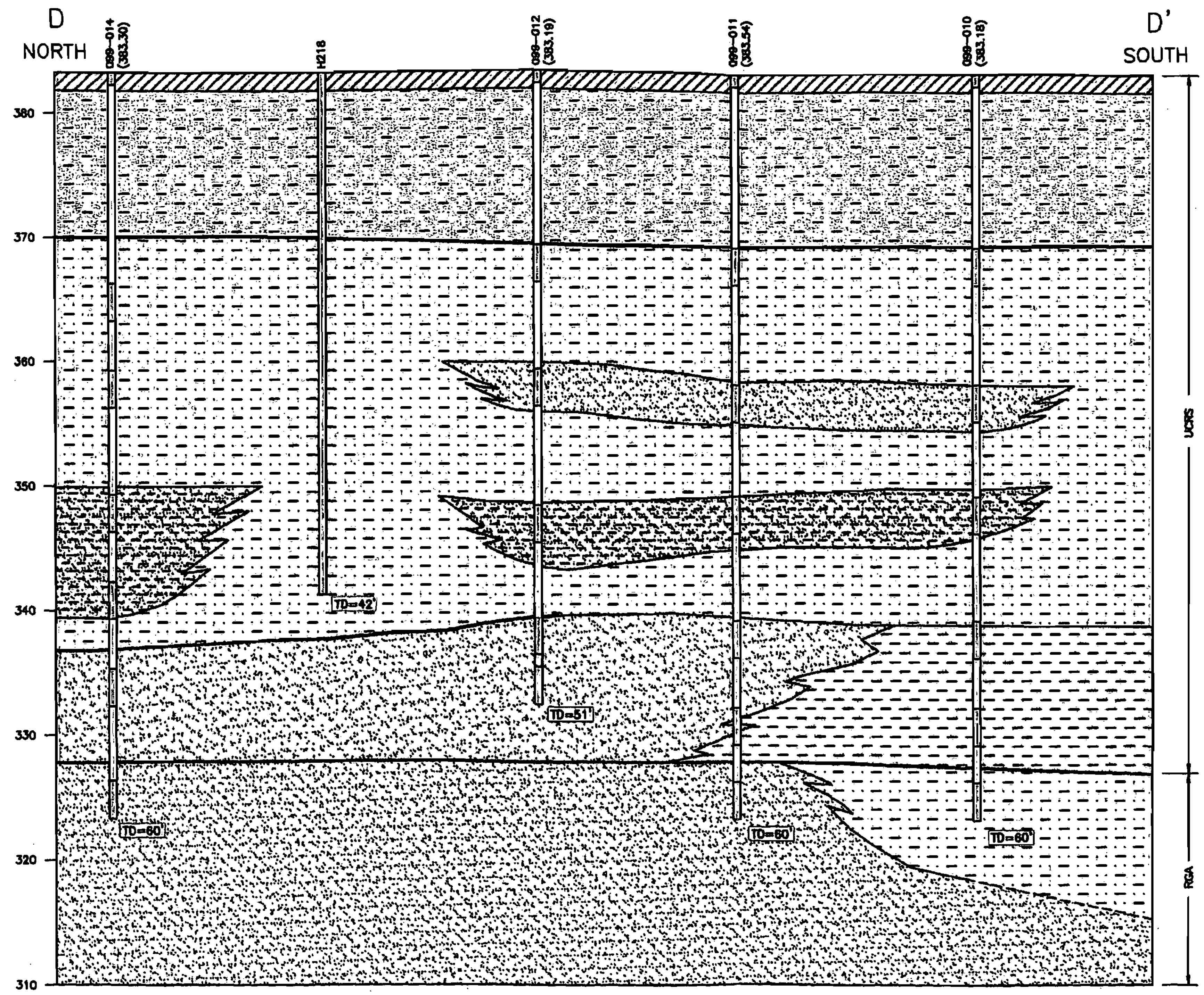
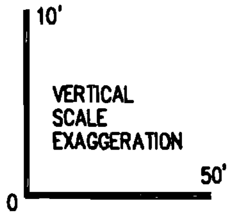
PADUCAH GASEOUS DIFFUSION PLANT

WAG 28 – SWMU 99
LITHOLOGIC CROSS-SECTION C-C'

Figure 3.4 August, 2000

AutoCAD File: 1999006-8310-B-0013.dwg



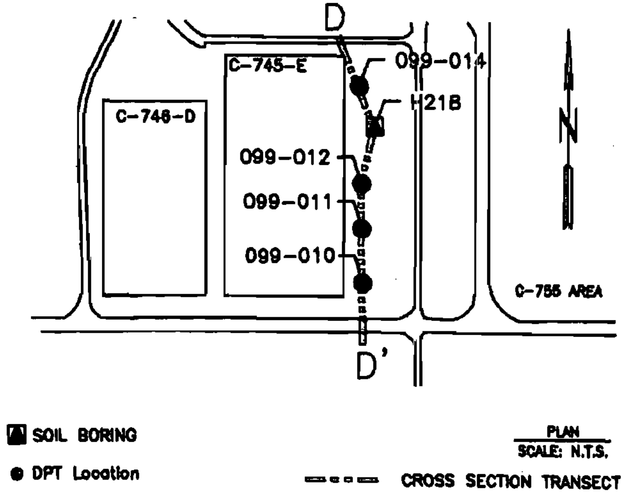


LITHOLOGIC UNITS

- ▨ .... FILL MATERIAL CONSISTING OF CRUSHED STONE WITH SAND AND CLAY MIXTURE.
- .... SILTY CLAYS AND CLAYEY SILTS
- .... CLAY TO SILTY CLAY
- .... SAND TO SILTY SAND, FINE TO MEDIUM GRAINSIZE, SUB-ROUNDED TO SUB-ANGULAR.
- .... GRAVEL, >2MM TO 2" FRAGMENTS, SUB-ROUNDED TO SUB-ANGULAR.

HYDRAULIC UNITS

- ☐ .... CONSTRUCTION FILL OR SURFICIAL LOESS
- .... HU1 – THE UPPER FLUVIAL/ALLUVIAL SILTY CLAYS RUST BROWN TO GREY BROWN; PLEISTOCENE AGE.
- .... HU2 – LOESS, CLAYEY SILTY SAND TO SANDY SILT, SAND LENSES ARE DISCONTINUOUS BUT CORRELATABLE, RUST BROWN TO YELLOW BROWN; PLEISTOCENE AGE.
- ☐ .... HU3 – CLAY TO SILTY CLAY, VERY IMPERMEABLE CLAY THAT ACTS AS A SEMICONFINING TO CONFINING LAYER, PRIMARY CONSTITUENT OF THE UPPER CONTINENTAL DEPOSITS; LOWER PLEISTOCENE AGE.
- .... HU4 – SAND WITH GRAVEL AND SILT, CONSIDERED THE UPPER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.
- ☐ .... HU5 – GRAVEL WITH SAND AND SILT, CONSIDERED THE LOWER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.
- .... SOIL BORING SAMPLE INTERVAL



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PADUCAH GASEOUS
DIFFUSION PLANT

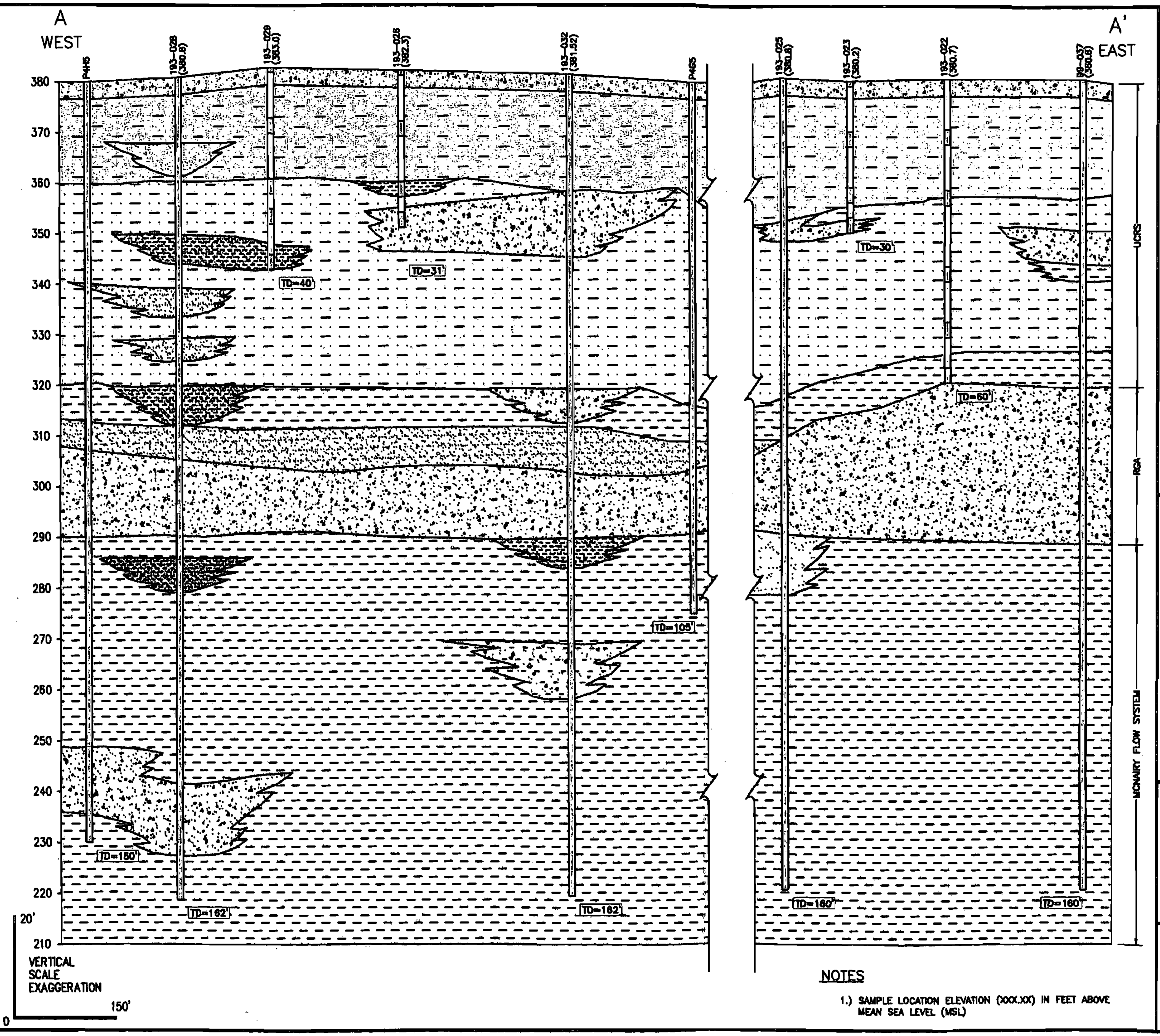
WAG 28 – SWMU 99
LITHOLOGIC CROSS SECTION D–D'

Figure 3.5 August, 2000

NOTES

1.) SAMPLE LOCATION ELEVATION (XXX.XX) IN FEET ABOVE MEAN SEA LEVEL (MSL)

AutoCAD File: 1999006-8310-B-0014.dwg

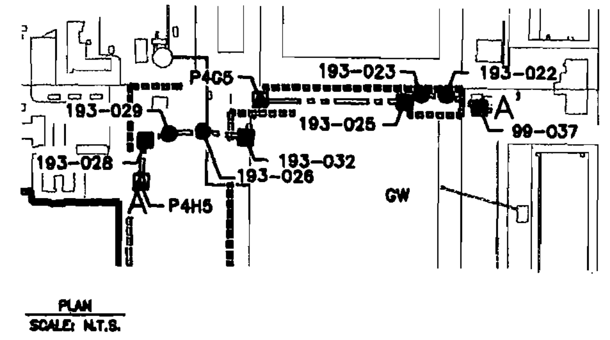


LITHOLOGIC UNITS

- ▨ .... FILL MATERIAL CONSISTING OF CRUSHED STONE WITH SAND AND CLAY MIXTURE.
- ☐ .... SILTY CLAYS AND CLAYEY SILTS
- ☐ .... CLAY TO SILTY CLAY
- ☐ .... SAND TO SILTY SAND, FINE TO MEDIUM GRAINSIZE, SUB-ROUNDED TO SUB-ANGULAR.
- ☐ .... GRAVEL, >2MM TO 2" FRAGMENTS, SUB-ROUNDED TO SUB-ANGULAR.

HYDRAULIC UNITS

- ☐ .... CONSTRUCTION FILL OR SURFICIAL LOESS
- ☐ .... HU1 – THE UPPER FLUVIAL/ALLUVIAL SILTY CLAYS RUST BROWN TO GREY BROWN; PLEISTOCENE AGE.
- ☐ .... HU2 – LOESS, CLAYEY SILTY SAND TO SANDY SILT, SAND LENSES ARE DISCONTINUOUS BUT CORRELATABLE, RUST BROWN TO YELLOW BROWN; PLEISTOCENE AGE.
- ☐ .... HU3 – CLAY TO SILTY CLAY, VERY IMPERMEABLE CLAY THAT ACTS AS A SEMICONFINING TO CONFINING LAYER, PRIMARY CONSTITUENT OF THE UPPER CONTINENTAL DEPOSITS; LOWER PLEISTOCENE AGE.
- ☐ .... HU4 – SAND WITH GRAVEL AND SILT, CONSIDERED THE UPPER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.
- ☐ .... HU5 – GRAVEL WITH SAND AND SILT, CONSIDERED THE LOWER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.
- ☐ .... SOIL BORING SAMPLE INTERVAL



PLAN
SCALE: N.T.S.

● DPT Location
– – – CROSS SECTION TRANSECT

NOTES

1.) SAMPLE LOCATION ELEVATION (XXX.XX) IN FEET ABOVE MEAN SEA LEVEL (MSL)

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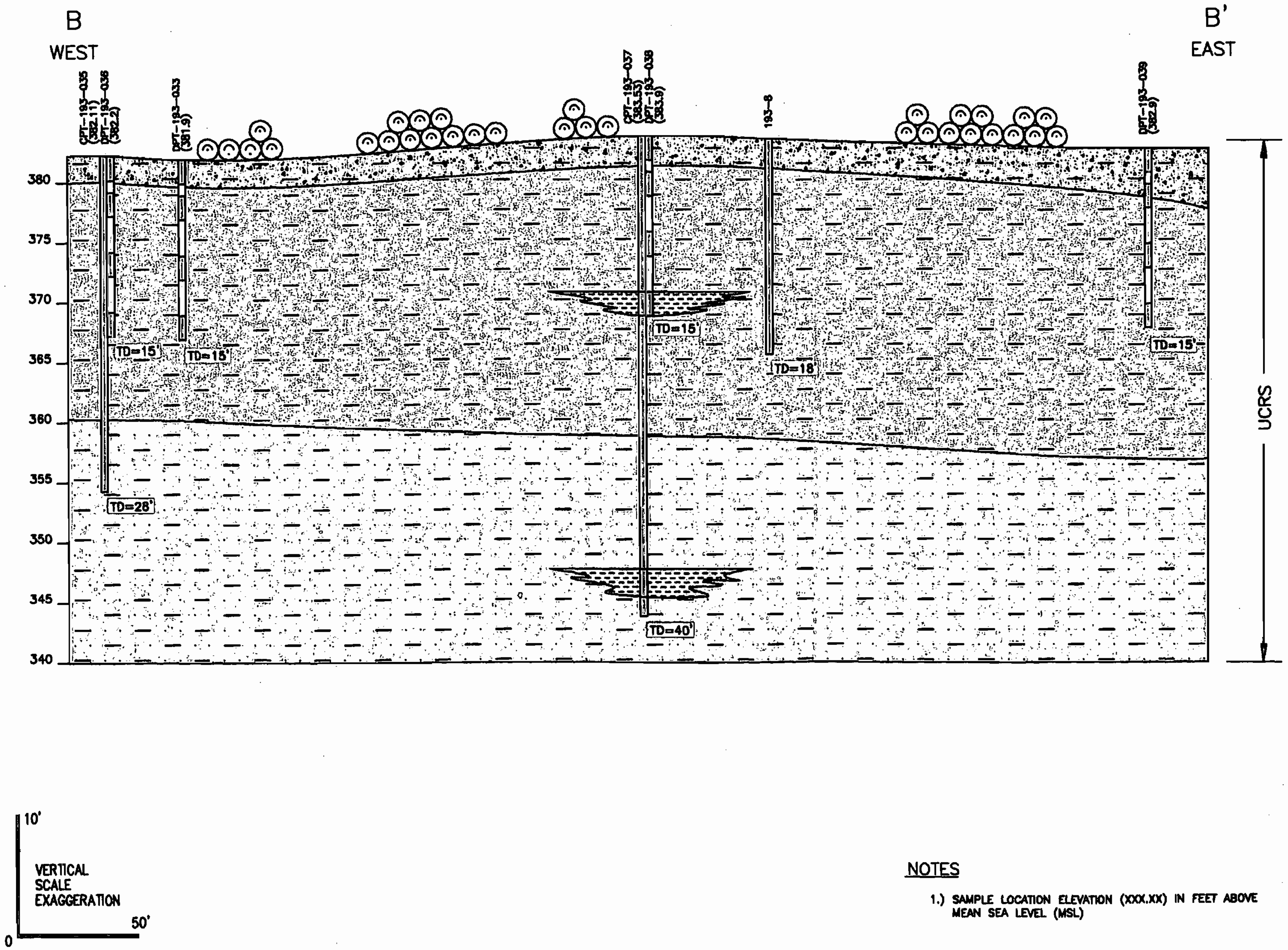
PADUCAH GASEOUS
DIFFUSION PLANT

WAG 28 – SWMU 193
LITHOLOGIC CROSS-SECTION A-A'

Figure 3.6 August, 2000

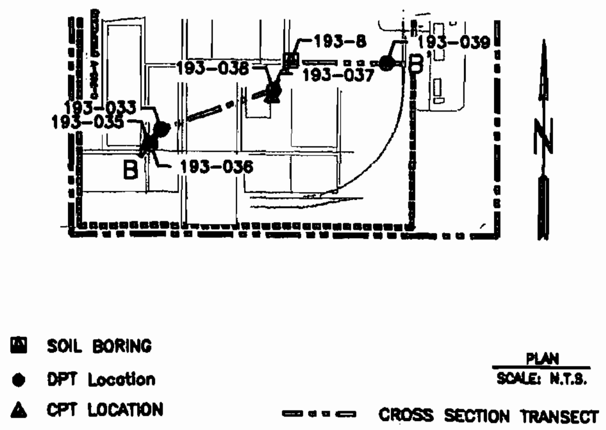


LITHOLOGIC UNITS

- ▨ .... FILL MATERIAL CONSISTING OF CRUSHED STONE WITH SAND AND CLAY MIXTURE.
- ▤ .... SILTY CLAYS AND CLAYEY SILTS
- ▤ .... CLAY TO SILTY CLAY
- ▒ .... SAND TO SILTY SAND, FINE TO MEDIUM GRAINSIZE, SUB-ROUNDED TO SUB-ANGULAR.
- ▒ .... GRAVEL, >2MM TO 2" FRAGMENTS, SUB-ROUNDED TO SUB-ANGULAR.

HYDRAULIC UNITS

- ▒ .... CONSTRUCTION FILL OR SURFICIAL LOESS
- ▒ .... HU1 - THE UPPER FLUVIAL/ALLUVIAL SILTY CLAYS RUST BROWN TO GREY BROWN; PLEISTOCENE AGE.
- ▒ .... HU2 - LOESS, CLAYEY SILTY SAND TO SANDY SILT, SAND LENSES ARE DISCONTINUOUS BUT CORRELATABLE, RUST BROWN TO YELLOW BROWN; PLEISTOCENE AGE.
- ▯ .... SOIL BORING SAMPLE INTERVAL



NOTES

1.) SAMPLE LOCATION ELEVATION (XXX.XX) IN FEET ABOVE MEAN SEA LEVEL (MSL)

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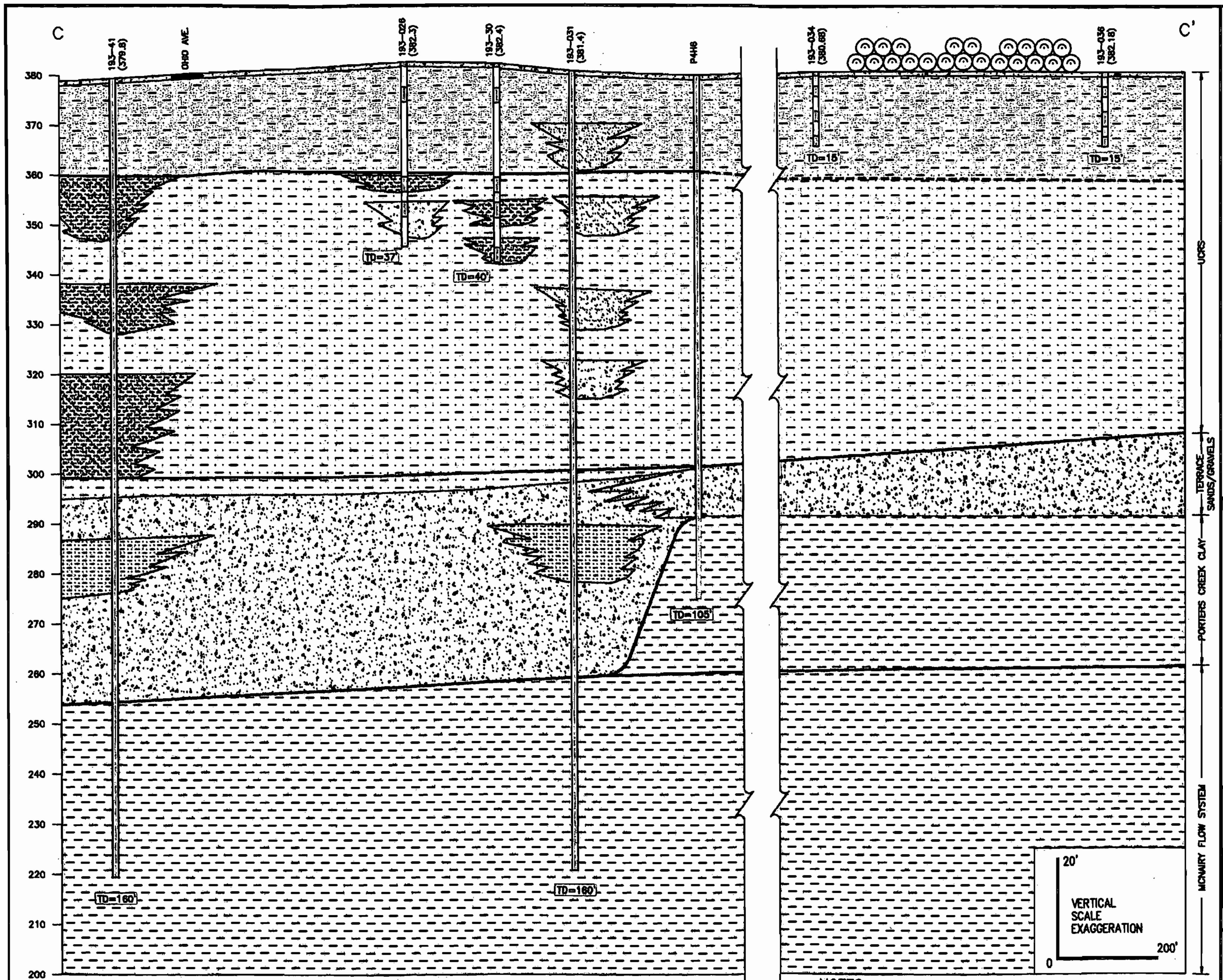
PADUCAH GASEOUS
DIFFUSION PLANT

WAG 28 - SWMU 193
LITHOLOGIC CROSS SECTION B-B'

Figure 3.7 August, 2000

DOE/OR/07-1846/D2 & V1

AutoCAD File: 1999006-8310-B-0022



NOTES

1.) SAMPLE LOCATION ELEVATION (XXX.XX) IN FEET ABOVE MEAN SEA LEVEL (MSL)

LITHOLOGIC UNITS

▨ ······· FILL MATERIAL CONSISTING OF CRUSHED STONE WITH SAND AND CLAY MIXTURE.

▤ ······· SILTY CLAYS AND CLAYEY SILTS

▤ ······· CLAY TO SILTY CLAY

▨ ······· SAND TO SILTY SAND, FINE TO MEDIUM GRAINSIZE, SUB-ROUNDED TO SUB-ANGULAR.

▨ ······· GRAVEL, >2MM TO 2" FRAGMENTS, SUB-ROUNDED TO SUB-ANGULAR.

HYDRAULIC UNITS

☐ ······· CONSTRUCTION FILL OR SURFICIAL LOESS

▨ ······· HU1 - THE UPPER FLUVIAL/ALLUVIAL SILTY CLAYS RUST BROWN TO GREY BROWN; PLEISTOCENE AGE.

☐ ······· HU2 - LOESS, CLAYEY SILTY SAND TO SANDY SILT, SAND LENSES ARE DISCONTINUOUS BUT CORRELATABLE, RUST BROWN TO YELLOW BROWN; PLEISTOCENE AGE.

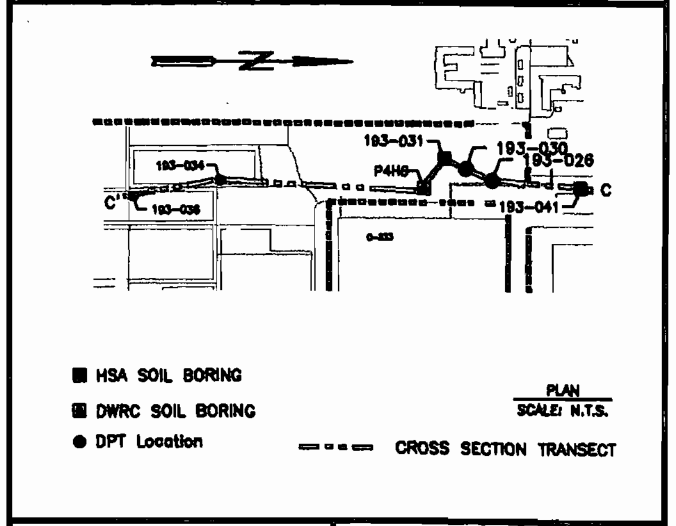
☐ ······· HU3 - CLAY TO SILTY CLAY, VERY IMPERMEABLE CLAY THAT ACTS AS A SEMICONFINING TO CONFINING LAYER, PRIMARY CONSTITUENT OF THE UPPER CONTINENTAL DEPOSITS; LOWER PLEISTOCENE AGE.

☐ ······· HU4 - SAND WITH GRAVEL AND SILT, CONSIDERED THE UPPER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.

☐ ······· HU5 - GRAVEL WITH SAND AND SILT, CONSIDERED THE LOWER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.

☐ ······· PORTERS CREEK CLAY - DARK GREY, SLIGHTLY TO VERY MICACEOUS CLAY WITH SOME INTERBEDDED FINE GRAINED CLAYEY SAND, PALEOCENE AGE.

☐ ······· MCNAIRY FORMATION - GREYISH WHITE TO DARK MICACEOUS CLAY, OFTEN SILTY, INTERBEDDED WITH LIGHT GREY TO YELLOW-BROWN VERY FINE SAND. CRETACEOUS AGE.



■ HSA SOIL BORING

▣ DWRC SOIL BORING

● DPT Location

▬ ▪ ▪ ▬ CROSS SECTION TRANSECT

PLAN
SCALE: N.T.S.

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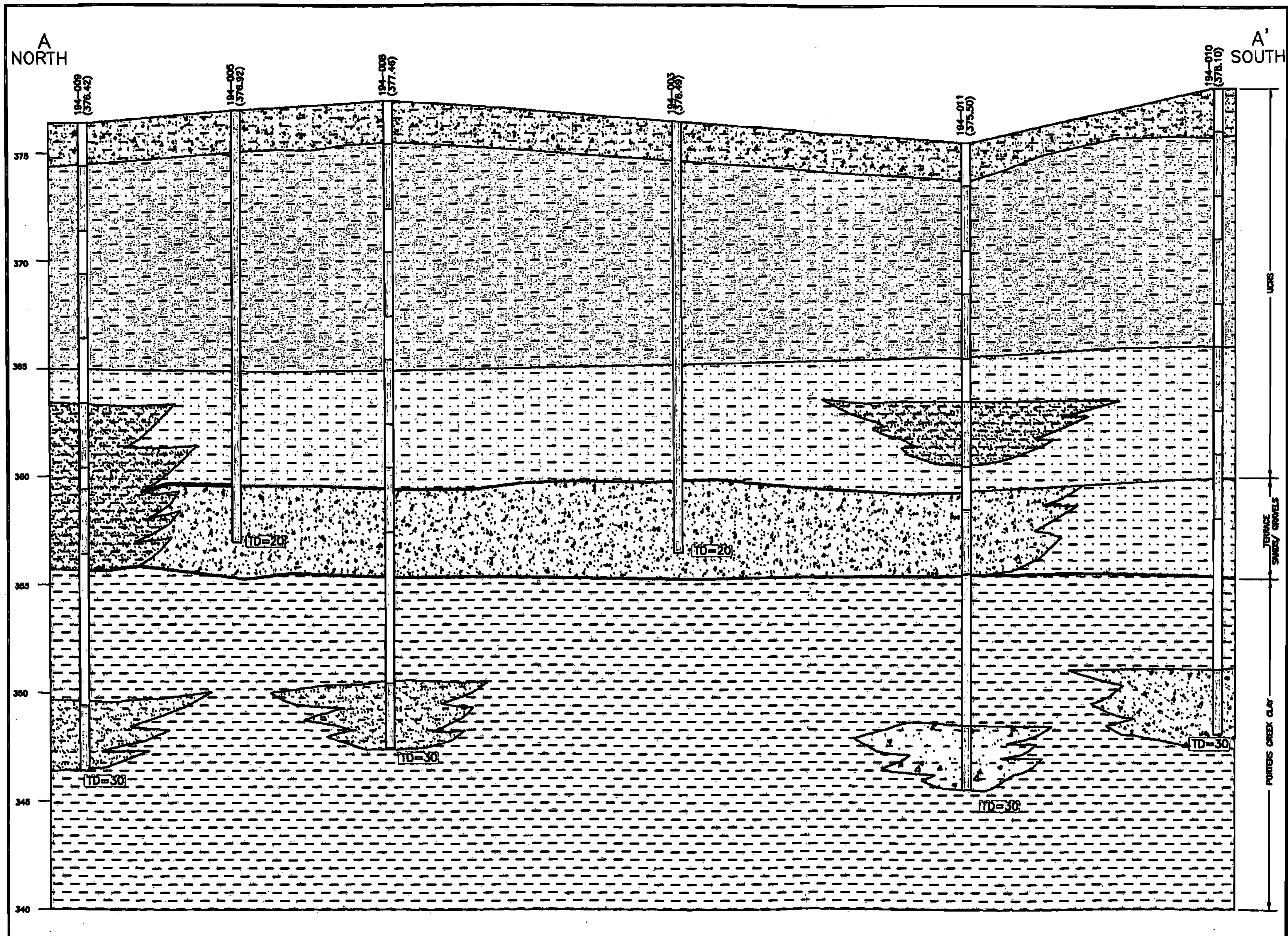
PADUCAH GASEOUS
DIFFUSION PLANT

LITHOLOGIC CROSS-SECTION C-C'
WAG 28 - SWMU 193

Figure 3.8 August, 2000

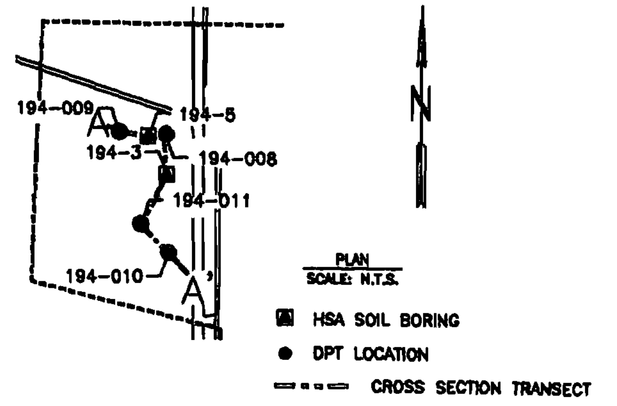


LITHOLOGIC UNITS

▨	FILL MATERIAL CONSISTING OF CRUSHED STONE WITH SAND AND CLAY MIXTURE.
▤	SILTY CLAYS AND CLAYEY SILTS
▤	CLAY TO SILTY CLAY
▒	SAND TO SILTY SAND, FINE TO MEDIUM GRAINSIZE, SUB-ROUNDED TO SUB-ANGULAR.
▒	GRAVEL, >2MM TO 2" FRAGMENTS, SUB-ROUNDED TO SUB-ANGULAR.

HYDRAULIC UNITS

☐	CONSTRUCTION FILL OR SURFICIAL LOESS
▒	HU1 - THE UPPER FLUVIAL/ALLUVIAL SILTY CLAYS RUST BROWN TO GREY BROWN; PLEISTOCENE AGE.
☐	HU2 - LOESS, CLAYEY SILTY SAND TO SANDY SILT, SAND LENSES ARE DISCONTINUOUS BUT CORRELATABLE, RUST BROWN TO YELLOW BROWN; PLEISTOCENE AGE.
☐	PORTERS CREEK CLAY - DARK GREY, SLIGHTLY TO VERY MICACEOUS CLAY WITH SOME INTERBEDDED FINE GRAINED CLAYEY SAND, PALEOCENE AGE.
▯	SOIL BORING SAMPLE INTERVAL



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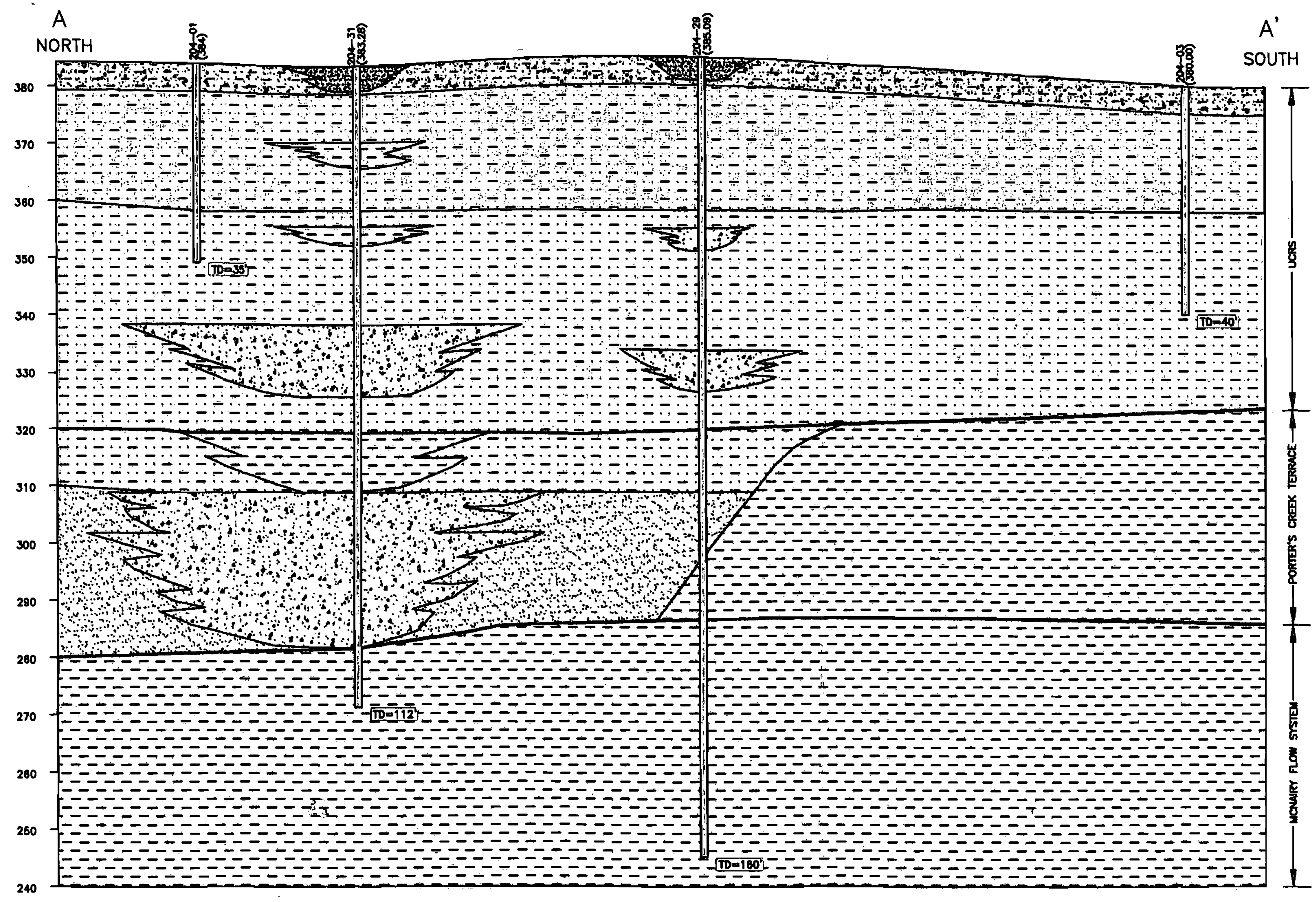
PADUCAH GASEOUS
DIFFUSION PLANT

WAG 28 - SWMU 194
LITHOLOGIC CROSS-SECTION A-A'

Figure 3.9 August, 2000

NOTES

1.) SAMPLE LOCATION ELEVATION (XXX.XX) IN FEET ABOVE MEAN SEA LEVEL (MSL)



20

VERTICAL SCALE EXAGGERATION

0

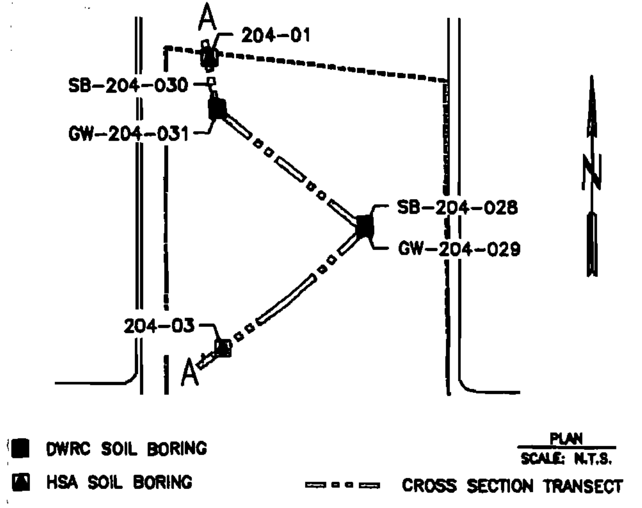
100

LITHOLOGIC UNITS

- ▨ ······· FILL MATERIAL CONSISTING OF CRUSHED STONE WITH SAND AND CLAY MIXTURE.
- ▦ ······· SILTY CLAYS AND CLAYEY SILTS
- ▤ ······· CLAY TO SILTY CLAY
- ░ ······· SAND TO SILTY SAND, FINE TO MEDIUM GRAINSIZE, SUB-ROUNDED TO SUB-ANGULAR.
- ▒ ······· GRAVEL, >2MM TO 2" FRAGMENTS, SUB-ROUNDED TO SUB-ANGULAR.

HYDRAULIC UNITS

- ☐ ······· CONSTRUCTION FILL OR SURFICIAL LOESS
- ☐ ······· HU1 – THE UPPER FLUVIAL/ALLUVIAL SILTY CLAYS RUST BROWN TO GREY BROWN; PLEISTOCENE AGE.
- ☐ ······· HU2 – LOESS, CLAYEY SILTY SAND TO SANDY SILT, SAND LENSES ARE DISCONTINUOUS BUT CORRELATABLE, RUST BROWN TO YELLOW BROWN; PLEISTOCENE AGE.
- ☐ ······· HU3 – CLAY TO SILTY CLAY, VERY IMPERMEABLE CLAY THAT ACTS AS A SEMICONFINING TO CONFINING LAYER, PRIMARY CONSTITUENT OF THE UPPER CONTINENTAL DEPOSITS; LOWER PLEISTOCENE AGE.
- ☐ ······· HU4 – SAND WITH GRAVEL AND SILT, CONSIDERED THE UPPER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.
- ☐ ······· HU5 – GRAVEL WITH SAND AND SILT, CONSIDERED THE LOWER PART OF THE RGA AS PART OF THE LOWER CONTINENTAL DEPOSITS; PLIOCENE AGE.
- ☐ ······· PORTERS CREEK CLAY – DARK GREY, SLIGHTLY TO VERY MICACEOUS CLAY WITH SOME INTERBEDDED FINE GRAINED CLAYEY SAND, PALEOCENE AGE.
- ☐ ······· MCNAIRY FORMATION – GREYISH WHITE TO DARK MICACEOUS CLAY, OFTEN SILTY, INTERBEDDED WITH LIGHT GREY TO YELLOW-BROWN VERY FINE SAND. CRETACEOUS AGE.
- ▯ ······· SOIL BORING SAMPLE INTERVAL



■ DWRC SOIL BORING

■ HSA SOIL BORING

PLAN
SCALE: N.T.S.

▬ ▪ ▪ ▬ CROSS SECTION TRANSECT

NOTES

1.) SAMPLE LOCATION ELEVATION (XXX.XX) IN FEET ABOVE MEAN SEA LEVEL (MSL)

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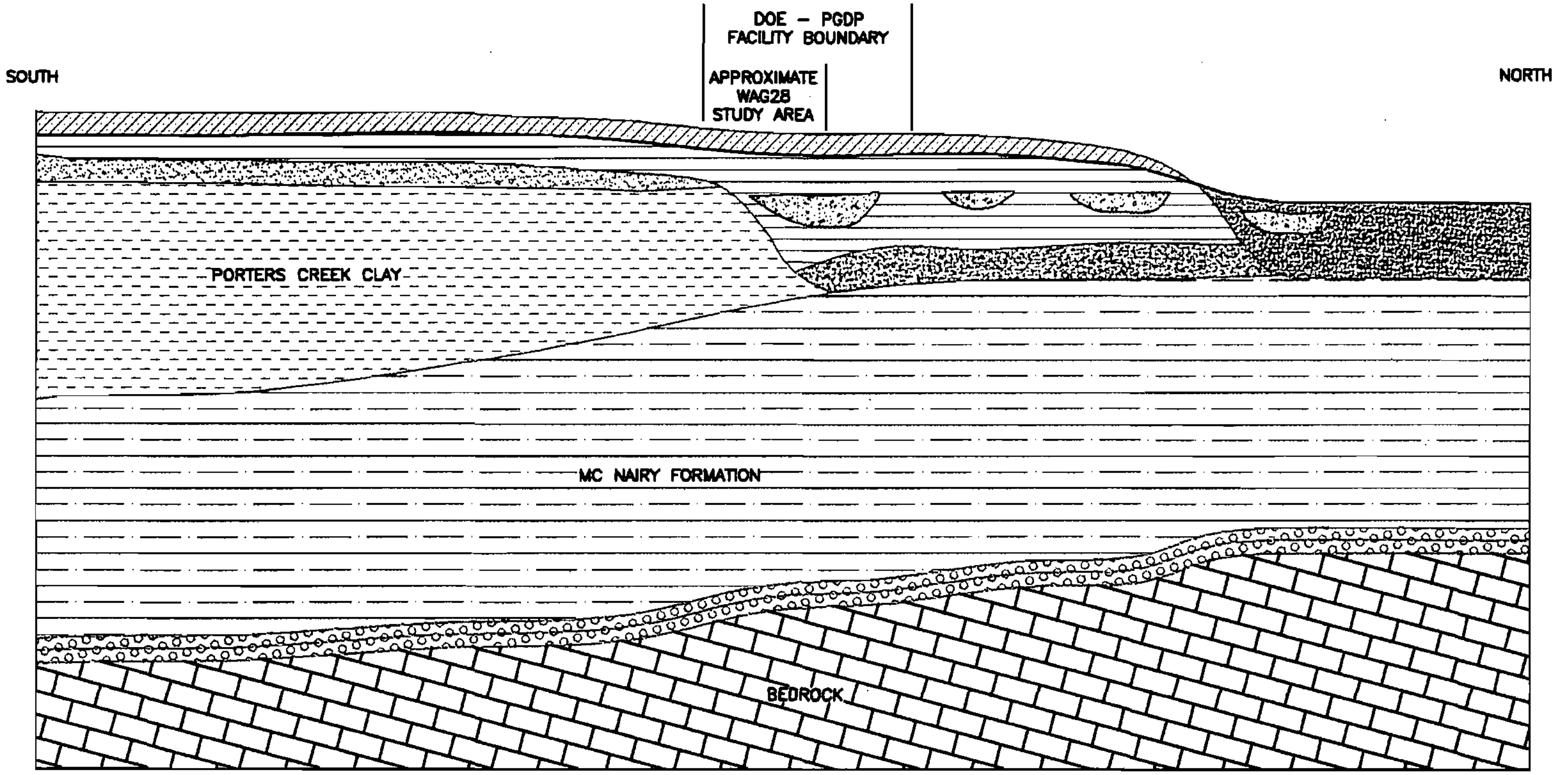
PADUCAH GASEOUS
DIFFUSION PLANT

WAG 28 – SMWU 204
LITHOLOGIC CROSS-SECTION A-A'

Figure 3.10 August, 2000



LITHOLOGIC UNITS

▨ ······· RUBBLE ZONE

▨ ······· BEDROCK (MISSIPPIAN CARBONATES)

▤ ······· MCNAIRY FORMATION

▨ ······· EOCENE SANDS/ TERRACE GRAVEL

▨ ······· REGIONAL GRAVEL AQUIFER

▤ ······· UPPER CONTINENTAL DEPOSITS

▭ ······· PORTERS CREEK CLAY

▨ ······· LOESS

▨ ······· OHIO RIVER ALLUVIUM

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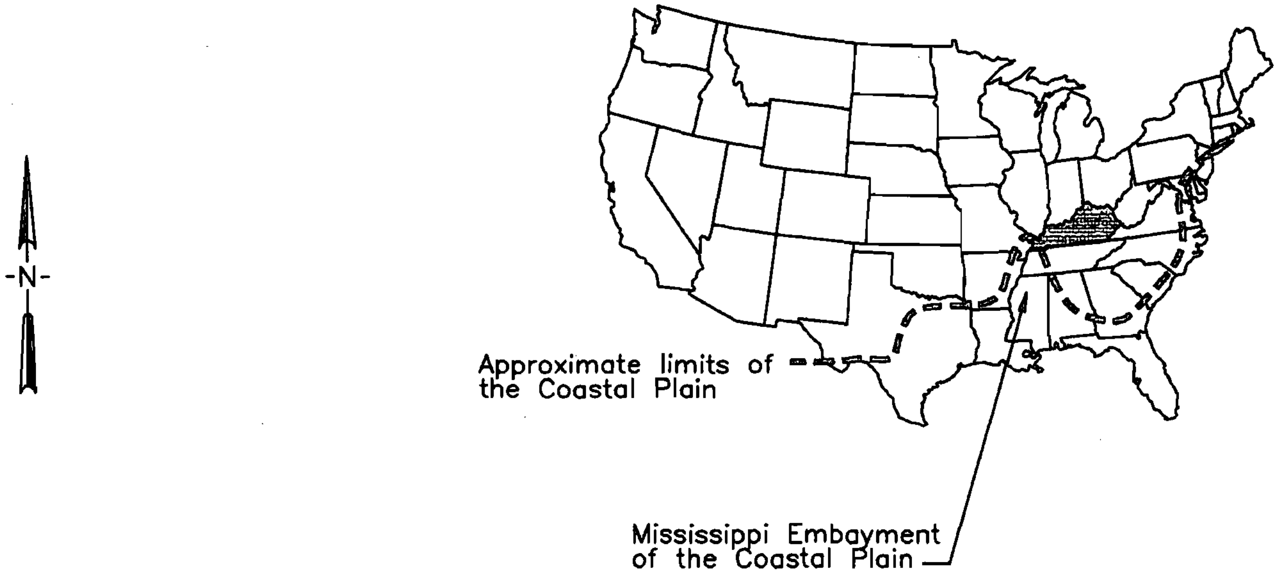
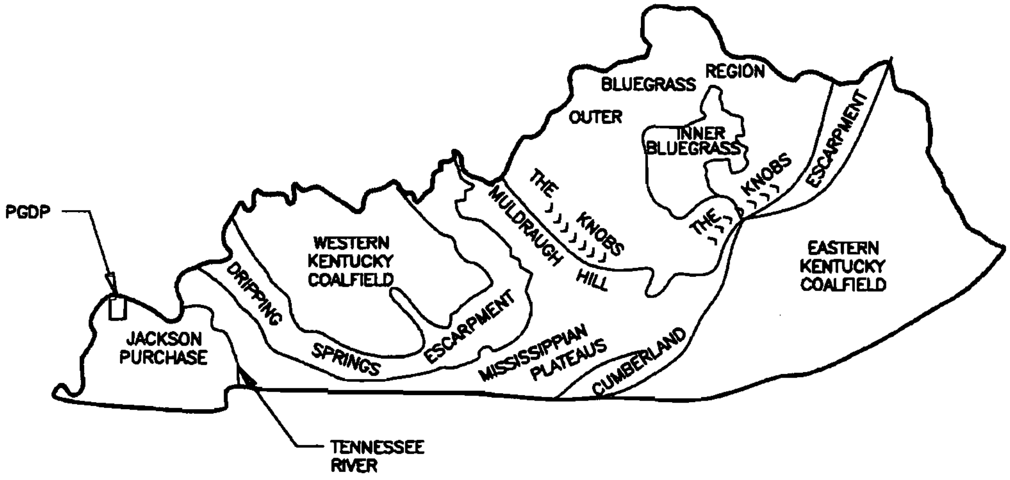
PADUCAH GASEOUS
DIFFUSION PLANT

GENERALIZED LITHOLOGIC CROSS SECTION
FOR THE PADUCAH GASEOUS DIFFUSION PLANT

Figure 3.11 August, 2000





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PADUCAH GASEOUS
DIFFUSION PLANT

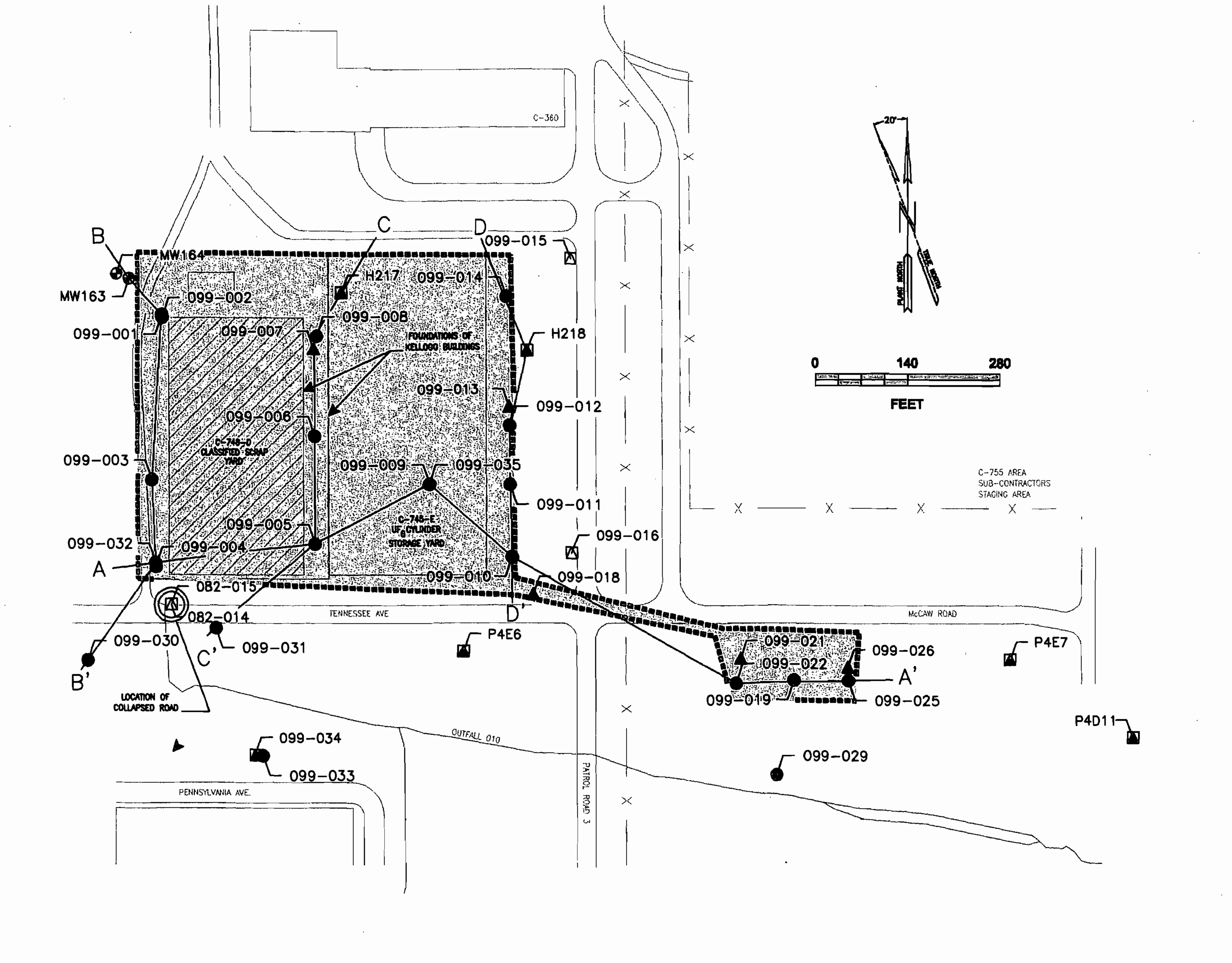
PHYSIOGRAPHIC PROVINCES FOR
THE COMMONWEALTH OF KENTUCKY

Figure 3.12 August, 2000

System	Series	Formation	Thickness in feet	Description	Hydrogeologic systems
Quaternary	Pleistocene and Recent	Alluvium	0 – 40	Brown or grey sand and silty clay or clayey silt with streaks of sand	Upper Continental Recharge System (UCRS)
	Pleistocene	Loess		Brown or yellowish-brown to tan to grey unstratified silty clay	
	Pleistocene	Continental Deposits	3 - 121	Upper Continental Deposits (Clay Facies) Orange to yellowish-brown to brown clayey silt, some very fine sand, trace of fine sand to gravel. Often micaceous.	
Tertiary	Pliocene-Miocene (?)			Lower Continental Deposits (Gravel Facies) Reddish-brown silty and sandy gravel, silt and clay.	Regional Gravel Aquifer
	Eocene	Eocene Sands (Undifferentiated)	0 - 100	Red brown, or white fine to coarse grained sand. Beds of white to dark grey clay are distributed at random.	McNairy Flow System
				White to grey sandy clay, clay conglomerate and boulders, scattered clay lenses and lenses of coarse red sand. Black to dark grey lignite clay, silt, or fine grained sand.	
	Paleocene	Porters Creek Clay	0 - 200	Dark grey, slightly to very micaceous clay. Fine grained clayey sand, commonly glauconitic in the upper part. Glauconitic sand and clay at the base. A gravel layer (Terrace Gravel) present atop the clay terrace, 2 – 8 feet thick.	
		Clayton and McNairy Formations	200 – 300	Greyish white to dark micaceous clay, often silty, interbedded with light grey to yellowish-brown very fine to medium grained sand. The upper part is mostly clay, the lower part is predominantly micaceous fine sand.	
Cretaceous		Tuscaloosa Formation	?	White, well rounded or broken chert gravel with clay.	
Mississippian		Mississippian Formation	500+	Dark grey limestone and interbedded chert, some shale.	

Figure 3.13 Lithostratigraphic column of the Jackson Purchase Region

DOE/OR/07-1846/D2 & V1



LEGEND

- ▨ ······· SWMU 99
- ▨ ······· SWMU 16
- ⊕ ······· MONITORING WELL LOCATION
- ☒ ······· SURFACE SOIL SAMPLE LOCATION
- ▲ ······· SOIL BORING AND GROUND WATER SAMPLES
- ● ······· DPT LOCATION
- ▲ ······· CPT LOCATION
- A–A' ······· CROSS-SECTION LINE

NOTES

1.) C-746-D (SWMU 16) PERIMETER SOILS WERE INCLUDED IN THIS INVESTIGATION BECAUSE THEY WERE ORIGANALY ASSOCIATED WITH THE KELLOGG BUILDING SITE OF SWMU 99

2.) THE FOLLOWING ARE HISTORICAL SAMPLING LOCATIONS.

P4D11 H218
P4E6 MW163
P4E7 MW164
H217

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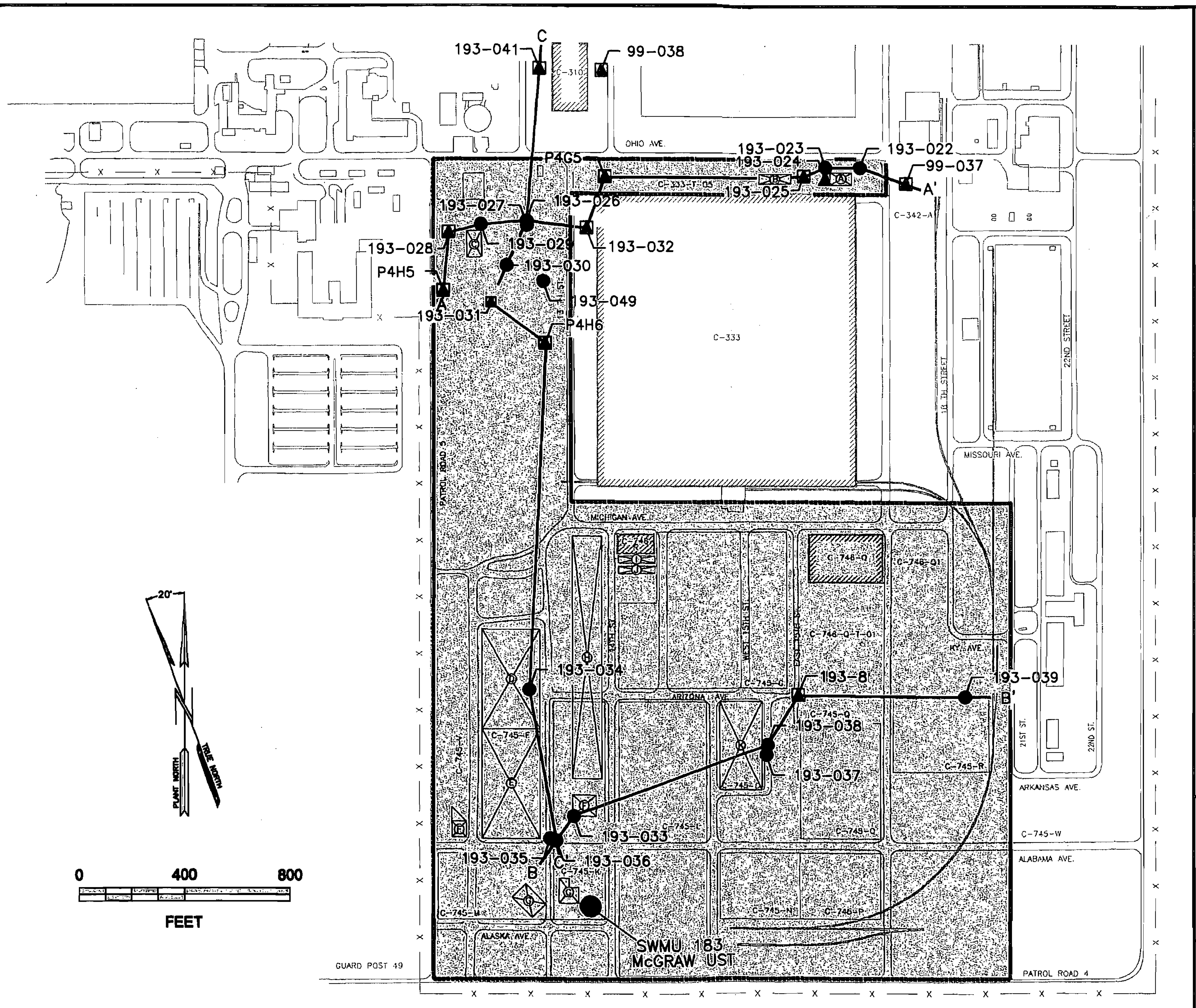
WAG 28 – SWMU 99
SAMPLE LOCATION AND SITE MAP

Figure 3.14 August, 2000

AutoCAD File: 1999006-8310-B-0003.DWG

DOE/OR/07-1846/D2 & V1

AutoCAD File: 1999006-8310-B-0006.DWG



LEGEND

▨	SWMU 193
▨	EXISTING BUILDINGS OF INTEREST
⊠ Ⓐ	SITE FOR FORMER BUILDING/ STRUCTURE OF POSSIBLE SOURCE CONTAMINANT
●	DPT LOCATION
▲	CPT LOCATION
■	SOIL BORING LOCATION AND GROUND WATER SAMPLES
A-A'	CROSS-SECTION LINE

NOTES

Ⓐ	SCHUMAN PIPE FABRICATION SHOP	Ⓖ	FILLING STATION
Ⓑ	WAREHOUSE	Ⓗ	GENERAL WAREHOUSE
Ⓒ	MILLWRIGHT SHOP	Ⓘ	ACETYLENE SHOP
Ⓓ	ELECTRICAL WAREHOUSE	Ⓙ	PAINT SHOP
Ⓔ	SHEET METAL SHOP	Ⓚ	EQUIPMENT SHOP
Ⓕ	LEACHING FIELDS		

HISTORICAL SAMPLING LOCATIONS

P4G5	P4H6
P4H5	193-8

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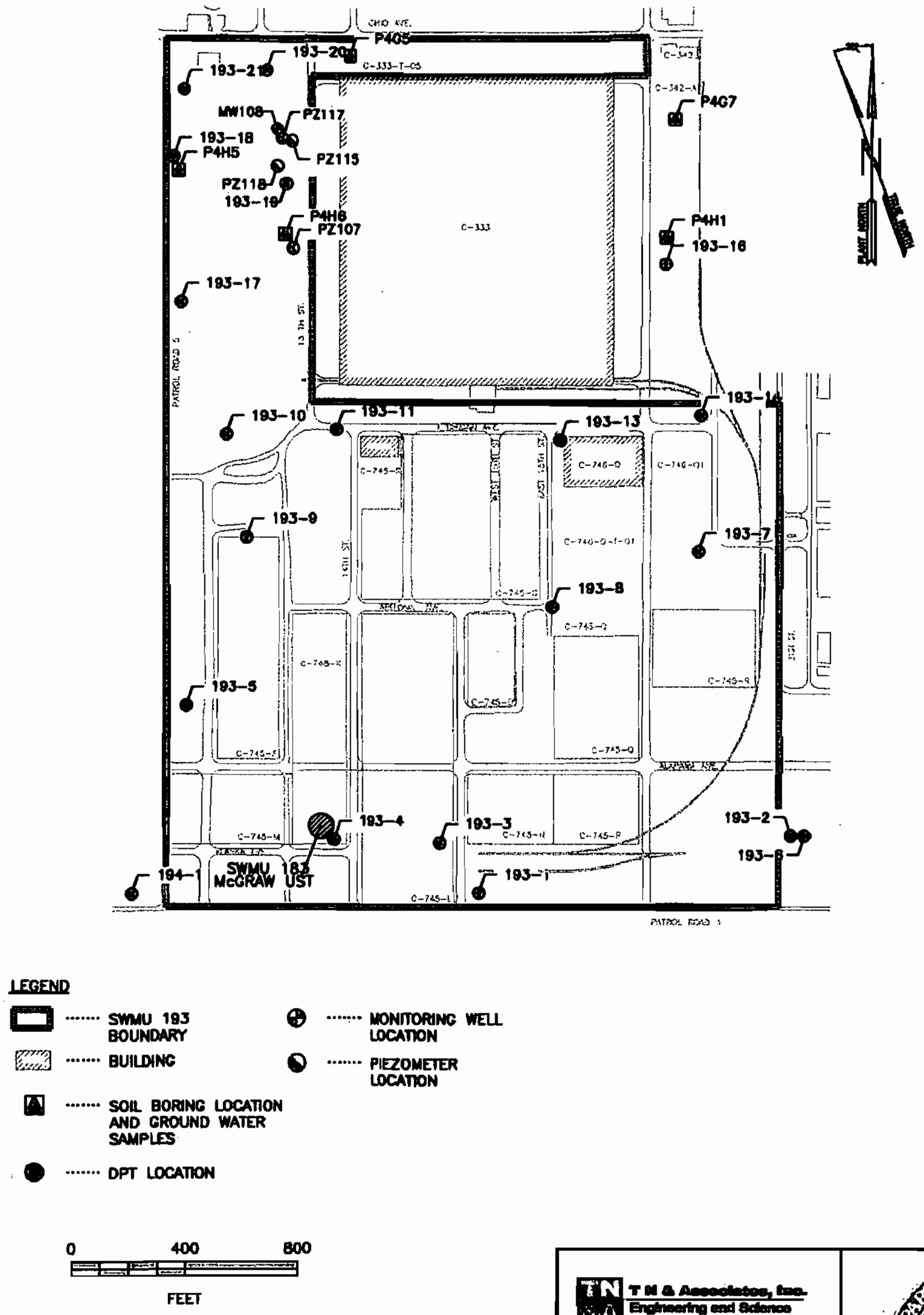
WAG 28 - SWMU 193
SAMPLE LOCATION ANS SITE MAP

Figure 3.15 August, 2000



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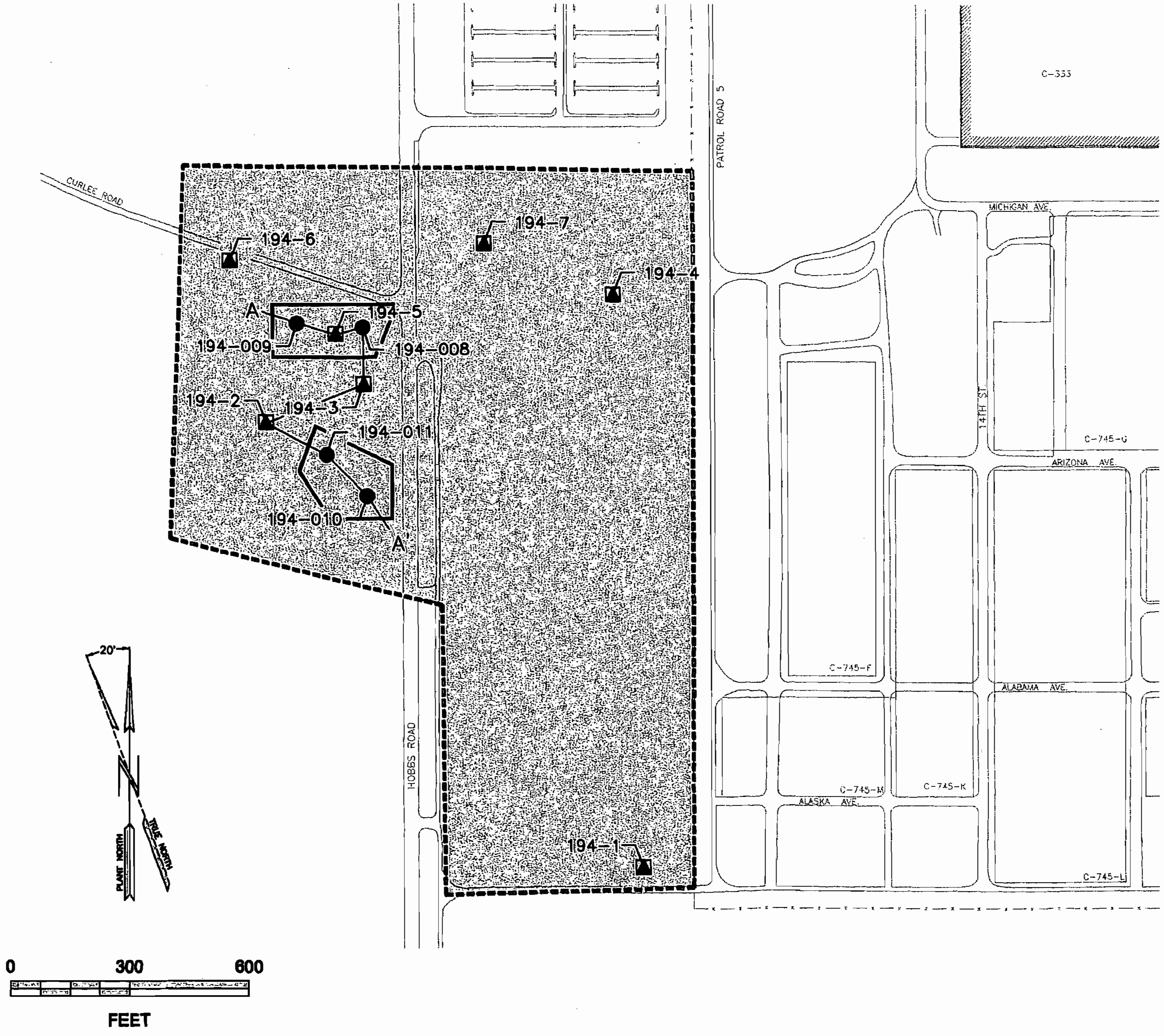
WAG 28 – SWMU 193
HISTORICAL SAMPLING LOCATIONS

Figure 3.16 August, 2000

AutoCAD File:1999006-8310-A-0007.dwg

DOE/OR/07-1846/D2 & V1



LEGEND

▨ ······· SWMU 194

● ······· DPT LOCATION

▲ ······· SOIL BORING AND GROUND WATER SAMPLES

☐ ······· FORMER LEACH FIELD

A-A' ······· CROSS-SECTION LINE

NOTES

1.) THE FOLLOWING ARE HISTORICAL SAMPLING LOCATIONS.

194-1 194-2
194-3 194-4
194-5 194-6
194-7

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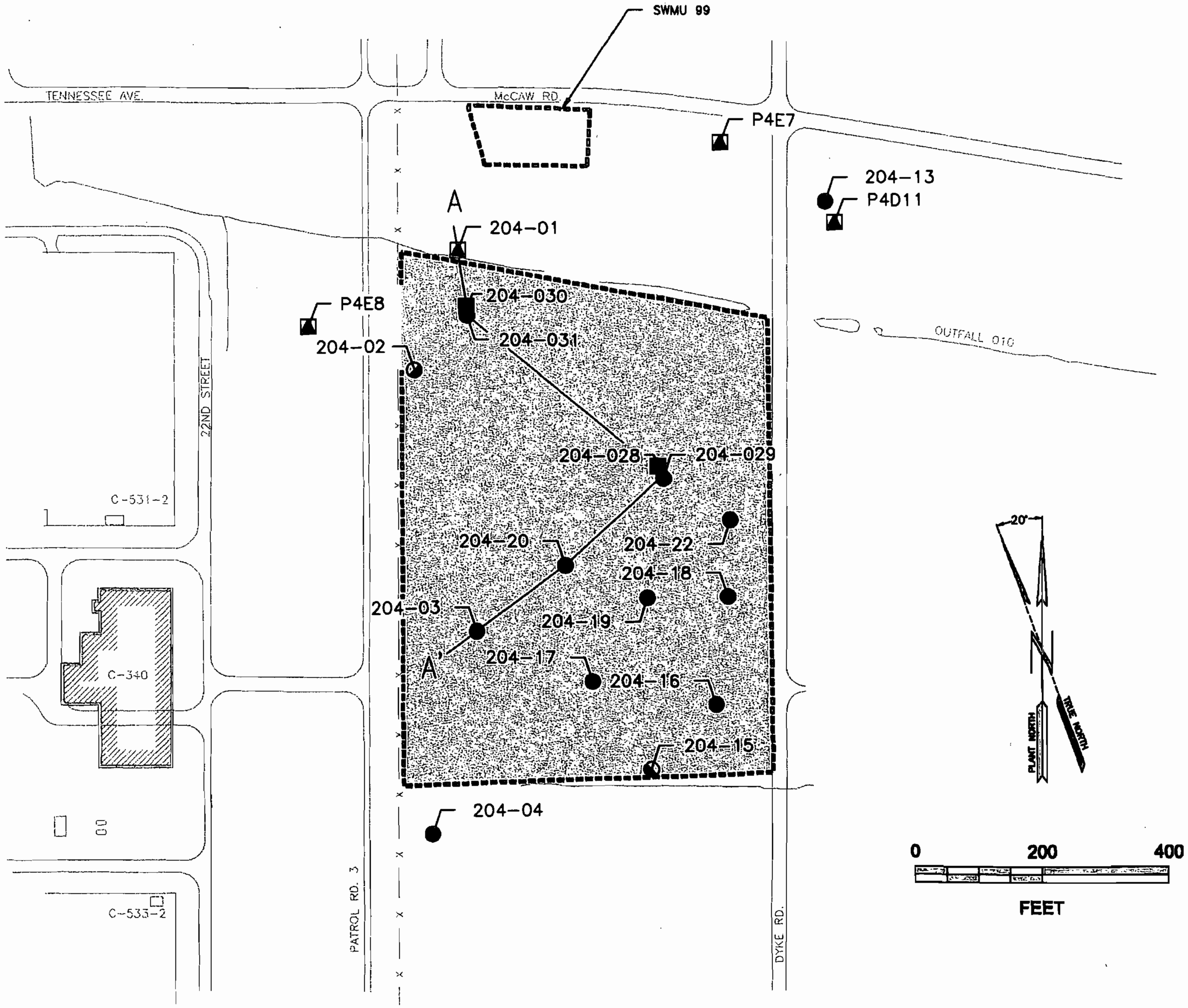
WAG 28 – SWMU 194
SAMPLE LOCATION AND SITE MAP

Figure 3.17 August, 2000

AutoCAD File: 1999006-8310-B-0004.DWG



LEGEND

▨ ······· AOC 204

— x — ······· SECURITY FENCE

◭ ······· SOIL BORING AND GROUND WATER SAMPLES

◐ ······· PIEZOMETER LOCATION

● ······· DPT LOCATION

A-A' ······· CROSS-SECTION LINE

■ ······· HOLLOW STEM AUGER BORING

NOTES

1.) THE FOLLOWING ARE HISTORICAL SAMPLING LOCATIONS.

204-01 204-02
204-03 204-04
204-13 204-15
204-16 204-17
204-18 204-19
204-20 204-22
P4D11 P4E8
P4E7

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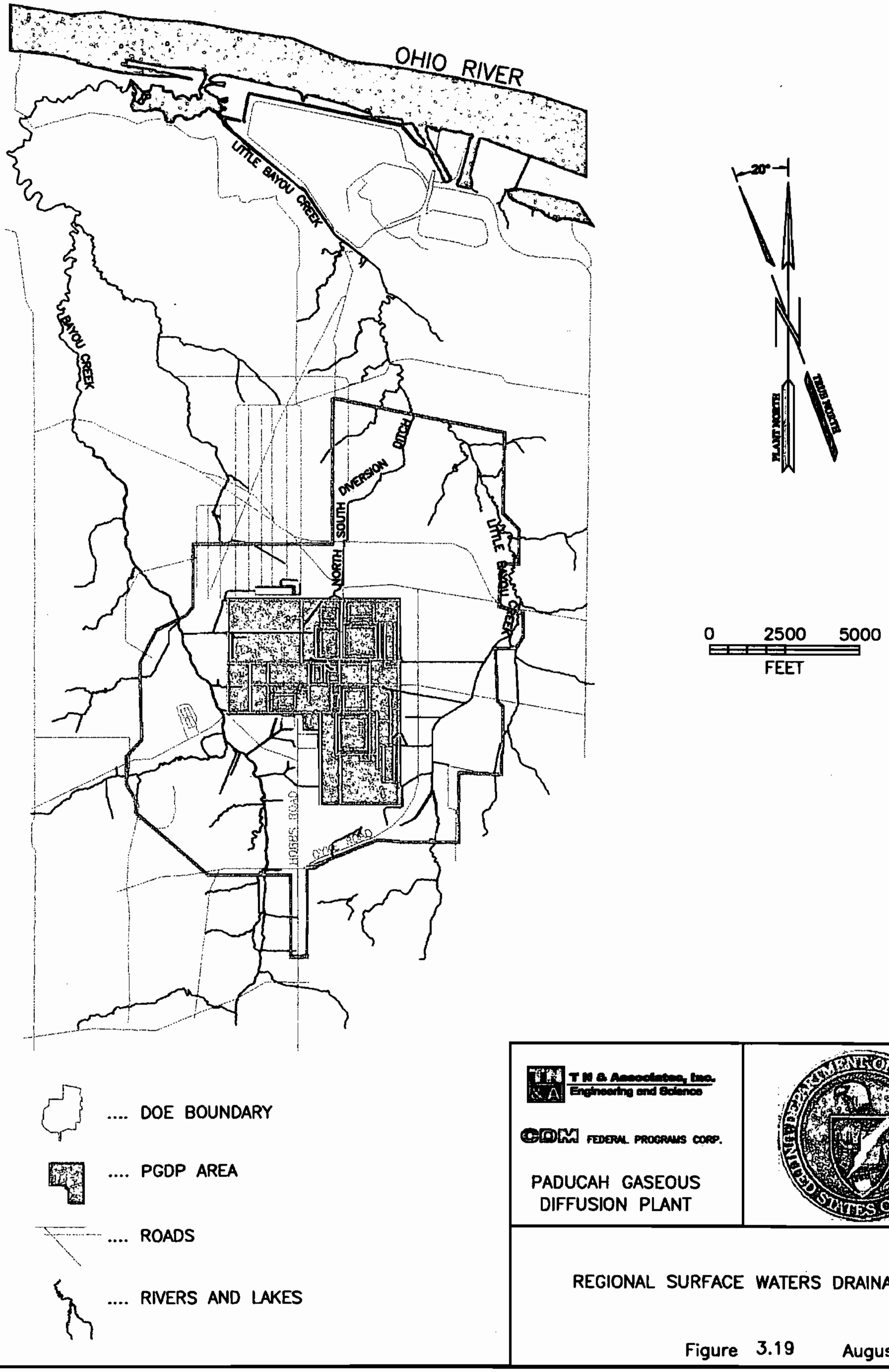
WAG 28 – AOC 204
SAMPLE LOCATION AND SITE MAP

Figure 3.18 August, 2000

AutoCAD File: 1999006-8310-B-0005.DWG



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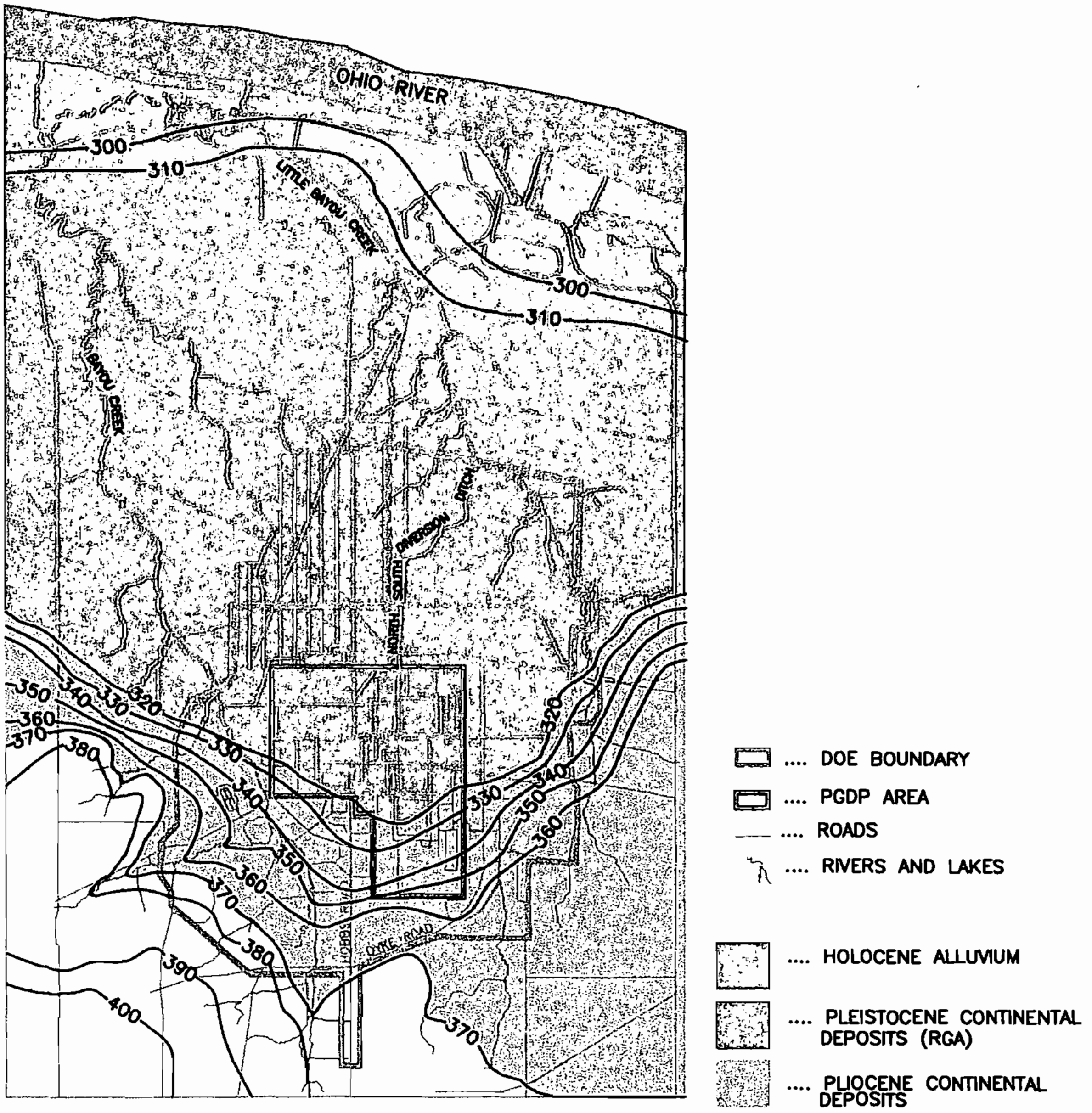
REGIONAL SURFACE WATERS DRAINAGE

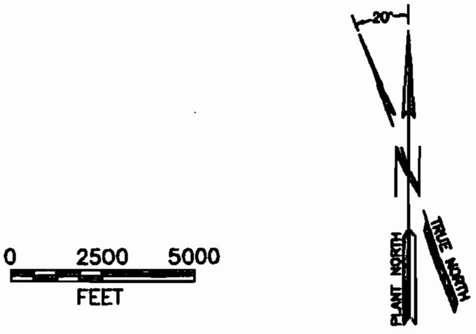
Figure 3.19 August, 2000

AutoCAD File: 19990006-8310-A-0019.DWG

DOE/OR/07-1846/D2 & V1



DOE – Paducah Gaseous Diffusion Plant
1999



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GEOLOGIC COMPONENTS OF THE REGIONAL
GROUNFWATER FLOW SYSTEM
IN THE VICINITY OF PGDP

Figure 3.20 August, 2000

AutoCAD File:1999006-8310-B-0020.DWG

4. NATURE AND EXTENT OF CONTAMINATION

4.1 INTRODUCTION

Environmental data from the four sites investigated during the WAG 28 RI field activities have been compiled, screened, and evaluated to assess the nature and extent of each site-related contaminant and to supplement previously collected data. Summary tables (Tables 4.1–4.25) containing analytical results for each of the four sites are included at the end of this chapter. A complete report of analytical results for all samples collected during this investigation is provided in Appendix C. Appendix F contains selected analytical data collected during previous investigations of the sites that comprise WAG 28. Appendix G contains a complete list, by sample identification number, of all samples analyzed during the WAG 28 RI; it also provides information concerning which of the five analytical groups (VOAs, SVOAs, PCBs, metals, and/or radionuclides) were tested for in each sample.

The extent of contamination discussed in this report is based on the presence of site-related contaminants in surface or subsurface soils and groundwater. This section consists of three main parts following this introduction:

- A description of soil to 60 ft (typically the unsaturated zone, or approximately to the RGA) for each of the four sites
- A description of contaminant impact on shallow UCRS groundwater
- A summary of findings for each site

The PGDP site remedial objective is to select and implement actions protective of human health and the environment (DOE 1998a). The RI activities included investigations of the nature and extent of potential groundwater contamination attributable to any of the four sites. Data collected from the WAG 28 RI also will be used as a basis for remedial action decisions concerning the Groundwater OU.

4.1.1 Screening Process

The data screening process used in this RI was critical for determining when analytes represented site-related contaminants as opposed to laboratory contaminants or constituents that occur naturally in the soil or groundwater. Additionally, screening was used as a tool to focus the discussion of the nature and extent of contamination on those constituents that are most likely to have a potential for impact to human health. The screening process is described in the following paragraphs.

The results in the WAG 28 database were screened in a multiphase process. First, data collected during this RI were screened to eliminate those sample results that were less than the minimum detection limit. These data were then compared with historical data representative of naturally occurring conditions and concentrations in the surface and subsurface soil at PGDP (i.e., background data). Revised groundwater background data are currently being collected as part of the ongoing Groundwater OU study and are not available for this report. Background values for metals and radionuclides in surface and subsurface soil were compiled from DOE (1997).

Reporting limits for soil analyses are sample-specific, due to varying soil moisture content. For certain metal analytes in some soil metals analyses, the sample-specific reporting limit, which was the laboratory's lowest concentration reportable, exceeded established background concentrations. However, the laboratory's MDL for all metal analytes was lower than the corresponding established background concentration. Table 4.1 identifies and provides MDLs for all of the metal analytes which had sample-specific reporting limits (or lowest concentrations reportable) in the WAG 28 database that exceeded the corresponding established background concentration. In some cases, the sample-specific minimum detectable activity for some radiological analytes also exceeded established background. For others, however, the difference is more significant (antimony, cadmium, thorium, and uranium-235). These analytes were carried further in the screening process for the baseline risk assessment and determination of COPCs.

Analyses of two inorganic analytes, lithium and total strontium (i.e., not radioisotopes of strontium), were supplied during the WAG 28 RI. These metals were not identified as COPCs and are not part of the Contract Laboratory Program Target Analyte List (TAL) proposed in the WAG 28 work plan (DOE 1998b). However, the analyses were supplied when the laboratory scope of work specified SW-846 methods. In a similar manner, boron was included in the reported analytical results for the historical data. Screening of lithium and strontium is problematic because no site-specific background data are available for these constituents. Additionally, no other concentration [such as EPA Soil Screening Levels (SSLs)] was available for screening purposes. Therefore, all detections of these metals would survive the screening process intended to exclude naturally occurring constituents. More importantly, concentrations for both metals fall within the range for occurrences in natural soils as reported by the USGS (1984) for surface soils in the contiguous United States. For these reasons, these metals have not been included in the discussion of nature and extent of contamination. A review of those analytical results is included in Appendix C. For completeness, however, these analytes have been incorporated in the risk evaluation in Vol. 4.

Tables 4.1 and 4.2 contain the background data for PGDP used to screen WAG 28 data. Because most organics such as VOAs, SVOAs, and PCBs are considered man-made, background for these compounds was set at zero. The analytical summary tables (Tables 4.3–4.24) contain all VOAs, SVOAs, PCBs, metals, and radionuclide results that were detected at WAG 28 *above background screening levels*. Where an environmental sample result and a duplicate result were available for the same sample, only the higher of the two results was included in these summary tables. All compounds/analytes or radionuclides that passed the background screening (e.g., exceeded background levels and were not identified as laboratory-introduced artifacts) were considered to be site-related contaminants.

To further focus the discussion on these contaminants that are most likely to have an adverse effect on human health, the maximum detected concentration for each analyte was compared to the applicable EPA SSLs. SSLs (Table 4.25) are risk-based concentrations for contaminant migration from soil to the groundwater pathway. EPA SSLs are calculated using a dilution/attenuation factor (DAF) of 20. As noted by EPA (1996b), a DAF of 20 is the default value selected that provides SSLs protective of groundwater for all sites up to 0.5 acre in size and for most sites up to 30 acres in size. This default DAF was considered appropriate for the WAG 28 risk assessment because the WAG 28 sites are relatively small and the geology at PGDP is expected to provide significant dilution and/or attenuation of soil leachate concentrations before migration to the uppermost aquifer at PGDP (i.e., the RGA).

Salient geological features at PGDP support the use of the default value: (1) the depth to the RGA ranges from 50 to 60 ft bgs (i.e., the aquifer is not in direct contact with the potentially contaminated soil); (2) the hydraulic conductivity of the overlying UCRS tends to be small, especially for the silty clay unit of the UCRS termed the HU3; and (3) the UCRS is generally unsaturated (except for an occasional perched water zone) to a depth in excess of 30 ft. The HU3 unit is of special importance because it is found at the bottom of the UCRS (i.e., directly above the RGA) and is up to 30 ft thick. Hence, HU3 forms at least a partial aquitard between the WAG 28 sites and the RGA.

Seven analytes known to be essential nutrients and known to be toxic *only* at extremely high concentrations were screened and removed from the data set according to regulatory guidance (EPA 1995). The maximum detected concentration of analytes known to be essential nutrients was compared to its respective Recommended Dietary Allowance (RDA) for children to determine if it would be appropriate to remove any essential nutrients from the data set. Generally, analytes whose potential intakes based on the maximum detected concentrations were less than one-fifth of the RDA for children were removed from the data set (as agreed upon by the Commonwealth of Kentucky and EPA in the PDGP risk assessment methods document). These analytes are calcium, chloride, iodine, magnesium, potassium, sodium, and phosphorous. Three essential nutrients, chromium, manganese, and zinc, were not screened using this process because of toxic effects seen from exposure to these chemicals at low concentrations.

To emphasize those chemicals that are considered likely to have had an adverse impact on the site media, the following discussion in this section is limited to analytes that exceed all screenings (background, SSL, and RDA). Constituents that only slightly exceeded PGDP screening levels, were detected only in one sample, or were common mineral-forming elements are not discussed in detail in this section. These constituents are, however, carried forward to the Risk Evaluation section for evaluation.

4.1.2 WAG 28 Soils

To determine the nature and extent of contamination found within each of the four sites, samples of surface and subsurface soils were collected as needed. These samples were analyzed for suites of constituents in five groups: VOAs, SVOAs, PCBs, inorganics, and radionuclides.

Following a general introduction and description of the WAG 28 activities, the four WAG 28 sites are individually characterized. The discussion of each site begins with an introduction that summarizes the area's history, including site conditions. In addition to topography and man-made features, the location of the physical boundaries of the site, previous sampling events, and relevant historical data are summarized. An accompanying base map depicts soil sample locations, facility structures, transportation pathways (e.g., roads), and topographic features (e.g., ditch locations).

Descriptions of the known processes and possible releases from each site that may have contributed to contaminant impact follow the paragraphs that characterize the site's physical properties. An understanding of the potential releases is key to the rationale behind the sampling that was performed during the WAG 28 RI. Following the "Rationale for RI Field Sampling," section, the text focuses on describing analytical results of samples collected at each of four sites. The text in this section includes the following information:

- Depth range from which samples were collected
- Number of locations within each site from which samples were collected
- Number and nature of individual constituents of each chemical group that were encountered
- Description of analytical results

The "Summary of Findings" for each site provides a synopsis of the analytical results, including interpretations. The area or areas of concern at each site, the constituents involved, and the probable source or sources are described.

4.1.3 WAG 28 Groundwater

Groundwater plumes of VOAs (notably trichloroethene) extend several miles off site to the north of PGDP (see Fig. 1.7). The Northeast Plume is delineated by a number of borings and monitoring wells in proximity to SWMUs that comprise WAG 28. One of the objectives of the WAG 28 RI is to assess whether any VOA sources are currently contributing to the known northeast trichloroethene plume or could contribute to groundwater contamination in the near future. Another objective was to evaluate each site's potential contribution to the elevated technetium-99 concentrations previously detected in PGDP groundwater.

To achieve these objectives, water samples were collected from the UCRS, RGA, and McNairy groundwater systems. In general, the water samples collected during the WAG 28 RI were analyzed for VOAs, metals, and radionuclides. Other selected parameters were measured to define the chemical and physical properties of the groundwater as needed to support fate and transport analysis.

4.1.4 Historical Data Review

Results of historical sampling at each SWMU/AOC are summarized in this section, and the findings of these previous investigations are used to draw conclusions concerning the nature and extent of contamination at each of the sites investigated. The historical soil data were combined with the WAG 28-generated data set to conduct the baseline risk assessment (BRA) as outlined in Vol. 4 of this report.

SWMU 99 was investigated during the CERCLA Phase II Site Investigation performed by CH2M Hill (1992), and five borings were drilled to the east and northeast of the SWMU 99 septic tank and leach field during the Groundwater Phase IV Investigation (*Northeast Plume Preliminary Characterization Summary Report*, DOE 1995a). The site evaluation of SWMUs 193 and 194 was also conducted as part of the Northeast Plume Investigation. An investigation of AOC 204 was included in the 1995 Site Investigation for the Outfall 010, 011, and 012 Areas (DOE 1995b). The historical data that were determined to be applicable to the WAG 28 study are listed in the WAG 28 work plan (DOE 1998b). The analytical results for these samples are included in Appendix F.

Most of the historical groundwater results contained in the historical database were obtained prior to 1998 (some as early as 1991). The results of the historical groundwater analyses are in Appendix F. Because the RGA groundwater is a dynamic system in which the concentrations of contaminants can change significantly over short periods of time, the historical results for groundwater were used only to assess historic contaminant trends for Chap. 4 of this report. When appropriate, the historical groundwater data were combined with the WAG 28 RI data set to conduct the BRA as outlined in Vol. 4 of this report.

4.2 WAG 28 SOIL AND GROUNDWATER

4.2.1 C-745 Kellogg Building Site (SWMU 99)

4.2.1.1 Location and physical description

The Kellogg Building Site (SWMU 99) is located along the eastern edge of PGDP, south of Building C-360, immediately north of Tennessee Avenue, and west of Patrol Road 3 as shown in Fig. 3.14. SWMU 99 originally consisted of two buildings built in 1951 of steel and sheet metal on concrete slabs as temporary support facilities during the construction of the cascade facilities. A gravel access road ran between the buildings. No other information is available regarding their construction and design. The Kellogg Buildings were taken out of service and demolished in 1955, leaving only the concrete pads. The building pads are now used to store UF_6 cylinders and classified scrap materials. The C-745-E Cylinder Storage Yard is located in the area that formerly housed the eastern building, and the C-746-D Classified Scrap Yard (former location of the western building) is used to store converter cells that have been modified for the storage of classified waste. Building C-746-D, the C-746-D Classified

Scrap Yard, and the concrete pad have been identified as SWMU 16 based on current usage; however, the soil and groundwater beneath it are included in the SWMU 99 investigation because it was originally associated with the Kellogg Building. The scrap materials currently in storage at this facility (SWMU 16) will not be evaluated as part of the WAG 28 RI.

A septic tank and a leach field that formerly serviced the Kellogg Buildings have also been identified as part of SWMU 99. The tank and the associated field were connected to the Kellogg Buildings by a vitreous clay drain line. Construction drawings show that these facilities were located approximately 350–400 ft southeast of the building sites in the grass-covered field east of Patrol Road 3 (see Fig. 3.14).

4.2.1.2 Site history

No releases from SWMU 99 have been documented; however, contaminants may have been released to the environment through normal operations (e.g., spills, leaks, unregulated disposal). Information regarding the specific activities conducted in the buildings, other than pipe fabrication, is limited. It is possible that degreasing operations using trichloroethene occurred within the buildings. Other potential release mechanisms are the septic tank and leach field. The tank and leach field are believed to have been designed to receive sanitary waste from building operations; however, the actual configuration of the drainage system is unknown. No records exist as to what was done with the residual contents of the tank after the buildings were demolished or whether any closure or removal actions were taken. Because there is insufficient documentation to confirm whether the septic tank and leach field received only sanitary waste, the drain line, septic tank, and leach field were investigated as part of the SWMU 99 investigation.

4.2.1.3 Location and results of previous sampling

SWMU 99 was investigated during the CERCLA Phase II SI performed by CH2M Hill (1992). Two deep soil borings (H217 and H218) were drilled to a depth of 45 ft bgs adjacent to the C-745-E Cylinder Yard. The locations of these borings are shown in Fig. 3.14. Composite soil samples were collected at 5-ft intervals and analyzed for VOAs, SVOAs, PCBs, TAL metals, and selected radionuclides (uranium-234, uranium-235, uranium-238, thorium-230, neptunium-237, plutonium-239, and technetium-99). Trichloroethene was not detected in any of the soil samples analyzed. Xylene was detected in the 0–5-ft sample from Boring H217 with a concentration of 4J μg/kg (estimated below the minimum detection limit). Inorganics detected in the soil samples from these borings included antimony (2.9 mg/kg), barium (243 mg/kg), chromium (51.8J mg/kg), copper (55.2 mg/kg), nickel (25.8 mg/kg), and zinc (57 mg/kg). The only radionuclide detected was uranium-238 in the surface soil samples from H217 at an activity of 2.4 ±0.1 pCi/g.

Two groundwater monitoring wells (MW-163 and MW-164) were installed northwest of the C-746-D Classified Scrap Yard. MW-163 was installed in the RGA (screened interval 94–99 ft bgs), while MW-164 was installed in the UCRS (screened interval 42–47 ft bgs). The analytical results for the three subsurface soil samples collected during the drilling of MW-163 closely resemble those from the two soil borings. Inorganics detected included barium (243 mg/kg), copper (55.2J mg/kg), lead (33.3J mg/kg), mercury (0.30J mg/kg), and vanadium (48.4 mg/kg). No radionuclides were detected in the samples from the MW-163 boring.

Groundwater samples were collected from MW-163 and MW-164 and analyzed for VOAs, SVOAs, TAL metals, and selected radionuclides. VOA (primarily trichloroethene), metal, and radionuclide concentrations were reported in the groundwater samples collected from both wells. The conclusion drawn with regard to metals and radionuclides during the Phase II SI was that there did not appear to be any relationship between the Kellogg Buildings and the metals and radionuclides detected in the soil and groundwater samples collected during the investigation (CH2M Hill 1992). The metals reported in the subsurface soil samples were widely distributed and found at varying depths. The radionuclides detected in the groundwater samples could not be traced to SWMU 99 because they were not detected with any frequency in the soil samples collected. Contaminants detected in these two wells may have been derived from a source located upgradient of SWMU 99. Figure 4.1 shows a plot of the trichloroethene concentrations over time for the UCRS groundwater in MW163 and for the RGA in MW164. No correlation or temporal pattern appears evident.

Five borings were drilled to the east (P4E7, P4D11) and northeast (P4D10, P4D12, P4D12A—*east of Fig. 3.14 map border*) of the septic tank and leach field during the Groundwater Phase IV Investigation. Groundwater samples collected from these downgradient borings revealed trichloroethene concentrations greater than 1000 µg/L throughout the RGA. The results from this investigation were presented in the *Northeast Plume Preliminary Characterization Summary Report* (DOE 1995a), and the recommendation was made to further investigate the septic tank and leach field as potential sources of the trichloroethene encountered during the Groundwater Phase III or IV Investigation.

4.2.1.4 Rationale for RI field sampling

The sampling strategy for SWMU 99 targeted the Kellogg Buildings sites and the location of the septic tank, leach field, and associated drain line. Sampling included soil and groundwater within the UCRS, groundwater from the RGA, and surface soils/sediments from adjacent drainage ditches. The sampling approach was designed to evaluate whether there have been releases from SWMU 99 and to characterize the nature of the contamination and determine the extent of the impact to surface soils, subsurface soils, and groundwater from these releases. SWMU 99 was a potential source of trichloroethene in UCRS and RGA groundwater because of the activities that were completed within these buildings during their period of operation. Additional data were needed to further characterize the leach field area, provide the information necessary to conduct the human health and ecological risk assessments, and evaluate remedial alternatives.

Trichloroethene previously has been identified as one of the primary contaminants of concern in subsurface soils and groundwater. SVOAs, metals, and PCBs were included as COPCs for surface and subsurface soils and shallow groundwater to confirm the results from previous investigations.

4.2.1.5 Nature and extent of contamination

SWMU 99 consists of the former Kellogg Building site within the security fence and the leach field and drainpipe outside the fence. Sampling results are discussed by media (soil and groundwater) and by horizon (surface soil and UCRS, RGA and McNairy groundwater).

The investigation began with the delineation of subsurface stratigraphy with multiple CPT logs to identify water-bearing units within the UCRS. This activity was followed by DPT sampling of surface and subsurface soil intervals from the UCRS at 17 locations (13 at the location of the former Kellogg Building and 4 at the leach fields) and, where present, groundwater from the UCRS. When analytical results displayed nominal concentrations of VOAs in the immediate vicinity of the former Kellogg Building, sampling was conducted to the south and southwest of the SWMU boundary to attempt to discover a contributing source. RGA borings were placed within the interior (SB-099-035) and to the south (SB-099-034) of the location of the former Kellogg Building to collect groundwater samples. Two surface soil/sediment samples (discussed separately) were obtained from the drainage ditch parallel to the East Patrol Road 3, and two soil samples (discussed separately) were taken during the excavation of a drainpipe that collapsed at the southwest corner of the SWMU. This pipe originated from the center of SWMU 99 and feeds the ditch flowing to Outfall 010.

In addition, a surface geophysical survey (EM-31 terrain conductivity) was performed southeast of the Kellogg Building to locate the position of the leach field and drainpipe (see Appendix A). The survey was unsuccessful in delineating either feature. Measurements in the field, based on construction drawings, placed the leach field near the base of a high-voltage power line tower. It is possible that the below-grade construction of the tower base destroyed the leach field. No evidence of the pipe was found. CPT logging and DPT sampling were situated in proximity to the suspected location to determine if residual contamination was present.

Surface Soils—Analytical Results

Samples taken from the 0–1-ft interval along with the DPT borings at the Kellogg Building consisted of gravel cover and associated construction fill material. No true surface soil horizon was observed at this site. Surface soil samples were not collected at the leach fields because potential releases would have been into the subsurface. The samples were analyzed for SVOAs, PCBs, and TAL metals and screened for radiological constituents. Two surface soil samples (SS-099-15 and -16) were collected in very shallow drainage ditches east of the SWMU to determine whether runoff has impacted surface water pathways adjacent to the site (see Fig. 3.14).

Organics—VOAs. Surface soil samples were not analyzed for VOAs.

Organics—SVOAs. Low concentrations of several SVOAs were detected in the surface soil samples. Two locations (DPT99-031 and DPT99-004), both near the southwest corner of SWMU 99, displayed a diverse suite of polycyclic aromatic hydrocarbons (PAHs). Almost all the detections were PAHs that are common to industrial settings. Both samples, which contained multiple PAHs, were collected from a shallow ditch that collects runoff from the adjacent roadway on the western side of the site. Surface soil samples that contained only one or two PAHs above screening levels were 099-001, -011, -012, -015, and -016. All of these PAHs are located on the eastern side of the site.

Organics—PCBs. PCB 1260 at a concentration of 0.63 mg/kg was the only PCB detected above screening levels at SWMU 99.

Inorganics. Several metals were observed in the surface soils at SWMU 99. Table 4.26 highlights those analytes that were detected in the surface soil samples above screening levels.

Table 4.26 Evaluation of inorganic analytes in surface soils at SWMU 99

Analyte	> Detection limit	> Background[a]	> EPA SSL[a]	> 1/5 RDA
Barium	Yes	Yes (2)	Yes (1)	Not applicable
Chromium	Yes	Yes (3)	Yes (1)	Not applicable
Lead	Yes	Yes (1)	Not available	Not applicable

[a] The number in parenthesis represents the number of individual analytes that exceed criteria.

Isolated single detections of barium from 099-014 at 2470 mg/kg, chromium from 099-016 at 45.7 mg/kg, and lead from location 099-006 at 47.3 mg/kg were the only metals detected that exceed screening levels.

Radionuclides. Gross alpha measurement for the surface soils ranged from 3.7 to 35 pCi/g, and gross beta measurements ranged from 3.8 to 156 pCi/g. Only two surface samples contained concentrations of radioisotopes above screening levels. Sample station DPT99-001 and DPT99-004 contained 49.4 and 16.6 pCi/g of technetium-99, respectively, and 1.1 pCi/g of cesium-137 each.

Subsurface Soils—Analytical Results

Subsurface soil samples were collected using DPT drilling methods at selected intervals throughout the UCRS. The samples were analyzed for VOAs, SVOAs, PCBs, and TAL metals and screened for radiological constituents.

Organics—VOAs. Methylene chloride, a laboratory contaminant, was the only VOA to exceed screening levels. Only two samples contained detectable concentrations of VOAs (trichloroethene only) in the subsurface UCRS soil samples at SWMU 99 (Table 4.27).

Table 4.27 Trichloroethene detected in soils above screening levels at SWMU 99

DPT station	Depth interval	Trichloroethene (µg/kg)
99-008	51–54 ft	30
99-033	10–13 ft	4.8

Organics—SVOAs. Low concentrations of several SVOAs were detected in subsurface soils collected from SWMU 99. The common plasticizer di-n-butylphthlate was the only SVOA to exceed the chemical-specific screening levels.

Organics—PCBs. No subsurface soils in SWMU 99 contained detectable concentrations of PCB compounds.

Inorganics. Table 4.28 highlights those metals that were detected above screening levels in the subsurface soil samples at SWMU 99.

Similar to surface soils, the subsurface soils at SWMU 99 contained many inorganic constituents above the analytical detection limit. However, when compared to screening values, only aluminum, chromium, cobalt, and lead exceeded all screening criteria. Figure 4.2 shows the distribution and concentrations of all the metals that were detected above screening levels, with the exception of aluminum.

Table 4.28 Evaluation of inorganic analytes in subsurface soils at SWMU 99

Analyte	> Detection limit	> Background[a]	> EPA SSL[a]	> 1/5 RDA
Aluminum	Yes	Yes (12)	Not available	Not applicable
Chromium	Yes	Yes (1)	Yes (1)	Not applicable
Cobalt	Yes	Yes (1)	Not available	Not applicable
Lead	Yes	Yes (2)	Not available	Not applicable

[a] The number in parenthesis represents the number of individual analytes that exceed criteria.

Aluminum exceeded the project screening criteria in 12 samples. However, the maximum concentration for this common soil-forming mineral was only 18,400 mg/kg, which is only slightly above background and is probably representative of the upper ranges for concentration of aluminum in naturally occurring soils. Chromium was reported at 57 mg/kg and 79 mg/kg compared to a subsurface background concentration of 43 mg/kg. Cobalt at 27.3 mg/kg and lead at 33.2 mg/kg each were reported above screening levels in only one sample.

Radionuclides. Gross alpha measurements for the subsurface soils ranged from 2 to 30 pCi/g , and gross beta measurements ranged from 1 to 23.9 pCi/g. No subsurface soil samples in SWMU 99 had measurable quantities of any specific radioisotopes.

Excavation Samples—Analytical Results

During the WAG 28 RI a collapsed section of Tennessee Avenue near SWMU 99 exposed a section of drainpipe that is believed to have drained the area beneath the Classified Scrap Yard at SWMU 99. The pipe apparently is a storm drain that eventually empties into a drainage ditch leading to Outfall 010. When discovered, a decision was made in the field to sample the contents of the pipe and surrounding soil. A backhoe was used to excavate the top of the pipe, and two samples were collected. While the sample identifiers 082014SA001C and 082015SA001C classify these as surface samples, the samples were actually collected from soil excavated from several feet below grade. Sample 082014SA001C was collected from soil that had been surrounding the outside of the pipe, and sample 082015SA001C was taken from soil within the collapsed pipe (Fig. 4.3).

An inspection of the excavated section of pipe indicated that the pipe had been sealed off above the collapse with a plywood board. As a result, any water entering the pipe would be diverted into the surrounding fill material and would not reach the collapsed section of the pipe. Table 4.29 shows selected analytical results obtained from the excavation samples. Contaminant releases appear to have impacted the surrounding soil but not to have entered the pipe itself.

Table 4.29 Primary contaminants in excavation soil samples at SWMU 99

Surface sample station	Cesium-137	PCBs	Technetium-99	Uranium-total	Thorium-234	Neptunium-237	Alpha/beta
82-014	1.9 pCi/g	1.8 mg/kg	2650 pCi/g	69.2 pCi/g	53 pCi/g	12.8 pCi/g	142/2730 pCi/g
82-015	ND	ND	ND	ND	ND	ND	22/28 pCi/g

ND = Non-detect

The information collected on the drainpipe has been used in the formulation of the risk assessment. These data also will be utilized in support of remedial alternative selections for SWMU 99 that are currently being developed under the Groundwater OU Feasibility Study, which is scheduled for release in June 2000.

UCRS Groundwater—Analytical Results

UCRS groundwater samples were obtained by bailing the DPT well bores after reaching total depth. In a few instances, groundwater samples were collected at a shallower depth when CPT logs indicated the presence of a water-bearing zone. A total of 14 UCRS water samples were collected for analyses.

Organics—VOAs. The primary VOAs detected in UCRS groundwater at SWMU 99 were trichloroethene and its degradation products. Trichloroethene was present at levels that are only slightly above the analytical reporting limit in a boring in the center of SWMU 99 and in a boring located immediately south of the SWMU. No VOAs were noted from SWMU 99 UCRS groundwater samples collected in the area of the leach fields. Table 4.30 summarizes the occurrences of VOAs at SWMU 99.

Table 4.30 VOAs observed in UCRS groundwater at SWMU 99

DPT station	Depth (ft bgs)	TCE (µg/L)	cis-1,2-DCE (µg/L)	1,1-DCE (µg/L)	Vinyl chloride (µg/L)
99-005	57–60	140	160	ND	ND
99-008	54–60	3	3	5	0.4J
99-011	59–62	0.5J	ND	ND	ND
99-014	57–60	ND	0.9J	ND	ND
99-031	41–46	3	2	ND	ND
99-032	39–44	0.9J	0.5J	ND	ND

ND = Non-detect

Organics—SVOAs. Five SVOA compounds were detected from the UCRS water samples collected at SWMU 99. Diethylphthalate was present in three samples at a maximum concentration of 21 µg/L. Pyridine, fluoranthene, phenanthrene, and pyrene were each reported in a single sample.

Organics—PCBs. UCRS water samples were not analyzed for this contaminant group.

Inorganics. In accordance with the WAG 28 RI work plan (DOE 1998b), UCRS groundwater samples collected from SWMU 99 were not analyzed for metals.

Radionuclides. Groundwater samples from the UCRS were screened for radiological constituents and technetium-99. Gross alpha activity ranged from 2.4 to 51.2 pCi/g, and gross beta activity ranged from 2.2 to 159.5 pCi/g. Technetium-99 was present at elevated levels in 9 samples (and one duplicate). The maximum concentration of 148 pCi/L was found at 41–46 ft bgs in soil boring 99-031, which is located south (upgradient) of the SWMU (see Table 4.31).

Table 4.31 Technetium-99 in UCRS groundwater samples at SWMU 99

DPT station	Depth (ft)	Results (pCi/L)	Detection Limit (pCi/L)
99-005	57–60	28	20
99-011	59–62	26	16
99-014	57–60	21	19
99-019	45	36	14
99-025	42–44	16	16
99-030	41–46	26	14
99-031	41–46	148	17
99-032 (PGDP)	39–44	79	18
99-033	41–46	48	14

RGA Groundwater—Analytical Results

Two DWRC borings sampled the RGA groundwater at SWMU 99. The first boring, SB99-034, was situated south of and across a drainage ditch from the former location of the Kellogg Building to test for an upgradient contaminant source. This boring encountered distinct RGA lithology from 70 to 105 ft bgs. The second boring, SB99-035, which was positioned in the middle of the Cylinder Yard of SWMU 99 to determine impacts to RGA groundwater immediately beneath the site, encountered sands and gravel interpreted to be RGA lithology from 65 to 105 ft bgs. Samples were taken from both boreholes at 5-ft intervals when groundwater was present. Table 4.32 shows the distribution of trichloroethene detected in those borings.

Much lower concentrations of trichloroethene degradation products were also present. The observed concentrations of trichloroethene are similar to those observed during sampling associated with the Phase IV Groundwater Investigation. Boring P4E6, which is located midway between borings SB 99-034 and SB 99-035, exhibited 519 µg/L trichloroethene from 103 to 105 ft bgs.

Table 4.32 Trichloroethene concentrations (µg/L) in RGA groundwater at SWMU 99

Interval (ft bgs)	SB 99-034	SB 99-035
77	0.3J	U
82	0.2J	0.2J
87	520	0.2J
92	440	NA
97	200	NA
102	270	NA
107	NA	350

NA = Not analyzed
U = Non-detect

The source for the observed trichloroethene may be located south of the former Kellogg Building. Impact to the groundwater in the vicinity of the site due to downgradient transport of trichloroethene to the north along the base of the RGA may be as high as 350 µg/L (see Fig. 4.4).

No borings were installed to sample the RGA within the area of the abandoned leach field. The closest boring, P4E7, which was installed and sampled during the Phase IV investigation, contained greater than 2000 µg/L trichloroethene in the RGA in 1998.

Radiological constituents detected in the RGA at SWMU 99 consisted of technetium-99 and related gross alpha/beta activity. Table 4.33 shows the results of technetium-99 analyses. The distribution of technetium-99 is similar to that of trichloroethene, which indicates a contaminant source that is not related to SWMU 99.

Three types of samples were prepared for inorganic analysis of the RGA water: (1) unfiltered samples providing total concentration of the inorganic analytes, (2) 0.45µ filtered samples providing dissolved concentrations of inorganic analytes, and (3) 5µ filtered samples providing concentrations of the dissolved phase and the colloidal phase. Table 4.34 provides the average, minimum, and maximum concentration in each sample type. A review of the results shows that the high concentrations of several metals is due to the presence of suspended sediments. Additionally, the aluminum present in the RGA groundwater is partitioned in a colloidal phase.

Table 4.33 Technetium-99 activity (pCi/L) in RGA groundwater at SWMU 99

Interval (ft bgs)	SB 99-034	SB 99-035
77	14.5	U
82	U	U
87	131	U
92	139	NA
97	U	NA
102	41.8	NA
107	NA	71

Table 4.34 Comparison of filtered and unfiltered groundwater samples in SWMU 99

Analyte	Not filtered			0.45 Micron			5.0 Micron		
(mg/L)	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Aluminum	175.2	4.78	659	0.20	0.2	0.2	0.98	0.2	5.03
Arsenic	0.007	0.005	0.01	0.005	0.005	0.005	0.005	0.005	0.005
Barium	1.29	0.2	3.3	0.31	0.13	0.53	0.32	0.14	0.52
Beryllium	0.034	0.008	0.1	0.005	0.005	0.005	0.005	0.005	0.005
Calcium	50.64	24.6	120	46.1	21.2	87.2	45.78	21	83.2
Chromium	0.70	0.06	1.78	0.05	0.05	0.05	0.05	0.05	0.05
Cobalt	0.22	0.02	0.57	0.05	0.01	0.13	0.05	0.01	0.13
Copper	0.24	0.06	0.64	0.05	0.05	0.05	0.05	0.05	0.05
Cyanide	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Iron	328.1	24.8	1200	1.14	0.2	5.59	1.23	0.2	4.69
Lead	0.17	0.05	0.41	0.05	0.05	0.05	0.05	0.05	0.05
Lithium	0.10	0.05	0.17	0.05	0.05	0.05	0.05	0.05	0.05
Magnesium	21.12	9.65	49.7	17.57	8.44	32.5	17.46	8.38	31
Manganese	2.53	0.48	4.6	0.90	0.32	2.15	0.88	0.35	1.63
Mercury	0.0050	0.0002	0.02	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel	0.35	0.06	0.91	0.05	0.05	0.06	0.05	0.05	0.06
Potassium	7.7	2	21.7	2.30	2	3.47	2.27	2	3.42
Sodium	46.3	15	67.9	60.4	49.1	88.1	59.54	48	85.5
Strontium	0.28	0.11	0.47	0.21	0.11	0.32	0.21	0.11	0.32
Vanadium	1.02	0.34	2.15	0.10	0.1	0.1	0.10	0.1	0.1
Zinc	0.96	0.24	2.55	0.20	0.2	0.2	0.20	0.2	0.2

4.2.1.6 Summary of findings

Several metals were detected in isolated soil samples from the surface and subsurface at SWMU 99. Occurrences of aluminum at levels slightly above background also are within the range of expected variability for naturally occurring concentrations. Isolated occurrences of barium, cobalt, chromium, and lead may represent small isolated spills or leaks. Due to a lack of screening data, the significance of metals present in the RGA cannot be adequately assessed. However, a lack of a defined metals source within the soils at SWMU 99 eliminates the site as a significant contributor of metals to the RGA.

Soil collected adjacent to a buried storm drain that was exposed in the roadbed of Tennessee Avenue contained elevated levels of PCBs, technetium-99, uranium, and several other radionuclides. The storm drain is believed to drain from the SWMU 99 Classified Scrap Yard Area. However, of the contaminants, only isolated detections of technetium-99 at concentrations exceeding background levels were found in surface or subsurface soil within the Classified Scrap Storage Area of SWMU 99. The source of technetium-99 observed in the surface soil and shallow subsurface is probably contaminated equipment currently stored at the site. Although the presence of these contaminants represents a potential source, the relationship to SWMU 99 is not fully understood.

Shallow groundwater in the UCRS contains small quantities of trichloroethene and technetium-99. Based on the distribution and concentrations of these contaminants, the source for these contaminants appears to be upgradient of SWMU 99. Elevated levels of trichloroethene and technetium-99 are also found near the base of the RGA. A source for these contaminants that is located upgradient of SWMU 99 is also indicated. This finding supports the conclusion concerning trichloroethene reached during the *Northeast Plume Preliminary Characterization Summary Report* (DOE 1995a).

4.2.2 McGraw Construction Facilities (SWMU 193)

4.2.2.1 Location and physical description

The McGraw Construction Facilities Area consists of a series of sites located to the south and west of Building C-333 (Fig. 3.15). The area encompasses approximately 100 acres of mostly flat land, about half of which is used to store UF_6 cylinders. The area is drained on the southwest by KPDES Outfall 017 and to the southeast by Outfall 013. The area to the west of Building C-333 is drained by the plant storm drain system, which eventually exits the plant through KPDES Outfall 009. The area south of Building C-333 drains through the plant storm drain system, which discharges through KPDES Outfall 011.

4.2.2.2 Site history

SWMU 193 was previously covered by temporary buildings used during the construction of PGDP including a steel fabrication shop, electrical warehouse, sheet metal shop, light and heavy equipment shops, steel reinforcing shop, truck wash, millwright shop, pipe fabrication shop, and concrete production plant. Several sanitary leach fields are noted in early drawings of the area. The buildings were in use from 1951 to the late 1950s. No descriptions of waste handling practices or of any inadvertent releases into the environment from SWMU 193 have been documented. Because of the likely waste handling practices and the types of wastes potentially generated in the early 1950s, releases of metals and volatile organic compounds may have occurred. Types of possible releases include disposal of solvents and metal-containing fluids into the sanitary system or adjacent to buildings.

4.2.2.3 Results from previous investigations

The area was initially investigated during the 1995 site evaluation of SWMUs 193 and 194 (DOE 1995b). The purpose of this site evaluation was to identify possible sources of contamination associated with some of the staging areas used during plant construction that were suspected to be potential source areas for the Northeast Plume (DOE 1995a). Analytes of interest during the investigation included PCBs; total petroleum hydrocarbons (TPH); trichloroethene; 1,2-dichloroethene (1,2-DCE);

trichloroethane; and metals (lead, cadmium, chromium). Because the area is currently used for the storage of UF_6 cylinders, gross alpha and gross beta analyses were added to the list of analytical parameters.

The site evaluation of SWMUs 193 and 194 included a geophysical survey, CPT soil borings, and GeoProbe™ water samples. Twenty-one soil borings were advanced, and 15 groundwater samples were collected. Boring depths ranged from 17 to 36 ft bgs. Soil sample depths were from 5 to 15.5 ft bgs. The geophysical survey was used to locate a UST (SWMU 183) used for waste oil storage at the filling station and a drum and tank storage area. The GeoProbe™ was used for deeper penetrations in the soil and to collect 15 water samples.

The Groundwater Phase IV Investigation (DOE 1995a) was completed concurrently with the site evaluation of SWMUs 193 and 194. Although the focus of the investigation was not SWMU 193, two RGA soil borings (P4H5 and P4H6) were completed in the vicinity of the Millwright Shop, formerly located near the northwestern corner of the C-333 Building.

Results from the site evaluation of SWMUs 193 and 194, the Groundwater Phase IV Investigation, and historical monitoring well data indicate that VOCs (primarily trichloroethene and its degradation products) have been present in the RGA groundwater at SWMU 193 at concentrations as high as 6700 µg/L from Piezometer 118.

Toluene at a very low concentration was the only organic compound detected in the subsurface soil, and no radionuclide isotopes were reported above screening levels. Metals were the most frequently detected constituent in SWMU 193 soils. Historical results are summarized in Table 4.35.

Table 4.35 Historical results of metals sampling at SWMU 193

Analyte	Boring	Depth	Max. conc.
Cadmium	193-02	15.5 ft bgs	13.2 mg/kg
Chromium	193-01	15.5 ft bgs	398 mg/kg
Lead	193-01	15.5 ft bgs	136 mg/kg

4.2.2.4 Rationale for RI field sampling

Sampling conducted during the site evaluation of SWMUs 193 and 194 did not investigate all potential sources located in the southern McGraw Construction area (see Fig. 3.16 for historical sampling locations). The Millwright Shop and/or the Schulman Pipe Fabrication Shop required characterization as potential source areas contributing to the Northeast Plume and a determination whether DNAPL was present beneath the sites. Therefore, it was determined that additional data were needed to further characterize the SWMU 193 area, provide the information necessary to conduct the human health and ecological risk assessment, and evaluate remedial alternatives, if necessary.

For purposes of the RI and BRA, SWMU 193 was divided into three subunits to allow a specific discussion of the nature and extent of contamination and characterization of human health risks for each area. The sampling strategy for SWMU 193 was targeted at the three areas within the McGraw Construction Facilities: the Millwright Shop, the Schulman Pipe Fabrication Shop, and the sanitary leach fields located in the southern portion of the SWMU.

The Millwright Shop, formerly located immediately west of Building C-333, was identified as a potential source of trichloroethene in UCRS and RGA groundwater because of activities thought to have taken place within this facility during its period of operation. Sampling during the SI reported concentrations greater than 1000 μg/L of trichloroethene in the RGA in the immediate vicinity of the shop. Based on the findings of the initial borings installed at the Millwright Shop, two contingency borings were drilled north of the site, adjacent to the C-310 Building, in an effort to define a potential source for the known contaminants present in the RGA groundwater.

The Schulman Pipe Fabrication Shop formerly located in the northeastern corner of the C-333 Building, also has been identified as a potential source of trichloroethene. Impacts to the UCRS and RGA groundwater were suspected because of activities within this facility during its period of operation and because of the historical concentrations greater than 1000 μg/L of trichloroethene in groundwater samples from borings in the vicinity of SWMU 193—Millwright Shop.

The southern half of SWMU 193 was the location of the former sanitary leach fields, civil engineering testing laboratory, light and heavy equipment shop, sheet metal shop, and steel fabrication shop. These facilities have been identified as potential sources of metals contamination in the UCD because of the activities thought to have occurred during their operational time frame.

4.2.2.5 Nature and extent of contamination

During the WAG 28 RI, a CPT boring was completed at the Millwright Shop to the top (approximately 60 ft bgs) of the HU3 hydrogeologic unit. The purpose of this boring was to better define lithology and to target specific zones for the collection of UCRS water samples and subsurface soil samples. Subsequently, four DPT borings were completed to a depth of between 31 and 60 ft bgs to collect soil and groundwater samples to determine if contaminants were released from the Millwright Shop to the surface and then migrated into UCRS.

One CPT boring was also completed at the Schulman Pipe Fabrication Shop to the top of the HU3 hydrogeologic unit. Based on a review of the CPT, soil and groundwater samples were collected from two shallow DPT borings pushed to a total depth of between 15 and 32 ft bgs to define the nature and extent of site contaminants.

Within the southern limit of SWMU 193, five shallow DPT borings (total depth of 15 ft bgs) were completed to evaluate metals concentrations in surface and shallow subsurface soils. Four soil samples (one surface/three subsurface) were collected from each boring.

At the Schulman Pipe Fabrication Shop and Millwright Shop locations, surface and subsurface soil samples were analyzed for SVOCs, TAL metals, gross alpha/beta, technetium-99, and for selected radionuclides (plutonium-239, neptunium-237, and thorium-230). Samples collected at depths of less than 15 ft bgs from the Schulman Fabrication Shop and the Millwright Shop were analyzed for PCBs. Subsurface soils were also analyzed for VOAs.

Samples collected from the leach fields were analyzed only for TAL metals, mercury, and hexavalent chromium.

<u>**Surface Soil—Analytical Results**</u>

Organics. SVOAs were the only organic compounds detected in the surface soils at SWMU 193. All the reported SVOAs were from borings 193-029 and 193-030 in the vicinity of the old Millwright Shop. Detected compounds included benzo(a)anthracene at maximum of 180 μg/kg; benzofluoranthene at 510 μg/kg; benzo(g,h,i)perylene at 166 μg/kg; chrysene at 170 μg/kg; dibenzo(a,h)anthracene at 130 μg/kg; indeno(1,2,3-cd)pyrene at 160 μg/kg; and two phthalates at a maximum concentration of 120 μg/kg.

Inorganics. . Chromium was reported at a concentration of 88.7 mg/kg from location DPT 193-023 (former Schulman Pipe Fabrication Shop location). Chromium was not above screening levels in the other surface soil sample collected almost 100 ft to the east. Lead was reported at 67.7 mg/kg from location 193-038 near the C-310 Building.

Table 4.36 shows the screening of inorganic analytes in surface soils for SWMU 193.

Table 4.36 Evaluation of inorganic analytes in surface soils at SWMU 193

Analyte	> Detection limit	> Background[a]	> EPA SSL[a]	> 1/5 RDA
Chromium	Yes	Yes (2)	Yes (1)	Not applicable
Lead	Yes	Yes (1)	No	Not applicable

[a] The number in parenthesis represents number of individual analytes that exceed criteria.

Radionuclides. No radionuclides were detected at activities above screening levels in any of the SWMU 193 surface soils. The highest alpha activity was 18.6 pCi/g at DPT 193-022 at the Schulman Pipe Shop, and the maximum beta activity was 23.7 pCi/g from location DPT 193-030 at the Millwright Shop.

Subsurface Soil—Analytical Results

Organics. Single occurrences of benzo(a)anthracene, benzo(b)fluoranthene, and di-n-octylphthlate from location 193-030 at the Millwright Shop were the only organic constituents reported from any of the subsurface soils at SWMU 193.

Inorganics. At the Millwright Shop three isolated occurrences of aluminum at a maximum concentration of 15,000 mg/kg at DPT193-026 and a single occurrence of hexavalent chromium (85.8 mg/kg at DPT193-049) exceeded all screening criteria.

At the Schulman Pipe Fabrication Shop aluminum at a concentration that was only slightly above background was the only other metal detected above screening levels.

Four metals were detected at the leach fields above screening levels. Of these, aluminum, which is a common soil-forming metal, was detected at a maximum concentration only slightly above screening levels. A single occurrence of cobalt and manganese above screening levels was also noted. Lead was present in one sample (193-036) from 2 to 5 ft bgs at a concentration of 23.4 mg/kg. Figure 4.5 shows the locations of these occurrences of metals.

Table 4.37 shows the screening of inorganic analytes for subsurface soils for SWMU 193.

Radionuclides. No radionuclides were detected above screening levels from any of the subsurface soils collected from SWMU 193. The maximum alpha and beta activities were 26.5 pCi/g and 20.8 pCi/g, respectively. Both readings were obtained from Boring 193-022 at the former Schulman Pipe Fabrication Shop.

Table 4.37 Evaluation of inorganic analytes in subsurface soils at SWMU 193

Analyte	> Detection limit	> Background[a]	> EPA SSL[a]	> 1/5 RDA
Aluminum	Yes	Yes (11)	Not available	Not applicable
Chromium	Yes	Yes (1)	Yes (1)	Not applicable
Cobalt	Yes	Yes (1)	Not available	Not applicable
Lead	Yes	Yes (1)	Not available	Not applicable
Manganese	Yes	Yes (1)	Yes (1)	Not applicable

[a] The number in parenthesis represents the number of individual analytes that exceed criteria.

UCRS Groundwater—Analytical Results

Five UCRS groundwater samples were collected from SWMU 193 using temporary PVC well points.. These samples were analyzed for VOCs, SVOCs, total and isotopic uranium, and radionuclide screening. Inorganic analyses of these open borehole samples were not performed.

Organics. Several organic compounds were present in concentrations that exceeded screening levels in the UCRS water samples collected at SWMU 193. Other than a single occurrence of acetone, a likely laboratory by-product, phthalates were the most commonly reported compound. Three of the common plasticizers, bis(2-ethylhexyl)phthalate, di-ethylhexylphthalate, and di-n-butylphthalate, were reported from one or two of the five water samples at concentrations that exceeded 23 μg/L. Relatively small quantities of trichloroethene (up to 72 μg/L) and *cis*-1,2-dichlorethene (up to 1.0 μg/L) were also detected.

Inorganics. In accordance with the WAG 28 work plan (DOE 1998b), UCRS water samples were not analyzed for inorganic constituents.

Radionuclides. Technetium-99 at a maximum activity of 108 pCi/L, thorium-234 at an activity of 0.54 pCi/L, and uranium-235 at 0.63 pCi/L were the only radionuclides detected above screening levels from the UCRS water sample collected from SWMU 193. All three radionuclides were present in the samples collected from boring 193-041. Only technetium-99 was present in boring 193-049 above screening levels.

RGA Groundwater—Analytical Results

Seven deep soil borings were completed to the top of the Levings Member of the McNairy Formation (approximately 160 ft bgs) at SWMU 193. All seven of the borings were drilled in the northern half of the site. The purpose of these borings was to further delineate the boundaries of the Northeast Plume and collect additional groundwater data to identify the source(s) of the trichloroethene that has previously been detected in the vicinity of the Millwright Shop and the Schulman Pipe Fabrication Shop. During drilling of these deep borings, RGA groundwater samples were collected at 5-ft intervals, and McNairy water samples were collected at 10-ft intervals when possible.

These soil borings also were located in areas where additional RGA groundwater data were needed to support the characterization of the Groundwater Operable Unit. In addition to the environmental samples described in the previous paragraph, two sets of soil and groundwater samples were collected for the feasibility study parameters.

Geophysical well logs were run in one of the RGA soil borings (Appendix H) located near the former Schulman Pipe Fabrication Shop. Gamma and neutron logs were used from each boring to correlate stratigraphic boundaries, to identify lithologies with water-producing zones, and to select subsurface soil sampling intervals.

Organics. Trichloroethene and its related degradation products were the most common organic constituents detected in the RGA groundwater samples. Trichloroethene was reported in 30 water samples analyzed from SWMU 193. The maximum concentration of trichloroethene (330 µg/L) was collected from SB193-041 near the base of the RGA. Similarly, two of the other highest trichloroethene concentrations also were collected from near the base of the RGA in nearby borings SB99-038 and SB193-025. Table 4.38 shows other sample intervals and associated borings where significant concentrations of trichloroethene were found. Trichloroethene was not detected in groundwater samples from SB193-028.

Trichloroethene degradation products, *cis*-1,2-dichloroethene and *trans*-1,2-dichloroethene, were found at concentrations below 100 µg/L in 18 and 14 samples, respectively. 1,1-dichloroethene was observed in five samples at a maximum concentration of 20 µg/L. The three isomers of dichloroethene were present throughout the vertical extent of the RGA and are generally correlated with the areas of high trichloroethene concentrations.

Table 4.38 SWMU 193 highest trichloroethene concentrations in RGA

Boring	Depth (ft bgs)	Trichloroethene (µg/L)
SB 99-038 (in SWMU 193)	87	160
	102	130
SB 193-025	77	180
	82	170
	87	87
	92	99
	102	110
SB 193-041	97	330

Bis(2-eythlhexyl) phthalate and diethylphthalate were also detected in the RGA water samples from SWMU 193. These two phthalate esters are plasticizers and occur as artifacts of the sampling and analysis process. They were found in only a few isolated samples at concentrations less than 25 µg/L.

Inorganics. In accordance with the WAG 28 work plan (DOE 1998b), RGA water samples were not submitted for inorganic analyses.

Radionuclides. Technetium-99 was the most commonly detected radionuclide in the RGA groundwater from SWMU 193. The highest technetium-99 activity of 1390 pCi/L was from the 95–97-ft interval of SB193-041 (see Table 4.39). This occurrence was in the same sample that had the highest trichloroethene detected at the site. In general, all of the technetium-99 activities that were above 100 pCi/L were found in two borings (SB193-41 and SB99-038) north of the old Millwright Shop. These elevated activities were reported throughout the RGA in SB193-041. Measurable levels of uranium-235 were also reported from SB193-041 (0.44–0.82 pCi/L) and in SB099-038 (0.68 pCi/L).

McNairy Groundwater—Analytical Results

Organics. Trichloroethene was the most commonly detected organic compound in the McNairy groundwater samples collected from SWMU 193. The highest trichloroethene concentration was 42 µg/L. Trichloroethene was not found deeper than 32 ft below the top of the McNairy Formation. Acetone and diethylphthalate, two common laboratory contaminants, were also reported from the McNairy in one and two samples, respectively.

Table 4.39 SWMU 193 technetium-99 concentrations in RGA

Boring	Depth (ft bgs)	Technetium-99 (pCi/L)
SB 99-038 (in SWMU 193)	77	18.7
	87	820
	92	320
	97	280
	102	84
SB 99-037	72	16.4
	77	14.5
	82	18
SB 193-041	80	519
	85	265
	90	ND
	95	1390

ND = Non-detect

Inorganics. In accordance with the WAG 28 work plan (DOE 1998b), McNairy water samples weresubmitted for inorganic analyses.

Radionuclides. Several radionuclides were detected at activities above screening levels from the McNairy groundwater at SWMU 193. One sample collected from SB193-041 at 117 ft bgs contained technetium-99 at 145 pCi/L, thorium-234 at 0.84 pCi/L, and each of the three uranium isotopes at maximum activities of less than 1.5 pCi/L.

4.2.2.6 Summary of findings

Aluminum was reported above screening levels in subsurface soils and would appear to be within expected variability for natural soils. Isolated occurrences of chromium, cobalt, manganese, and lead in the surface and subsurface soils at SWMU 193 may represent small releases or outliers of natural conditions.

Trichloroethene is the most widespread contaminant in groundwater at SWMU 193. Trichloroethene was detected in the UCRS water samples collected from SWMU 193 at a concentration below 100 µg/L. Within the RGA, the maximum trichloroethene content was 330 µg/L. All of the elevated trichloroethene levels (those above 100 µg/L) occurred in samples that were collected from borings SB193-041, SB99-038, and SB193-025 between 77 and 102 ft bgs in the lower portion of the RGA. These three borings lie along a line that extends from the location of the old Schulman Pipe Fabrication Shop toward the northwest.

Associated with the areas of elevated trichloroethene are several trichloroethene degradation products, including *cis*-1,2-dichloroethene and *trans*-1,2-dichloroethene. The distribution of the maximum concentrations for both breakdown products was closely associated with the highest concentrations of trichloroethene. However, the maximum concentration detected for either contaminant was less than 10 µg/L.

Based on historical information, as late as 1994 the RGA displayed concentrations of trichloroethene as high as 6700 µg/L beneath the former Millwright Shop location at PZ-118. Resampling of PZ-118 in August 1999 by the Environmental Compliance Group showed that the level of trichloroethene in this well had dropped to approximately 1200 µg/L (oral communication). As part of the WAG 28 RI, three deep borings (SB193-028, SB193-031, and SB193-032) were drilled adjacent to PZ-118. The highest trichloroethene content detected in these samples was 40 μg/L. No trichloroethene was present in the RGA samples collected from location SB 93-028 that may represent an upgradient extent of trichloroethene contamination in the RGA/McNairy system in this area.

Historical occurrences of trichloroethene have not been reported in soils at SWMU 193, and trichloroethene was not encountered in the UCRS soils during the WAG 28 RI. As a result, a source for the trichloroethene previously identified in the RGA has not been recognized during this investigation. A significant decrease in the trichloroethene concentrations in the RGA groundwater beneath the Millwright Shop was observed between the 1994 sampling event and the WAG 28 sampling event. This occurrence may be attributed to dilution and diffusion of trichloroethene as the contaminant zone migrated to the north-northeast during the intervening 5- year period.

Although trichloroethene is a DNAPL, downward movement of trichloroethene from the porous RGA sands and gravels into the underlying McNairy clays is not a widespread phenomenon at SWMU 193. The maximum concentration of trichloroethene reported from the McNairy water samples was 42 μg/L, and the deepest penetration of trichloroethene into the McNairy was 32 ft below the base of the RGA.

Technetium-99 is the most widespread of the radionuclides detected in the groundwater at SWMU 193. Two UCRS sample that contained elevated technetium-99 were collected at the Millwright Shop between 55 to 62 ft bgs (from borings SB193-041 and -049) near the base of the UCRS. The distribution and location of the highest technetium-99 activities in the RGA closely mimic the distribution of trichloroethene. This would indicate that the source for the two contaminants (trichloroethene and technetium-99) has a common release point. Technetium-99 activity in the McNairy was above screening levels in two isolated water samples.

4.2.3 McGraw Construction Facilities Leach Fields (SWMU 194)

The McGraw Construction Facilities have been divided into two SWMUs (SWMU 193 and SWMU 194) because of the size of the area. SWMU 194 was the site of the administrative portion of the McGraw Construction Facilities and two leach fields immediately west of the administrative buildings.

4.2.3.1 Location and physical description

SWMU 194 is located in the southwestern corner of PGDP and includes the area shown in Fig. 3.17. The McGraw Construction Facilities were built in the early 1950s during the construction of PGDP. SWMU 194 consisted of an administration building, cafeteria, security guard headquarters, hospital, purchasing building, paper and stationary warehouse, boiler house, and two leach fields located west of Hobbs Road. All of these facilities have been demolished. The site now consists of an open grass-covered area that is mowed regularly as part of PGDP maintenance operations. This SWMU is located outside the main security fence that surrounds the primary plant buildings and structures.

4.2.3.2 Location and results of previous sampling

A site evaluation of SWMU 194 was undertaken as part of the Northeast Plume Investigation and the Groundwater Phase IV Investigation. Soil borings were completed to identify possible sources of contamination associated with various buildings and operations within SWMU 194. Seven soil borings were completed within the boundaries of SWMU 194 during the site evaluation. Three of those borings (194-2, 194-3, and 194-5) were in the immediate vicinity of the leach fields. The locations of the borings are shown in Fig. 3.17. Samples were collected from 5, 10, and 15 ft bgs and analyzed for trichloroethene; 1,2-dichloroethene; benzene, toluene, ethylbenzene, and xylenes; PCBs; TPH; selected metals (cadmium, chromium, and lead); PCBs; and gross alpha/beta. No groundwater samples were collected from any of the borings at SWMU 194.

The analytical results from these samples indicate that there is limited soil contamination at SWMU 194. Chromium and lead were detected in 24 of 24 samples and 20 of 24 samples, respectively, and cadmium was detected in only 1 of 24 samples. However, of the detections, only two samples for chromium were above background concentrations, and only one sample was above background for lead. The highest concentrations for both of the analytes (chromium at 103 mg/kg and lead at 360 mg/kg) were observed in soil boring 194-3, which is located near the leach fields.

Ethylbenzene and xylene were both detected in 1 of 20 samples at concentrations slightly above the analytical detection limit. PCBs were not detected in any of the samples analyzed. Gross alpha and gross beta were found at reportable activities in all 24 samples analyzed. The maximum concentration reported for gross alpha was 2.5 pCi/g, while that for gross beta was 7.0 pCi/g.

4.2.3.3 Rationale for RI field sampling

The SWMU 194 RI was designed to characterize the site according to its potential for release of contaminated materials to the environment. Based on the history of SWMU 194, it was considered unlikely that the SWMU is currently releasing contaminants to the environment because the facilities associated with this SWMU have been out of service for more than 40 years. The highest concentrations of metals detected during previous investigative activities were found in two of the soil borings drilled near the leach fields.

Accordingly, the sampling strategy for SWMU 194 targeted metals only for analyses in the subsurface soils in the vicinity of the leach fields that formerly serviced the administrative portion of the McGraw Construction Facilities. Because any releases from the leach fields would have been to the subsurface soils, no surface soil sampling was deemed necessary for characterization of this SWMU. As noted, no groundwater samples were collected from SWMU 194 because the preliminary COPCs were metals that characteristically have limited mobility in the subsurface environment.

4.2.3.4 Nature and extent of contamination

Four DPT borings (see Fig. 3.17) were placed within the general outline of the leach fields to obtain subsurface soil samples. Borings identified as DPT 194-8 and 194-9 were located in the northernmost leach field, while DPT 194-10 and 194-11 were situated in the southern leach field. From each boring, a 3-ft sample was obtained at depths of 2–5, 7–10, 12–15, 17–20, and 27–30 ft bgs. Each sample was submitted to the PGDP laboratory for TAL metals analysis. No other analyses were conducted for SWMU 194.

Subsurface Soil—Analytical Results

Inorganics. Although a number of metals were identified in the SWMU 194 subsurface soil samples, only a few were observed at concentrations above applicable screening levels (Fig. 4.6). Table 4.40 highlights the metals that exceeded screening levels for SWMU 194 subsurface soils.

Aluminum slightly exceeded the background screening level in three samples. Chromium was detected in two samples at levels that exceeded screening criteria (44.1 and 53.7 mg/kg, respectively).

Table 4.40 Evaluation of inorganic analytes in subsurface soils at SWMU 194

Analyte	> Detection limit	> Background[a]	> EPA SSL[a]	> 1/5 RDA
Aluminum	Yes	Yes (3)	Not available	Not applicable
Chromium	Yes	Yes (2)	Yes (2)	Not applicable

[a]The number in parenthesis represents the number of individual analytes that exceed criteria.

4.2.3.5 Summary of findings

Metals detected in the shallow subsurface at SWMU 194 represent both naturally occurring conditions and possible releases to the subsurface. Aluminum levels detected at the site are considered to represent naturally occurring concentrations. Chromium reported from the site could represent small isolated releases to the subsurface from the leach field. Occurrences of cadmium and lead previously reported at the site were not confirmed by the WAG 28 RI soil sampling, which indicates that elevated levels of these two metals are likely confined to isolated areas.

4.2.4 Area of Concern 204

4.2.4.1 Location and physical description

AOC 204 is located on the eastern side of the PGDP reservation, bounded on the east by Dyke Road and on the west by the security fence as shown in Fig. 3.18. The surface of AOC 204 is undulating with surface elevations ranging from 364 to 382 ft above msl. The area is covered with heavy vegetation and a young stand of trees. A small ditch (approximately 4 ft wide and 3 ft deep) cuts across the mound from north to south. The northern and southern limits of AOC 204 are defined by KPDES Outfalls 010 and 011, respectively, but the site does not incorporate the actual drainage ditches. An evaluation of the ditches and the associated sediments and water within the ditches is not considered in the WAG 28 RI. These features will be included in the Surface Soils OU and Surface Water OU RIs.

AOC 204 consists of a mounded area thought to have been a staging area or construction debris burial ground associated with the original construction of the plant. The focus of the WAG 28 RI was to determine if a contaminant source related to the mound is impacting the site. Types of debris that have been identified on the mound include asphalt, concrete, telephone poles, railroad ties, and cable. Debris was not reported in subsurface samples collected during previous investigations, and no debris was encountered during the drilling of WAG 28 borings within the mound.

4.2.4.2 Site history

No releases from AOC 204 have been documented, and limited information is available regarding any disposal activities in this area. Site evaluation activities conducted by LMES suggested there is a source of trichloroethene in the area of AOC 204 that may be migrating northward beneath AOC 204. The source of the contamination detected during the site evaluation is believed to be from KPDES Outfall 011.

A geophysical survey was conducted during the SI using EM-31 and EM-61 electromagnetometers to confirm the presence of buried debris. The survey did not find conclusive evidence of a landfill or buried metal; however, data did indicate four anomalies in the AOC 204 area.

4.2.4.3 Location and results of previous sampling

An investigation of AOC 204 was included in the final SE for the Outfall 010, 011, and 012 Areas (DOE 1995b). The SE conducted during 1995 included a much larger area surrounding and downstream of Outfalls 011 and 012 than the defined boundary of AOC 204. The field activities conducted within the vicinity of AOC 204 included a geophysical survey, drilling of soil borings, collection of ditch sediment and water samples, and the installation of two temporary piezometers (Fig. 3.18). Results of this sampling are discussed in the above referenced report. Ten soil borings were completed within the AOC 204 boundary (204-1, 204-2, 204-3, 204-15, 204-16, 204-17, 204-18, 204-19, 204-20, and 204-22). Surface soil samples were collected from 0 to 1 ft and submitted for PCB analysis. No PCBs were detected in the surface soil horizon at AOC 204. Subsurface soil samples were collected at 5-ft intervals starting at 5 ft bgs to a depth of 35 ft or refusal. These samples were only analyzed for trichloroethene; 1,1,1-trichloroethane; 1,1-dichloroethene, perchloroethene; and PCBs. Again, no PCBs were detected in the subsurface soil samples from the AOC 204 borings. Table 4.41 shows the sample intervals and concentrations of 1,1,1-trichloroethane and trichloroethene in the subsurface at this site. No other VOAs were recorded in the subsurface soil samples. In addition, the results of water sample analyses from borings 204-04 and 204-13 were reviewed as indicators of upgradient and downgradient shallow groundwater conditions in respect to AOC 204. Neither sample contained detectable concentrations of VOAs.

Boring 204-15, adjacent to Outfall 011, was the only boring that contained volatile compounds over its entire depth. This indicates that the VOA contamination is related to transport via shallow groundwater recharged from Outfall 011. The other borings that contained trichloroethene/ trichloroethane are located within the interior of AOC 204 away from the outfall. However, in these borings, VOAs were generally not present at shallow depths except for an anomalous detection at 10 ft in boring 204-19. Because an upgradient boring (204-04) is free of contamination, Outfall 011 is considered the probable source of contaminants for AOC 204.

Table 4.41 Historical 1,1,1-trichloroethane /trichloroethene concentrations in borings within AOC 204 (μg/kg for soil; μg/L for water)

Depth (ft)	204-1	204-2	204-3	204-15	204-16	204-17	204-18	204-19	204-20	204-22
5	ND	ND	ND	24/70	ND	ND	ND	ND	ND	ND
10	ND	ND	ND	20/48	ND	ND	ND	18/ND	ND	ND
15	ND	ND	ND	16/73	ND	ND	ND	ND	ND	ND
20	ND	ND	ND	11/27	ND	ND	ND	ND	ND	ND
25	ND	ND	ND	13/ND	ND	ND	ND	15/29	ND	ND
30	ND	ND	ND	ND	ND	ND	ND	14/123	ND	ND
35	ND	ND	ND	NA	ND	12/21	ND	15/54	16/88	ND
Water sample	ND	ND	ND	18/19	ND	16/31	ND	NA	ND/396	ND

ND = Non-detect
NA = Not available

4.2.4.4 Rationale for RI field sampling

Previous sampling activities infer that KPDES Outfall 011 is the source of trichloroethene detected in groundwater samples collected from borings completed within the AOC 204 area. The sampling strategy for AOC 204 was designed to determine whether AOC 204 also is a source of the trichloroethene contamination in the subsurface near AOC 204.

One deep boring (SB-204-029) was installed near the historical shallow borings 204-19 and 204-20 that contained detectable concentrations of VOAs. It was planned to obtain groundwater samples from historical boring 204-020 and a second deep boring located at the northern portion of AOC 204 (boring 204-031) at 5-ft intervals until the Porters Creek Clay was encountered. This sampling was planned to determine whether a localized source or a source located upgradient of AOC 204 was impacting groundwater. Additionally, two HSA borings were completed to sample soil intervals from the near surface through the HU3 interval. This sampling was designed to determine whether a source was present within the confines of AOC 204.

4.2.4.5 Nature and extent of contamination

Subsurface soil samples were obtained by split spoon samplers from HSA drilling for two borings within AOC 204. Each of these borings was paired with a DWRC borehole that collected groundwater samples primarily from the RGA. Boring HSA204-028 (pair to DWRC SB204-029) was located within the interior of the site in proximity to the historical borings that indicated volatiles in the subsurface. Boring HSA204-028 collected a total of 12 soil samples over a total depth of 60 ft (one every 5 ft) from the UCRS, including a 10-ft terrace gravel from 50–60 ft. Boring HSA 204-030 (pair to DWRC SB 204-031) collected 15 soil samples over a total depth of 75 ft and was located on the northern edge of the site. This boring encountered sands within the UCRS from a depth of 55 to 60 ft but did not penetrate the RGA at this location. These samples were submitted for VOA and radionuclide analysis only. In addition, select soil and water samples were submitted for feasibility study parameters such as total organic content, anion, pH, and redox potential (see Table 4.42).

Table 4.42 Feasibility study analyses conducted for samples at AOC 204

Station name	Matrix	Sample depth (ft bgs)	Analysis	Results	Units
204-028	Soil	23	pH	7.37	
204-028	Soil	23	Total Organic Carbon	330	µg/g
204-029	Water	37	Chemical Oxygen Demand	25	mg/L
204-029	Water	37	Carbonate as $CaCO_3$	10	mg/L
204-029	Water	37	Phosphate as Phosphorous	2	mg/L
204-029	Water	37	Nitrate	5	mg/L
204-029	Water	37	Bicarbonate as $CaCO_3$	313	mg/L
204-029	Water	37	Chloride	148.2	mg/L
204-029	Water	37	Redox—Initial	188	mV
204-029	Water	37	Ammonia	0.25	mg/L
204-029	Water	37	Sulfate	5.4	mg/L
204-029	Water	37	Sulfide	1	mg/L
204-029	Water	37	Alkalinity	321	mg/L
204-029	Water	37	Fluoride	0.96	mg/L
204-029	Water	37	Total Organic Carbon	6.1	mg/L
204-029	Water	37	Silica	24	mg/L
204-029	Water	37	Nitrate as Nitrogen	1	mg/L
204-029	Water	37	pH	7.25	

Surface Soils—Analytical Results

No surface soils were collected from AOC 24 during the WAG 28 RI.

Subsurface Soils—Analytical Results

Organics. VOAs analyses were conducted for all subsurface soil samples. No samples contained concentrations of VOAs above the analytical detection limit. No SVOA or PCB analyses were performed on these samples.

Inorganics. No inorganic analyses were performed on soil samples collected from AOC 204.

Radionuclides. Gross alpha measurement exhibited a range of 9 to 25 pCi/g for the subsurface soil samples, and gross beta measurements ranged from 9 to 51 pCi/g. The highest beta activity occurred at the depth interval of 48–50 ft in boring HSA204-028. The corresponding technetium-99 analysis for this interval was below the detection limit as were all other radionuclides in the soils. It is unknown what beta emitter may have contributed to this anomalous beta value or if measurement error is a possibility.

UCRS Groundwater—Analytical Results

UCRS groundwater samples were obtained from the DWRC drilling when water-producing zones were encountered. In most instances, perched water zones were encountered in the unsaturated UCRS horizon. At AOC 204, two UCRS groundwater samples (at 37 ft and 47 ft bgs) were collected from SB204-29, and only one sample (at 52 ft bgs) was collected from SB204-31.

Organics. No volatiles were detected in SB204-029. Trichloroethene (2.0 μg/L) and *cis*-1,2-dichloroethene (1.4 μg/L) were reported at concentrations below screening levels but slightly above the detection limit in the 52-ft sample from SB204-031 (Table 4.43). No other organics were noted in the UCRS (Fig. 4.5).

Table 4.43 VOAs in water samples from SB204-031

Unit	Depth (ft bgs)	Trichloroethene (μg/L)	*cis*-1,2-Dichloroethene (μg/L)
UCRS	52	2	1.4
RGA	72	19	ND
RGA	87	590	6
RGA	92	770	6
RGA	97	125	0.9

ND = Non-detect

Radionuclides. Gross alpha activities above the detection threshold in the UCRS ranged from 1.6 to 7.4 pCi/L, with one exception. At the 47-ft interval in SB204-029, a gross alpha measurement of 24.8 pCi/L was observed. This measurement corresponds to the same stratigraphic interval that displayed an anomalously high gross beta value in the UCRS soil. Alpha spectroscopy was not performed on this water sample to determine if uranium- or thorium-series alpha emitters were present, but these isotopes were not seen in the soils analyses.

Gross beta activities for the UCRS water samples were slightly above the measurement threshold and ranged from 3 to 5 pCi/L.

RGA Groundwater—Analytical Results

SB204-029 was positioned on the terrace shelf where the RGA is absent and, therefore, no RGA samples were collected. SB204-031, which is located to the west of SB204-029 off the terrace, encountered definitive RGA gravels from about 75 to 95 ft bgs; however, drilling also penetrated sands and gravels from 65 to 75 ft bgs, which may or may not be part of the RGA. One water sample was collected from this upper gravel unit, and three water samples were collected from the RGA.

Organics. Volatile organics were detected in relatively significant concentrations within the RGA at the northern end of AOC 204 at SB204-031 (Table 4.43). Only trichloroethene and its degradation product, dichloroethene, were noted above detection limits in the samples (Fig. 4.7).

Radionuclides. Only gross alpha and beta activities were observed within the RGA at AOC 204.

4.2.4.6 Summary of findings

Previous investigations conducted at AOC 204 identified VOAs in the subsurface soils and the possibility of a buried source on site. Sampling conducted for the WAG 28 RI did not confirm the presence of VOAs in the soils, but did observe trichloroethene and its by-products in the groundwater. Trichloroethene was noted primarily in the RGA, but not in concentrations that would indicate a nearby source. The lack of significant concentrations of trichloroethene in the shallow UCRS soils does not support the presence of an on-site source at AOC 204. Radionuclides were not observed in either the groundwater or soils at levels of concern.

4.3 WAG 28 RGA EVALUATION

A primary objective of the WAG 28 RI was to evaluate the nature and extent of contamination, provide analytical data to support a baseline human health risk assessment (BHHRA) and screening ecological risk assessment, and to support the evaluation of remedial alternatives, if necessary. As part of this process, the impact on RGA groundwater from possible contaminant releases was investigated for the four sites within WAG 28 (SWMUs 99, 193, and 194 and AOC 204). Although none of the WAG 28 sites are believed to be contributors to the Northeast Plume, the results of this investigation can be used to draw conclusions concerning other potential contaminant sources that may be impacting the RGA.

Sampling of the UCRS soils during the WAG 28 RI indicates that a source for the contamination in the RGA groundwater at SWMU 193 does not exist at the former location of the Millwright Shop as originally believed. Moreover, trichloroethene concentrations currently present in the RGA groundwater beneath the site have decreased significantly during the last 5 years. This decrease in trichloroethene concentrations in the RGA at SWMU 193 is best attributed to migration and dispersion of the contaminated groundwater plume.

SWMU 99 did not contain significant contaminant concentrations in either the UCRS soils or UCRS groundwater that would suggest that the site is currently or will in the future become a significant contributor of contaminants to the Northeast Plume. However, elevated levels of radionuclides were discovered in shallow soils associated with a broken storm drain that may channel flow from the Classified Scrap Yard Storage Area (SWMU 16, which overlies the former location of the Kellogg Building) to Outfall 010. This storm drain could have served as a conduit for the transport of contaminants that may have impacted Little Bayou Creek and the underlying RGA.

At AOC 204, contaminants detected in the UCRS soils appear to be related to the downward percolation of surface water flow in Outfall 011. This infiltration of contaminants from a surface water stream would appear to represent one potential source for the contaminants that are present in the Northeast Plume.

The results of the WAG 28 RI show that widespread contamination is not present in either the UCRS soil or the UCRS groundwater at any of the areas investigated. As a result, none of the four sites are a significant source contributor of contaminants to the underlying RGA groundwater. Based on the results of the WAG 28 RI, the WAG 28 sites are not considered to be the primary source for the identified Northeast Plume.

ANALYTICAL RESULTS QUALIFIER CODES FOR TABLES 4.3 THROUGH 4.24

Laboratory Qualifiers

*	Duplicate analysis not within control limits.
B	Applies when the analyte is found in the associated blank.
E	Result estimated due to interferences.
J	Indicates an estimated value.
N	Sample spike recovery not within control limits.
U	Analyte analyzed for but not detected at or below the lowest concentration reported.
W	Post-digestion spike recovery out of control limits.
X	Other specific flags and footnotes may be required to properly define the results.
Y	MS, MSD recovery, and/or RPD failed acceptance criteria.

Validation Qualifiers

X	No validation performed (some of these will change).
R	Result unusable.
NJ	Sample spike recovery not within control limits; indicates an estimated value.
N	Sample spike recovery not within control limits.
J	Indicates an estimated value.
=	Validated result, which is detected and unqualified.

Assessment Qualifiers

U	Compound analyzed for but not detected at or below the lowest concentration reported.
BL-T	Result may be biased low; sample holding time exceeded.

Others

BG	Background

Description of Laboratory and Analytical Method Database Codes – WAG 28 RI

LAB_CODE	LABORATORY TYPE – SUBCONTRACT LABORATORY
ONSE	Organic Close Support Laboratory (CSL) – ONSITE Environmental Labs, Inc.
PARGN	Radiological Close Support Laboratory (CSL) – Paragon Analytics, Inc.
PGDP	Fixed-base laboratory – USEC C-710 laboratory, PGDP, Paducah, KY
PORTS	Fixed-base laboratory – USEC Portsmouth, Ohio laboratory

ANA_METHOD	ANALYTICAL METHOD NAME (CSL or Fixed Base Method, Lab)
AS7300	Uranium-235 (Fixed Base Method, PGDP)
DNT	Gamma Spectroscopy of Soils/Tc-99 in Water (CSL Methods, PARGN)
EPA-310.1	Alkalinity (Fixed Base Method, PGDP)
EPA-340.2	Fluoride (Fixed Base Method, PGDP)
EPA-350.2	Ammonia (Fixed Base Method, PGDP)
EPA-370.1	Dissolved Silica (Fixed Base Method, PGDP)
EPA-410.4 1978	Chemical Oxygen Demand (Fixed Base Method, PGDP)
EPA-900.0	Gross Alpha and Beta Activity in Water (Fixed Base Method, PGDP)
OA-97-334-016	Total Organic Carbon in Soils (Fixed Base Method, PORTS)
OA33999026	TCE and Degradation Species in Soils (Fixed Base/Confirmation Method, PORTS)
RL-7100	Technetium-99 in Water (Fixed Base Method, PGDP)
RL-7111	Gross Alpha and Beta Activity in Soil (Fixed Base Method, PGDP)
RL-7116	Technetium-99 in Soils (Fixed Base Method, PGDP)
RL-7124	Gamma Spectroscopy of Soils (Fixed Base/Confirmation Method, PGDP)
SM-2320 B 17	Bicarbonate Hardness (Fixed Base Method, PGDP)
SM-2580 B	Redox Potential (Fixed Base Method, PGDP)
SW846-6010A	Metals in Water or Soils by ICP (Fixed Base Method, PGDP)
SW846-7060	Arsenic in Water or Soils by GFAA (Fixed Base Method, PGDP)
SW846-7421 E3R0 Sep86	Lead in Water or Soils by Graphite Furnace AA (Fixed Base Method, PGDP)
SW846-7470	Mercury in Water by Cold Vapor AA (Fixed Base Method, PGDP)
SW846-8021M	TCE and Degradation Species in Soils and Water (CSL Method, ONSE)
SW846-8082M	PCBs in Water and Soils (CSL Method, ONSE)
SW846-8260	VOCs in Water and Soils by GC/MS (Fixed Base/Confirmation Method, PGDP)
SW846-8260A	VOCs in Water and Soils by GC/MS (Fixed Base/Confirmation Method, PORTS)
SW846-8270	SVOCs in Water and Soils by GC/MS (Fixed Base/Confirmation Method)
SW846-8270M	SVOCs in Water and Soils by GC/MS (CSL Method, ONSE)
SW846-9040	pH in Water (Fixed Base Method, PGDP)
SW846-9045	pH in Soils (Fixed Base Method, PGDP)
SW846-9056	Anions (Chloride and Sulfate) in Water (Fixed Base Method, PGDP)
SW846-9060	Total Organic Carbon in Water (Fixed Base Method, PGDP)
SW846-9310	Gross Alpha and Beta Activity in Water and Soils (CSL Method, PARGN)

Table 4.1. Metals background values

	Soil	
	Background Data(β) *(mg/kg)*	
Analytical Compound (a)	*Surface (0-1 ft bgs)*	*Subsurface (> 1 ft bgs)*
Aluminum	13000	12000
Antimony	0.21	0.21
Arsenic	12	7.9
Barium	200	170
Beryllium	0.67	0.69
Boron	NA	NA
Cadmium	0.21	0.21
Calcium	200000	6100
Chromium	16	43
Chromium, hexavalent	NA	NA
Cobalt	14	13
Copper	19	25
Cyanide	NA	NA
Iron	28000	28000
Lead	36	23
Lithium	NA	NA
Magnesium	7700	2100
Manganese	1500	820
Mercury	0.2	0.13
Molybdenum	NA	NA
Nickel	21	22
Potassium	1300	950
Selenium	0.8	0.7
Silica	NA	NA
Silver	2.3	2.7
Sodium	320	340
Strontium	NA	NA
Thallium	0.21	0.34
Vanadium	38	37
Zinc	65	60

(a) ***Method Detection Limit is greater than background for the following: MDL in mg/kg for antimony = 3.8, cadmium = 0.12, mercury = 2.1, selenium = 0.05, and silver = 0.16.***

(β) ***Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE 1997)***

Table 4.2. Radioactive isotopes background values

	Soil	
	Background Data[a] (pCi/g)	
Analytical Compound	***Near Surface***	***Subsurface***
Alpha activity	NA	NA
Americium-241	NA	NA
Beta activity	NA	NA
Cesium-137	0.49	0.28
Cobalt-60	NA	NA
Neptunium-237	0.1	NA
Plutonium-239	0.025	NA
Plutonium-239/240	NA	NA
Potassium-40	16	16
Protactinium-234m	NA	NA
Radium	NA	NA
Radium-226	1.5	1.5
Radon-222	NA	NA
Strontium-90	4.7	NA
Technetium-99	2.5	2.8
Thorium-230	1.5	1.4
Thorium-234	NA	NA
Uranium	NA	NA
Uranium (MG/KG OR MG/L)	4.9	4.8
Uranium-234	2.5	2.4
Uranium-235	0.14	0.14
Uranium-238	1.2	1.2

(a) ***Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE, 1997)***

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
099005SA001	0	3	Aluminum	PGDP	SW846-6010A	14100**	NW	J		12000
	0	3	Lithium	PGDP	SW846-6010A	7.5**		=		N/A
	0	3	Strontium	PGDP	SW846-6010A	14.4		=		N/A
099006SA001	0	3	Lead	PGDP	SW846-6010A	47.3**		=		23
	0	3	Lithium	PGDP	SW846-6010A	3.86**		=		N/A
	0	3	Strontium	PGDP	SW846-6010A	12		=		N/A
099019SA006	3	6	Beryllium	PGDP	SW846-6010A	1		=		0.69
	3	6	Lithium	PGDP	SW846-6010A	11.4**		=		N/A
	3	6	Nickel	PGDP	SW846-6010A	25.1		=		22
	3	6	Strontium	PGDP	SW846-6010A	19.1		=		N/A
099019SA011	8	11	Calcium	PGDP	SW846-6010A	7170		J		6100
	8	11	Lithium	PGDP	SW846-6010A	9.81**		=		N/A
	8	11	Magnesium	PGDP	SW846-6010A	2200	N	J		2100
	8	11	Strontium	PGDP	SW846-6010A	22.2		=		N/A
099022SA006	3	6	Aluminum	PGDP	SW846-6010A	15000**	*NW	J		12000
	3	6	Lithium	PGDP	SW846-6010A	7.12**		=		N/A
	3	6	Strontium	PGDP	SW846-6010A	13.9		=		N/A
099022SA012	9	12	Lithium	PGDP	SW846-6010A	6.5**		=		N/A
	9	12	Strontium	PGDP	SW846-6010A	9.46		=		N/A
099025SA006	3	6	Aluminum	PGDP	SW846-6010A	13500**	*NW	J		12000
	3	6	Lithium	PGDP	SW846-6010A	6.75**		=		N/A
	3	6	Strontium	PGDP	SW846-6010A	15.1	*	J		N/A
099025SA012	9	12	Aluminum	PGDP	SW846-6010A	12100**	*NW	J		12000
	9	12	Lithium	PGDP	SW846-6010A	8.78**		=		N/A
	9	12	Strontium	PGDP	SW846-6010A	11.1	*	J		N/A
099029SA006C	3	6	Lithium	PGDP	SW846-6010A	7.22**		X		N/A

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
099029SA006C	3	6	Strontium	PGDP	SW846-6010A	15.6		X		N/A
099029SA012C	9	12	Aluminum	PGDP	SW846-6010A	17000**	NW	X		12000
	9	12	Arsenic	PGDP	SW846-7060	8.05	W	X		7.9
	9	12	Lithium	PGDP	SW846-6010A	11.2**		X		N/A
	9	12	Magnesium	PGDP	SW846-6010A	2530		X		2100
	9	12	Potassium	PGDP	SW846-6010A	1040		X		950
	9	12	Strontium	PGDP	SW846-6010A	21.7		X		N/A
099030SA013C	10	13	Lithium	PGDP	SW846-6010A	6.95**		X		N/A
	10	13	Strontium	PGDP	SW846-6010A	10.4		X		N/A
099031SA013C	10	13	Aluminum	PGDP	SW846-6010A	12600**	NW	X		12000
	10	13	Lithium	PGDP	SW846-6010A	8.69**		X		N/A
	10	13	Strontium	PGDP	SW846-6010A	8.88		X		N/A
099001SA001	0	1	Calcium	PGDP	SW846-6010A	306000	*NW	R		200000
	0	1	Lithium	PGDP	SW846-6010A	2.82**		=		N/A
	0	1	Strontium	PGDP	SW846-6010A	269	*	J		N/A
	0	1	Zinc	PGDP	SW846-6010A	163	*N	J		65
099003SA001	0	1	Lithium	PGDP	SW846-6010A	4.38**		=		N/A
	0	1	Strontium	PGDP	SW846-6010A	69.4	*	J		N/A
099004SA001	0	1	Calcium	PGDP	SW846-6010A	260000	*JN	J		200000
	0	1	Lithium	PGDP	SW846-6010A	4.79**		=		N/A
	0	1	Magnesium	PGDP	SW846-6010A	22200	*N	J		7700
	0	1	Strontium	PGDP	SW846-6010A	234	*	=		N/A
	0	1	Zinc	PGDP	SW846-6010A	124	*N	J		65
099008SA001	0	1	Beryllium	PGDP	SW846-6010A	0.84		=		0.67
	0	1	Chromium	PGDP	SW846-6010A	20.4	*N	=		16
	0	1	Lithium	PGDP	SW846-6010A	4.88**		=		N/A

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***
N/A - Background value does not exist

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
099008SA001	0	1	Nickel	PGDP	SW846-6010A	21.6	*N	=		21
	0	1	Strontium	PGDP	SW846-6010A	14.6	*	=		N/A
	0	1	Zinc	PGDP	SW846-6010A	114	*N	J		65
099009SA001	0	1	Calcium	PGDP	SW846-6010A	287000	*N	J		200000
	0	1	Lithium	PGDP	SW846-6010A	11.6**		=		N/A
	0	1	Magnesium	PGDP	SW846-6010A	27300	*N	J		7700
	0	1	Sodium	PGDP	SW846-6010A	366	NW	J		320
	0	1	Strontium	PGDP	SW846-6010A	514		=		N/A
	0	1	Zinc	PGDP	SW846-6010A	76.4		=		65
099010SA001	0	1	Calcium	PGDP	SW846-6010A	276000	N	J		200000
	0	1	Lithium	PGDP	SW846-6010A	4.52**		=		N/A
	0	1	Magnesium	PGDP	SW846-6010A	10200	*N	J		7700
	0	1	Strontium	PGDP	SW846-6010A	344		=		N/A
	0	1	Zinc	PGDP	SW846-6010A	85.1		=		65
099011SA001	0	1	Barium	PGDP	SW846-6010A	250		=		200
	0	1	Calcium	PGDP	SW846-6010A	257000	N	J		200000
	0	1	Chromium	PGDP	SW846-6010A	16.4		=		16
	0	1	Lithium	PGDP	SW846-6010A	10.9**		=		N/A
	0	1	Magnesium	PGDP	SW846-6010A	16700	*N	J		7700
	0	1	Strontium	PGDP	SW846-6010A	449		=		N/A
	0	1	Zinc	PGDP	SW846-6010A	79.4		=		65
099012SA001	0	1	Calcium	PGDP	SW846-6010A	262000	N	J		200000
	0	1	Lithium	PGDP	SW846-6010A	12.9**		=		N/A
	0	1	Magnesium	PGDP	SW846-6010A	14400	*N	J		7700
	0	1	Strontium	PGDP	SW846-6010A	345		=		N/A
	0	1	Zinc	PGDP	SW846-6010A	74.6		=		65

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
099014SA001	0	1	Barium	PGDP	SW846-6010A	2470**		=		200
	0	1	Calcium	PGDP	SW846-6010A	231000	*N	J		200000
	0	1	Lithium	PGDP	SW846-6010A	11.6**		=		N/A
	0	1	Magnesium	PGDP	SW846-6010A	16500	*N	J		7700
	0	1	Strontium	PGDP	SW846-6010A	373		=		N/A
	0	1	Zinc	PGDP	SW846-6010A	79		=		65
099015SA001	0	1	Lithium	PGDP	SW846-6010A	7.86**		=		N/A
	0	1	Strontium	PGDP	SW846-6010A	84		=		N/A
	0	1	Zinc	PGDP	SW846-6010A	81.9		=		65
099016SA001	0	1	Beryllium	PGDP	SW846-6010A	0.89		=		0.67
	0	1	Chromium	PGDP	SW846-6010A	45.7**		=		16
	0	1	Lithium	PGDP	SW846-6010A	5.76**		=		N/A
	0	1	Strontium	PGDP	SW846-6010A	57.2		=		N/A
	0	1	Zinc	PGDP	SW846-6010A	72.7		=		65
099030SA001C	0	1	Lithium	PGDP	SW846-6010A	7.26**		X		N/A
	0	1	Strontium	PGDP	SW846-6010A	34.5		X		N/A
099031SA001C	0	1	Lithium	PGDP	SW846-6010A	8.01**		X		N/A
	0	1	Strontium	PGDP	SW846-6010A	25.1		X		N/A
099001SA017	14	17	Beryllium	PGDP	SW846-6010A	0.8	N	J		0.69
	14	17	Lead	PGDP	SW846-6010A	23.6**		=		23
	14	17	Lithium	PGDP	SW846-6010A	3.59**		=		N/A
	14	17	Strontium	PGDP	SW846-6010A	10	*	J		N/A
099001SA027	24	27	Lithium	PGDP	SW846-6010A	2.38**		=		N/A
	24	27	Strontium	PGDP	SW846-6010A	3.81	*	J		N/A
099001SA037	34	37	Lithium	PGDP	SW846-6010A	6.27**		=		N/A
	34	37	Strontium	PGDP	SW846-6010A	3.09	*	J		N/A

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
099001SA060	57	60	Beryllium	PGDP	SW846-6010A	1.17	N	J		0.69
	57	60	Calcium	PGDP	SW846-6010A	25700	*NW	R		6100
	57	60	Lithium	PGDP	SW846-6010A	6.14**		=		N/A
	57	60	Magnesium	PGDP	SW846-6010A	4530	*NW	J		2100
	57	60	Strontium	PGDP	SW846-6010A	24	*	J		N/A
099001SD017	14	17	Beryllium	PGDP	SW846-6010A	1.23	N	J		0.69
	14	17	Cobalt	PGDP	SW846-6010A	27.3**	N	J		13
	14	17	Iron	PGDP	SW846-6010A	30300	*N	J		28000
	14	17	Lead	PGDP	SW846-6010A	33.2**		=		23
	14	17	Lithium	PGDP	SW846-6010A	5.1**		=		N/A
	14	17	Manganese	PGDP	SW846-6010A	976	N	J		820
	14	17	Strontium	PGDP	SW846-6010A	10	*	J		N/A
	14	17	Vanadium	PGDP	SW846-6010A	38.8		J		37
099003SA019	16	19	Lithium	PGDP	SW846-6010A	3.54**		=		N/A
	16	19	Strontium	PGDP	SW846-6010A	6.89		=		N/A
099003SA028	25	28	Strontium	PGDP	SW846-6010A	6.47		=		N/A
099003SA044	41	44	Lithium	PGDP	SW846-6010A	2.74**		=		N/A
099003SA054	51	54	Lithium	PGDP	SW846-6010A	2.19**		=		N/A
	51	54	Strontium	PGDP	SW846-6010A	4.38	*	J		N/A
099003SA060	57	60	Lithium	PGDP	SW846-6010A	3.14**		=		N/A
	57	60	Strontium	PGDP	SW846-6010A	2.92	*	J		N/A
099004SA019	16	19	Lithium	PGDP	SW846-6010A	2.62**		=		N/A
	16	19	Strontium	PGDP	SW846-6010A	5.85	*	=		N/A
099004SA028	25	28	Lithium	PGDP	SW846-6010A	2.35**		=		N/A
	25	28	Strontium	PGDP	SW846-6010A	4.7	*	=		N/A
099004SA037	34	37	Lithium	PGDP	SW846-6010A	4.27**		=		N/A

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
099004SA037	34	37	Strontium	PGDP	SW846-6010A	2.64	*	=		N/A
099004SA044	41	44	Lithium	PGDP	SW846-6010A	3.08**		=		N/A
099004SA054	51	54	Beryllium	PGDP	SW846-6010A	0.94		=		0.69
	51	54	Lithium	PGDP	SW846-6010A	4.87**		=		N/A
	51	54	Strontium	PGDP	SW846-6010A	6.56	*	=		N/A
099004SA060	57	60	Lithium	PGDP	SW846-6010A	4.84**		=		N/A
	57	60	Strontium	PGDP	SW846-6010A	5.74	*	=		N/A
099005SA019	16	19	Lithium	PGDP	SW846-6010A	4.17**		=		N/A
	16	19	Strontium	PGDP	SW846-6010A	6.25		=		N/A
099005SA028	25	28	Strontium	PGDP	SW846-6010A	3.56		=		N/A
099005SA037	34	37	Lithium	PGDP	SW846-6010A	4.1**		=		N/A
	34	37	Strontium	PGDP	SW846-6010A	3		=		N/A
099005SA044	41	44	Beryllium	PGDP	SW846-6010A	0.81		=		0.69
099005SA054	51	54	Lithium	PGDP	SW846-6010A	3.62**		=		N/A
	51	54	Strontium	PGDP	SW846-6010A	2.24		=		N/A
099005SA060	57	60	Strontium	PGDP	SW846-6010A	3.39		=		N/A
099006SA019	19	22	Lithium	PGDP	SW846-6010A	2.88**		=		N/A
	19	22	Strontium	PGDP	SW846-6010A	5.51		=		N/A
099006SA028	25	28	Strontium	PGDP	SW846-6010A	4.08		=		N/A
099006SA037	34	37	Beryllium	PGDP	SW846-6010A	1.23		=		0.69
	34	37	Chromium	PGDP	SW846-6010A	79.1**		=		43
	34	37	Iron	PGDP	SW846-6010A	29100	N	J		28000
	34	37	Lithium	PGDP	SW846-6010A	7.08**		=		N/A
	34	37	Strontium	PGDP	SW846-6010A	2.55		=		N/A
099006SA044	41	44	Lithium	PGDP	SW846-6010A	2.22**		=		N/A
	41	44	Strontium	PGDP	SW846-6010A	2.22		=		N/A

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***
N/A - Background value does not exist

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
099006SA054	51	54	Strontium	PGDP	SW846-6010A	2.3		=		N/A
099006SA060	57	60	Lithium	PGDP	SW846-6010A	3.68**		=		N/A
	57	60	Strontium	PGDP	SW846-6010A	3.01		=		N/A
099006SD019	22	24	Strontium	PGDP	SW846-6010A	4.3		=		N/A
099008SA019	16	19	Lithium	PGDP	SW846-6010A	4.82**		=		N/A
	16	19	Strontium	PGDP	SW846-6010A	6.46		=		N/A
099008SA028	25	28	Lithium	PGDP	SW846-6010A	4.59**		=		N/A
	25	28	Strontium	PGDP	SW846-6010A	5.62		=		N/A
099008SA044	39	45	Lithium	PGDP	SW846-6010A	6**		=		N/A
	39	45	Strontium	PGDP	SW846-6010A	3.65		=		N/A
099008SA054	51	54	Boron	PGDP	SW846-6010A	100	*NU	J		N/A
	51	54	Lithium	PGDP	SW846-6010A	3**		=		N/A
	51	54	Strontium	PGDP	SW846-6010A	2.8	*	=		N/A
099008SA060	54	60	Lithium	PGDP	SW846-6010A	3.11**		=		N/A
	54	60	Strontium	PGDP	SW846-6010A	3.2	*	=		N/A
099008SD044	39	45	Lithium	PGDP	SW846-6010A	4.56**		=		N/A
	39	45	Strontium	PGDP	SW846-6010A	3.36		=		N/A
099009SA017	17	20	Lithium	PGDP	SW846-6010A	3.8**		=		N/A
	17	20	Sodium	PGDP	SW846-6010A	359	NW	J		340
	17	20	Strontium	PGDP	SW846-6010A	7.8		=		N/A
099009SA027	24	27	Lithium	PGDP	SW846-6010A	2.62**		=		N/A
	24	27	Strontium	PGDP	SW846-6010A	3.6		=		N/A
	24	27	Vanadium	PGDP	SW846-6010A	38.2		=		37
099009SA038	35	38	Aluminum	PGDP	SW846-6010A	12100**	NW	J		12000
	35	38	Beryllium	PGDP	SW846-6010A	1.23		=		0.69
	35	38	Lithium	PGDP	SW846-6010A	6.97**		=		N/A

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
099009SA038	35	38	Strontium	PGDP	SW846-6010A	3.39		=		N/A
	35	38	Vanadium	PGDP	SW846-6010A	39		=		37
099009SA047	44	47	Lithium	PGDP	SW846-6010A	3.22**		=		N/A
	44	47	Strontium	PGDP	SW846-6010A	2.48		=		N/A
099010SA028	25	28	Lithium	PGDP	SW846-6010A	2.89**		=		N/A
	25	28	Strontium	PGDP	SW846-6010A	2.89		=		N/A
099010SA037	34	37	Aluminum	PGDP	SW846-6010A	15000**	NW	J		12000
	34	37	Beryllium	PGDP	SW846-6010A	1.1		=		0.69
	34	37	Lithium	PGDP	SW846-6010A	6.39**		=		N/A
	34	37	Strontium	PGDP	SW846-6010A	3.59		=		N/A
099010SA047	44	47	Lithium	PGDP	SW846-6010A	3.9**		=		N/A
	44	47	Strontium	PGDP	SW846-6010A	2.38		=		N/A
099010SA054	51	54	Aluminum	PGDP	SW846-6010A	12700**	*NW	J		12000
	51	54	Beryllium	PGDP	SW846-6010A	1.03		=		0.69
	51	54	Lithium	PGDP	SW846-6010A	5.23**		=		N/A
	51	54	Strontium	PGDP	SW846-6010A	3.27		=		N/A
099010SA060	57	60	Beryllium	PGDP	SW846-6010A	0.74		=		0.69
	57	60	Lithium	PGDP	SW846-6010A	2.47**		=		N/A
	57	60	Strontium	PGDP	SW846-6010A	2.31		=		N/A
099011SA017	14	17	Aluminum	PGDP	SW846-6010A	13200**	NW	J		12000
	14	17	Lithium	PGDP	SW846-6010A	7.06**		=		N/A
	14	17	Sodium	PGDP	SW846-6010A	405	NW	J		340
	14	17	Strontium	PGDP	SW846-6010A	8.22		=		N/A
099011SA027	24	27	Lithium	PGDP	SW846-6010A	3.76**		=		N/A
	24	27	Strontium	PGDP	SW846-6010A	4.43		=		N/A
099011SA038	35	38	Aluminum	PGDP	SW846-6010A	15700**	NW	J		12000

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
099011SA038	35	38	Beryllium	PGDP	SW846-6010A	0.87		=		0.69
	35	38	Lithium	PGDP	SW846-6010A	10.9**		=		N/A
	35	38	Strontium	PGDP	SW846-6010A	3.95		=		N/A
099011SA054	51	54	Lithium	PGDP	SW846-6010A	2.44**		=		N/A
	51	54	Strontium	PGDP	SW846-6010A	2.26		=		N/A
099011SA060	57	60	Lithium	PGDP	SW846-6010A	2.25**		=		N/A
	57	60	Strontium	PGDP	SW846-6010A	2.48		=		N/A
099012SA017	14	17	Lithium	PGDP	SW846-6010A	4.72**		=		N/A
	14	17	Strontium	PGDP	SW846-6010A	7.61		=		N/A
099012SA027	24	27	Beryllium	PGDP	SW846-6010A	0.78		=		0.69
	24	27	Lithium	PGDP	SW846-6010A	4.3**		=		N/A
	24	27	Strontium	PGDP	SW846-6010A	4.4		=		N/A
099012SA035	32	35	Lithium	PGDP	SW846-6010A	3.59**		=		N/A
	32	35	Strontium	PGDP	SW846-6010A	3.76		=		N/A
099012SA047	44	47	Lithium	PGDP	SW846-6010A	3.9**		=		N/A
	44	47	Strontium	PGDP	SW846-6010A	2.73		=		N/A
099012SA051	48	51	Strontium	PGDP	SW846-6010A	2.33		=		N/A
099014SA037	34	37	Aluminum	PGDP	SW846-6010A	18400**	NW	J		12000
	34	37	Beryllium	PGDP	SW846-6010A	1.05		=		0.69
	34	37	Lithium	PGDP	SW846-6010A	13.8**		=		N/A
	34	37	Strontium	PGDP	SW846-6010A	4.74		=		N/A
099014SA044	41	44	Lithium	PGDP	SW846-6010A	5.18**		=		N/A
	41	44	Strontium	PGDP	SW846-6010A	2.5		=		N/A
099014SA051	48	51	Lithium	PGDP	SW846-6010A	2.64**		=		N/A
	48	51	Strontium	PGDP	SW846-6010A	3.08		=		N/A
099014SA060	57	60	Strontium	PGDP	SW846-6010A	2.24		=		N/A

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	*Sample Interval (ft bgs)*		*Analytical Compound*	*Laboratory*	*Method*	*Results (mg/kg)*	*Lab Qualifier*	*Validation Qualifier*	*Data Assessment*	*BG (mg/kg)*
	Top	*Bottom*								
099019SA017	14	17	Aluminum	PGDP	SW846-6010A	14100**	*NW	J		12000
	14	17	Lithium	PGDP	SW846-6010A	8.35**		=		N/A
	14	17	Strontium	PGDP	SW846-6010A	9.7		=		N/A
099019SA025	22	25	Beryllium	PGDP	SW846-6010A	1.25		=		0.69
	22	25	Chromium	PGDP	SW846-6010A	57.7**		=		43
	22	25	Nickel	PGDP	SW846-6010A	29		=		22
	22	25	Strontium	PGDP	SW846-6010A	2.66		=		N/A
	22	25	Vanadium	PGDP	SW846-6010A	66.1		=		37
099019SA031	28	31	Beryllium	PGDP	SW846-6010A	1.24		=		0.69
	28	31	Lithium	PGDP	SW846-6010A	3.2**		=		N/A
	28	31	Strontium	PGDP	SW846-6010A	4.71		=		N/A
099022SA017	14	17	Lithium	PGDP	SW846-6010A	3.76**		=		N/A
	14	17	Strontium	PGDP	SW846-6010A	6.34		=		N/A
099022SA023	19	22	Strontium	PGDP	SW846-6010A	4.14		=		N/A
099022SA028	25	28	Strontium	PGDP	SW846-6010A	3.59		=		N/A
099022SA038	35	38	Lithium	PGDP	SW846-6010A	4.23**		=		N/A
	35	38	Strontium	PGDP	SW846-6010A	2.17		=		N/A
099022SA060	57	60	Lithium	PGDP	SW846-6010A	4.63**		=		N/A
	57	60	Strontium	PGDP	SW846-6010A	7.71		=		N/A
099025SA017	14	17	Lithium	PGDP	SW846-6010A	4.79**		=		N/A
	14	17	Strontium	PGDP	SW846-6010A	7.18	*	J		N/A
099025SA023	19	22	Strontium	PGDP	SW846-6010A	4.7	*	J		N/A
099025SA025	23	25	Lithium	PGDP	SW846-6010A	3.43**		=		N/A
	23	25	Strontium	PGDP	SW846-6010A	4.6	*	J		N/A
099025SA041	38	41	Lithium	PGDP	SW846-6010A	2.52**		=		N/A
099029SA017C	14	17	Lithium	PGDP	SW846-6010A	6.62**		X		N/A

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***
N/A - Background value does not exist

Table 4.3 Inorganic compounds detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
099029SA017C	14	17	Strontium	PGDP	SW846-6010A	8.77		X		N/A
099029SA025C	22	25	Strontium	PGDP	SW846-6010A	3.22		X		N/A
099029SA031C	28	31	Lithium	PGDP	SW846-6010A	2.41**		X		N/A
	28	31	Strontium	PGDP	SW846-6010A	4.36		X		N/A
099029SA045C	42	45	Lithium	PGDP	SW846-6010A	3.64**		X		N/A
	42	45	Strontium	PGDP	SW846-6010A	4.18		X		N/A
099029SD025C	22	25	Strontium	PGDP	SW846-6010A	4.07		X		N/A
099030SA031C	28	31	Beryllium	PGDP	SW846-6010A	0.74		X		0.69
	28	31	Lithium	PGDP	SW846-6010A	2.3**		X		N/A
	28	31	Strontium	PGDP	SW846-6010A	4.67		X		N/A
099030SA038C	35	38	Beryllium	PGDP	SW846-6010A	0.8		X		0.69
	35	38	Lithium	PGDP	SW846-6010A	6.12**		X		N/A
	35	38	Strontium	PGDP	SW846-6010A	4.7		X		N/A
099030SA046C	43	46	Lithium	PGDP	SW846-6010A	3.62**		X		N/A
	43	46	Strontium	PGDP	SW846-6010A	4.31		X		N/A
099031SA031C	28	31	Lithium	PGDP	SW846-6010A	2.41**		X		N/A
	28	31	Strontium	PGDP	SW846-6010A	4.34		X		N/A
099031SA038C	35	38	Beryllium	PGDP	SW846-6010A	1.04		X		0.69
	35	38	Lithium	PGDP	SW846-6010A	3.81**		X		N/A
	35	38	Strontium	PGDP	SW846-6010A	2.77		X		N/A
099031SA046C	43	46	Lithium	PGDP	SW846-6010A	3.65**		X		N/A
	43	46	Strontium	PGDP	SW846-6010A	2.61		X		N/A

SWMU 99 samples not containing any detectable inorganic compounds above BG are:

099001SA057

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.4 Radioactive isotopes detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (pci/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pci/g)
	Top	Bottom								
082014SA001C	0	1	Cesium-137	PARGN	DNT	1.9**		X		0.49
	0	1	Neptunium-237	PGDP	RL-7124	12.8**		X		0.1
	0	1	Technetium-99	PGDP	RL-7116	2650**		X		2.5
	0	1	Thorium-234	PARGN	DNT	53**		X		N/A
	0	1	Thorium-234	PGDP	RL-7124	44.7**		X		N/A
	0	1	Uranium	PGDP	RL-7124	69.2**		X		N/A
	0	1	Uranium-234	PGDP	RL-7124	16.4**		X		2.5
	0	1	Uranium-235	PGDP	RL-7124	0.34**		X		0.14
	0	1	Uranium-235	PGDP	AS7300	0.277**		X		0.14
	0	1	Uranium-238	PGDP	RL-7124	51.7**		X		1.2
099001SA001	0	1	Cesium-137	PARGN	DNT	1.1**		X		0.49
	0	1	Technetium-99	PGDP	RL-7116	49.4**		J		2.5
099004SA001	0	1	Cesium-137	PARGN	DNT	1.18**		X		0.49
	0	1	Technetium-99	PGDP	RL-7116	16.6**		J		2.5

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.4 Radioactive isotopes detected above BG in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (pci/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pci/g)
	Top	Bottom								

SWMU 99 samples not containing any detectable radioactive isotopes above BG are:

082015SA001C
099003SA001
099006SA001
099008SA001
099009SA001
099010SA001
099011SA001
099012SA001
099014SA001
099015SA001
099016SA001
099030SA001C
099031SA001C
099033SA001C
099001SA017
099001SA027
099001SA037
099001SA048
099001SA057
099001SA060
099001SD017
099003SA019
099003SA028
099003SA037
099003SA044
099003SA054
099003SA060
099004SA019
099004SA028
099004SA037
099004SA044
099004SA054
099004SA060
099005SA001
099005SA019
099005SA028
099005SA037
099005SA044
099005SA054
099005SA060
099006SA019
099006SA028
099006SA037
099006SA044
099006SA054
099006SA060
099006SD019
099008SA019
099008SA028
099008SA037
099008SA044
099008SA054
099008SA060
099008SD044
099009SA017
099009SA027
099009SA038
099009SA047
099010SA017
099010SA028
099010SA037
099010SA047
099010SA054
099010SA060
099011SA017
099011SA027
099011SA038
099011SA047
099011SA054
099011SA060
099012SA017
099012SA027
099012SA035
099012SA047
099012SA051
099014SA027
099014SA037
099014SA044
099014SA051
099014SA060
099019SA006
099019SA011
099019SA017
099019SA025
099019SA031
099019SA045
099022SA006
099022SA012
099022SA017
099022SA023
099022SA028
099022SA038
099022SA049
099022SA054
099022SA060
099025SA006
099025SA012
099025SA017
099025SA023
099025SA025
099025SA041
099025SA047
099025SA050
099025SD047
099029SA006C
099029SA012C
099029SA017C
099029SA025C
099029SA031C
099029SA045C
099029SA051C
099029SD025C
099030SA013C
099030SA031C
099030SA038C
099030SA043C
099030SA046C
099031SA013C
099031SA031C
099031SA038C
099031SA043C
099031SA046C
099033SA013C
099033SA023C
099033SA032C
099033SA038C
099033SA043C
099033SA046C

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.5 SVOA and PCB compounds detected in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
082014SA001C	0	1	PCB-1016	ONSE	SW846-8082 M	1870**		X	
099001SA001	0	1	PCB-1254	ONSE	SW846-8082 M	96**	J	X	
099004SA001	0	1	PCB-1260	ONSE	SW846-8082 M	429**		X	
099014SA001	0	1	PCB-1260	ONSE	SW846-8082 M	60**	J	X	
099030SA001C	0	1	PCB-1260	ONSE	SW846-8082 M	82**	J	X	
099031SA001C	0	1	PCB-1260	ONSE	SW846-8082 M	90**	J	X	
099033SA001C	0	1	PCB-1260	ONSE	SW846-8082 M	631**		X	
099001SA001	0	1	Benzo(a)anthracene	ONSE	SW846-8270 M	220**	J	X	
	0	1	Benzo(k)fluoranthene	ONSE	SW846-8270 M	520**		X	
	0	1	Fluoranthene	ONSE	SW846-8270 M	140	J	X	
099004SA001	0	1	Acenaphthene	ONSE	SW846-8270 M	330	J	X	
	0	1	Acenaphthylene	ONSE	SW846-8270 M	610**		X	
	0	1	Anthracene	ONSE	SW846-8270 M	750		X	
	0	1	Benzo(a)anthracene	ONSE	SW846-8270 M	1700**		X	
	0	1	Benzo(a)pyrene	ONSE	SW846-8270 M	2100**		X	
	0	1	Benzo(b)fluoranthene	ONSE	SW846-8270 M	5700**		X	
	0	1	Benzo(g,h,i)perylene	ONSE	SW846-8270 M	550**		X	
	0	1	Benzo(k)fluoranthene	ONSE	SW846-8270 M	790**		X	
	0	1	Chrysene	ONSE	SW846-8270 M	2100**		X	
	0	1	Dibenzo(a,h)anthracene	PGDP	SW846-8270	480**	JU	J	
	0	1	Fluoranthene	ONSE	SW846-8270 M	2300		X	
	0	1	Fluoranthene	PGDP	SW846-8270	650		=	
	0	1	Indeno(1,2,3-cd)pyrene	ONSE	SW846-8270 M	780**		X	
	0	1	Phenanthrene	ONSE	SW846-8270 M	850**		X	
	0	1	Pyrene	ONSE	SW846-8270 M	2700		X	
	0	1	Pyrene	PGDP	SW846-8270	590		=	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.5 SVOA and PCB compounds detected in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099011SA001	0	1	Benzo(b)fluoranthene	ONSE	SW846-8270 M	170**	J	X	
099012SA001	0	1	Benzo(b)fluoranthene	ONSE	SW846-8270 M	200**	J	X	
099015SA001	0	1	Benzo(b)fluoranthene	ONSE	SW846-8270 M	340**	J	X	
099016SA001	0	1	Benzo(b)fluoranthene	ONSE	SW846-8270 M	300**	J	X	
	0	1	Fluoranthene	ONSE	SW846-8270 M	140	J	X	
	0	1	Pyrene	ONSE	SW846-8270 M	130	J	X	
099031SA001C	0	1	Acenaphthene	ONSE	SW846-8270 M	300	J	X	
	0	1	Anthracene	ONSE	SW846-8270 M	491	J	X	
	0	1	Benzo(a)anthracene	ONSE	SW846-8270 M	1280**		X	
	0	1	Benzo(a)pyrene	ONSE	SW846-8270 M	1700**		X	
	0	1	Benzo(b)fluoranthene	ONSE	SW846-8270 M	3240**		X	
	0	1	Benzo(g,h,i)perylene	ONSE	SW846-8270 M	1180**		X	
	0	1	Benzo(k)fluoranthene	ONSE	SW846-8270 M	466**	J	X	
	0	1	Chrysene	ONSE	SW846-8270 M	1360**		X	
	0	1	Dibenzofuran	ONSE	SW846-8270 M	123**	J	X	
	0	1	Fluoranthene	ONSE	SW846-8270 M	2660		X	
	0	1	Fluorene	ONSE	SW846-8270 M	219	J	X	
	0	1	Indeno(1,2,3-cd)pyrene	ONSE	SW846-8270 M	1050**		X	
	0	1	Phenanthrene	ONSE	SW846-8270 M	1630**		X	
	0	1	Pyrene	ONSE	SW846-8270 M	2250		X	
099006SA060	57	60	Di-n-butylphthalate	PGDP	SW846-8270	1200**		=	
099008SA037	34	37	Di-n-butylphthalate	ONSE	SW846-8270 M	290**	J	X	
	34	37	Diethylphthalate	ONSE	SW846-8270 M	220	J	X	
099009SA027	24	27	Di-n-butylphthalate	PGDP	SW846-8270	950**		=	
099012SA017	14	17	Acenaphthene	ONSE	SW846-8270 M	1200**		X	
	14	17	Anthracene	ONSE	SW846-8270 M	1400		X	

**** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.5 SVOA and PCB compounds detected in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099012SA017	14	17	Benzo(a)anthracene	ONSE	SW846-8270 M	750**		X	
	14	17	Benzo(a)pyrene	ONSE	SW846-8270 M	184**	J	X	
	14	17	Benzo(b)fluoranthene	ONSE	SW846-8270 M	1400**		X	
	14	17	Chrysene	ONSE	SW846-8270 M	810**		X	
	14	17	Dibenzofuran	ONSE	SW846-8270 M	640**		X	
	14	17	Fluoranthene	PGDP	SW846-8270	1200	J	=	
	14	17	Fluoranthene	ONSE	SW846-8270 M	2400		X	
	14	17	Fluorene	ONSE	SW846-8270 M	1600**		X	
	14	17	Indeno(1,2,3-cd)pyrene	ONSE	SW846-8270 M	130**	J	X	
	14	17	Phenanthrene	PGDP	SW846-8270	1400**	J	=	
	14	17	Phenanthrene	ONSE	SW846-8270 M	2100**		X	
	14	17	Pyrene	ONSE	SW846-8270 M	1900		X	
	14	17	Pyrene	PGDP	SW846-8270	760	J	=	
099014SA044	41	44	Di-n-butylphthalate	PGDP	SW846-8270	730**		=	
099019SA045	42	45	Di-n-butylphthalate	PGDP	SW846-8270	710**	B	N	
099025SA050	48	51	Diethylphthalate	ONSE	SW846-8270 M	1900**		X	
099029SA017C	14	17	Di-n-butylphthalate	PGDP	SW846-8270	1400**	B	X	
099029SA045C	42	45	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	240	J	X	
099030SA046C	43	46	Di-n-butylphthalate	PGDP	SW846-8270	1400**	X	X	

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.5 SVOA and PCB compounds detected in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							

SWMU 99 samples not containing any detectable SVOA and PCB compounds are:

082015SA001C
099003SA001
099006SA001
099008SA001
099009SA001
099010SA001
099011SA001
099012SA001
099014SA001
099015SA001
099016SA001
099030SA001C
099001SA017
099001SA027
099001SA037
099001SA057
099001SA060
099001SD017
099003SA019
099003SA028
099003SA044
099003SA054
099003SA060
099004SA019
099004SA028
099004SA037
099004SA044
099004SA054
099004SA060
099005SA001
099005SA019
099005SA028
099005SA037
099005SA044
099005SA054
099005SA060
099006SA019
099006SA028
099006SA037
099006SA044
099006SA054
099006SD019
099008SA019
099008SA028
099008SA044
099008SA054
099008SA060
099008SD044
099009SA017
099009SA027
099009SA038
099009SA047
099010SA017
099010SA028
099010SA037
099010SA047
099010SA054
099010SA060
099011SA017
099011SA027
099011SA038
099011SA047
099011SA054
099011SA060
099012SA017
099012SA027
099012SA035
099012SA047
099012SA051
099014SA027
099014SA037
099014SA051
099014SA060
099019SA006
099019SA011
099019SA017
099019SA025
099019SA031
099019SA051
099022SA006
099022SA012
099022SA017
099022SA023
099022SA028
099022SA038
099022SA049
099022SA054
099022SA060
099025SA006
099025SA012
099025SA017
099025SA023
099025SA025
099025SA041
099025SA047
099025SD047
099029SA006C
099029SA012C
099029SA017C
099029SA025C
099029SA031C
099029SA051C
099029SD025C
099030SA013C
099030SA031C
099030SA038C
099030SA043C
099031SA013C
099031SA031C
099031SA038C
099031SA046C
099033SA013C
099033SA023C

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.6 VOA compounds detected in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099022SA006	3	6	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099022SA012	9	12	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099025SA012	9	12	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099029SA012C	9	12	Acetone	PORTS	SW846-8260A	550**	J	X	BL-T
099033SA013C	10	13	Trichloroethene	PORTS	OA33499026	4.8**		X	
099003SA019	16	19	Acetone	PGDP	SW846-8260	12	J	R	BL-T
099003SA060	57	60	Acetone	PGDP	SW846-8260	10	J	R	BL-T
099004SA019	16	19	Methylene chloride	PGDP	SW846-8260	7000**	J	=	
099005SA028	25	28	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099005SA037	34	37	Acetone	PGDP	SW846-8260	1200**	JU	J	BL-T
099005SA044	41	44	Acetone	PORTS	SW846-8260A	260**		R	BL-T
099005SA054	51	54	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099006SA019	19	22	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099006SA026	25	28	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099006SA037	34	37	Acetone	PORTS	SW846-8260A	460**		J	BL-T
	34	37	Acetone	PGDP	SW846-8260	1200**	JU	J	BL-T
099008SA054	51	54	Trichloroethene	PORTS	OA33499026	30**		=	
	51	54	Trichloroethene	PGDP	SW846-8260	1200**	U	J	
099009SA017	17	20	Acetone	PORTS	SW846-8260A	1400**	J	R	BL-T
099009SA027	24	27	Acetone	PGDP	SW846-8260	1200**	JU	J	BL-T
099009SA038	35	38	Acetone	PORTS	SW846-8260A	350**	J	R	BL-T
099012SA035	32	35	Bromomethane	PORTS	SW846-8260A	20**	J	R	BL-T
099014SA017	17	20	Acetone	PGDP	SW846-8260	1200**	JU	J	BL-T
099014SA044	41	44	Acetone	PORTS	SW846-8260A	710**		J	BL-T
099019SA025	22	25	Acetone	PORTS	SW846-8260A	390**	J	R	BL-T
099019SA031	28	31	Acetone	PORTS	SW846-8260A	1100**	J	R	BL-T

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.6 VOA compounds detected in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099019SA045	42	45	Acetone	PORTS	SW846-8260A	500**	J	J	BL-T
099019SA051	47	48	Acetone	PORTS	SW846-8260A	1100**	J	R	BL-T
099022SA023	19	22	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099022SA028	25	28	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099022SA049	46	49	Acetone	PGDP	SW846-8260	1200**	JUX	J	BL-T
	46	49	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099022SA054	51	54	Acetone	PGDP	SW846-8260	1200**	JU	J	BL-T
099025SA017	14	17	Acetone	PGDP	SW846-8260	1200**	JU	J	BL-T
099025SA025	23	25	Methylene chloride	PGDP	SW846-8260	10**	JU	J	BL-T
099025SA041	38	41	Methylene chloride	PGDP	SW846-8260	1200**	JU	J	BL-T
099029SA051C	48	51	Methylene chloride	PGDP	SW846-8260	6800**	JX	X	
099029SD025C	22	25	Acetone	PORTS	SW846-8260A	280**	J	X	BL-T

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.6 VOA compounds detected in soil at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							

SWMU 99 samples not containing any detectable VOA compounds are:

082014SA001C
082015SA001C
099001SA017
099001SA027
099001SA037
099001SA048
099001SA057
099001SA060
099001SD017
099003SA028
099003SA037
099003SA044
099003SA054
099004SA028
099004SA037
099004SA044
099004SA054
099004SA060
099005SA019
099005SA060
099006SA044
099006SA054
099006SA060
099006SD019
099008SA019
099008SA028
099008SA037
099008SA044
099008SA060
099008SD044
099009SA047
099010SA017
099010SA028
099010SA037
099010SA047
099010SA054
099010SA060
099011SA017
099011SA027
099011SA038
099011SA047
099011SA054
099011SA060
099012SA017
099012SA027
099012SA047
099012SA051
099014SA027
099014SA037
099014SA051
099014SA060
099019SA006
099019SA011
099019SA017
099022SA017
099022SA038
099022SA060
099025SA006
099025SA023
099025SA034
099025SA047
099025SA050
099025SD047
099029SA017C
099029SA025C
099029SA031C
099029SA045C
099030SA013C
099030SA031C
099030SA038C
099030SA043C
099030SA046C
099031SA013C
099031SA031C
099031SA038C
099031SA043C
099031SA046C
099033SA023C
099033SA032C
099033SA038C
099033SA043C
099033SA046C

** - *Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099034WA075C	77	77	Aluminum	PGDP	SW846-6010A	4.78**	N	X	
	77	77	Barium	PGDP	SW846-6010A	0.2		X	
	77	77	Calcium	PGDP	SW846-6010A	32.9	N	X	
	77	77	Iron	PGDP	SW846-6010A	24.8	N	X	
	77	77	Magnesium	PGDP	SW846-6010A	12.9		X	
	77	77	Manganese	PGDP	SW846-6010A	0.48		X	
	77	77	Nickel	PGDP	SW846-6010A	0.06		X	
	77	77	Potassium	PGDP	SW846-6010A	2.44		X	
	77	77	Sodium	PGDP	SW846-6010A	44.9	N	X	
	77	77	Strontium	PGDP	SW846-6010A	0.12		X	
099034WA075C-45	77	77	Barium	PGDP	SW846-6010A	0.16		X	
	77	77	Calcium	PGDP	SW846-6010A	34.9	N	X	
	77	77	Iron	PGDP	SW846-6010A	0.28	B	X	
	77	77	Magnesium	PGDP	SW846-6010A	13.4		X	
	77	77	Manganese	PGDP	SW846-6010A	0.45		X	
	77	77	Sodium	PGDP	SW846-6010A	50.3	N	X	
	77	77	Strontium	PGDP	SW846-6010A	0.12		X	
099034WA075C-5	77	77	Barium	PGDP	SW846-6010A	0.21		X	
	77	77	Calcium	PGDP	SW846-6010A	38	N	X	
	77	77	Iron	PGDP	SW846-6010A	0.41	B	X	
	77	77	Magnesium	PGDP	SW846-6010A	14.7		X	
	77	77	Manganese	PGDP	SW846-6010A	0.4		X	
	77	77	Nickel	PGDP	SW846-6010A	0.05	B	X	
	77	77	Sodium	PGDP	SW846-6010A	51.3	N	X	
	77	77	Strontium	PGDP	SW846-6010A	0.11		X	
099034WA080C	82	82	Aluminum	PGDP	SW846-6010A	160**	N	X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099034WA080C	82	82	Arsenic	PGDP	SW846-7060	0.007	*NW	X	
	82	82	Barium	PGDP	SW846-6010A	0.84		X	
	82	82	Beryllium	PGDP	SW846-6010A	0.01	B	X	
	82	82	Calcium	PGDP	SW846-6010A	50.3	N	X	
	82	82	Chromium	PGDP	SW846-6010A	0.47		X	
	82	82	Cobalt	PGDP	SW846-6010A	0.07**		X	
	82	82	Copper	PGDP	SW846-6010A	0.11		X	
	82	82	Iron	PGDP	SW846-6010A	148	N	X	
	82	82	Lead	PGDP	SW846-7421 E3R0 Sep86	0.07**	NW	X	
	82	82	Lithium	PGDP	SW846-6010A	0.05**		X	
	82	82	Magnesium	PGDP	SW846-6010A	21.9		X	
	82	82	Manganese	PGDP	SW846-6010A	0.7		X	
	82	82	Nickel	PGDP	SW846-6010A	0.2		X	
	82	82	Potassium	PGDP	SW846-6010A	9.04		X	
	82	82	Sodium	PGDP	SW846-6010A	44	N	X	
	82	82	Strontium	PGDP	SW846-6010A	0.37		X	
	82	82	Vanadium	PGDP	SW846-6010A	0.62		X	
	82	82	Zinc	PGDP	SW846-6010A	0.41		X	
099034WA080C-45	82	82	Barium	PGDP	SW846-6010A	0.29		X	
	82	82	Calcium	PGDP	SW846-6010A	46	N	X	
	82	82	Iron	PGDP	SW846-6010A	1.27	B	X	
	82	82	Magnesium	PGDP	SW846-6010A	18.1		X	
	82	82	Manganese	PGDP	SW846-6010A	0.32		X	
	82	82	Potassium	PGDP	SW846-6010A	2.08		X	
	82	82	Sodium	PGDP	SW846-6010A	52.9	N	X	
	82	82	Strontium	PGDP	SW846-6010A	0.31		X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

	Sample Interval (ft bgs)								
Sample ID	**Top**	**Bottom**	**Analytical Compound**	**Laboratory**	**Method**	**Results (mg/l)**	**Lab Qualifier**	**Validation Qualifier**	**Data Assessment**
099034WA080C-5	82	82	Barium	PGDP	SW846-6010A	0.29		X	
	82	82	Calcium	PGDP	SW846-6010A	47.1	N	X	
	82	82	Iron	PGDP	SW846-6010A	1.31	B	X	
	82	82	Magnesium	PGDP	SW846-6010A	18.4		X	
	82	82	Manganese	PGDP	SW846-6010A	0.39		X	
	82	82	Potassium	PGDP	SW846-6010A	2.16		X	
	82	82	Sodium	PGDP	SW846-6010A	52.7	N	X	
	82	82	Strontium	PGDP	SW846-6010A	0.32		X	
099034WA085C	87	87	Aluminum	PGDP	SW846-6010A	19.3**	N	X	
	87	87	Barium	PGDP	SW846-6010A	0.3		X	
	87	87	Calcium	PGDP	SW846-6010A	24.6	N	X	
	87	87	Chromium	PGDP	SW846-6010A	0.08		X	
	87	87	Cobalt	PGDP	SW846-6010A	0.02**		X	
	87	87	Iron	PGDP	SW846-6010A	65.4	N	X	
	87	87	Magnesium	PGDP	SW846-6010A	9.71		X	
	87	87	Manganese	PGDP	SW846-6010A	0.59		X	
	87	87	Nickel	PGDP	SW846-6010A	0.12		X	
	87	87	Potassium	PGDP	SW846-6010A	3.18		X	
	87	87	Sodium	PGDP	SW846-6010A	45	N	X	
	87	87	Strontium	PGDP	SW846-6010A	0.22		X	
099034WA085C-45	87	87	Barium	PGDP	SW846-6010A	0.18		X	
	87	87	Calcium	PGDP	SW846-6010A	28.8	N	X	
	87	87	Iron	PGDP	SW846-6010A	0.67	B	X	
	87	87	Magnesium	PGDP	SW846-6010A	11.1		X	
	87	87	Manganese	PGDP	SW846-6010A	0.51		X	
	87	87	Potassium	PGDP	SW846-6010A	2.53		X	

**** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099034WA085C-45	87	87	Sodium	PGDP	SW846-6010A	61.3	N	X	
	87	87	Strontium	PGDP	SW846-6010A	0.25		X	
099034WA085C-5	87	87	Barium	PGDP	SW846-6010A	0.2		X	
	87	87	Calcium	PGDP	SW846-6010A	29.2	N	X	
	87	87	Iron	PGDP	SW846-6010A	1.18	B	X	
	87	87	Magnesium	PGDP	SW846-6010A	11.3		X	
	87	87	Manganese	PGDP	SW846-6010A	0.49		X	
	87	87	Potassium	PGDP	SW846-6010A	2.42		X	
	87	87	Sodium	PGDP	SW846-6010A	60.9	N	X	
	87	87	Strontium	PGDP	SW846-6010A	0.26		X	
099034WA090C	92	92	Aluminum	PGDP	SW846-6010A	183**	N	X	
	92	92	Arsenic	PGDP	SW846-7060	0.005	*NW	X	
	92	92	Barium	PGDP	SW846-6010A	1.73		X	
	92	92	Beryllium	PGDP	SW846-6010A	0.01	B	X	
	92	92	Calcium	PGDP	SW846-6010A	29.6	N	X	
	92	92	Chromium	PGDP	SW846-6010A	0.79		X	
	92	92	Cobalt	PGDP	SW846-6010A	0.17**		X	
	92	92	Copper	PGDP	SW846-6010A	0.12		X	
	92	92	Iron	PGDP	SW846-6010A	123	N	X	
	92	92	Lithium	PGDP	SW846-6010A	0.1**		X	
	92	92	Magnesium	PGDP	SW846-6010A	13.3		X	
	92	92	Manganese	PGDP	SW846-6010A	4.6		X	
	92	92	Mercury	PGDP	SW846-7470	0.0002	BN	X	
	92	92	Nickel	PGDP	SW846-6010A	0.35		X	
	92	92	Potassium	PGDP	SW846-6010A	7.51		X	
	92	92	Sodium	PGDP	SW846-6010A	56.8	N	X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

	Sample Interval (ft bgs)								
Sample ID	Top	Bottom	Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
099034WA090C	92	92	Strontium	PGDP	SW846-6010A	0.35		X	
	92	92	Vanadium	PGDP	SW846-6010A	0.92		X	
	92	92	Zinc	PGDP	SW846-6010A	0.38		X	
099034WA090C-45	92	92	Barium	PGDP	SW846-6010A	0.27		X	
	92	92	Calcium	PGDP	SW846-6010A	24.1	N	X	
	92	92	Cobalt	PGDP	SW846-6010A	0.02**		X	
	92	92	Magnesium	PGDP	SW846-6010A	9.45		X	
	92	92	Manganese	PGDP	SW846-6010A	1.2		X	
	92	92	Potassium	PGDP	SW846-6010A	2.16		X	
	92	92	Sodium	PGDP	SW846-6010A	63.7	N	X	
	92	92	Strontium	PGDP	SW846-6010A	0.25		X	
099034WA090C-5	92	92	Aluminum	PGDP	SW846-6010A	0.2**		X	
	92	92	Barium	PGDP	SW846-6010A	0.28		X	
	92	92	Calcium	PGDP	SW846-6010A	24.9	N	X	
	92	92	Cobalt	PGDP	SW846-6010A	0.02**		X	
	92	92	Magnesium	PGDP	SW846-6010A	9.75		X	
	92	92	Manganese	PGDP	SW846-6010A	1.26		X	
	92	92	Potassium	PGDP	SW846-6010A	2.22		X	
	92	92	Sodium	PGDP	SW846-6010A	63.9	N	X	
	92	92	Strontium	PGDP	SW846-6010A	0.26		X	
099034WA095C	97	97	Aluminum	PGDP	SW846-6010A	22.7**	N	X	
	97	97	Barium	PGDP	SW846-6010A	0.48		X	
	97	97	Beryllium	PGDP	SW846-6010A	0.008	B	X	
	97	97	Calcium	PGDP	SW846-6010A	27.8	N	X	
	97	97	Chromium	PGDP	SW846-6010A	0.17		X	
	97	97	Cobalt	PGDP	SW846-6010A	0.1**	*N	X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099034WA095C	97	97	Copper	PGDP	SW846-6010A	0.07		X	
	97	97	Iron	PGDP	SW846-6010A	331	N	X	
	97	97	Magnesium	PGDP	SW846-6010A	9.65		X	
	97	97	Manganese	PGDP	SW846-6010A	3.76		X	
	97	97	Nickel	PGDP	SW846-6010A	0.25		X	
	97	97	Potassium	PGDP	SW846-6010A	3.43		X	
	97	97	Sodium	PGDP	SW846-6010A	67.9	N	X	
	97	97	Strontium	PGDP	SW846-6010A	0.35		X	
	97	97	Vanadium	PGDP	SW846-6010A	0.37		X	
	97	97	Zinc	PGDP	SW846-6010A	0.24		X	
099034WA095C-45	97	97	Barium	PGDP	SW846-6010A	0.22		X	
	97	97	Calcium	PGDP	SW846-6010A	26.2	N	X	
	97	97	Cobalt	PGDP	SW846-6010A	0.03**		X	
	97	97	Iron	PGDP	SW846-6010A	0.41	B	X	
	97	97	Magnesium	PGDP	SW846-6010A	9.46		X	
	97	97	Manganese	PGDP	SW846-6010A	2.15		X	
	97	97	Nickel	PGDP	SW846-6010A	0.06	B	X	
	97	97	Potassium	PGDP	SW846-6010A	2.86		X	
	97	97	Sodium	PGDP	SW846-6010A	72.4	N	X	
	97	97	Strontium	PGDP	SW846-6010A	0.32		X	
099034WA095C-5	97	97	Barium	PGDP	SW846-6010A	0.23		X	
	97	97	Calcium	PGDP	SW846-6010A	25.4	N	X	
	97	97	Cobalt	PGDP	SW846-6010A	0.03**		X	
	97	97	Iron	PGDP	SW846-6010A	0.61	B	X	
	97	97	Magnesium	PGDP	SW846-6010A	9.39		X	
	97	97	Manganese	PGDP	SW846-6010A	1.63		X	

** - *Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099034WA095C-5	97	97	Nickel	PGDP	SW846-6010A	0.06	B	X	
	97	97	Potassium	PGDP	SW846-6010A	2.47		X	
	97	97	Sodium	PGDP	SW846-6010A	70.8	N	X	
	97	97	Strontium	PGDP	SW846-6010A	0.3		X	
099034WA100C	102	102	Aluminum	PGDP	SW846-6010A	136**	N	X	
	102	102	Barium	PGDP	SW846-6010A	1.17		X	
	102	102	Beryllium	PGDP	SW846-6010A	0.03		X	
	102	102	Calcium	PGDP	SW846-6010A	34.9	N	X	
	102	102	Chromium	PGDP	SW846-6010A	0.86		X	
	102	102	Cobalt	PGDP	SW846-6010A	0.09**	*N	X	
	102	102	Copper	PGDP	SW846-6010A	0.26		X	
	102	102	Iron	PGDP	SW846-6010A	1200	N	X	
	102	102	Lead	PGDP	SW846-7421 E3R0 Sep86	0.05**	NW	X	
	102	102	Lithium	PGDP	SW846-6010A	0.09**		X	
	102	102	Magnesium	PGDP	SW846-6010A	19.9		X	
	102	102	Manganese	PGDP	SW846-6010A	3.61		X	
	102	102	Nickel	PGDP	SW846-6010A	0.6		X	
	102	102	Potassium	PGDP	SW846-6010A	10.7		X	
	102	102	Sodium	PGDP	SW846-6010A	51.5	N	X	
	102	102	Strontium	PGDP	SW846-6010A	0.47		X	
	102	102	Vanadium	PGDP	SW846-6010A	0.97		X	
	102	102	Zinc	PGDP	SW846-6010A	0.9		X	
099034WA100C-45	102	102	Barium	PGDP	SW846-6010A	0.13		X	
	102	102	Calcium	PGDP	SW846-6010A	21.2	N	X	
	102	102	Magnesium	PGDP	SW846-6010A	8.44		X	
	102	102	Manganese	PGDP	SW846-6010A	0.39		X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099034WA100C-45	102	102	Potassium	PGDP	SW846-6010A	3.47		X	
	102	102	Sodium	PGDP	SW846-6010A	54	N	X	
	102	102	Strontium	PGDP	SW846-6010A	0.25		X	
099034WA100C-5	102	102	Barium	PGDP	SW846-6010A	0.14		X	
	102	102	Calcium	PGDP	SW846-6010A	21	N	X	
	102	102	Iron	PGDP	SW846-6010A	0.21	B	X	
	102	102	Magnesium	PGDP	SW846-6010A	8.38		X	
	102	102	Manganese	PGDP	SW846-6010A	0.35		X	
	102	102	Potassium	PGDP	SW846-6010A	3.42		X	
	102	102	Sodium	PGDP	SW846-6010A	52.3	N	X	
	102	102	Strontium	PGDP	SW846-6010A	0.25		X	
099034WD075C	77	77	Aluminum	PGDP	SW846-6010A	7.48**	N	X	
	77	77	Barium	PGDP	SW846-6010A	0.29		X	
	77	77	Calcium	PGDP	SW846-6010A	39.6	N	X	
	77	77	Chromium	PGDP	SW846-6010A	0.06		X	
	77	77	Iron	PGDP	SW846-6010A	43.1	N	X	
	77	77	Magnesium	PGDP	SW846-6010A	15.7		X	
	77	77	Manganese	PGDP	SW846-6010A	0.52		X	
	77	77	Nickel	PGDP	SW846-6010A	0.1		X	
	77	77	Potassium	PGDP	SW846-6010A	2		X	
	77	77	Sodium	PGDP	SW846-6010A	51	N	X	
	77	77	Strontium	PGDP	SW846-6010A	0.11		X	
099034WD075C-45	77	77	Barium	PGDP	SW846-6010A	0.21		X	
	77	77	Calcium	PGDP	SW846-6010A	39.9	N	X	
	77	77	Iron	PGDP	SW846-6010A	1.09	B	X	
	77	77	Magnesium	PGDP	SW846-6010A	15.5		X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099034WD075C-45	77	77	Manganese	PGDP	SW846-6010A	0.42		X	
	77	77	Sodium	PGDP	SW846-6010A	54	N	X	
	77	77	Strontium	PGDP	SW846-6010A	0.11		X	
099034WD075C-5	77	77	Barium	PGDP	SW846-6010A	0.21		X	
	77	77	Calcium	PGDP	SW846-6010A	41.6	N	X	
	77	77	Iron	PGDP	SW846-6010A	1.18	B	X	
	77	77	Magnesium	PGDP	SW846-6010A	15.9		X	
	77	77	Manganese	PGDP	SW846-6010A	0.47		X	
	77	77	Nickel	PGDP	SW846-6010A	0.05	B	X	
	77	77	Sodium	PGDP	SW846-6010A	55.5	N	X	
	77	77	Strontium	PGDP	SW846-6010A	0.12		X	
099035WA065C	67	67	Aluminum	PGDP	SW846-6010A	111**	N	X	
	67	67	Barium	PGDP	SW846-6010A	0.77	N	X	
	67	67	Beryllium	PGDP	SW846-6010A	0.01	BN	X	
	67	67	Calcium	PGDP	SW846-6010A	67.4	N	X	
	67	67	Chromium	PGDP	SW846-6010A	0.2	N	X	
	67	67	Cobalt	PGDP	SW846-6010A	0.14**	N	X	
	67	67	Copper	PGDP	SW846-6010A	0.06	N	X	
	67	67	Iron	PGDP	SW846-6010A	114	N	X	
	67	67	Lead	PGDP	SW846-7421 E3R0 Sep86	0.05**		X	
	67	67	Magnesium	PGDP	SW846-6010A	27.6	N	X	
	67	67	Manganese	PGDP	SW846-6010A	1.88	N	X	
	67	67	Mercury	PGDP	SW846-7470	0.002	BW	X	
	67	67	Nickel	PGDP	SW846-6010A	0.09		X	
	67	67	Potassium	PGDP	SW846-6010A	6.67	N	X	
	67	67	Sodium	PGDP	SW846-6010A	64.5	N	X	

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099035WA065C	67	67	Strontium	PGDP	SW846-6010A	0.17		X	
	67	67	Vanadium	PGDP	SW846-6010A	0.34	N	X	
	67	67	Zinc	PGDP	SW846-6010A	0.26		X	
099035WA065C-45	64	67	Barium	PGDP	SW846-6010A	0.48		X	
	64	67	Calcium	PGDP	SW846-6010A	74.9	N	X	
	64	67	Cobalt	PGDP	SW846-6010A	0.09**		X	
	64	67	Iron	PGDP	SW846-6010A	3.23	N	X	
	64	67	Magnesium	PGDP	SW846-6010A	28.2	N	X	
	64	67	Manganese	PGDP	SW846-6010A	1.32		X	
	64	67	Sodium	PGDP	SW846-6010A	88.1	N	X	
	64	67	Strontium	PGDP	SW846-6010A	0.16		X	
099035WA065C-5	64	67	Aluminum	PGDP	SW846-6010A	5.03**	N	X	
	64	67	Barium	PGDP	SW846-6010A	0.49		X	
	64	67	Calcium	PGDP	SW846-6010A	72.9	N	X	
	64	67	Cobalt	PGDP	SW846-6010A	0.1**		X	
	64	67	Iron	PGDP	SW846-6010A	3.27	N	X	
	64	67	Magnesium	PGDP	SW846-6010A	27.5	N	X	
	64	67	Manganese	PGDP	SW846-6010A	1.46		X	
	64	67	Sodium	PGDP	SW846-6010A	85.5	N	X	
	64	67	Strontium	PGDP	SW846-6010A	0.15		X	
099035WA075C	77	77	Aluminum	PGDP	SW846-6010A	110**	N	X	
	77	77	Barium	PGDP	SW846-6010A	1.77	N	X	
	77	77	Beryllium	PGDP	SW846-6010A	0.04	N	X	
	77	77	Calcium	PGDP	SW846-6010A	77.2	N	X	
	77	77	Chromium	PGDP	SW846-6010A	0.25	N	X	
	77	77	Cobalt	PGDP	SW846-6010A	0.47**	N	X	

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099035WA075C	77	77	Copper	PGDP	SW846-6010A	0.17	N	X	
	77	77	Iron	PGDP	SW846-6010A	76.8	N	X	
	77	77	Lead	PGDP	SW846-7421 E3R0 Sep86	0.2**		X	
	77	77	Magnesium	PGDP	SW846-6010A	27.4	N	X	
	77	77	Manganese	PGDP	SW846-6010A	2.52	N	X	
	77	77	Mercury	PGDP	SW846-7470	0.02	BW	X	
	77	77	Nickel	PGDP	SW846-6010A	0.1		X	
	77	77	Potassium	PGDP	SW846-6010A	4.23	N	X	
	77	77	Sodium	PGDP	SW846-6010A	15	N	X	
	77	77	Strontium	PGDP	SW846-6010A	0.15		X	
	77	77	Vanadium	PGDP	SW846-6010A	0.42	N	X	
	77	77	Zinc	PGDP	SW846-6010A	0.53		X	
099035WA075C-45	77	77	Barium	PGDP	SW846-6010A	0.49		X	
	77	77	Calcium	PGDP	SW846-6010A	87.2	N	X	
	77	77	Cobalt	PGDP	SW846-6010A	0.07**		X	
	77	77	Magnesium	PGDP	SW846-6010A	32.5	N	X	
	77	77	Manganese	PGDP	SW846-6010A	0.53		X	
	77	77	Sodium	PGDP	SW846-6010A	63.8	N	X	
	77	77	Strontium	PGDP	SW846-6010A	0.14		X	
099035WA075C-5	77	77	Aluminum	PGDP	SW846-6010A	0.53**	N	X	
	77	77	Barium	PGDP	SW846-6010A	0.52		X	
	77	77	Calcium	PGDP	SW846-6010A	83.2	N	X	
	77	77	Cobalt	PGDP	SW846-6010A	0.06**		X	
	77	77	Iron	PGDP	SW846-6010A	0.38	BN	X	
	77	77	Magnesium	PGDP	SW846-6010A	31	N	X	
	77	77	Manganese	PGDP	SW846-6010A	0.45		X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099035WA075C-5	77	77	Sodium	PGDP	SW846-6010A	59.2	N	X	
	77	77	Strontium	PGDP	SW846-6010A	0.13		X	
099035WA080C	82	82	Aluminum	PGDP	SW846-6010A	659**	N	X	
	82	82	Arsenic	PGDP	SW846-7060	0.01	*NW	X	
	82	82	Barium	PGDP	SW846-6010A	2.87	N	X	
	82	82	Beryllium	PGDP	SW846-6010A	0.1	N	X	
	82	82	Calcium	PGDP	SW846-6010A	120	N	X	
	82	82	Chromium	PGDP	SW846-6010A	1.6	N	X	
	82	82	Cobalt	PGDP	SW846-6010A	0.4**	N	X	
	82	82	Copper	PGDP	SW846-6010A	0.64	N	X	
	82	82	Iron	PGDP	SW846-6010A	486	N	X	
	82	82	Lead	PGDP	SW846-7421 E3R0 Sep86	0.41**		X	
	82	82	Lithium	PGDP	SW846-6010A	0.17**		X	
	82	82	Magnesium	PGDP	SW846-6010A	49.7	N	X	
	82	82	Manganese	PGDP	SW846-6010A	3.5	N	X	
	82	82	Mercury	PGDP	SW846-7470	0.001	BW	X	
	82	82	Nickel	PGDP	SW846-6010A	0.68		X	
	82	82	Potassium	PGDP	SW846-6010A	21.7	N	X	
	82	82	Sodium	PGDP	SW846-6010A	39.6	N	X	
	82	82	Strontium	PGDP	SW846-6010A	0.37		X	
	82	82	Vanadium	PGDP	SW846-6010A	2.15	N	X	
	82	82	Zinc	PGDP	SW846-6010A	2.46		X	
099035WA080C-45	82	82	Barium	PGDP	SW846-6010A	0.53		X	
	82	82	Calcium	PGDP	SW846-6010A	83.5	N	X	
	82	82	Cobalt	PGDP	SW846-6010A	0.13**		X	
	82	82	Iron	PGDP	SW846-6010A	5.59	N	X	

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099035WA080C-45	82	82	Magnesium	PGDP	SW846-6010A	31.4	N	X	
	82	82	Manganese	PGDP	SW846-6010A	1.42		X	
	82	82	Sodium	PGDP	SW846-6010A	57.6	N	X	
	82	82	Strontium	PGDP	SW846-6010A	0.16		X	
099035WA080C-5	82	82	Barium	PGDP	SW846-6010A	0.5		X	
	82	82	Calcium	PGDP	SW846-6010A	81.1	N	X	
	82	82	Cobalt	PGDP	SW846-6010A	0.13**		X	
	82	82	Iron	PGDP	SW846-6010A	4.69	N	X	
	82	82	Magnesium	PGDP	SW846-6010A	30.4	N	X	
	82	82	Manganese	PGDP	SW846-6010A	1.59		X	
	82	82	Sodium	PGDP	SW846-6010A	55.7	N	X	
	82	82	Strontium	PGDP	SW846-6010A	0.17		X	
099035WA085C	84	87	Aluminum	PGDP	SW846-6010A	380**	N	X	
	84	87	Barium	PGDP	SW846-6010A	1.73	N	X	
	84	87	Beryllium	PGDP	SW846-6010A	0.07	N	X	
	84	87	Calcium	PGDP	SW846-6010A	69.3	N	X	
	84	87	Chromium	PGDP	SW846-6010A	1.44	N	X	
	84	87	Cobalt	PGDP	SW846-6010A	0.57**	N	X	
	84	87	Copper	PGDP	SW846-6010A	0.38	N	X	
	84	87	Iron	PGDP	SW846-6010A	1080	N	X	
	84	87	Lead	PGDP	SW846-7421 E3R0 Sep86	0.34**		X	
	84	87	Lithium	PGDP	SW846-6010A	0.1**		X	
	84	87	Magnesium	PGDP	SW846-6010A	29.6	N	X	
	84	87	Manganese	PGDP	SW846-6010A	4.42	N	X	
	84	87	Mercury	PGDP	SW846-7470	0.002	BW	X	
	84	87	Nickel	PGDP	SW846-6010A	0.91		X	

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099035WA085C	84	87	Potassium	PGDP	SW846-6010A	11.9	N	X	
	84	87	Sodium	PGDP	SW846-6010A	25.5	N	X	
	84	87	Strontium	PGDP	SW846-6010A	0.21		X	
	84	87	Vanadium	PGDP	SW846-6010A	1.58	N	X	
	84	87	Zinc	PGDP	SW846-6010A	2.55		X	
099035WA085C-45	84	87	Barium	PGDP	SW846-6010A	0.42		X	
	84	87	Calcium	PGDP	SW846-6010A	60.4	N	X	
	84	87	Cobalt	PGDP	SW846-6010A	0.12**		X	
	84	87	Iron	PGDP	SW846-6010A	0.33	BN	X	
	84	87	Magnesium	PGDP	SW846-6010A	23.4	N	X	
	84	87	Manganese	PGDP	SW846-6010A	1.3		X	
	84	87	Sodium	PGDP	SW846-6010A	49.1	N	X	
	84	87	Strontium	PGDP	SW846-6010A	0.14		X	
099035WA085C-5	84	87	Aluminum	PGDP	SW846-6010A	0.47**	N	X	
	84	87	Barium	PGDP	SW846-6010A	0.41		X	
	84	87	Calcium	PGDP	SW846-6010A	59	N	X	
	84	87	Cobalt	PGDP	SW846-6010A	0.12**		X	
	84	87	Iron	PGDP	SW846-6010A	0.28	BN	X	
	84	87	Magnesium	PGDP	SW846-6010A	22.7	N	X	
	84	87	Manganese	PGDP	SW846-6010A	1.24		X	
	84	87	Sodium	PGDP	SW846-6010A	48	N	X	
	84	87	Strontium	PGDP	SW846-6010A	0.13		X	
099035WA105C	107	107	Aluminum	PGDP	SW846-6010A	309**	N	X	
	107	107	Arsenic	PGDP	SW846-7060	0.007	*NW	X	
	107	107	Barium	PGDP	SW846-6010A	3.3	N	X	
	107	107	Beryllium	PGDP	SW846-6010A	0.03	N	X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
099035WA105C	107	107	Calcium	PGDP	SW846-6010A	34.1	N	X	
	107	107	Chromium	PGDP	SW846-6010A	1.78	N	X	
	107	107	Cobalt	PGDP	SW846-6010A	0.12**	N	X	
	107	107	Copper	PGDP	SW846-6010A	0.31	N	X	
	107	107	Iron	PGDP	SW846-6010A	245	N	X	
	107	107	Lead	PGDP	SW846-7421 E3R0 Sep86	0.08**		X	
	107	107	Lithium	PGDP	SW846-6010A	0.14**		X	
	107	107	Magnesium	PGDP	SW846-6010A	16.1	N	X	
	107	107	Manganese	PGDP	SW846-6010A	3.76	N	X	
	107	107	Mercury	PGDP	SW846-7470	0.0006	BW	X	
	107	107	Nickel	PGDP	SW846-6010A	0.72		X	
	107	107	Potassium	PGDP	SW846-6010A	9.69	N	X	
	107	107	Sodium	PGDP	SW846-6010A	49.5	N	X	
	107	107	Strontium	PGDP	SW846-6010A	0.45		X	
	107	107	Vanadium	PGDP	SW846-6010A	1.81	N	X	
	107	107	Zinc	PGDP	SW846-6010A	0.95		X	
099035WA105C-45	107	107	Barium	PGDP	SW846-6010A	0.28		X	
	107	107	Calcium	PGDP	SW846-6010A	25.8	N	X	
	107	107	Magnesium	PGDP	SW846-6010A	9.86	N	X	
	107	107	Manganese	PGDP	SW846-6010A	0.84		X	
	107	107	Potassium	PGDP	SW846-6010A	2.45		X	
	107	107	Sodium	PGDP	SW846-6010A	58	N	X	
	107	107	Strontium	PGDP	SW846-6010A	0.27		X	
099035WA105C-5	107	107	Aluminum	PGDP	SW846-6010A	4.09**	N	X	
	107	107	Barium	PGDP	SW846-6010A	0.31		X	
	107	107	Calcium	PGDP	SW846-6010A	26	N	X	

**** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.7 Inorganic compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099035WA105C-5	107	107	Cobalt	PGDP	SW846-6010A	0.01**		X	
	107	107	Iron	PGDP	SW846-6010A	1.03	N	X	
	107	107	Magnesium	PGDP	SW846-6010A	10.1	N	X	
	107	107	Manganese	PGDP	SW846-6010A	0.84		X	
	107	107	Potassium	PGDP	SW846-6010A	2.59		X	
	107	107	Sodium	PGDP	SW846-6010A	58.7	N	X	
	107	107	Strontium	PGDP	SW846-6010A	0.27		X	

SWMU 99 samples not containing any detectable inorganic compounds are:

(All SWMU 99 samples analyzed for inorganics contained at least one detected analyte.)

**** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.8 Radioactive isotopes detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Laboratory	Method	Results (pci/l)	Lab Qualifier	Validation Qualifier	Data Assessment
099034WA075C	77	77	Technetium-99	PARGN	DNT	14.5**		X	
099034WA085C	87	87	Technetium-99	PARGN	DNT	110**		X	
	87	87	Technetium-99	PGDP	RL-7100	131**		X	
099034WA090C	92	92	Technetium-99	PARGN	DNT	139**		X	
099034WA100C	102	102	Technetium-99	PARGN	DNT	35**		X	
	102	102	Technetium-99	PGDP	RL-7100	41.8**		X	
099035WA080C	82	82	Technetium-99	PGDP	RL-7100	21.9**		X	U
099035WA105C	107	107	Technetium-99	PARGN	DNT	71**		X	
099005WA054	57	80	Technetium-99	PARGN	DNT	28**		X	
099011WA047	59	62	Technetium-99	PARGN	DNT	26**		X	
099014WA051	57	60	Technetium-99	PARGN	DNT	21**		X	
099019WA045	45	45	Technetium-99	PARGN	DNT	36**		X	
099025WA050	42	44	Technetium-99	PARGN	DNT	16**		X	
099030WA043C	41	46	Technetium-99	PARGN	DNT	26**		X	
099031WA043C	41	46	Technetium-99	PARGN	DNT	148**		X	
099032WA044C	39	44	Technetium-99	PARGN	DNT	57**		X	
	39	44	Technetium-99	PGDP	RL-7100	79**		X	
099033WA046C	41	46	Technetium-99	PARGN	DNT	48**		X	

SWMU 99 samples not containing any detectable radioactive isotopes are:

099019WA045-45 099019WA045-5 099022WA054 099029WA045C 099029WD045C 099034WA080C
099034WA095C 099034WD075C 099035WA065C 099035WA065C-45 099035WA085C-5 099035WA075C
099035WA085C

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.9 SVOA and PCB compounds detected in groundwater at SWMU 99

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099034WA075C	77	77	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	15	J	X	
099034WA080C	82	82	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	16	J	X	
099034WA100C	102	102	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	16	J	X	
099035WA065C	67	67	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	20		X	
099035WA080C	82	82	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	8	J	X	
099035WA105C	107	107	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	6	J	X	
099011WA047	59	62	Diethylphthalate	ONSE	SW846-8270 M	21		X	
099022WA054	51	54	Bis(2-ethylhexyl)phthalate	PGDP	SW846-8270	7		=	
	51	54	Di-n-butylphthalate	PGDP	SW846-8270	2**	J	=	
	51	54	Di-n-octylphthalate	PGDP	SW846-8270	8**		=	
	51	54	Diethylphthalate	PGDP	SW846-8270	17		=	
	51	54	Pentachlorophenol	PGDP	SW846-8270	3**	J	=	
	51	54	Phenol	PGDP	SW846-8270	8**		=	
	51	54	Pyridine	PGDP	SW846-8270	5**	U	NJ	
099031WA043C	41	46	Diethylphthalate	ONSE	SW846-8270 M	11		X	
	41	46	Fluoranthene	ONSE	SW846-8270 M	9	J	X	
	41	46	Phenanthrene	ONSE	SW846-8270 M	6**	J	X	
	41	46	Pyrene	ONSE	SW846-8270 M	8**	J	X	

SWMU 99 samples not containing any detectable SVOA and PCB compounds are:

099005WA054
099014WA051
099019WA045
099025WA050
099029WA045C
099029WD045C
099030WA043C
099032WA044C
099034WA085C
099034WA090C
099034WA095C
099034WD075C
099035WA075C
099035WA085C

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.10 VOA compounds detected in groundwater at SWMU 99

Sample ID	**Sample Interval (ft bgs)**		**Analytical Compound**	**Laboratory**	**Method**	**Results (ug/l)**	**Lab Qualifier**	**Validation Qualifier**	**Data Assessment**
	Top	**Bottom**							
099034WA075C	77	77	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.6**	J	X	
	77	77	Trichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
099034WA080C	82	82	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.5**	J	X	
	82	82	Trichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
099034WA085C	87	87	1,1-Dichloroethene	ONSE	SW846-8021 M	11**		X	
	87	87	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	4**		X	
	87	87	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.6**	J	X	
	87	87	Trichloroethene	ONSE	SW846-8021 M	400**		X	
	87	87	Trichloroethene	PGDP	SW846-8260	520**		X	
099034WA090C	92	92	1,1-Dichloroethene	ONSE	SW846-8021 M	13**		X	
	92	92	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	5**		X	
	92	92	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.6**	J	X	
	92	92	Trichloroethene	ONSE	SW846-8021 M	440**		X	
099034WA095C	97	97	1,1-Dichloroethene	ONSE	SW846-8021 M	24**		X	
	97	97	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	4**		X	
	97	97	Trichloroethene	ONSE	SW846-8021 M	200**		X	
099034WA100C	102	102	1,1-Dichloroethene	ONSE	SW846-8021 M	19**		X	
	102	102	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	3**		X	
	102	102	Trichloroethene	PGDP	SW846-8260	260**		X	
	102	102	Trichloroethene	ONSE	SW846-8021 M	270**		X	
099034WD075C	77	77	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.8**	J	X	
	77	77	Trichloroethene	ONSE	SW846-8021 M	0.3**	J	X	
099035WA080C	82	82	Trichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
099035WA085C	84	87	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.3	J	X	
	84	87	Trichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
099035WA105C	107	107	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	3.6**		X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.10 VOA compounds detected in groundwater at SWMU 99

	Sample Interval (ft bgs)								
Sample ID	Top	Bottom	Analytical Compound	Laboratory	Method	Results (ug/l)	Lab Qualifier	Validation Qualifier	Data Assessment
099035WA105C	107	107	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.3**	J	X	
	107	107	Trichloroethene	ONSE	SW846-8021 M	350**		X	
099005WA054	57	60	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	16**		X	
	57	60	Trichloroethene	ONSE	SW846-8021 M	14**		X	
099008WA054	54	60	1,1-Dichloroethene	ONSE	SW846-8021 M	5**		X	
	54	60	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	3**		X	
	54	60	Trichloroethene	ONSE	SW846-8021 M	3**		X	
	54	60	Vinyl chloride	ONSE	SW846-8021 M	0.4**	J	X	
099011WA047	59	62	Trichloroethene	ONSE	SW846-8021 M	0.5**	J	X	
099014WA051	57	60	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.9**	J	X	
099031WA043C	41	46	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	2**		X	
	41	46	Trichloroethene	ONSE	SW846-8021 M	3**		X	
099032WA044C	39	44	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.5**	J	X	
	39	44	Trichloroethene	ONSE	SW846-8021 M	0.9**	J	X	

SWMU 99 samples not containing any detectable VOA compounds are:

099019WA045
099022WA054
099025WA050
099029WA045C
099029WD045C
099030WA043C
099033WA046C
099035WA065C
099035WA075C

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.11 Inorganic compounds detected above BG in soil at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
193023SA013	10	13	Lithium	PGDP	SW846-6010A	5.37**		=		N/A
	10	13	Sodium	PGDP	SW846-6010A	448	N	J		340
	10	13	Strontium	PGDP	SW846-6010A	8.11		=		N/A
193026SA013	10	13	Aluminum	PGDP	SW846-6010A	12500**	NW	J		12000
	10	13	Lithium	PGDP	SW846-6010A	5.66**		=		N/A
	10	13	Strontium	PGDP	SW846-6010A	6.36		=		N/A
193029SA013	10	13	Lithium	PGDP	SW846-6010A	8.67**		=		N/A
	10	13	Strontium	PGDP	SW846-6010A	7.56		=		N/A
193030SA013	10	13	Lithium	PGDP	SW846-6010A	6.53**		=		N/A
	10	13	Silver	PGDP	SW846-6010A	4	U	=		2.7
	10	13	Strontium	PGDP	SW846-6010A	8.34		=		N/A
193033SA005	2	5	Calcium	PGDP	SW846-6010A	138000	*NW	J		6100
	2	5	Lithium	PGDP	SW846-6010A	6.22**		=		N/A
	2	5	Strontium	PGDP	SW846-6010A	133	NW	J		N/A
193033SA010	7	10	Lithium	PGDP	SW846-6010A	6.18**		=		N/A
	7	10	Manganese	PGDP	SW846-6010A	2270**	N	J		820
	7	10	Strontium	PGDP	SW846-6010A	11.4	NW	J		N/A
193033SA015	12	15	Aluminum	PGDP	SW846-6010A	12400**	NW	J		12000
	12	15	Lithium	PGDP	SW846-6010A	6.79**		=		N/A
	12	15	Strontium	PGDP	SW846-6010A	7.25	NW	J		N/A
193033SD005	2	5	Lithium	PGDP	SW846-6010A	7.8**		=		N/A
	2	5	Strontium	PGDP	SW846-6010A	11	NW	J		N/A
193034SA005	2	5	Beryllium	PGDP	SW846-6010A	0.98	N	J		0.69
	2	5	Lithium	PGDP	SW846-6010A	9.18**		=		N/A
	2	5	Sodium	PGDP	SW846-6010A	444	W	J		340
	2	5	Strontium	PGDP	SW846-6010A	15.4	NW	J		N/A

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***
N/A - Background value does not exist

Table 4.11 Inorganic compounds detected above BG in soil at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
193034SA010	7	10	Calcium	PGDP	SW846-6010A	9550	X	J		6100
	7	10	Lithium	PGDP	SW846-6010A	8.5**		=		N/A
	7	10	Sodium	PGDP	SW846-6010A	427	W	J		340
	7	10	Strontium	PGDP	SW846-6010A	21.7	NW	J		N/A
193034SA015	12	15	Lithium	PGDP	SW846-6010A	2.5**		=		N/A
	12	15	Sodium	PGDP	SW846-6010A	347	W	J		340
	12	15	Strontium	PGDP	SW846-6010A	8.18	NW	J		N/A
193036SA005	2	5	Cobalt	PGDP	SW846-6010A	86.1**	N	J		13
	2	5	Lead	PGDP	SW846-6010A	23.4**		=		23
	2	5	Lithium	PGDP	SW846-6010A	8.74**		=		N/A
	2	5	Magnesium	PGDP	SW846-6010A	2600	*NW	J		2100
	2	5	Manganese	PGDP	SW846-6010A	2190	N	J		820
	2	5	Strontium	PGDP	SW846-6010A	18.2	NW	J		N/A
193036SA010	7	10	Lithium	PGDP	SW846-6010A	8.9**		=		N/A
	7	10	Strontium	PGDP	SW846-6010A	12.4	NW	J		N/A
193036SA015	12	15	Aluminum	PGDP	SW846-6010A	13100**	NW	J		12000
	12	15	Beryllium	PGDP	SW846-6010A	0.82	N	J		0.69
	12	15	Iron	PGDP	SW846-6010A	28500	NW	J		28000
	12	15	Lithium	PGDP	SW846-6010A	8.94**		=		N/A
	12	15	Strontium	PGDP	SW846-6010A	8.74	NW	J		N/A
	12	15	Vanadium	PGDP	SW846-6010A	44.2	N	J		37
193038SA005	2	5	Aluminum	PGDP	SW846-6010A	13200**	NW	J		12000
	2	5	Lithium	PGDP	SW846-6010A	7.32**		=		N/A
	2	5	Magnesium	PGDP	SW846-6010A	2370	*NW	J		2100
	2	5	Strontium	PGDP	SW846-6010A	9.81	NW	J		N/A
193038SA010	7	10	Lithium	PGDP	SW846-6010A	11.2**		=		N/A

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.11 Inorganic compounds detected above BG in soil at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
193038SA010	7	10	Strontium	PGDP	SW846-6010A	11	NW	J		N/A
193038SA015	12	15	Aluminum	PGDP	SW846-6010A	13700**	NW	J		12000
	12	15	Lithium	PGDP	SW846-6010A	7.51**		=		N/A
	12	15	Sodium	PGDP	SW846-6010A	350	W	J		340
	12	15	Strontium	PGDP	SW846-6010A	7.3	NW	J		N/A
193039SA005	2	5	Calcium	PGDP	SW846-6010A	290000	NW	J		6100
	2	5	Magnesium	PGDP	SW846-6010A	4950	*NW	J		2100
	2	5	Strontium	PGDP	SW846-6010A	195	NW	J		N/A
193039SA010	7	10	Beryllium	PGDP	SW846-6010A	0.91	N	J		0.69
	7	10	Iron	PGDP	SW846-6010A	30000	NW	J		28000
	7	10	Lithium	PGDP	SW846-6010A	9.2**		=		N/A
	7	10	Magnesium	PGDP	SW846-6010A	2260	*NW	J		2100
	7	10	Sodium	PGDP	SW846-6010A	406	W	J		340
	7	10	Strontium	PGDP	SW846-6010A	15	NW	J		N/A
	7	10	Zinc	PGDP	SW846-6010A	63.3		=		60
193039SA015	12	15	Lithium	PGDP	SW846-6010A	7.45**		=		N/A
	12	15	Sodium	PGDP	SW846-6010A	421	N	J		340
	12	15	Strontium	PGDP	SW846-6010A	11.1		=		N/A
193049SA013C		13	Aluminum	PGDP	SW846-6010A	14000**	*NW	X		12000
		13	Beryllium	PGDP	SW846-6010A	0.7		X		0.69
		13	Lithium	PGDP	SW846-6010A	8.9**		X		N/A
		13	Strontium	PGDP	SW846-6010A	9.07		X		N/A
193022SA001	0	1	Lithium	PGDP	SW846-6010A	7.72**		=		N/A
	0	1	Strontium	PGDP	SW846-6010A	93.9		=		N/A
193022SD001	0	1	Lithium	PGDP	SW846-6010A	6.34**		=		N/A
	0	1	Strontium	PGDP	SW846-6010A	83.6		=		N/A

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***
N/A - Background value does not exist

Table 4.11 Inorganic compounds detected above BG in soil at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
193023SA001	0	1	Beryllium	PGDP	SW846-6010A	1.57		=		0.67
	0	1	Chromium	PGDP	SW846-6010A	88.7**	*N	J		16
	0	1	Lithium	PGDP	SW846-6010A	3.44**		=		N/A
	0	1	Strontium	PGDP	SW846-6010A	14.2		=		N/A
	0	1	Vanadium	PGDP	SW846-6010A	65	*N	J		38
193026SA001	0	1	Lithium	PGDP	SW846-6010A	11.2**		=		N/A
	0	1	Strontium	PGDP	SW846-6010A	12.1		=		N/A
193029SA001	0	1	Lithium	PGDP	SW846-6010A	3.78**		=		N/A
	0	1	Magnesium	PGDP	SW846-6010A	17000	N	J		7700
	0	1	Strontium	PGDP	SW846-6010A	147		=		N/A
193030SA001	0	1	Calcium	PGDP	SW846-6010A	273000	*N	J		200000
	0	1	Lithium	PGDP	SW846-6010A	4.2**		=		N/A
	0	1	Strontium	PGDP	SW846-6010A	253		=		N/A
193033SA001	0	1	Calcium	PGDP	SW846-6010A	361000	NW	J		200000
	0	1	Strontium	PGDP	SW846-6010A	199	NW	J		N/A
193034SA001	0	1	Boron	PGDP	SW846-6010A	100	NU	J		N/A
	0	1	Calcium	PGDP	SW846-6010A	325000	NW	J		200000
	0	1	Lithium	PGDP	SW846-6010A	12.5**		=		N/A
	0	1	Magnesium	PGDP	SW846-6010A	14500	*NW	J		7700
	0	1	Potassium	PGDP	SW846-6010A	1570	NW	J		1300
	0	1	Strontium	PGDP	SW846-6010A	391	NW	J		N/A
193036SA001	0	1	Calcium	PGDP	SW846-6010A	400000	NW	J		200000
	0	1	Strontium	PGDP	SW846-6010A	294	NW	J		N/A
	0	1	Zinc	PGDP	SW846-6010A	75		=		65
193038SA001	0	1	Calcium	PGDP	SW846-6010A	253000	NW	J		200000
	0	1	Copper	PGDP	SW846-6010A	28.2		=		19

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.**
***N/A* - Background value does not exist**

Table 4.11 Inorganic compounds detected above BG in soil at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
193038SA001	0	1	Lead	PGDP	SW846-6010A	67.7**		=		36
	0	1	Lithium	PGDP	SW846-6010A	5.43**		=		N/A
	0	1	Magnesium	PGDP	SW846-6010A	8180	*NW	J		7700
	0	1	Strontium	PGDP	SW846-6010A	196	NW	J		N/A
	0	1	Zinc	PGDP	SW846-6010A	92.5		=		65
193039SA001	0	1	Calcium	PGDP	SW846-6010A	344000	NW	J		200000
	0	1	Lithium	PGDP	SW846-6010A	10.2**		=		N/A
	0	1	Magnesium	PGDP	SW846-6010A	13900	*NW	J		7700
	0	1	Strontium	PGDP	SW846-6010A	380	NW	J		N/A
193049SA001C		1	Chromium	PGDP	SW846-6010A	26.5		X		16
		1	Lithium	PGDP	SW846-6010A	8.18**		X		N/A
		1	Potassium	PGDP	SW846-6010A	1440	N	X		1300
		1	Strontium	PGDP	SW846-6010A	74		X		N/A
193022SA013	10	13	Lithium	PGDP	SW846-6010A	6.73**		=		N/A
	10	13	Strontium	PGDP	SW846-6010A	9		=		N/A
193022SA024	21	24	Lithium	PGDP	SW846-6010A	3.45**		=		N/A
	21	24	Strontium	PGDP	SW846-6010A	4.22		=		N/A
193022SA030	27	30	Lithium	PGDP	SW846-6010A	5.81**		=		N/A
	27	30	Strontium	PGDP	SW846-6010A	3.32		=		N/A
193022SA040	37	40	Aluminum	PGDP	SW846-6010A	13800**	NW	J		12000
	37	40	Lithium	PGDP	SW846-6010A	7.71**		=		N/A
	37	40	Sodium	PGDP	SW846-6010A	351	N	J		340
	37	40	Strontium	PGDP	SW846-6010A	3.46		=		N/A
193022SA051	48	51	Lithium	PGDP	SW846-6010A	4.37**		=		N/A
	48	51	Strontium	PGDP	SW846-6010A	2.36		=		N/A
193022SA060	57	60	Lithium	PGDP	SW846-6010A	3.44**		=		N/A

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.11 Inorganic compounds detected above BG in soil at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
193022SA060	57	60	Strontium	PGDP	SW846-6010A	4.58		=		N/A
193023SA024	21	24	Lithium	PGDP	SW846-6010A	2.21**		=		N/A
	21	24	Strontium	PGDP	SW846-6010A	2.98		=		N/A
193023SA030	27	30	Aluminum	PGDP	SW846-6010A	12400**	NW	J		12000
	27	30	Beryllium	PGDP	SW846-6010A	0.99		=		0.69
	27	30	Lithium	PGDP	SW846-6010A	7.01**		=		N/A
	27	30	Strontium	PGDP	SW846-6010A	3.75		=		N/A
193026SA026	23	26	Aluminum	PGDP	SW846-6010A	15500**	NW	J		12000
	23	26	Lithium	PGDP	SW846-6010A	6.4**		=		N/A
	23	26	Sodium	PGDP	SW846-6010A	386	N	J		340
	23	26	Strontium	PGDP	SW846-6010A	4.6		=		N/A
193029SA026	23	26	Lithium	PGDP	SW846-6010A	3.89**		=		N/A
	23	26	Strontium	PGDP	SW846-6010A	4.77		=		N/A
193029SA039	36	39	Aluminum	PGDP	SW846-6010A	12600**	NW	J		12000
	36	39	Lithium	PGDP	SW846-6010A	6.29**		=		N/A
	36	39	Strontium	PGDP	SW846-6010A	3.46		=		N/A
193030SA026	23	26	Lithium	PGDP	SW846-6010A	2.85**		=		N/A
	23	26	Strontium	PGDP	SW846-6010A	4.33		=		N/A
193049SA023C		23	Beryllium	PGDP	SW846-6010A	2.63		X		0.69
		23	Chromium	PGDP	SW846-6010A	85.8**		X		43
		23	Iron	PGDP	SW846-6010A	47700	*NW	X		28000
		23	Lithium	PGDP	SW846-6010A	3**		X		N/A
		23	Strontium	PGDP	SW846-6010A	3.19		X		N/A
		23	Vanadium	PGDP	SW846-6010A	103	N	X		37
193049SA050C		50	Aluminum	PGDP	SW846-6010A	14900**	*NW	X		12000
		50	Beryllium	PGDP	SW846-6010A	1.13		X		0.69

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***
N/A - Background value does not exist

Table 4.11 Inorganic compounds detected above BG in soil at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
193049SA050C		50	Lithium	PGDP	SW846-6010A	6.68**		X		N/A
		50	Strontium	PGDP	SW846-6010A	4.99		X		N/A
193049SA055C		55	Lithium	PGDP	SW846-6010A	4.32**		X		N/A
		55	Strontium	PGDP	SW846-6010A	4.79		X		N/A
193049SA060C		60	Lithium	PGDP	SW846-6010A	3.34**		X		N/A
		60	Strontium	PGDP	SW846-6010A	3.34		X		N/A

SWMU 193 samples not containing any detectable inorganic compounds above BG are:

193049SA039C

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***
N/A - Background value does not exist

Table 4.12 Radioactive isotopes detected above BG in soil at SWMU 193

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						

None

SWMU 193 samples not containing any detectable radioactive isotopes above BG are:

193022SA001
193022SD001
193023SA001
193026SA001
193029SA001
193030SA001
193049SA001C
193022SA013
193022SA024
193022SA030
193022SA040
193022SA051
193022SA060
193023SA013
193023SA024
193023SA030
193026SA013
193026SA026
193026SA031
193029SA013
193029SA026
193029SA031
193029SA039
193030SA013
193030SA026
193030SA031
193030SA040
193049SA013C
193049SA023C
193049SA039C
193049SA050C
193049SA055C
193049SA060C

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***
N/A - Background value does not exist

Tuesday, January 18, 2000

Table 4.13 SVOA and PCB compounds detected in soil at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
193029SA001	0	1	Anthracene	ONSE	SW846-8270 M	116	J	X	
	0	1	Benzo(a)anthracene	ONSE	SW846-8270 M	160**	J	X	
	0	1	Benzo(a)pyrene	ONSE	SW846-8270 M	250**	J	X	
	0	1	Benzo(b)fluoranthene	ONSE	SW846-8270 M	51**	J	X	
	0	1	Benzo(g,h,i)perylene	ONSE	SW846-8270 M	166**	J	X	
	0	1	Bis(2-ethylhexyl)phthalate	PGDP	SW846-8270	170	J	=	
	0	1	Chrysene	ONSE	SW846-8270 M	170**	J	X	
	0	1	Diethylphthalate	ONSE	SW846-8270 M	400	J	X	
	0	1	Fluoranthene	ONSE	SW846-8270 M	310	J	X	
	0	1	Indeno(1,2,3-cd)pyrene	ONSE	SW846-8270 M	138**	J	X	
	0	1	Pyrene	PGDP	SW846-8270	210	J	=	
	0	1	Pyrene	ONSE	SW846-8270 M	295	J	X	
193030SA001	0	1	Benzo(a)anthracene	ONSE	SW846-8270 M	180**	J	X	
	0	1	Benzo(a)pyrene	ONSE	SW846-8270 M	240**	J	X	
	0	1	Benzo(b)fluoranthene	ONSE	SW846-8270 M	39**	J	X	
	0	1	Benzo(g,h,i)perylene	ONSE	SW846-8270 M	170**	J	X	
	0	1	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	81	J	X	
	0	1	Chrysene	ONSE	SW846-8270 M	170**	J	X	
	0	1	Di-n-butylphthalate	ONSE	SW846-8270 M	77**	J	X	
	0	1	Di-n-octylphthalate	ONSE	SW846-8270 M	120**	J	X	
	0	1	Dibenzo(a,h)anthracene	ONSE	SW846-8270 M	130**	J	X	
	0	1	Fluoranthene	ONSE	SW846-8270 M	230	J	X	
	0	1	Indeno(1,2,3-cd)pyrene	ONSE	SW846-8270 M	160**	J	X	
	0	1	Pyrene	ONSE	SW846-8270 M	24	J	X	
193030SA026	23	26	Benzo(a)anthracene	ONSE	SW846-8270 M	38**	J	X	
	23	26	Benzo(b)fluoranthene	ONSE	SW846-8270 M	45**	J	X	

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.13 SVOA and PCB compounds detected in soil at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
193030SA026	23	26	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	54	J	X	
	23	26	Di-n-octylphthalate	ONSE	SW846-8270 M	62**	J	X	
193049SA050C		50	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	520		X	

SWMU 193 samples not containing any detectable SVOA and PCB compounds are:

193022SA001
193022SD001
193023SA001
193026SA001
193029SA001
193030SA001
193049SA001C
193022SA013
193022SA024
193022SA030
193022SA040
193022SA051
193022SA060
193023SA013
193023SA024
193023SA030
193026SA013
193026SA026
193029SA013
193029SA026
193029SA039
193030SA013
193049SA013C
193049SA023C
193049SA055C
193049SA060C

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.14 VOA compounds detected in soil at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
193026SA013	10	13	Acetone	PGDP	SW846-8260	11	J	J	
193023SA001	0	1	Toluene	PGDP	SW846-8260	10	JU	J	
193022SA013	10	13	Acetone	PGDP	SW846-8260	80**	J	J	
193022SA024	21	24	Acetone	PGDP	SW846-8260	13	J	J	
193022SA040	37	40	Acetone	PGDP	SW846-8260	10	JU	J	
193022SA051	48	51	Acetone	PGDP	SW846-8260	110**	J	J	
193023SA024	21	24	Acetone	PGDP	SW846-8260	88**	J	J	
	21	24	Bromomethane	PGDP	SW846-8260	10**	JU	J	
193023SA030	27	30	Acetone	PGDP	SW846-8260	22**	J	J	
193026SA031	28	31	Acetone	PGDP	SW846-8260	27**	J	J	
193030SA031	28	31	Acetone	PGDP	SW846-8260	20**	J	J	
193049SA050C		50	Trichloroethene	PGDP	SW846-8260	25**	J	X	
193049SA055C		55	trans-1,2-Dichloroethene	PORTS	OA33499026	220**		X	

SWMU 193 samples not containing any detectable VOA compounds are:

193022SA001	193022SD001	193026SA001	193029SA001	193030SA001	193049SA001C
193022SA030	193022SA060	193023SA013	193026SA026	193029SA013	193029SA026
193029SA031	193029SA039	193030SA013	193030SA026	193030SA040	193049SA013C
193049SA023C	193049SA039C	193049SA060C			

** - *Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.15 Inorganic compounds detected in groundwater at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
193032WA085	84	87	Silica	PGDP	EPA-370.1	19**		=	
193028WA040	37	37	Silica	PGDP	EPA-370.1	17**		=	

SWMU 193 samples not containing any detectable inorganic compounds are:

(All SWMU 193 samples analyzed for inorganic compounds contained at least one detected analyte.)

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.16 Radioactive isotopes detected in groundwater at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (pci/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
193031WA110	117	117	Technetium-99	PARGN	DNT	14.8**		X	
193041WA130C	102	102	Technetium-99	PARGN	DNT	109**		X	
	102	102	Uranium-235	PGDP	AS7300	0.82**		X	
193041WA140C		117	Technetium-99	PARGN	DNT	145**		X	
		117	Thorium-234	PGDP	RL-7124	0.84**		X	
		117	Uranium	PGDP	RL-7124	2.18**		X	U
		117	Uranium-234	PGDP	RL-7124	0.81**		X	U
		117	Uranium-235	PGDP	AS7300	0.5**	B	X	
		117	Uranium-235	PGDP	RL-7124	0.53**		X	
		117	Uranium-238	PGDP	RL-7124	1.32**		X	
099037WA025C	72	72	Technetium-99	PARGN	DNT	16.4**		X	
099037WA075C	77	77	Technetium-99	PARGN	DNT	14.5**		X	
099037WA080C	82	82	Technetium-99	PARGN	DNT	18**		X	
099038WA025C	77	77	Technetium-99	PARGN	DNT	18.7**		X	
099038WA080C	87	87	Technetium-99	PARGN	DNT	820**		X	
099038WA090C	92	92	Technetium-99	PGDP	RL-7100	322**		X	
	92	92	Technetium-99	PARGN	DNT	337**		X	
099038WA095C	97	97	Technetium-99	PARGN	DNT	280**		X	
	97	97	Uranium-235	PGDP	AS7300	0.68**		X	
099038WA100C	102	102	Technetium-99	PARGN	DNT	84**		X	
099038WD080C	87	87	Technetium-99	PARGN	DNT	670**		X	
193025WA080	82	82	Technetium-99	PARGN	DNT	16.8**		X	
193025WA100	102	102	Technetium-99	PARGN	DNT	15.3**		X	
193031WA075	77	77	Technetium-99	PARGN	DNT	19.8**		X	
193031WA080	82	82	Technetium-99	PARGN	DNT	19.2**		X	
193031WD080	82	82	Technetium-99	PARGN	DNT	18.2**		X	

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

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Table 4.16 Radioactive isotopes detected in groundwater at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (pci/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
193032WA070	64	67	Technetium-99	PARGN	DNT	18.9**		X	
193032WA075	74	77	Technetium-99	PARGN	DNT	41**		X	
193032WA080	79	82	Technetium-99	PARGN	DNT	43**		X	
193032WA085	84	87	Technetium-99	PARGN	DNT	23.4**		X	
193032WA090	87	90	Technetium-99	PARGN	DNT	13.9**		X	
193041WA080C		82	Technetium-99	PARGN	DNT	579**		X	
		82	Uranium-235	PGDP	AS7300	0.44**	B	X	
193041WA085C		87	Technetium-99	PARGN	DNT	265**		X	
		87	Uranium-235	PGDP	AS7300	0.73**	B	X	
193041WA095C		97	Technetium-99	PARGN	DNT	1390**		X	
193041WD080C		82	Technetium-99	PARGN	DNT	551**		X	
193041WA025C		62	Technetium-99	PARGN	DNT	108**		X	
		62	Thorium-234	PGDP	RL-7124	0.54**		X	U
		62	Uranium-235	PGDP	AS7300	0.63**	B	X	
193049WA060C	55	60	Technetium-99	PARGN	DNT	33**		X	

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.16 Radioactive isotopes detected in groundwater at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (pci/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							

SWMU 193 samples not containing any detectable radioactive isotopes are:

099037WA130C
099038WA080C-45
099038WA080C-5
099038WA090C-45
099038WA090C-5
099038WA095C-45
099038WA095C-5
099038WA100C-45
099038WA100C-5
099038WA130C
099038WD080C-45
099038WD080C-5
193023WA071
193023WA071-45
193023WA071-5
193025WA040
193025WA070
193025WA075
193025WA085
193025WA090
193025WA095
193025WA110
193025WA120
193025WA160
193025WD075
193025WD095
193028WA040
193028WA080
193028WA085
193028WA090
193028WA095
193028WA110
193028WA120
193028WA160
193031WA070
193031WA085
193031WA090
193031WA100
193032WA095
193032WA100
193032WA110
193032WA130
193032WA160
193041WA025C-45
193041WA025C-5
193041WA080C-45
193041WA080C-5
193041WA085C-45
193041WA085C-5
193041WA090C
193041WA130C-45
193041WA130C-5
193041WA140C-45
193041WD080C-45
193041WD080C-5

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.17 SVOA and PCB compounds detected in groundwater at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
193031WA100	102	102	Diethylphthalate	ONSE	SW846-8270 M	15		X	
193031WA110	117	117	Diethylphthalate	ONSE	SW846-8270 M	19		X	
193025WA095	97	97	Di-n-butylphthalate	ONSE	SW846-8270 M	13**	J	X	
193025WA100	102	102	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	18	J	X	
193028WA085	87	87	Pentachlorophenol	PGDP	SW846-8270	12**	Y	=	
193031WA090	92	92	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	13	J	X	
	92	92	Diethylphthalate	ONSE	SW846-8270 M	9	J	X	
193041WA080C		82	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	13	J	X	
193041WA085C		87	Diethylphthalate	ONSE	SW846-8270 M	11		X	
193041WD080C		82	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	22		X	
193025WA040	67	67	Di-n-butylphthalate	ONSE	SW846-8270 M	13**	J	X	
193028WA040	37	37	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	23		X	
	37	37	Di-n-butylphthalate	ONSE	SW846-8270 M	15**	J	X	
	37	37	Diethylphthalate	ONSE	SW846-8270 M	9	J	X	
193041WA025C		62	Bis(2-ethylhexyl)phthalate	ONSE	SW846-8270 M	13	J	X	

SWMU 193 samples not containing any detectable SVOA and PCB compounds are:

193022WA051
193023WA071
193025WA070
193025WA075
193025WA080
193025WA085
193025WA090
193025WA110
193025WA120
193025WA160
193025WD075
193025WD095
193028WA080
193028WA090
193028WA095
193028WA110
193028WA120
193028WA160
193031WA070
193031WA075
193031WA080
193031WA085
193031WD080
193032WA070
193032WA075
193032WA080
193032WA085
193032WA090
193032WA095
193032WA100
193032WA110
193032WA130
193032WA160
193041WA090C
193041WA095C
193041WA130C
193041WA140C

** - *Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.18 VOA compounds detected in groundwater at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099038WA130C	112	112	Trichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
193025WA120	122	122	Trichloroethene	PGDP	SW846-8260	2**		=	
	122	122	Trichloroethene	ONSE	SW846-8021 M	2**		X	
193031WA110	117	117	Acetone	PGDP	SW846-8260	14		=	
193032WA110	112	112	Trichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
193032WA130	127	127	Trichloroethene	ONSE	SW846-8021 M	1.7**		X	
193041WA130C	102	102	Trichloroethene	ONSE	SW846-8021 M	42**		X	
193041WA140C		117	Trichloroethene	ONSE	SW846-8021 M	11**		X	
099037WA025C	72	72	Trichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
099037WA075C	77	77	Trichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
099037WA080C	82	82	1,1-Dichloroethene	ONSE	SW846-8021 M	20**		X	
	82	82	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.7**	J	X	
	82	82	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.3**	J	X	
	82	82	Trichloroethene	ONSE	SW846-8021 M	2**		X	
099038WA025C	77	77	Trichloroethene	ONSE	SW846-8021 M	9**		X	
099038WA080C	87	87	1,1-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
	87	87	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	5**		X	
	87	87	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.3**	J	X	
	87	87	Trichloroethene	ONSE	SW846-8021 M	160**		X	
099038WA090C	92	92	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	3**		X	
	92	92	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.5**	J	X	
	92	92	Trichloroethene	ONSE	SW846-8021 M	40**		X	
	92	92	Trichloroethene	PGDP	SW846-8260	70**		X	
099038WA095C	97	97	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	5**		X	
	97	97	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.7**	J	X	
	97	97	Trichloroethene	ONSE	SW846-8021 M	70**		X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.18 VOA compounds detected in groundwater at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
099038WA100C	102	102	1,1-Dichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
	102	102	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	6**		X	
	102	102	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
	102	102	Trichloroethene	ONSE	SW846-8021 M	130**		X	
099038WD080C	87	87	1,1-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
	87	87	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	5**		X	
	87	87	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.5**	J	X	
	87	87	Trichloroethene	ONSE	SW846-8021 M	120**		X	
193025WA070	72	72	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.6**	J	X	
	72	72	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.11**	J	X	
	72	72	Trichloroethene	ONSE	SW846-8021 M	30**		X	
193025WA075	77	77	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.5**	J	X	
	77	77	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
	77	77	Trichloroethene	ONSE	SW846-8021 M	170**		X	
193025WA080	82	82	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.8**	J	X	
	82	82	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.3**	J	X	
	82	82	Trichloroethene	ONSE	SW846-8021 M	170**		X	
193025WA085	87	87	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.7**	J	X	
	87	87	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
	87	87	Trichloroethene	ONSE	SW846-8021 M	87**		X	
193025WA090	92	92	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.6**	J	X	
	92	92	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
	92	92	Trichloroethene	ONSE	SW846-8021 M	99**		X	
193025WA095	97	97	1,1-Dichloroethene	ONSE	SW846-8021 M	0.28**	J	X	
	97	97	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.26	J	X	
	97	97	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.55**	J	X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.18 VOA compounds detected in groundwater at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
193025WA095	97	97	Trichloroethene	ONSE	SW846-8021 M	46**		X	
193025WA100	102	102	1,1-Dichloroethene	ONSE	SW846-8021 M	0.23**	J	X	
	102	102	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.34	J	X	
	102	102	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.43**	J	X	
	102	102	Trichloroethene	ONSE	SW846-8021 M	110**		X	
193025WA110	112	112	Trichloroethene	ONSE	SW846-8021 M	9**		X	
193025WD075	77	77	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.5**	J	X	
	77	77	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
	77	77	Trichloroethene	ONSE	SW846-8021 M	180**		X	
193025WD095	97	97	1,1-Dichloroethene	ONSE	SW846-8021 M	0.35**	J	X	
	97	97	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.35	J	X	
	97	97	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.81**	J	X	
	97	97	Trichloroethene	ONSE	SW846-8021 M	51**		X	
193028WA085	87	87	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.11	J	X	
	87	87	Trichloroethene	ONSE	SW846-8021 M	0.29**	J	X	
193028WA090	97	97	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1	J	X	
	97	97	Trichloroethene	ONSE	SW846-8021 M	0.2**	J	X	
193031WA080	82	82	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1	J	X	
	82	82	Trichloroethene	ONSE	SW846-8021 M	0.3**	J	X	
193031WA085	87	87	Trichloroethene	ONSE	SW846-8021 M	2**		X	
193031WA090	92	92	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.4	J	X	
	92	92	Trichloroethene	ONSE	SW846-8021 M	0.5**	J	X	
193031WD080	82	82	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1	J	X	
	82	82	Trichloroethene	ONSE	SW846-8021 M	0.4**	J	X	
193032WA070	64	67	Trichloroethene	ONSE	SW846-8021 M	1.8**		X	
193032WA075	74	77	Trichloroethene	ONSE	SW846-8021 M	16**		X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.18 VOA compounds detected in groundwater at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
193032WA080	79	82	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.87**	J	X	
	79	82	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.11**	J	X	
	79	82	Trichloroethene	ONSE	SW846-8021 M	31**	E	X	
193032WA085	84	87	Trichloroethene	ONSE	SW846-8021 M	25**	E	X	
	84	87	Trichloroethene	PGDP	SW846-8260	40**		=	
193032WA090	87	90	Trichloroethene	ONSE	SW846-8021 M	21**	E	X	
193032WA095	94	97	Trichloroethene	ONSE	SW846-8021 M	23**	E	X	
193032WA100	102	102	Trichloroethene	ONSE	SW846-8021 M	6.6**		X	
193041WA080C		82	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.8**	J	X	
		82	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
		82	Trichloroethene	ONSE	SW846-8021 M	58**		X	
193041WA085C		87	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	2**		X	
		87	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
		87	Trichloroethene	ONSE	SW846-8021 M	52**		X	
193041WA090C		92	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.8**	J	X	
		92	Trichloroethene	ONSE	SW846-8021 M	52**		X	
193041WA095C		97	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	2**		X	
		97	Trichloroethene	ONSE	SW846-8021 M	330**		X	
193041WD080C		82	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.4	J	X	
		82	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
		82	Trichloroethene	ONSE	SW846-8021 M	48**		X	
193023WA071	71	71	Acetone	PGDP	SW846-8260	33**		=	
	71	71	Trichloroethene	ONSE	SW846-8021 M	0.6**	J	X	
	71	71	Trichloroethene	PGDP	SW846-8260	1**		=	
193025WA040	67	67	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.19	J	X	
	67	67	Trichloroethene	ONSE	SW846-8021 M	3**		X	

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***

Table 4.18 VOA compounds detected in groundwater at SWMU 193

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
193041WA025C		62	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	1**		X	
		62	Trichloroethene	ONSE	SW846-8021 M	72**		X	

SWMU 193 samples not containing any detectable VOA compounds are:

099037WA130C
193028WA040
193028WA080
193028WA095
193028WA110
193028WA120
193028WA160
193031WA070
193031WA075
193031WA100
193032WA160
193049WA060C

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.19 Inorganic compounds detected above BG in soil at SWMU 194

Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
194008SA005	2	5	Beryllium	PGDP	SW846-6010A	0.83		X		0.69
	2	5	Calcium	PGDP	SW846-6010A	6810	NW	X		6100
	2	5	Lithium	PGDP	SW846-6010A	8.1**		X		N/A
	2	5	Strontium	PGDP	SW846-6010A	26	*N	X		N/A
	2	5	Zinc	PGDP	SW846-6010A	62.6	*N	X		60
194008SA010	7	10	Lithium	PGDP	SW846-6010A	6.86**		X		N/A
	7	10	Strontium	PGDP	SW846-6010A	15.9	*N	X		N/A
194008SA015	12	15	Lithium	PGDP	SW846-6010A	4.69**		X		N/A
	12	15	Strontium	PGDP	SW846-6010A	7.12	*N	X		N/A
194009SA005	2	5	Beryllium	PGDP	SW846-6010A	0.73		X		0.69
	2	5	Lithium	PGDP	SW846-6010A	8.75**		X		N/A
	2	5	Strontium	PGDP	SW846-6010A	17	*N	X		N/A
194009SA010	7	10	Lithium	PGDP	SW846-6010A	6.87**		X		N/A
	7	10	Strontium	PGDP	SW846-6010A	13.4	*N	X		N/A
194009SA015	12	15	Lithium	PGDP	SW846-6010A	2.11**		X		N/A
	12	15	Strontium	PGDP	SW846-6010A	4.4		X		N/A
194009SD015	12	15	Lithium	PGDP	SW846-6010A	3.23**		X		N/A
	12	15	Strontium	PGDP	SW846-6010A	5.44		X		N/A
194010SA005	2	5	Aluminum	PGDP	SW846-6010A	14500**	*NW	X		12000
	2	5	Beryllium	PGDP	SW846-6010A	0.83		X		0.69
	2	5	Lithium	PGDP	SW846-6010A	9**		X		N/A
	2	5	Magnesium	PGDP	SW846-6010A	2330	*NW	X		2100
	2	5	Sodium	PGDP	SW846-6010A	364		X		340
	2	5	Strontium	PGDP	SW846-6010A	16.8	*N	X		N/A
	2	5	Zinc	PGDP	SW846-6010A	67.6	*N	X		60
194010SA010	7	10	Lithium	PGDP	SW846-6010A	7.17**		X		N/A

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***
N/A - Background value does not exist

Table 4.19 Inorganic compounds detected above BG in soil at SWMU 194

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
194010SA010	7	10	Sodium	PGDP	SW846-6010A	363		X		340
	7	10	Strontium	PGDP	SW846-6010A	12.2	*N	X		N/A
194010SA015	12	15	Aluminum	PGDP	SW846-6010A	12700**	*NW	X		12000
	12	15	Lithium	PGDP	SW846-6010A	6.68**		X		N/A
	12	15	Strontium	PGDP	SW846-6010A	7.46	*N	X		N/A
194011SA005	2	5	Beryllium	PGDP	SW846-6010A	4.8		X		0.69
	2	5	Lithium	PGDP	SW846-6010A	8.84**		X		N/A
	2	5	Magnesium	PGDP	SW846-6010A	2340	*NW	X		2100
	2	5	Sodium	PGDP	SW846-6010A	369		X		340
	2	5	Strontium	PGDP	SW846-6010A	16.4	*N	X		N/A
194011SA010	7	10	Lithium	PGDP	SW846-6010A	4.78**		X		N/A
	7	10	Strontium	PGDP	SW846-6010A	9.16	*N	X		N/A
194011SA015	12	15	Lithium	PGDP	SW846-6010A	2.41**		X		N/A
	12	15	Strontium	PGDP	SW846-6010A	3.92	*N	X		N/A
194008SA020	17	20	Lithium	PGDP	SW846-6010A	2.66**		X		N/A
	17	20	Strontium	PGDP	SW846-6010A	4.06	*N	X		N/A
194009SA020	17	20	Strontium	PGDP	SW846-6010A	5.98		X		N/A
194010SA020	17	20	Aluminum	PGDP	SW846-6010A	13900**	*NW	X		12000
	17	20	Beryllium	PGDP	SW846-6010A	0.89		X		0.69
	17	20	Lithium	PGDP	SW846-6010A	5.94**		X		N/A
	17	20	Sodium	PGDP	SW846-6010A	360		X		340
	17	20	Strontium	PGDP	SW846-6010A	7.33	*N	X		N/A
	17	20	Vanadium	PGDP	SW846-6010A	45		X		37
194010SA030	27	30	Beryllium	PGDP	SW846-6010A	1.17		X		0.69
	27	30	Chromium	PGDP	SW846-6010A	53.7**		X		43
	27	30	Lithium	PGDP	SW846-6010A	2.33**		X		N/A

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

Table 4.19 Inorganic compounds detected above BG in soil at SWMU 194

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
	Top	Bottom								
194010SA030	27	30	Vanadium	PGDP	SW846-6010A	63		X		37
194011SA020	17	20	Strontium	PGDP	SW846-6010A	2.86	*N	X		N/A
	17	20	Vanadium	PGDP	SW846-6010A	44.8		X		37
194011SA030	27	30	Beryllium	PGDP	SW846-6010A	1.28		X		0.69
	27	30	Chromium	PGDP	SW846-6010A	44.1**		X		43
	27	30	Iron	PGDP	SW846-6010A	31700	*NW	X		28000
	27	30	Vanadium	PGDP	SW846-6010A	57.4		X		37
	27	30	Zinc	PGDP	SW846-6010A	61.8	*N	X		60

SWMU 194 samples not containing any detectable inorganic compounds above BG are:

(All SWMU 194 samples analyzed for inorganic compounds contained at least one detected analyte.)

***** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.***
N/A - Background value does not exist

Table 4.20 Radioactive isotopes detected above BG in soil at AOC 204

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pci/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pci/g)
			Top	Bottom						

None

AOC 204 samples not containing any detectable radioactive isotopes above BG are:

204028SA005
204028SA010
204028SA015
204028SA020
204028SA025
204028SA030
204028SA035
204028SA040
204028SA045
204028SA050
204028SA055
204028SA060
204028SD010
204030SA005C
204030SA010C
204030SA015C
204030SA020C
204030SA025C
204030SA030C
204030SA035C
204030SA040C
204030SA045C
204030SA050C
204030SA055C
204030SA060C
204030SA065C
204030SA070C
204030SA075C
204030SD040C

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*
N/A - Background value does not exist

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Table 4.21 VOA compounds detected in soil at AOC 204

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom					

None

AOC 204 samples not containing any detectable VOA compounds are:

204028SA005 204028SA010 204028SA015 204028SA020 204028SA025 204028SA030
204028SA035 204028SA040 204028SA045 204028SA050 204028SA055 204028SA060
204028SD010 204030SA005C 204030SA010C 204030SA015C 204030SA020C 204030SA025C
204030SA030C 204030SA035C 204030SA040C 204030SA045C 204030SA050C 204030SA055C
204030SA060C 204030SA065C 204030SA070C 204030SA075C 204030SD040C

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.22 Inorganic compounds detected in groundwater at AOC 204

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (mg/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
204029WA035	37	37	Silica	PGDP	EPA-370.1	24**		X	

AOC 204 samples not containing any detectable inorganic compounds are:

(All AOC 204 samples analyzed for inorganic compounds contained at least one detected analyte.)

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.23 Radioactive isotopes detected in groundwater at AOC 204

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pci/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom					

None

AOC 204 samples not containing any detectable radioactive isotopes are:

204029WA025
204029WA035
204029WA095
204031WA025C
204031WA070C
204031WA085C
204031WA090C
204031WA095C

** - *Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.24 VOA compounds detected in groundwater at AOC 204

Sample ID	Sample Interval (ft bgs)		Analytical Compound	Laboratory	Method	Results (ug/l)	Lab Qualifier	Validation Qualifier	Data Assessment
	Top	Bottom							
204031WA095C	97	97	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	0.9**	J	X	
	97	97	Trichloroethene	ONSE	SW846-8021 M	125**		X	
204031WA070C	72	72	Trichloroethene	ONSE	SW846-8021 M	19**		X	
204031WA085C	87	87	1,1-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
	87	87	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	6**		X	
	87	87	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
	87	87	Trichloroethene	ONSE	SW846-8021 M	590**		X	
	87	87	Vinyl chloride	ONSE	SW846-8021 M	0.1**	J	X	
204031WA090C	92	92	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	6**		X	
	92	92	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
	92	92	Trichloroethene	ONSE	SW846-8021 M	770**		X	
204031WA025C	52	52	1,1-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
	52	52	cis-1,2-Dichloroethene	ONSE	SW846-8021 M	1.4**		X	
	52	52	trans-1,2-Dichloroethene	ONSE	SW846-8021 M	0.1**	J	X	
	52	52	Trichloroethene	ONSE	SW846-8021 M	2**		X	

AOC 204 samples not containing any detectable VOA compounds are:

204029WA025 204029WA035 204029WA095

*** - Result exceeds EPA's soil screening values, Recommended Dietary Allowances for children or comparison values do not exist for analyte.*

Table 4.25 EPA Soil Screening Levels $^{(a)}$

Analytical Compound	*Soil Screening Level (mg/kg)*	*Recommended Dietary Allowances for Children (g/day)*	
		RDA	*1/5 RDA*
	Inorganic Compounds		
Alkalinity	NA	NA	NA
Aluminum	NA	NA	NA
Ammonia	NA	NA	NA
Antimony	5.4	NA	NA
Arsenic	200	NA	NA
Barium	1600	NA	NA
Beryllium	63	NA	NA
Bicarbonate as CaCO3	NA	NA	NA
Boron	210	NA	NA
Cadmium	7.5	NA	NA
Calcium	NA	800	160
Carbonate as CaCO3	NA	NA	NA
Chemical Oxygen Demand (COD)	NA	NA	NA
Chloride	NA	600	120
Chromium	38	NA	NA
Chromium, hexavalent	42	NA	NA
Cobalt	NA	NA	NA
Copper	11000	1.0-2.0	0.2
Cyanide	0.87	NA	NA
Fluoride	NA	1.5-2.5	0.3
Iron	NA	10	2
Lead	NA	NA	NA
Lithium	NA	NA	NA
Magnesium	NA	170	34
Manganese	2200	NA	NA
Mercury	2.1	NA	NA
Molybdenum	74	0.05-0.15	0.01
Nickel	950	NA	NA
Nitrate as Nitrogen	NA	NA	NA
pH	NA	NA	NA
Phosphate as Phosphorous	NA	NA	NA
Potassium	NA	1600	3200
RedOx	NA	NA	NA
Selenium	300	0.03	0.006
Silica	NA	NA	NA
Silver	31	NA	NA
Sodium	NA	400	800
Strontium	15000	NA	NA

Table 4.25 EPA Soil Screening Levels [(a)]

Analytical Compound	*Soil Screening Level (mg/kg)*	*Recommended Dietary Allowances for Children (g/day)*	
		RDA	*1/5 RDA*
Inorganic Compounds			
Sulfate	NA	NA	NA
Sulfide	NA	NA	NA
Thallium	NA	NA	NA
Total Organic Carbon (TOC)	NA	NA	NA
Total Phosphate as Phosphorus	NA	NA	NA
Vanadium	5100	NA	NA
Zinc	14000	NA	NA
Organic Compounds			
1,1,1-Trichloroethane	1.9	NA	NA
1,1,2,2-Tetrachloroethane	0.0033	NA	NA
1,1,2-Trichloroethane	0.018	NA	NA
1,1-Dichloroethane	21	NA	NA
1,1-Dichloroethene	0.058	NA	NA
1,2,4-Trichlorobenzene	5.3	NA	NA
1,2-Dichlorobenzene	17	NA	NA
1,2-Dichloroethane	0.024	NA	NA
1,2-Dichloroethene	NA	NA	NA
1,2-Dichloropropane	0.03	NA	NA
1,2-Dimethylbenzene	NA	NA	NA
1,3-Dichlorobenzene	NA	NA	NA
1,4-Dichlorobenzene	2.2	NA	NA
2,4,5-Trichlorophenol	250	NA	NA
2,4,6-Trichlorophenol	0.15	NA	NA
2,4-Dichlorophenol	1.1	NA	NA
2,4-Dimethylphenol	9	NA	NA
2,4-Dinitrophenol	0.29	NA	NA
2,4-Dinitrotoluene	0.00098	NA	NA
2,6-Dinitrotoluene	0.00085	NA	NA
2-Butanone	NA	NA	NA
2-Chloronaphthalene	270	NA	NA
2-Chlorophenol	3.6	NA	NA
2-Hexanone	NA	NA	NA
2-Methyl-4,6-dinitrophenol	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA
2-Methylphenol	NA	NA	NA
2-Nitroaniline	NA	NA	NA
2-Nitrobenzenamine	NA	NA	NA

Table 4.25 EPA Soil Screening Levels (a)

Analytical Compound	*Soil Screening Level (mg/kg)*	*Recommended Dietary Allowances for Children (g/day)*	
		RDA	*1/5 RDA*
Organic Compounds			
2-Nitrophenol	NA	NA	NA
3,3'-Dichlorobenzidine	0.0062	NA	NA
3-Nitroaniline	NA	NA	NA
3-Nitrobenzenamine	NA	NA	NA
4,4'-DDD	14	NA	NA
4,4'-DDE	45	NA	NA
4,4'-DDT	26	NA	NA
4,6-Dinitro-2-methylphenol	NA	NA	NA
4-Bromophenyl phenyl ether	NA	NA	NA
4-Bromophenyl-phenylether	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA
4-Chloroaniline	0.97	NA	NA
4-Chlorobenzenamine	NA	NA	NA
4-Chlorophenyl phenyl ether	NA	NA	NA
4-Chlorophenyl-phenylether	NA	NA	NA
4-Methyl-2-pentanone	NA	NA	NA
4-Methylphenol	NA	NA	NA
4-Nitroaniline	NA	NA	NA
4-Nitrobenzenamine	NA	NA	NA
4-Nitrophenol	NA	NA	NA
Acenaphthene	630	NA	NA
Acenaphthylene	NA	NA	NA
Acetone	15	NA	NA
Aldrin	0.49	NA	NA
alpha-BHC	NA	NA	NA
alpha-Chlordane	NA	NA	NA
Anthracene	13000	NA	NA
Benzene	0.034	NA	NA
Benzo(a)anthracene	NA	NA	NA
Benzo(a)pyrene	8.2	NA	NA
Benzo(b)fluoranthene	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA
Benzoic Acid	590	NA	NA
Benzyl Alcohol	63	NA	NA
Benzyl Butyl Phthalate	17000	NA	NA
beta-BHC	NA	NA	NA
bis(2-Chloroethoxy)methane	NA	NA	NA

Table 4.25 EPA Soil Screening Levels [(a)]

Analytical Compound	Soil Screening Level (mg/kg)	Recommended Dietary Allowances for Children (g/day)	
		RDA	1/5 RDA
Organic Compounds			
bis(2-Chloroethyl)ether	0.00036	NA	NA
bis(2-Chloroisopropyl)ether	NA	NA	NA
bis(2-Ethylhexyl)phthalate	3600	NA	NA
Bromodichloromethane	0.63	NA	NA
Bromoform	0.75	NA	NA
Bromomethane	0.25	NA	NA
Carbazole	0.59	NA	NA
Carbon Disulfide	29	NA	NA
Carbon tetrachloride	0.066	NA	NA
Chlorobenzene	1.3	NA	NA
Chloroethane	NA	NA	NA
Chloroform	0.59	NA	NA
Chloromethane	0.04	NA	NA
Chrysene	NA	NA	NA
cis-1,2-Dichloroethene	0.4	NA	NA
cis-1,3-Dichloropropene	NA	NA	NA
delta-BHC	NA	NA	NA
Di-n-butylphthalate	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA
Dibenzofuran	NA	NA	NA
Dibromochloromethane	0.39	NA	NA
Dichlorodifluoromethane	550	NA	NA
Dieldrin	0.0046	NA	NA
Diethylphthalate	450	NA	NA
Dimethylbenzene	NA	NA	NA
Dimethylphthalate	NA	NA	NA
Endosulfan I	20	NA	NA
Endosulfan II	20	NA	NA
Endosulfan Sulfate	NA	NA	NA
Endrin	0.99	NA	NA
Endrin Ketone	NA	NA	NA
Ethane	NA	NA	NA
Ethylbenzene	13	NA	NA
Ethylene	290	NA	NA
Fluoranthene	6300	NA	NA
Fluorene	810	NA	NA
gamma-BHC(Lindane)	NA	NA	NA

Table 4.25 EPA Soil Screening Levels [(a)]

Analytical Compound	*Soil Screening Level (mg/kg)*	*Recommended Dietary Allowances for Children (g/day)*	
		RDA	*1/5 RDA*
	Organic Compounds		
gamma-Chlordane	NA	NA	NA
Heptachlor	23	NA	NA
Heptachlor Epoxide	0.67	NA	NA
Hexachlorobenzene	2.2	NA	NA
Hexachlorobutadiene	2.4	NA	NA
Hexachlorocyclopentadiene	400	NA	NA
Hexachloroethane	0.46	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA
Isophorone	0.53	NA	NA
m,p-Xylene	NA	NA	NA
Methoxychlor	160	NA	NA
Methylene Chloride	0.023	NA	NA
N-Nitroso-di-n-propylamine	0.00006	NA	NA
N-Nitrosodiphenylamine	0.97	NA	NA
Naphthalene	61	NA	NA
Nitrobenzene	0.12	NA	NA
PCB-1016	0.056	NA	NA
PCB-1221	NA	NA	NA
PCB-1232	NA	NA	NA
PCB-1242	0.056	NA	NA
PCB-1248	NA	NA	NA
PCB-1254	0.34	NA	NA
PCB-1260	0.49	NA	NA
PCB-1268	NA	NA	NA
Pentachlorophenol	0.028	NA	NA
Phenanthrene	NA	NA	NA
Phenol	110	NA	NA
Polychlorinated biphenyl	6.2	NA	NA
Pyrene	4600	NA	NA
Pyridine	0.15	NA	NA
Styrene	3.5	NA	NA
Tetrachloroethene	0.058	NA	NA
Toluene	12	NA	NA
Total Petroleum Hydrocarbon	NA	NA	NA
Toxaphene	31	NA	NA
trans-1,2-Dichloroethene	0.68	NA	NA
trans-1,3-Dichloropropene	NA	NA	NA
Trichloroethene	0.057	NA	NA

Table 4.25 EPA Soil Screening Levels [(a)]

Analytical Compound	*Soil Screening Level (mg/kg)*	*Recommended Dietary Allowances for Children (g/day)*	
		RDA	*1/5 RDA*
Organic Compounds			
Vinyl Acetate	160	NA	NA
Vinyl chloride	0.013	NA	NA
Volatile Organic Qualitative Scan	NA	NA	NA
Xylene	1400	NA	NA
Radionuclides			
Alpha activity	NA	NA	NA
Americium-241	NA	NA	NA
Beta activity	NA	NA	NA
Cesium-137	NA	NA	NA
Cobalt-60	NA	NA	NA
Neptunium-237	NA	NA	NA
Plutonium-239	NA	NA	NA
Plutonium-239/240	NA	NA	NA
Potassium-40	NA	NA	NA
Protactinium-234m	NA	NA	NA
Radium	NA	NA	NA
Radium-226	NA	NA	NA
Radon-222	NA	NA	NA
Strontium-90	NA	NA	NA
Technetium-99	NA	NA	NA
Thorium-230	NA	NA	NA
Thorium-234	NA	NA	NA
Uranium	NA	NA	NA
Uranium (MG/KG OR MG/L)	NA	NA	NA
Uranium-234	NA	NA	NA
Uranium-235	NA	NA	NA
Uranium-238	NA	NA	NA

(a) EPA's soil screening levels were calculated using EPA's soil screening level guidance available on the world wide web at http://risk.lsd.ornl.gov/calc_start.htm

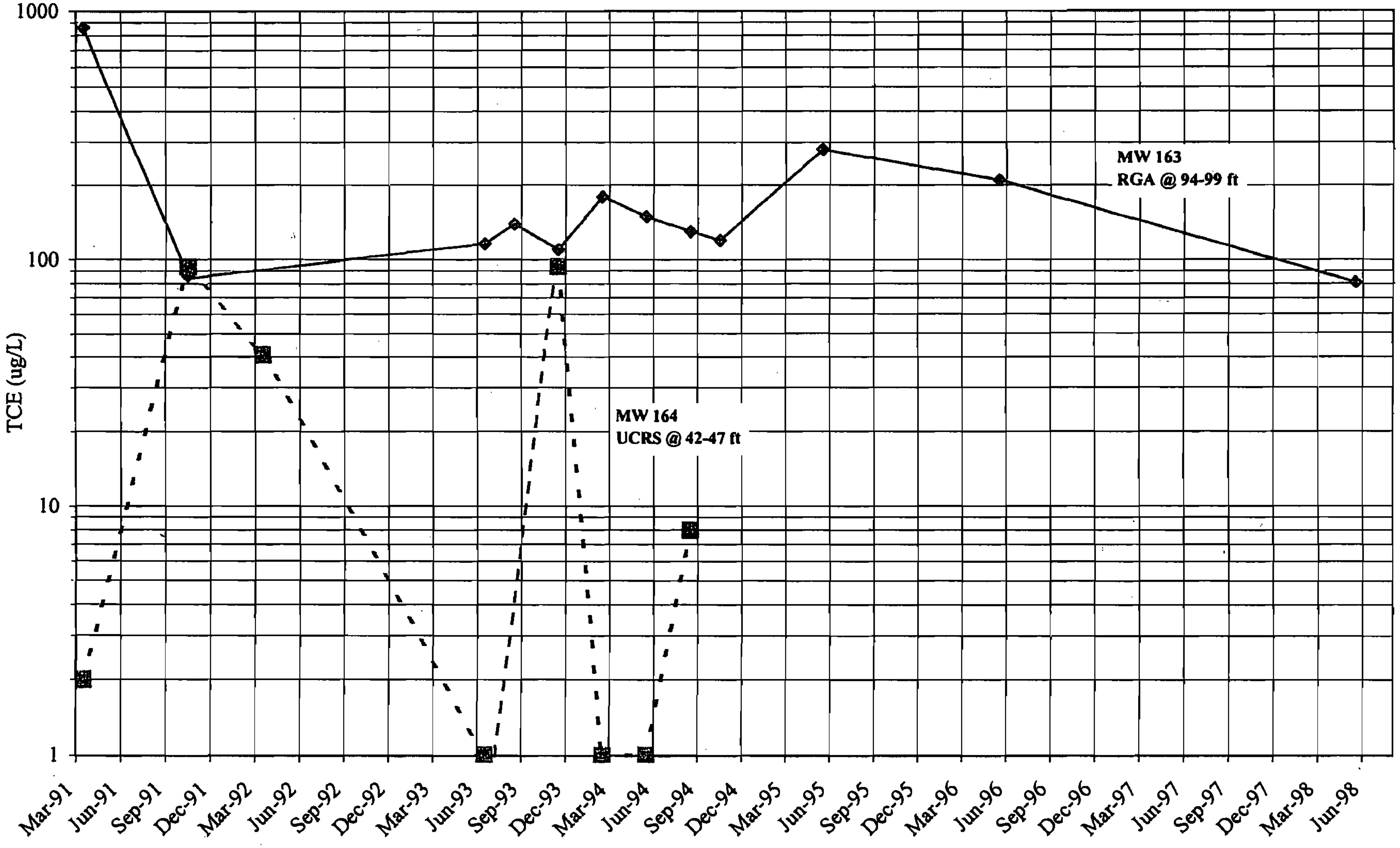
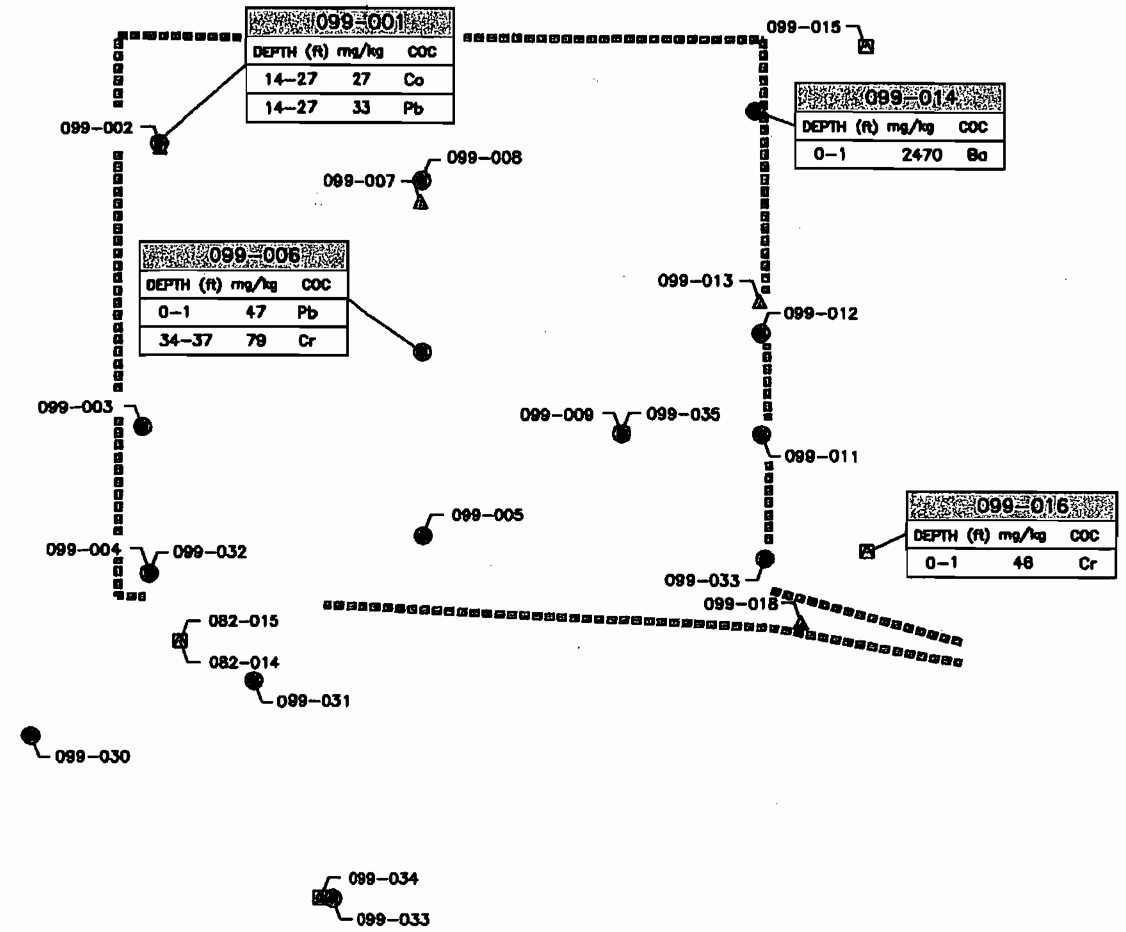


Figure 4.1 TCE Concentrations in Monitoring Wells at SWMU 99



099-001

DEPTH (ft)	mg/kg	COC
14–27	27	Co
14–27	33	Pb

099-014

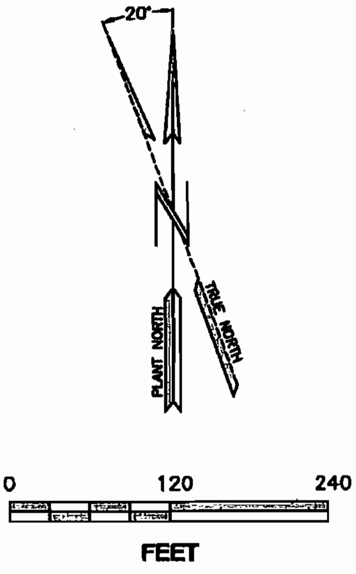
DEPTH (ft)	mg/kg	COC
0–1	2470	Ba

099-006

DEPTH (ft)	mg/kg	COC
0–1	47	Pb
34–37	79	Cr

099-016

DEPTH (ft)	mg/kg	COC
0–1	46	Cr



NOTES:

1. COC = CONTAMINANT OF CONCERN

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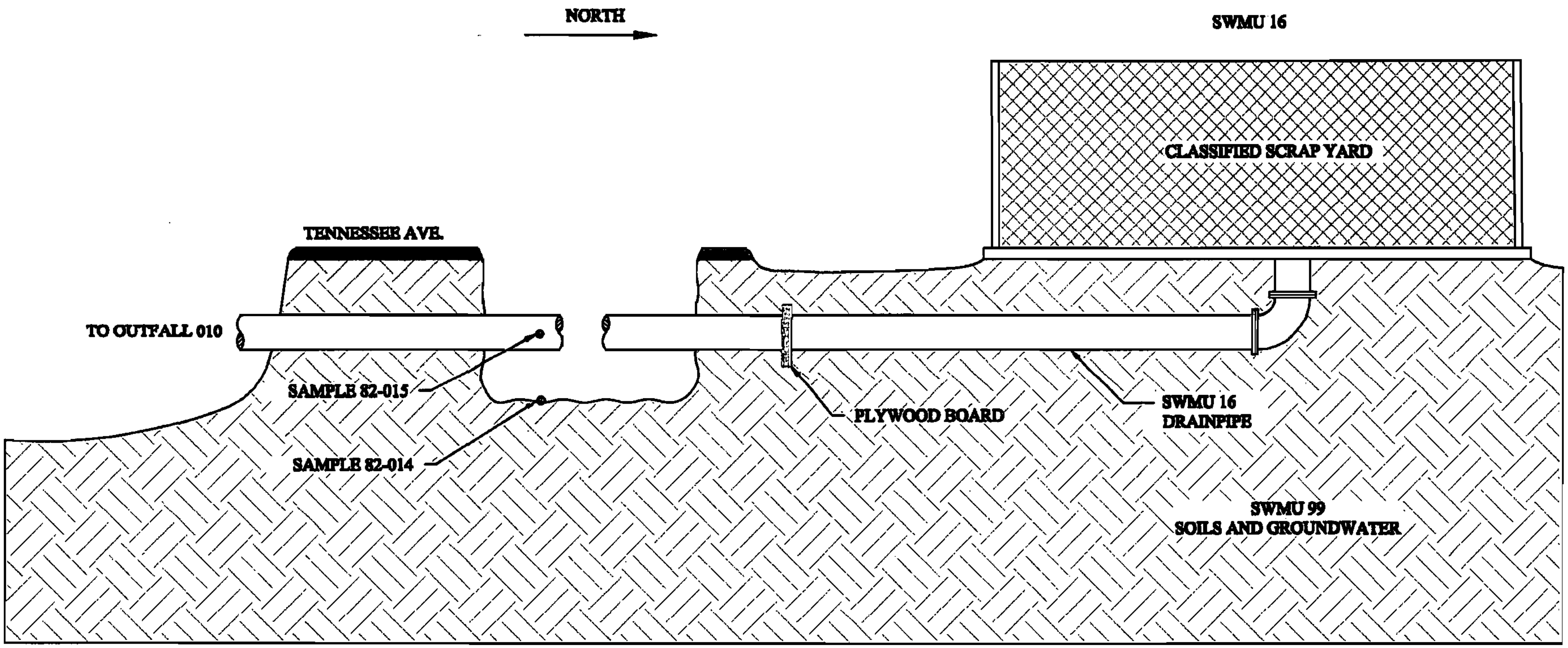
DIFFUSION PLANT

WAG 28 – SWMU 99
METAL CONCENTRATIONS
ABOVE SCREENING LEVELS IN UCRS SOILS

Figure 4.2 August, 2000

AutoCAD File: 1999006-8310-A-0030.DWG



NOT TO SCALE

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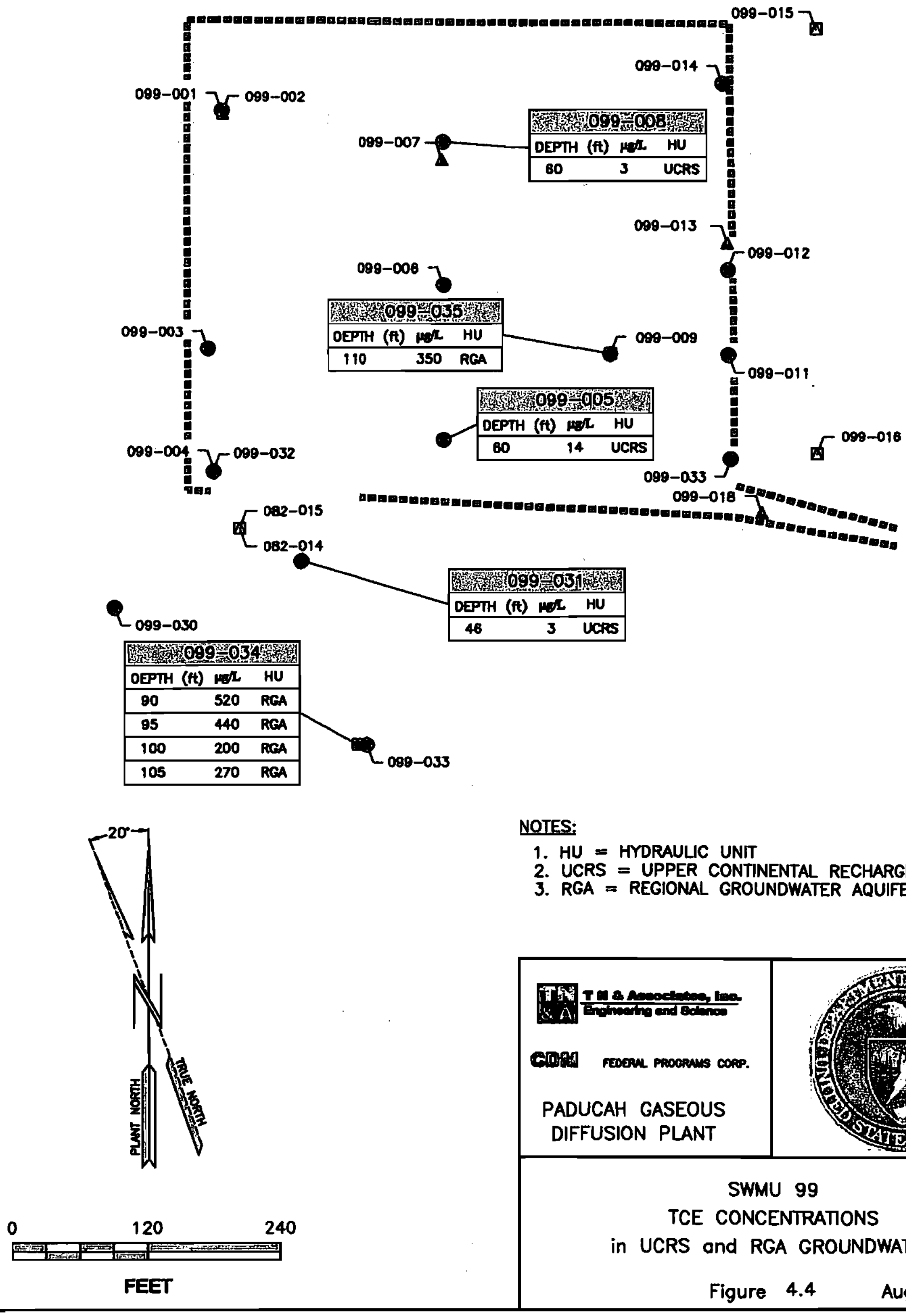
SAMPLE LOCATIONS OF EXCAVATION
SAMPLES ADJACENT TO SWMU 99

Figure 4.3 August, 2000



099-008		
DEPTH (ft)	µg/L	HU
60	3	UCRS

099-035		
DEPTH (ft)	µg/L	HU
110	350	RGA

099-005		
DEPTH (ft)	µg/L	HU
60	14	UCRS

099-031		
DEPTH (ft)	µg/L	HU
46	3	UCRS

099-034		
DEPTH (ft)	µg/L	HU
90	520	RGA
95	440	RGA
100	200	RGA
105	270	RGA

NOTES:

1. HU = HYDRAULIC UNIT
2. UCRS = UPPER CONTINENTAL RECHARGE SYSTEM
3. RGA = REGIONAL GROUNDWATER AQUIFER

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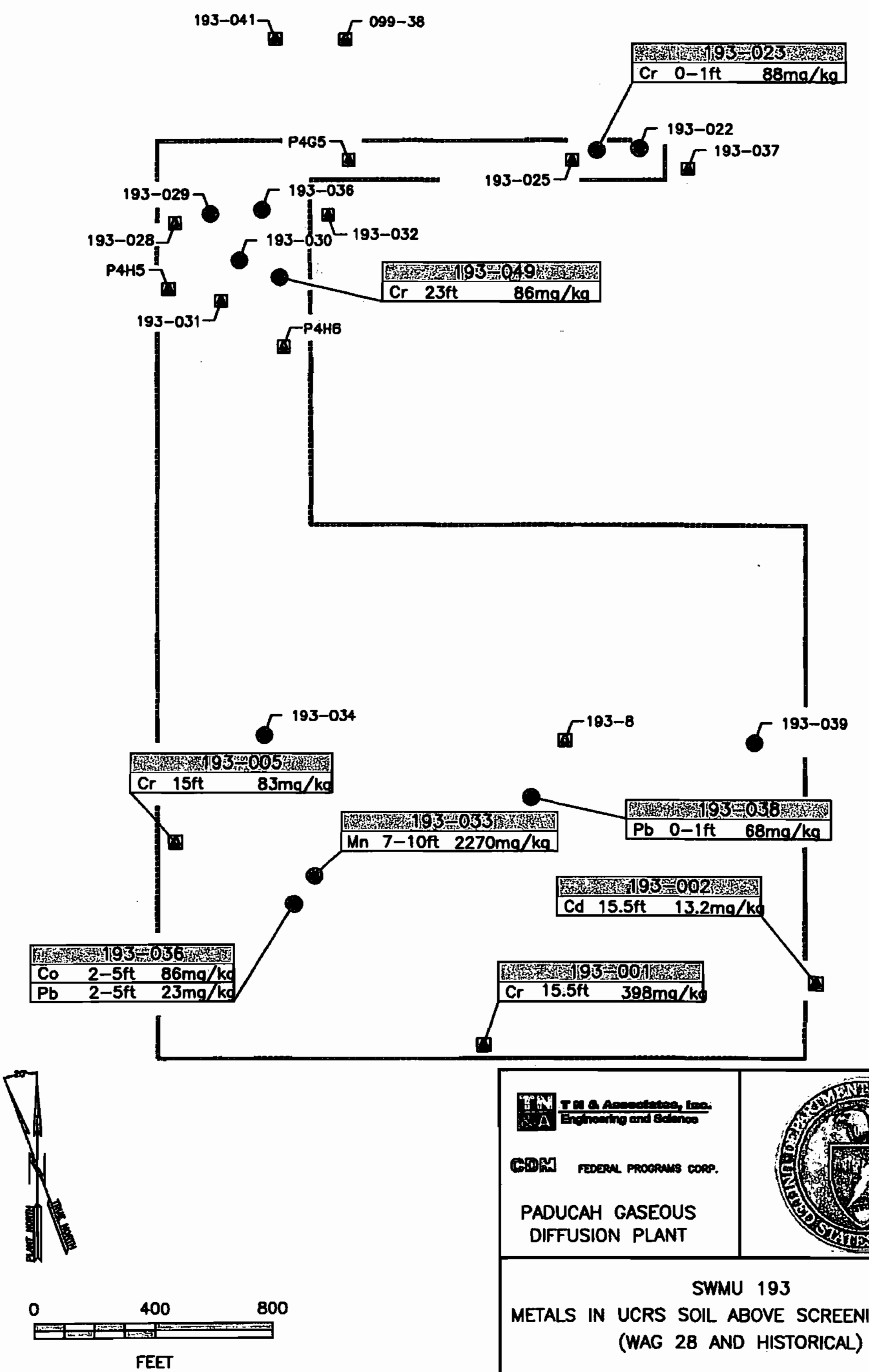
SWMU 99
TCE CONCENTRATIONS
in UCRS and RGA GROUNDWATER

Figure 4.4 August, 2000

AutoCAD File: 19990006-8310-A-0024.DWG



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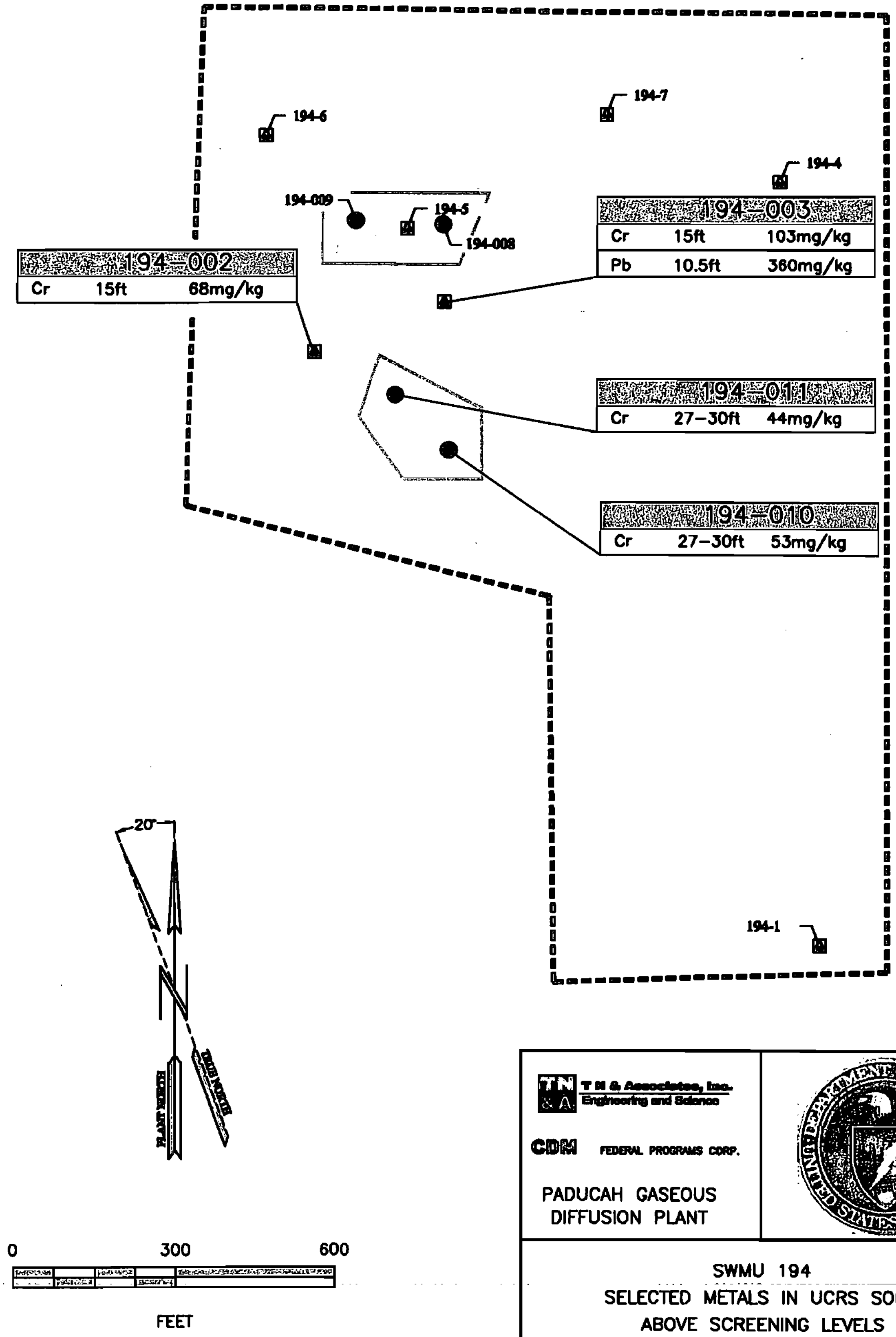
DIFFUSION PLANT

SWMU 193
METALS IN UCRS SOIL ABOVE SCREENING LEVELS
(WAG 28 AND HISTORICAL)

Figure 4.5 August, 2000

AutoCAD File: 19990006-8310-A-0025.dwg



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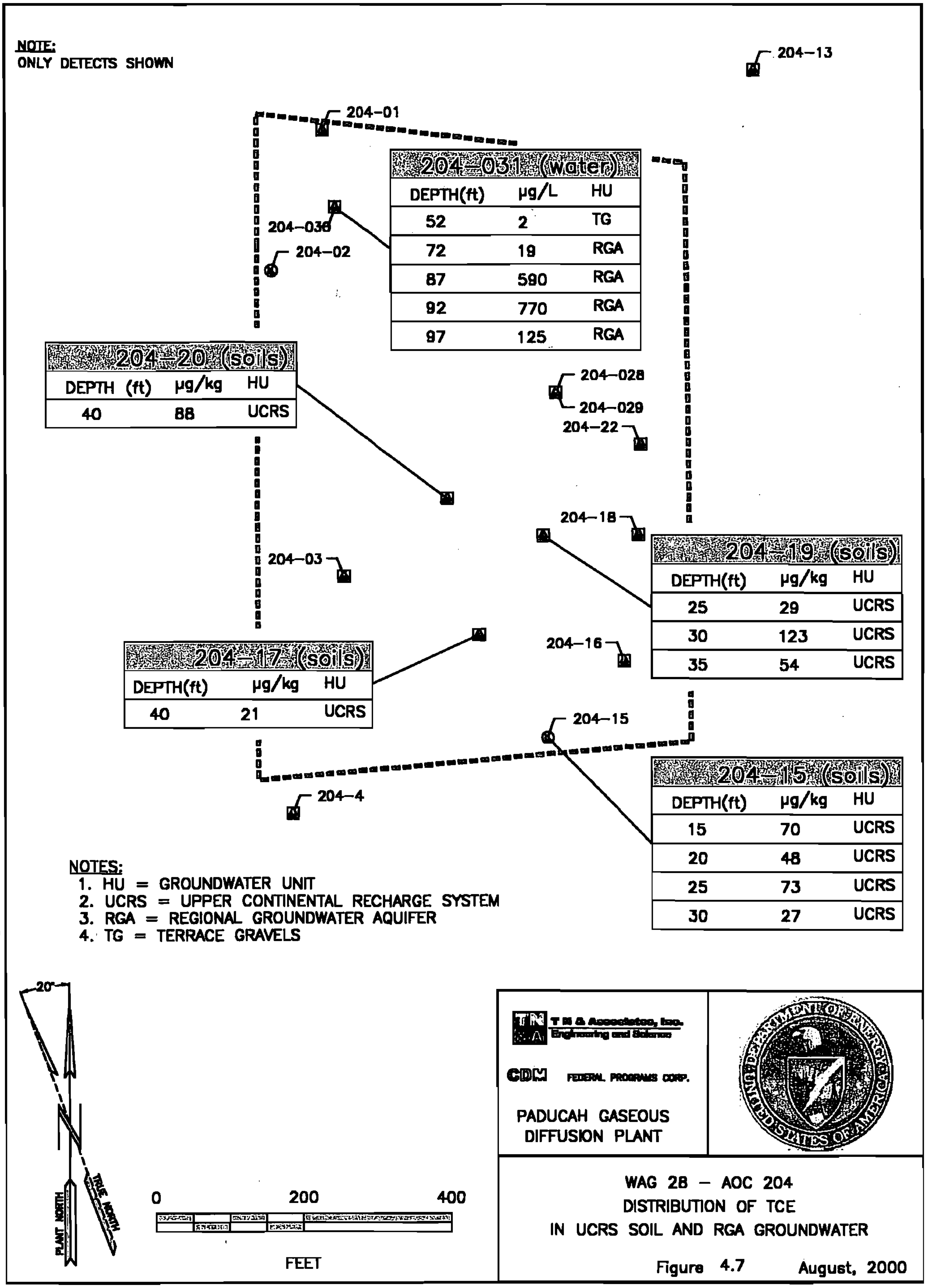
PADUCAH GASEOUS
DIFFUSION PLANT

SWMU 194
SELECTED METALS IN UCRS SOILS
ABOVE SCREENING LEVELS

Figure 4.6 August, 2000

NOTE:
ONLY DETECTS SHOWN



204-031 (water)

DEPTH(ft)	µg/L	HU
52	2	TG
72	19	RGA
87	590	RGA
92	770	RGA
97	125	RGA

204-20 (soils)

DEPTH (ft)	µg/kg	HU
40	88	UCRS

204-19 (soils)

DEPTH(ft)	µg/kg	HU
25	29	UCRS
30	123	UCRS
35	54	UCRS

204-17 (soils)

DEPTH(ft)	µg/kg	HU
40	21	UCRS

204-15 (soils)

DEPTH(ft)	µg/kg	HU
15	70	UCRS
20	48	UCRS
25	73	UCRS
30	27	UCRS

NOTES:
1. HU = GROUNDWATER UNIT
2. UCRS = UPPER CONTINENTAL RECHARGE SYSTEM
3. RGA = REGIONAL GROUNDWATER AQUIFER
4. TG = TERRACE GRAVELS

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WAG 28 – AOC 204
DISTRIBUTION OF TCE
IN UCRS SOIL AND RGA GROUNDWATER

Figure 4.7 August, 2000

AutoCAD File: 19990006-8310-A-0027.dwg

5. CONTAMINANT FATE AND TRANSPORT

5.1 INTRODUCTION

This chapter provides an overview of the release mechanisms, potential migration pathways, mechanisms for transport, and the behavior of radiological and chemical substances reported in the WAG 28 sites, (i.e., SWMUs 99, 193, and 194 and AOC 204). Computer-based contaminant fate and transport modeling (leachability analysis) was performed for the four sites using the most current chemical data available. These models simulated vertical transport from the UCRS to the RGA and horizontal transport within the RGA to predict the likely future maximum concentration of source-related COPCs at downgradient site boundaries. The ultimate objectives of these analyses were to evaluate potential future impacts to human health and the environment and to provide a basis for evaluating the effectiveness of proposed remedial alternatives in the feasibility study. Although some vertical migration of low concentrations of contaminants from the RGA to the McNairy Formation occurs, vertical transport within the McNairy is insignificant compared to that in the RGA. Therefore, vertical contaminant transport to the McNairy and horizontal transport within the McNairy are not addressed in the fate and transport modeling.

Physical, chemical, and biological processes affect the nature and distribution of chemicals in the environment. Although, in many instances, the specific chemicals, sources, and concentrations differ across the four sites, physio-chemical and hydrogeologic conditions that affect the migration and fate of contaminants are similar. Therefore, migration is addressed for the entire WAG 28 area.

A summary of the principles of contaminant fate and transport analysis and the results of the modeling activities are included in the following sections. Section 5.2 discusses source areas and potential contaminant migration pathways at WAG 28. This discussion considers site topography, geology, hydrology, and site-related chemicals. Section 5.3 presents a discussion of the persistence of the contaminants in the environment and the physical and chemical properties of the site-related chemicals that were used in the fate and transport modeling. Contaminant release mechanisms and transport media are also described in this section. Chemical migration rates for the WAG 28 COPCs are presented in Sect. 5.4. Section 5.5 presents the soil leachability analysis, including its application and underlying assumptions. A discussion of uncertainties associated with the modeling results is also presented in Sect. 5.5.

5.2 CONCEPTUAL SITE MODEL

The conceptual site model developed for WAG 28 is a representation of known site conditions that serves as the framework for quantitative modeling. Site conditions described by the conceptual site model include waste source information, the surrounding geologic and hydrologic conditions, site-related chemicals, and current spatial distribution of the site-related chemicals. This information is combined to identify the likely chemical migration pathways.

Potential sources at the WAG 28 sites include unrecorded activities conducted at numerous former plant shops and buildings, buried waste contained in a former construction debris field, and sanitary systems and leach fields. Releases from these sources could directly impact soils below or adjacent to the source and/or sediments and surface water in nearby drainages. Continuing transport processes may also result in secondary releases that could impact larger areas or affect additional environmental media. Transport processes that could be active at the WAG 28 sites include volatilization, mobilization of dust particles, soil erosion and surface runoff, vertical infiltration in soil, and lateral and vertical migration in groundwater.

The air pathway is not a viable exposure route for the WAG 28 sites; air monitoring during the field investigation indicated no impacts to on-site workers. Flow in ditches that cross the WAG 28 SWMUs is intermittent based on seasonal rainfall. Surface water is not a viable exposure pathway because any runoff from the site flows into surface ditches, the storm sewer system, and eventually into Outfalls 009, 010, 011, 012, 013, and 017. The plant ditches are generally considered to be located in areas where the local groundwater table is below the bottoms of the ditches. Therefore, the ditches probably function as influent (losing) streams most of the time, resulting in some discharge to the subsurface. However, some sediment samples were collected to confirm that runoff is not a potential pathway for migration at these sites. All these routes of surface water contaminant migration ultimately discharge to Bayou Creek or Little Bayou Creek. All surface water at the PGDP will be considered as part of the Surface Water OU.

Data were collected during the RI to characterize potential exposure pathways for site-related chemicals in groundwater and surface and subsurface soil. Where data on source characteristics were lacking, sampling was also performed to evaluate the nature of the source. Based on this evaluation, a fate and transport model was developed and used to simulate vertical transport of contaminants from the source areas to the UCRS and RGA. The model then calculated predicted contaminant concentrations in groundwater after migration to two downgradient receptor points within the RGA (the PGDP security fence and the DOE property boundary) and calculated the risk to potential receptors associated with these simulated concentrations (see Sect. 5.4).

5.2.1 Contaminant Sources

Based on historical process knowledge and the findings of the sampling and analyses performed at WAG 28, the following are identified contaminant sources.

5.2.1.1 SWMU 99

The Kellogg Building Site (SWMU 99) is located along the eastern edge of PGDP, south of Building C-360 (Fig. 3.14). The Kellogg Buildings, built in 1951, were taken out of service and demolished in 1955, leaving only the concrete pads, which are now used to store UF_6 cylinders and classified scrap materials. Information regarding the specific activities conducted within these buildings, other than pipe fabrication, is limited, but degreasing operations using trichloroethene and releases from an associated septic tank and leach field represent probable contaminant sources that were investigated during the WAG 28 RI. The WAG 28 investigation did not identify a source for metals, VOCs, or radionuclides in the soils at SWMU 99.

During the WAG 28 investigation a collapsed drainpipe that extends underneath Tennessee Avenue was located at the southwest corner of SWMU 99. This pipe appears to carry surface runoff from the Classified Scrap Yard to the drainage ditch leading to Outfall 010. A contaminant release appears to have impacted the surrounding soil, but contaminants are not present within the pipe at the break. The source for the contaminant is believed to be runoff from the classified scrap.

5.2.1.2 SWMU 193

SWMU 193 is located south and west of the C-333 Building (Fig. 3.15). Based on process knowledge and historical investigations, three sites within SWMU 193 had been identified as potential source contributors of the metals in the soil and trichloroethene in the Northeast Plume. The three most likely source contributors were the Millwright Shop, the Schulman Pipe Fabrication Shop, and several septic leach fields. None of the staging area buildings or associated utilities still exist. Current operations at SWMU 193 include storage of cylinders containing depleted uranium.

During the WAG 28 RI, only small, isolated occurrences of soil containing elevated metals concentrations were identified at SWMU 193. The contaminants may have been derived from small undocumented leaks and spills and from the septic leach fields. No source for the trichloroethene or technetium-99 found in the RGA groundwater in the vicinity of SWMU 193 was identified at any of the SWMU 193 sites investigated.

5.2.1.3 SWMU 194

SWMU 194, former site of the McGraw Construction Facilities, is located west of Hobbs Road (Fig. 3.17). All former facilities have been demolished, and the site now consists of an open, grass-covered area that is mowed regularly as part of PGDP maintenance operations. The source of contamination for SWMU 194 is subsurface leaks from two leach fields immediately west of the location of the former administrative buildings.

A previous SE of SWMU 194 conducted during the Northeast Plume Investigation (DOE 1995a) indicated only a limited area of metal contamination in the vicinity of the leach fields. Based on this information, sampling conducted during the WAG 28 RI targeted metals contamination in the subsurface soils at the leach fields. The results of the RI indicated that four metals are present in the subsurface at concentrations in excess of screening levels. These could represent small isolated releases of contaminants to the subsurface from the leach fields.

5.2.1.4 AOC 204

AOC 204, located on the eastern side of the PGDP (Fig. 3.18), is covered with heavy vegetation and a young stand of trees. The site consists of a mounded area thought to have been a staging area or construction debris burial ground associated with the original construction of the plant. Types of debris that have been found lying on the surface of the mound include asphalt, concrete, telephone poles, railroad ties, and cable; however, no buried debris has been identified within the mound by geophysical surveys or drilling activities. The northern and southern limits of AOC 204 are defined by KPDES Outfalls 010 and 011, respectively, but the site does not incorporate the actual drainage ditches.

Previous investigations conducted at AOC 204 identified VOAs in the subsurface soils and the possibility of a buried source on site. Sampling conducted for the WAG 28 RI did not confirm the presence of VOAs in the soils but did observe trichloroethene and its by-products in the groundwater. Trichloroethene was noted primarily in the RGA, but not in concentrations that would indicate a nearby source. Moreover, the lack of significant concentrations of trichloroethene in the shallow UCRS soils would not support the contention that a buried source on site is responsible for the presence of trichloroethene at AOC 204. Radionuclides were not observed in either the groundwater or soils at levels of concern. No other releases from AOC 204 have been documented.

5.2.2 Hydrologic Properties and Water Balance

A description of the site hydrogeology and hydrology is provided in Chap. 3. Stormwater runoff from WAG 28 is captured by the stormwater drainage system, which consists of ditches and sewers. Surface flow from SWMU 99, AOC 204, and the eastern side of SWMU 193 is predominately eastward to Outfalls 010, 011, 012, and 013. These outfalls discharge into Little Bayou Creek to the east of PGDP. Surface water flows away from the western side of SWMU 193 and from SWMU 194 is to the west into Outfalls 009 and 017, respectively. Outfalls 009 and 017 both discharge into Bayou Creek west of PGDP.

Three hydrogeologic units underlie PGDP and control the flow of groundwater and thus contaminant migration. These are, in descending order:

- **UCRS:** approximately 50 ft of interbedded, discontinuous lenses of sand, silt, clay, and gravel beneath an overlying loess deposit

- **RGA:** approximately 70 ft of gravel, sand, and silt deposits that overlie the McNairy Formation

- **McNairy Formation:** approximately 225 ft of a sandy, silty confining clay

For modeling purposes, it was assumed that the UCRS is not perennially saturated. Instead, it was assumed that groundwater infiltrates and migrates downward to recharge the RGA. This is a conservative assumption because, if saturated conditions in UCRS were assumed, contaminant transport through it would have been further attenuated.

A water balance is a means of quantitatively accounting for all components of the hydrologic cycle at a site. The components of a simple steady-state water balance model include precipitation (P), evapotranspiration (ET), surface runoff (Sr), and groundwater recharge or deep percolation (Gr). The simple steady-state model is defined as follows:

$P = ET + Sr + Gr$

$P-ET = Sr + Gr$

The amount of rainfall that enters the surface runoff and groundwater recharge components (Sr + Gr) is the amount available to promote chemical migration away from a waste source.

The annual average water balance estimates for WAG 28, based on the GeoTrans (1992) model for PGDP, are summarized below:

- evapotranspiration = 54 percent of total rainfall

- surface runoff = 38 percent of total rainfall

- groundwater recharge (percolation) = 8 percent of total rainfall; a small amount of which (7 percent of the recharged water) flows laterally through the top portion of the surface soil and is discharged to the surface water drainage system prior to reaching the saturated zone.

A past study (GeoTrans 1992) has suggested that as much as 93 percent of the recharge to the UCRS may flow downward to recharge the RGA.

5.2.3 Site-Related Chemicals, Release Mechanisms, Migration Pathways, and Chemical Properties

Site-related chemicals for WAG 28 are discussed in Chap. 4. All waste-source chemicals that passed screening criteria and which were not considered laboratory contaminants are addressed in the quantitative fate and transport modeling. The following are primary site-related chemicals identified during the WAG 28 RI:

- VOAs, including trichloroethene and its degradation products (*cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, and vinyl chloride), 1,1-dichloroethene, bromomethane, methylene chloride, and acetone

- SVOAs, including bis-2(ethylhexyl)phthalate, diethylphthalate, di-n-butylphthalate, benzo(b)fluoranthene, benzo(g,h,i)perylene, fluoranthene, phenanthrene, pyrene, and pyridine

- Fifteen metals: aluminum, arsenic, barium, beryllium, chromium, cobalt, iron, lead, lithium, manganese, mercury, nickel, strontium, vanadium, and zinc

- Technetium-99, neptunium-237, thorium-234, and uranium and its decay products uranium-234, uranium-235, and uranium-238

Detections of these chemicals in soil and/or groundwater confirm the potential for multimedia chemical transport. The migration pathways considered to be the most viable exposure routes for each of the WAG 28 sites are discussed here and include the potential for:

- leaching of contaminants through soil to groundwater and

- migration of groundwater to downgradient receptors.

The fate and transport of organic compounds, metals, and radionuclides are functions of both site characteristics and the physical and chemical interactions between the contaminants and the environmental media with which they come into contact. The physical and chemical properties of the contaminants that influence these interactions include, but are not limited to, (1) their solubility in water, (2) their tendency to transform or degrade (usually described by a half-life or an environmental half-life in a given medium), and (3) their chemical affinity for solids or organic matter (usually described by a partitioning coefficient K_d, K_{oc}, or K_{ow}). Tables 5.1–5.3 list the physical and chemical properties that affect contaminant migration of the primary chemicals reported at WAG 28.

5.2.3.1 Organic compounds

The organic constituents detected at WAG 28 include VOCs and SVOCs. These contaminants may be degraded in the environment by various processes including hydrolysis, oxidation/reduction, photolysis, or biodegradation. Degradation may reduce the toxicity of a chemical or, as in the case of trichloroethene, may result in more toxic daughter products. The environmental half-lives of organic compounds in various media, defined as the time necessary for half of the chemical concentration to react, can vary from minutes to years, depending on the chemical and environmental conditions. Organic chemicals with differing chemical structures will biodegrade at different rates. Primary biodegradation consists of any biologically induced structural change in an organic chemical, while complete biodegradation is the biologically mediated degradation of an organic compound into carbon dioxide, water, oxygen, and other metabolic inorganic products (Dragun 1988). The biodegradation rate of an organic chemical is generally dependent on the presence and population size of soil microorganisms capable of degrading the chemical.

The mobility of an organic compound is affected by its volatility, its partitioning behavior between solids and water, water solubility, and concentration. The Henry's Law constant value (K_H) for a compound is the ratio of the compound's vapor pressure to its aqueous solubility. The K_H value can be used to make general predictions about the compound's tendency to volatilize from water. Substances with K_H values less than 1×10^{-7} atm/m^3/mol will generally volatilize slowly while compounds with K_H greater than 1×10^{-3} atm/m^3/mol will volatilize rapidly. Vapor pressure is a measure of the pressure at which a compound and its vapor are in equilibrium. The value can be used to determine the extent to which a compound would travel in air, as well as the rate of volatilization from soils and solution. In general, compounds with vapor pressures lower than 1×10^{-7} mm mercury will not be present in the atmosphere, soil, or air in significant amounts, while compounds with vapor pressures higher than 1×10^{-2} mm mercury will exist primarily in the air (Dragun 1988).

Water solubility and the tendency to adsorb to particles or organic matter can correlate with retardation in groundwater transport. In general organic chemicals with high solubilities are more mobile in water than those that sorb more strongly to soils. The following are properties that must be measured when identifying a compound's mobility within a specific medium:

- K_{oc}, the soil organic carbon partition coefficient, is a measure of the tendency for organic compounds to be adsorbed to the organic matter of soil and sediments. K_{oc} is expressed as the ratio of the amount of chemical adsorbed per unit weight of organic carbon to the chemical concentration in solution at equilibrium.

- K_{ow}, the octanol-water partition coefficient, is an indicator of hydrophobicity (the tendency of a chemical to avoid the aqueous phase) and is correlated with potential adsorption to soils. It is also used to estimate the potential for bioconcentration of chemicals into tissues.

- K_d, the soil/water partition coefficient, is a measure of the tendency of a chemical to adsorb to soil or sediment particles. For organic compounds, this coefficient is calculated as the product of the K_{oc} value and the fraction of organic carbon in the soils. In general, chemicals with higher K_d values sorb more strongly to soil/sediment particles and are less mobile than those with lower K_d values.

Because the chemical and physical properties do not vary significantly within a given class of organic compounds, the fate and transport mechanisms can be discussed separately for each class of constituents without discussing them individually.

5.2.3.2 Polycyclic aromatic hydrocarbons

PAHs are common components of fuel oils and tar mixtures. Fuel use, vehicular traffic, and asphalt surfaces can contribute to detected levels of PAHs. PAHs are relatively persistent and represent a broad class of compounds ranging from low molecular weight components (such as naphthalene) to high molecular weight compounds [such as dibenzo(a,h)anthracene]. Solubility, volatility, biodegradability, and toxicity vary widely across this class of compounds.

Volatility, as indicated by the Henry's Law constant, decreases as the molecular weight of PAHs increases. Particulate emissions to ambient air can result from adsorption onto soot particles that can be carried on wind currents and then returned to the surface (dry deposition). High molecular weight PAHs are more likely to be transported via particulate emissions, whereas low molecular weight PAHs have a higher tendency to volatilize.

The behavior of PAHs in tar and oil waste mixtures is determined to a large extent by the mobility and behavior of the waste itself. For example, as tar waste weathers, volatilization, degradation, and leaching of the more mobile constituents occur. The overall loss rate decreases exponentially over time, and the material left behind becomes richer in more viscous and persistent components. Therefore, low molecular weight PAHs can migrate from spills and continuous releases of tars and oils; however, as weathering occurs, the rate of release decreases. Higher molecular weight PAHs would persist in the vicinity of the original release.

Table 5.1 Physical and chemical properties of volatile and semivolatile compounds

	SWMU 099			SWMU 193			SWMU 194		AOC 204			Mol. wt.	Solubility S_w	S_w @ temp.	K_{OW}	Vapor pressure	Henry's constant (K_h)	K_h @ temp.	Air Diff. coeff.	Soil Organic Carbon Partition Coef. K_{OC}	Biodegradation rate, l	Biodeg. half-life	Log	CAS No.	Biodeg. half-life
Constituents	SS	SB	GW	SS	SB	GW	SS	SB	SS	SB	GW	(g/mol)	(mg/L)	(°C)	(ml/ml)	(torr @ °C)	(atm.m³/mol)	(°C)	(cm²/s)	(ml/g)	(1/d)	(day)	(K_{OW})		(hr)
Volatile Organics																									
1,1-Dichloroethene			X			X					X	96.9	2.10E+02	25	3.02E+01	591@ 25	1.49E-02	25	0.114	s 6.50E+01 m	3.85E-03	180	1.48	75-35-4	4.32E+03
cis-1,2-Dichloroethene			X			X					X	96.9	3.50E+03		7.24E+01		4.08E-03		0.074	3.55E+01			1.86		
trans-1,2-Dichloroethene			X			X					X	96.9	6.30E+03		1.17E+02	324@20-25 e	9.38E-03		0.071	3.80E+01			2.07	156-60-5	
Acetone						X						58.1	1.00E+06		5.75E-01	270 @ 30	5.14E-07	25 #	0.110	s 3.63E-01	2.48E-02	28	-0.24	67-64-1	6.72E+02
Bromomethane					X							94.9	1.75E+04	20	1.26E+01	1420 @ 20	1.53E-04	25 #	0.110	s 7.93E+00	6.19E-03	112	1.10	74-83-9	2.69E+03
Trichloroethene			X			X					X	131.4	1.10E+03	25	3.39E+02	77 @ 25	1.17E-02	25	0.088	s 9.40E+01 m	4.19E-04	1653	2.53	79-01-6	3.97E+04
Vinyl Chloride			X								X	62.5	1.10E+00	25	3.98E+00	760@20-25 e	2.78E-02	25	0.106	s 2.51E+00	2.41E-04	6.90E+04	0.60	75-01-4	6.90E+04
Semi-volatile Organics																									
Benzo(b)fluoranthene	X											252.3	1.00E-03	#	3.72E+06	5E-7 L	2.94E-07	25 #	0.044	# 2.34E+06	2.84E-04	2440	6.57	205-99-2	5.86E+04
Benzo(g,h,i)perylene				X								276.3	2.60E-04	25	1.70E+07	1E-10 @ 20	1.40E-07		0.042	1.07E+07	2.67E-04	2600	7.23	191-24-2	6.24E+04
Bis-(2-Ethylhexyl)phthalate			X			X						390.6	1.30E+00	25	2.00E+05	1.2 @ 200	3.00E-07	20	0.032	s 1.11E+05 m	1.78E-03	389	5.30	117-81-7	9.34E+03
Diethylphthalate			X			X						222.2	2.10E-02		9.12E+02	0.05 @ 70	1.17E-08	25 #	0.053	8.20E+01 m	3.09E-03	224	2.96	84-66-2	5.38E+03
Di-n-butylphthalate						X						278.4	4.00E+02	25	1.58E+05	0.1 @ 115	2.80E-07	25	0.042	1.57E+03 m	3.01E-02	23	5.20	84-74-2	5.52E+02
Fluoranthene			X									202.3	2.65E-01	25	2.14E+05	5E-6 L	6.50E-06	25	0.069	s 4.91E+04 m	3.94E-04	1760	5.33	206-44-0	4.22E+04
Phenanthrene			X									178.2	8.16E-01	21	2.88E+04	1 @ 118	3.93E-05	25	0.054	1.82E+04	8.66E-04	800	4.46	85-01-8	1.92E+04
Pyrene			X									202.3	1.60E-01	26	1.51E+05	2.5 @ 200	5.10E-06	25	0.051	6.80E+04 m	9.12E-05	7600	5.18	129-00-0	1.82E+05
Pyridine			X									79.1	VS	20 sl		14@20	1.10E-05	25							

Solubilities, Henry's Constant, and Log (K_{ow}) have been taken from RREL Treatability Data Base (EPA 1994) unless otherwise indicated.

Biodegradation half-lives are taken from Howard, P.H., R.S. Beothling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko. 1991. Hand Book of Environmental Degradation Rates. Lewis Publishers, Inc., Chelsea, MI., unless otherwise indicated.

Air diffusion coefficients are obtained from EPA 1987 unless otherwise indicated.

(#) indicates EPA, 1991, Soil Transport and Fate (STF) Database. USEPA Center for Subsurface Modeling Support, as the source, and (s) indicates Shen et. Al 1993 as the source.

(e) represents Electronic Handbook of Risk Assessment Values, 1996, Electronic Handbook Publishers, Redmond, WA.

(w)=EPA WATER7 database November 1990, m=measured Koc Values, and L=source from EPA 1995.

(X) indicates detected above the method detection limit and screening levels.

SS = surface soil

SB = subsurface soil

GW = groundwater

VS = very soluble

Table 5.2 Distribution coefficients (K_d) for inorganic COPCs at WAG 28 sites

Site-related	SWMU 099			SWMU 193			SWMU 194		AOC 204			K_d[a] for loam	K_d[a] for sand
Analytes	SS	SB	GW	SS	SB	GW	SS	SB	SS	SB	GW	(mL/kg)	(mL/kg)
Aluminum	X	X	X		X			X				1500.0	1500.0
Arsenic			X									200[b]	25.0
Barium	X		X									50[b]	0.5
Beryllium			X									800.0	650.0
Chromium	X	X	X	X	X			X				418.0	35.0
Cobalt		X	X		X							1,300 (100 to 9700)	60.0
Iron		X			X			X				351.0	220.0
Lead			X									16000 (100 to 59000)	270.0
Lithium	X	X	X	X	X			X					
Manganese	X	X	X		X							750 (40 to 77000)	50.0
Mercury			X									10[c] to 10,000[c]	82.0
Nickel			X									438.0	400.0
Strontium	X	X	X	X	X			X				20,000 (10 to 300,000)	15,000 (50 to 190,000)
Vanadium			X									1.0E+03[b]	1000.0
Zinc			X									200.0	200.0

[a] K_d values obtained from Sheppard, M. I., and D. H. Thibault 1990. "Default Soil Solid/Liquid Partition Coefficients for Four Major Soil Types: A Compendium," *Health Physics*, Vol. 59, No. 4, pp. 472–482, unless otherwise noted; the range is provided in parentheses, if available.
[b] K_d values obtained from Baes, C. F., III, et al. 1984. *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture*, prepared by Oak Ridge National Laboratory, Oak Ridge, Tennessee, for Martin Marietta Energy Systems, Inc.
[c] Source: Looney, B. B., Grant, M. W., and King, C. M. 1987. *Estimation of Geochemical Parameters for Assessing Subsurface Transport at the Savanah River Plant,* Environmental Information Document E. I. Du Pont de Nemours & Company, Savannah River Laboratory, DPST-85-904.

X Indicates constituent detected above screening values
SS = surface soil
SB = subsurface soil
GW = groundwater

Table 5.3. Radioactive half-lives, decay constants, and distribution coefficients (K_d) for radionuclide COPCs at WAG 28 sites

Site-related radionuclides	SWMU 099			SWMU 193			SWMU 194		AOC 204			Half-life (year)	Decay constant (day^{-1})	K_d in loam[a] (L/kg)	K_d in sand[a] (L/kg)
	SS	SB	GW	SS	SB	GW	SS	SB	SS	SB	GW				
Neptunium-237	X											2.14E+06	8.87E-10	25 (1.3 to 79)	5
Radium-226												1.60E+03	1.19E-06	36,000 (1,262 to 530,000)	500
Technetium-99	X		X			X						2.10E+05	9.04E-09	0.1 (0.01 to 0.4)	0.1
Thorium-230												8.00E+04	2.37E-08	24,000	5,800
Thorium-234						X									
Uranium	X					X									
Uranium-233/234	X					X						1.62E+05	1.17E-08	421[b]	35
Uranium-235						X						7.10E+08	2.67E-12	421[b]	35
Uranium-238	X					X						4.51E+09	4.21E-13	421[b]	35

[a] K_d values obtained from Sheppard, M. I., and D. H. Thibault 1990. "Default Soil Solid/Liquid Partition Coefficients for Four Major Soil Types: A Compendium," *Health Physics*, Vol. 59, No. 4, pp. 472–482, or Baes, C. F., III, and R. D. Sharp 1983. "A Proposal for Estimation of Soil Leaching and Leaching Constants for Use in Assessment Models," *Journal of Environmental Quality* 12(1):17–28.

[b] K_d values obtained from site-specific uranium sorption analysis (Science Applications International Corporation. 1998. *Remedial Investigation Report for Solid Waste Management Units 7 and 9 of Waste Area Grouping 22 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1604/V1&D2. Paducah, KY.)

X Indicates constituent detected above screening levels.
SS = surface soil
SB = subsurface soil
GW = groundwater

Lower molecular weight PAHs have higher water solubilities and are more likely to be released into groundwater than higher molecular weight PAH compounds. The higher molecular weight PAHs have relatively high K_{oc} values, indicating an increased tendency for adsorption to soil or other organic matter. A primary fate and transport mechanism is the migration of adsorbed PAHs with mobile soil and sediment. The erosion of soil and movement of suspended sediments may result in PAH migration to surface water. However, the low solubility of adsorbed PAHs indicates that they would not partition significantly to water. Most PAHs in aquatic environments are associated with particulate materials. Only about 33 percent are present in dissolved form (SAIC 1998).

Photolysis, oxidation, and biodegradation are common attenuation mechanisms for PAH compounds. Although all PAHs transform in the presence of light via photolysis, their transformation rates are highly variable. Photolysis may reduce the concentrations of these chemicals in surface waters or surface soils but is not relevant for subsurface soils. Biodegradation rates of PAHs in soils are also extremely variable across the chemical class. Generally, the dicyclic and tricyclic PAHs biodegrade more readily than the higher molecular weight PAHs. Factors that affect the rate of biodegradation in soils include the types of microorganisms present, the availability of nutrients, the presence of oxygen, and the chemical concentration. The extent to which chemicals may biodegrade also can be affected by their presence in mixtures. Some PAHs are more degradable than others. If both stable and mobile PAHs are present in a mixture, the less degradable materials may be co-metabolized at rates similar to or greater than the rates of the more degradable compounds.

In general, PAHs are not mobile in soil or groundwater. Model simulations of solute transport of PAHs in soil (Clausen 1996) and their physical properties (Table 5.1) indicate limited migration potential.

The distribution of PAHs above screening levels at the WAG 28 sites is not widespread. In the soil these compounds are limited to surface samples (one from SWMU 99 and two from SWMU 193). Only two groundwater samples, both from the UCRS, contained detectable concentrations of PAHs.

5.2.3.3 Chlorinated VOAs

Chlorinated VOAs are not widespread in soils investigated during the WAG 28 RI. A single detection of bromomethane above screening levels was obtained from a UCRS soil sample from SWMU 193. Methylene chloride was detected in 13 soil samples but was considered to be a laboratory contaminant rather than a site-related contaminant. Trichloroethene and various degradation products (*cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, and vinyl chloride) were detected in groundwater at SWMUs 99 and 193 and AOC 204.

These chemicals have high vapor pressures and Henry's Law constants, indicating a potential for volatilization. Therefore, they are not expected to persist in surface soils. The rate of loss from volatilization depends on the compound, temperature, soil gas permeability, and chemical-specific vapor pressure.

Release and transport mechanisms include vertical migration through unsaturated soils toward the water table. The range of K_{oc} values indicates that chlorinated VOAs are mobile through soils and tend not to partition significantly from water to soil. As these compounds migrate through soil, some are retained in the pore spaces. Some VOAs may spread across layers of lower permeability. Lateral migration may occur if a low-permeability zone (or higher permeability zone) is reached, in which case the nonaqueous-phase liquids will migrate, depending in part on the contours of the layer surface. Generally, the flow is predominantly vertical through more permeable zones, such as those formed by sandy materials.

Biodegradation and chemical degradation are important considerations in evaluating chlorinated solvents because of the potential formation of COPCs and/or losses of COPCs. The redox conditions in the RGA appear to be somewhat variable; however, the groundwater chemistry indicates that only limited anaerobic degradation is occurring.

Aerobic and anaerobic biodegradation are important transformation processes for chlorinated aliphatic compounds in natural water systems and soil, and considerable research has been done on the degradation mechanisms and pathways for this class of compounds. Although several degradation pathways could occur for these constituents, the patterns described below have been identified for degradation under anaerobic conditions. The anaerobic degradation pathway is as follows:

PCE------> trichloroethene------> DCE-----> vinyl chloride or chloroethene

The anaerobic biodegradation of trichloroethene, which initially forms *cis*-1,2-dichloroethene, occurs under reducing conditions where sulfide- and/or methane-producing conditions exist. Such conditions occur primarily in the presence of other natural or anthropogenic carbon sources.

The total organic carbon (TOC) level in soil at the PGDP, as determined during the WAG 27 RI (DOE 1999), averages 801mg/kg. A single TOC soil value of 330 mg/kg was reported from a subsurface soil sample collected at AOC 204 during the WAG 28 RI. The relatively low TOC content of site soils does not promote the anaerobic biodegradation of trichloroethene.

Dichloroethene is an indicator for this degradation pathway, because it is not used as a pure product but is found solely as a degradation product. 1,2-Dichloroethene may further degrade anaerobically to vinyl chloride, but the rate is slower and the process may require stronger reducing conditions than those required for reduction of trichlomethane or trichloroethene.

Trichloroethene generally would be expected to persist under aerobic or denitrifying conditions. Denitrifying conditions are indicated when nitrates are present in groundwater, but no oxygen is present.

Aerobic biodegradation of trichloroethene may occur under certain conditions. For example, specialized microorganisms have been identified that aerobically degrade some of these solvents in the presence of ammonia, methane, and toluene. Lower molecular weight chlorinated hydrocarbons, such as dichloroethene, undergo anaerobic degradation less readily than the higher molecular weight chlorinated hydrocarbons such as trichloroethene, but undergo aerobic degradation more readily.

In summary, although trichloroethene, dichloroethene, and vinyl chloride were reported in groundwater at concentrations exceeding screening levels at SWMUs 99 and 193 and AOC 204, these contaminants were not detected in the soils. Therefore, no sources for trichloroethene were identified in any of the WAG 28 soils.

5.2.3.4 Metals

Inorganic chemicals released to unsaturated soil become dissolved in soil moisture or adsorbed onto soil particles. Dissolved inorganic analytes detected at WAG 28 include the metals listed in Table 5.2. These dissolved metals are subject to movement with vadose zone water. Aqueous transport mechanics may result in metal migration through the vadose zone to groundwater. Metals, unlike organic compounds, cannot be degraded. However, metals migration can be attenuated by retarding reactions such as adsorption, surface complexation, coprecipitation, and ion-exchange reactions with the soils with which they come into contact. Such reactions are affected by pH; oxidation-reduction conditions; and the type and amount of organic matter, clay, and hydrous oxides present. These reactions are typically reversible, resulting in dynamic metal solubility in immature or poorly developed soils. Some metals, such as arsenic and chromium, can be transformed to other oxidation states in soil. Such transformations can reduce the metals' toxicities and/or affect their mobilities by affecting the way in which they react with soil particles or other solid surfaces by ion exchange, adsorption, precipitation, or complexation.

The oxidation state and chemical speciation of inorganic chemicals control solubility and thus, to a great extent, mobility in the environment. The mobility of both metals and radionuclides can be significantly enhanced by the formation of organometallic and/or anionic complexes. Chemical speciation may be an important process in determining the chemical form present in the soil. However, speciation is very complex and difficult to distinguish in routine laboratory analysis; therefore, its impact may not be measurable or predictable. In soil, metals are typically found in the following states:

- Dissolved in interstitial fluids
- Occupying exchange sites on inorganic soil constituents
- Adsorbed on inorganic soil constituents
- Associated with insoluble soil organic matter
- Precipitated as pure or mixed solids
- Present in the structure of secondary minerals
- Present in the structure of primary minerals

In situations where metals have been introduced into the environment through human activities, metals are typically associated with the first five conditions. The dissolved aqueous fraction and its equilibrium solid fraction are of primary importance when considering the migration potential of metals associated with soils. The unfilterable inorganics represent the dissolved fraction, which is the more mobile fraction. Of the compounds that are most likely to form in soils, chlorides, nitrates, and nitrites are the most soluble. Sulfates, carbonates, and hydroxides have low to moderate solubility. In general, soluble compounds are transported in aqueous forms that are subject to retardation, whereas insoluble compounds remain as precipitates and limit the overall dissolution of metals.

Adsorption depends on the surface charge, the dissolved ion and its charge, and the pH of the soils. Positively charged metal ions (such as trivalent chromium, cadmium, lead, iron, manganese, and zinc) tend to be adsorbed, and the transport of these species is slower than the groundwater or pore water velocity. The retardation factor (R_f) describes numerically the extent to which the velocity of the contaminant migration is decreased and is largely derived from the partition coefficient (K_d).

Table 5.2 presents the range of K_d values for metals for the loam-type soils prevalent at WAG 28. The K_d values of metals vary widely in the same soil type and may vary by orders of magnitude among samples from the same site. However, for purposes of conducting transport analyses in the vertical direction through the UCRS (i.e., migration from the site sources to the RGA) and for lateral transport in the RGA, default K_d values from the Multimedia Environmental Pollutant Assessment System (MEPAS) modeling program were used for the soil type specified.

Contaminant persistence is a function of physical, chemical, and biological processes that affect the chemical as it moves through air, soil, and water. Some inorganic contaminants may undergo chemical species transformation after being released to the environment. An important example of one such transformation is the change of the charge state from Cr^{+6} to Cr^{+3}. Organometallic compounds can undergo a variety of chemical reactions that may transform one compound into another, change the state of the compound, or cause a compound to combine with other chemicals; however, the metallic portion of the organometallic compounds only changes oxidation states. With the exception of changing oxidation states or possibly exchanging metallic species, inorganic contaminants are much more stable than organic contaminants.

The mobility of metals is directly related to their solubility in water or other fluids and to pH and redox conditions. In the absence of fluids to mobilize and transport metals, virtually no transport is possible. Even if fluids are present, metals become more mobile only under favorable pH and redox conditions. Movement of metals is also controlled by the solubility (pH- and Eh-dependent), adsorption, and redox state of the metal. With the exceptions of hexavalent chromium, barium, and selenium, the solubility of other metals of concern is inversely proportional to pH. However, iron, manganese, and aluminum oxides, plus carbonates, hydroxides, and organic materials, may cause metals to precipitate or be adsorbed onto soil particles. Based on WAG 27 data (DOE 1999), the pH of the RGA water samples ranged from a low of 5.75 (at SWMU 001) to a high of 8.28 (at SWMU 091), with an average of 6.24. A single water sample collected from the RGA (SWMU 193) during the WAG 28 investigation had a pH of 6.53.

Chemical distributions in both soil and water are more difficult to predict for metals than for organic compounds. A direct relationship between the measured total metal concentration in soil and the extractable aqueous concentration cannot be assumed. The metal may be fixed in the interior of the soil and unavailable for exchange or release to water, or exchangeable metal may be present at the surface of the particles.

Published K_d values generally represent the potential relationship between water and exchangeable metal at the surface of the soil, which is as follows:

$$C_{total} = C_{fixed} + C_{adsorbed}$$
$$K_d = C_{adsorbed}/C_{water}$$

where

C_{total} = total concentration of metal (fixed plus adsorbed)
C_{fixed} = fixed concentration of metal (contained within the chemical structure of the minerals)
$C_{adsorbed}$ = adsorbed concentration of metal
C_{water} = concentration of metal in water

This relationship is useful in determining retardation (the tendency for the metal to sorb to the surface of the soil), but it does not relate the total metal concentration in the solid to a dissolved concentration.

At the four sites investigated during WAG 28, eight metals were detected in soils at levels that exceeded screening values. Five of these (barium, chromium, cobalt, iron, and manganese) were detected in less than 4 percent of the WAG 28 soil samples analyzed for metals. The remaining three (aluminum, lithium, and strontium) were detected in 16 percent, 86 percent, and 94 percent of the WAG 28 soil samples, respectively. While it is possible that aluminum could be a contaminant related to past processes at PGDP, it must be considered that aluminum is the second most abundant metal in the earth's crust and that the maximum detection of aluminum (18,400 mg/kg from sample 099014SA037) is only 1.5 times subsurface background values established for PGDP soils. Similarly, lithium and strontium should be considered in light of their natural occurrence in soils. No background values for PGDP are available for these two metals. However, the maximum reported detections at the WAG 28 sites for each (14 mg/kg for lithium and 514 mg/kg for strontium) are within the range of variability that could be expected when national averages as determined by the USGS are considered (USGS 1984).

5.2.3.5 Radionuclides

Radionuclides represent a special case of inorganic species. Although radionuclides behave chemically as metals, the radioactive nuclides undergo spontaneous transformations that involve the emission of particles and radiant energy. Most important for WAG 28 are the emission of alpha and beta particles and the emission of gamma energy. The resulting daughters (i.e., product nuclides) may be radioactive themselves (in which case they too will undergo spontaneous decay) or may be stable nuclides. The decay process can occur by various spontaneous mechanisms.

Two of the more important decay modes are alpha decay and beta decay; the latter being differentiated into negatron and positron decay. As with inorganic and organic chemical species that do not undergo nuclear transformations, the persistence of radionuclide contaminants at WAG 28 is related largely to their geochemical mobility in the environment. Table 5.3 presents the half-lives ($t_{1/2}$), radioactive decay constants, and K_d values for the site-related radionuclides. The K_d values for uranium in Table 5.3 are the most conservative, site-specific values reported.

Natural uranium consists of three primary isotopes: uranium-234, uranium-235, and uranium-238. The decay products of uranium isotopes are also radioactive and form decay chains.

Uranium hexafluoride is the sole raw material used in the enrichment process at PGDP. Some of the uranium feed material that was handled at PGDP has been reclaimed or recycled from reprocessed, spent reactor fuel. The chemical processes by which recycled uranium is purified leave trace amounts of transuranic elements (neptunium and plutonium) and fission products (mainly technetium-99). Technetium-99 (in the +7 oxidation state) is highly soluble in groundwater and is very mobile (its K_d is similar to that of trichloroethene). The groundwater plumes of trichloroethene and technetium-99 at PGDP are similar in size and geometry.

On an activity basis, the principal radionuclides expected to pass through chemical processing and contaminate the recycled uranium are the transuranic radionuclides produced in highest abundance and with moderate half-lives: neptunium-237, plutonium-238, plutonium-239, plutonium-240, and americium-241. However, characterization studies (DOE 1999, SAIC 1998) have generally shown that these radioisotopes are usually present in activities that are less than 1 percent of the uranium activity unless treatment processes have collected and concentrated them in sludges or trap material. Of the transuranic radionuclides, neptunium fluoride is believed to have been the most mobile in the gaseous phase and to have migrated further in the process system before being deposited. The others are believed to have been present in the feed in lower concentrations and to have been more persistent in the heel of the feed cylinders.

In addition, certain fission and activation products may form volatile compounds in the fluorination process: zirconium-95, niobium-95, technetium-99, ruthenium-106, cesium-134, and cesium-137. However, zironium-95, niobium-95, ruthenium-106, and cesium-134 have short half-lives (65 days, 55-days, 368 days, and 2.1 years, respectively) compared to the 15-plus years since recycled uranium was last introduced; as a result, they are unlikely to be present in significant quantities today. Because cesium-137 has a half-life of 30 years, it is the most likely fission product (except for technetium-99) still to be present at the site.

Only two soil samples from the WAG 28 sites contained activities of radionuclides above screening levels. Both of these samples, 099004SA001 and 082014SA001C, were collected from the 0- to 1-ft bgs range at SWMU 99. Elevated activities of radionuclides, predominantly technetium-99, in groundwater were detected at both SWMUs 99 and 193 during the WAG 28 RI. Groundwater samples from AOC 204 did not contain levels of technetium-99 above screening levels. No water samples were collected from SWMU 194.

Buildup of Uranium Daughter Products. Uranium, uranium-234, and uranium-238 were detected in only one soil sample during the WAG 28 RI. This sample, 082014SA001C, was collected adjacent to a collapsed drainpipe at the southwest corner of SWMU 99. Uranium, uranium-234, uranium-235, and uranium-238 were detected in RGA and McNairy groundwater samples from two sampling locations during the WAG 28 RI. Both locations, 099-038 and 193-041, are adjacent to the C-310 Building north of SWMU 193.

Uranium-238 and Uranium-235 have very long half-lives; however, secular equilibrium is attained quickly and daughter activity increases rapidly. Half-lives for these radionuclides and several daughter products are listed in Table 5.3.

5.3 CHEMICAL MIGRATION RATES AND PATHWAYS

Most chemicals in soil or groundwater migrate at a velocity slower than that of water, which is the transport medium. The retardation factor, R_f, is the relative chemical migration velocity, which is calculated as follows:

$$R_f = 1 + (K_d \rho) / \eta$$

where

R_f = chemical-specific retardation factor (dimensionless)
ρ = bulk mass density of dry aquifer system skeleton (g/cc)
[1.67 g/cc (based on soil samples collected during the WAG 27 RI—DOE 1999)]
η = total porosity (dimensionless)
(0.37 value from literature)
K_d = chemical-specific distribution coefficient (cc/g)
The distribution coefficient K_d for organic constituents is estimated as follows:
$K_d = K_{oc} * foc$

where

K_{oc} = chemical-specific organic carbon partition coefficient
foc = fraction of organic carbon
[0.00801 (based on soil samples collected during the WAG 27 RI—DOE 1999)]

In general, metals are persistent in the environment. Metals are not typically volatile, so any emissions to ambient air would be in the form of particulate emissions. The chemical migration rates for site-related COCs are presented in Table 5.4.

5.3.1 Soil to Groundwater Pathway—UCRS

Contaminants present in surface and subsurface soils may leach to the underlying aquifer. Several factors influence the dissolution of COPCs in soils and the rate of contaminant movement through soils. These include the physical/chemical properties of the contaminants (e.g., solubility, density, viscosity, K_d) and the physical/chemical properties of the environment (e.g., rainfall, percolation rate, soil permeability, porosity, particle size, and amount of organic carbon). Contaminants migrate to groundwater through infiltration, leaching, and the movement of subsurface water within the capillary fringe.

The assumptions, and consequently the limitations, of using the above equation, often referred to as the linear absorption isotherm, are many. Assumptions made are based on homogeneity of the transport medium, steady-state flow of groundwater, reaction rates being faster than transport rates, constant temperature, low or moderate contaminant concentrations, and reversible reactions between the solid porous medium and dissolved phase of contaminant. Because these assumptions are seldom, if ever, completely met in the natural environment, they pose an inherent limitation on the applications in which they are used. Additionally, the effects of biodegradation have not been included in the modeling effort for this remedial investigation.

Generally, groundwater is relatively deep at WAG 28, and many of the potential source areas have been present for a long time. Therefore, leaching potential is indicated by the observed groundwater concentrations. The amount of water available for infiltration is based on an average rainfall recharge rate of 4 in. per year. The interstitial groundwater velocity (in./year) is estimated by dividing the average rainfall recharge rate by the volumetric moisture content of the unsaturated zone. The depth to the water table in many areas is approximately 50–60 ft, suggesting a 60-year travel time from the surface to the water table. In areas beneath pavement or other low-permeability zones, less infiltration would occur. Adjacent to paved areas, higher rates of recharge may occur as runoff increases the infiltration in localized areas. The basis for these numbers can be found in Appendix B of Vol. 4.

Vertical migration rates can be increased by advection/leaching and diffusion. Diffusion along permeable zones of sand can significantly increase the rate of contaminant migration as the chemical moves to counteract concentration gradients. Vertical groundwater gradients are documented for the UCRS in *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III* (Clausen et al. 1992a) (See Vol. 4, Appendix B.)

Chemicals also can attenuate in the vadose zone. Chemicals that strongly sorb to soils, including most PAH compounds, tend to remain in or near the point of release. The R_fs for these constituents indicate that they would be expected to migrate much more slowly than water in some instances. In addition to their strong tendency to adsorb, these compounds biodegrade during the slow transport, limiting the impacted area. Other constituents such as VOAs tend to volatilize in the unsaturated zone, decreasing their persistence in that medium.

5.3.2 Groundwater Migration—RGA

The primary COCs reported in RGA groundwater include trichloroethene and the associated daughter products *cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, and vinyl chloride; 1,1-dichloroethene; technetium-99; and several metals. VOAs were detected above screening values at SWMU 99, SWMU 193, and AOC 204; the highest VOA concentration reported was for trichloroethene at 0.820 mg/L. Technetium-99 was detected above screening values in RGA groundwater at SWMUs 99 and 193; reported activities for technetium-99 ranged from 1390 pCi/L (193041WA095C) to 13.9 pCi/L. RGA groundwater containing elevated metals concentrations was confined to boring SB099-034 and SB099-035 at SWMU 99.

Once in the groundwater, the COCs generally move through the RGA via advection. Using the hydraulic properties of the RGA as a conservative estimate of advective transport, the seepage velocity (advection velocity) is estimated at 2 ft/day. [The advection (seepage) velocity, $v=ki/n$, where k is the hydraulic conductivity (1500 ft/d), i is the hydraulic gradient (0.0004), and n is the effective porosity (30%).] Therefore, based on advection alone, it is estimated that contaminants could migrate as far as 730 ft each year.

Table 5.4 Horizontal groundwater migration potential

Chemical name of groundwater COPC	Distribution coefficient K_d (cc/g)	Retardation factor (R_f)	Chemical migration rate (ft/year)	Chemical migration rate (20% increase due to dispersion) (ft/yr)	Horizontal migration potential (C-720) [distance (ft) over 46 years]	Horizontal migration potential (C-720) [distance (ft) over 25 years]
Volatile Organic Compounds						
1,1 Dichloroethene	0.1	2.9	149.1	178.9	8230.1	4472.9
cis-1,2-Dichloroethene	0.03	2.8	154.7	185.7	8540.2	4641.4
Trans-1,2-Dichloroethene	0.03	2.8	154.2	185.1	8513.0	4626.6
Acetone	0.00	2.7	162.0	194.4	8941.4	4859.4
Bromomethane	0.0	2.7	160.4	192.4	8851.8	4810.8
Methylene chloride	0.0	2.7	159.9	191.9	8827.6	4797.6
Trichloroethene	0.1	3.0	144.0	172.8	7946.5	4318.8
Vinyl Chloride	0.002	2.7	161.5	193.8	8915.8	4845.5
Metals						
Aluminum	1500.0	6773.0	0.1	0.1	3.6	1.9
Arsenic	25.0	115.5	3.8	4.5	209.3	113.7
Barium	0.5	5.0	88.3	106.0	4875.0	2649.5
Beryllium	650.0	2936.5	0.1	0.2	8.2	4.5
Chromium	35.0	160.7	2.7	3.3	150.5	81.8
Cobalt	60.0	273.5	1.6	1.9	88.4	48.0
Iron	220.0	995.7	0.4	0.5	24.3	13.2
Lead	270.0	1221.4	0.4	0.4	19.8	10.8
Lithium						
Manganese	50.0	228.4	1.9	2.3	105.9	57.5
Mercury	82.0	372.8	1.2	1.4	64.9	35.2
Nickel	400.0	1808.1	0.2	0.3	13.4	7.3
Strontium						
Vanadium	1000.0	4516.2	0.1	0.1	5.4	2.9
Zinc	200.0	905.4	0.5	0.6	26.7	14.5
Radionuclides						
Neptunium-237	5.0	25.3	17.3	20.8	956.8	520.0
Technetium-99	0.1	3.2	138.9	166.6	7665.6	4166.1
Thorium-234						
Uranium-233/234	35.0	160.7	2.7	3.3	150.5	81.8
Uranium-235	35.0	160.7	2.7	3.3	150.5	81.8
Uranium-238	35.0	160.7	2.7	3.3	150.5	81.8

COCs spread both horizontally and vertically due to the process of dispersion, while adsorption retards the movement of chemicals in groundwater. Adsorption, which retards the movement of chemicals, counteracts the advection and dispersion processes. Adsorption is generally described by a chemical's distribution coefficient (K_d). The migration potential for one year was calculated for COCs in accordance with the groundwater flow velocities at that location. These calculations were based on the following equation:

$$V_c = V / R_f$$

where

V_c = chemical horizontal migration velocity in feet per year (ft/yr)
V = site-specific groundwater flow velocity (ft/yr)
R_f = chemical-specific retardation factor (dimensionless)

Calculated horizontal migration velocities are based on advection, retardation, and dispersion but not on the effects of biodegradation. Of the COCs identified in Table 5.5, the most mobile constituents include the chlorinated VOAs and technetium-99. Other constituents, such as metals, are not readily transported in groundwater.

5.4 FATE AND TRANSPORT MODELING

Contaminant fate and transport modeling has been conducted for SWMU 99, SWMU 193, SWMU 194, and AOC 204 using the MEPAS software developed at Pacific Northwest National Laboratory. The MEPAS model calculates the fate and transport of contaminants from specified source terms and determines the associated risk to identified receptors. It can model contaminant releases to the atmosphere, surface water, and groundwater. For purposes of this analysis, only the groundwater contaminant transport portion of the model was run to calculate predicted contaminant concentrations in groundwater at receptor points within the RGA. Concentrations were modeled to two receptor points: the PGDP security fence and the DOE property boundary to determine if WAG 28 sites contribute to off-site plumes. The output tables (Tables 5.5 through 5.8) list the maximum concentrations for each source constituent and the corresponding times at which these concentrations reach each receptor point.

The following section provides a general overview of the results of the modeling for each area in WAG 28. More details concerning contaminant screening, development of the contaminant source terms, and the specific parameter values entered into the model are provided in Vol. 4, Appendix B. The results of the MEPAS modeling are compared to risk-based values in Chap. 6 to assist in the evaluation of risks to future residential groundwater users.

5.4.1 SWMU 99

Based on soil boring logs, three model layers (two partially saturated and one saturated) were delineated at SWMU 99. These layers correspond to the upper portion of the UCRS (HU1 and HU2) (1–43 ft bgs), the HU3 aquitard (43–60 ft bgs), and the RGA (HU4 and HU5) (60–105 ft bgs). Figure B.7 in Appendix B, Vol. 4, presents a cross section delineating the layers modeled at the unit. The travel distances from the source to each downgradient exposure point varies depending on the location of the source volume. The MEPAS model does not accept zero distance values, so a small, non-zero value was used (10 ft) as the distance to the PGDP security fence for sources located east of the former Kellogg Building site, outside the fence. For sources located outside the fence, a distance of 4500 feet was used to model transport to the DOE property boundary at the eastern side of the plant. For sources located west of the former Kellogg Building site, the distances used were 700 ft to the PGDP security fence and 4800 ft to the DOE property boundary.

Surface and subsurface soil data used to develop the source terms were provided by the WAG 28 RI, the CERCLA SI, and the Northeast Plume Investigation (DOE 1995a). Discrete subsurface source areas were defined for each contaminant present in each subsurface layer (surface soil, partially saturated layer 1, and partially saturated layer 2). Maximum concentrations were used to estimate contaminant inventories. Five metals, four radionuclides, and one organic constituent were detected above screening levels in surface soils at the site. Five metals and three radionuclides were detected above screening levels in the partially saturated zone soils.

Four contaminants [aluminum, barium, benzo(b)fluoranthene, and chromium] were detected only once above screening levels in surface soil. Four separate source terms for these contaminants, centered around the appropriate sample locations, were developed as described in Table B.5 in Appendix B of Vol. 4. Lithium and strontium were identified as present above screening levels in surface soils at SWMU 99. No background values are available for lithium and strontium at PGDP, so all detected values were used to develop their source volumes. Because lithium and strontium were widespread across the unit, their source areas were defined to cover a 315 ft by 375 ft area. The radionuclides neptunium-237, uranium-234, uranium-238, and technetium-99 were detected above screening levels in surface soils from one SS082-014. A rectangular source area, 90 ft by 190 ft, was used to model these contaminants. Technetium-99 was also detected above screening levels in soils from two additional borings, DPT99-001 and DPT99-004. Another technetium-99 source term was developed approximately 315 ft by 330 ft to model that source. All radionuclide surface soil sources are located inside the plant security fence.

Three metals, aluminum, lithium, and strontium, were present in both partially saturated zone 1 and partially saturated zone 2 soils at levels above screening values, so separate source terms were developed for each, as shown in Table B.5 in Appendix B of Vol. 4. The radionuclides neptunium-237, plutonium-239, and uranium-238 were detected above screening levels in subsurface soils from the CERCLA SI borings H217 and H218 located at the former Kellogg Building site inside the plant security fence. A 125-ft by 190-ft source area centered around these borings was used to model these contaminants. Chromium was detected at two borings located inside the plant security fence, DPT99-019 in the 22–25 ft bgs sample, and DPT99-06 in the 35–38-ft bgs sample. The two source areas were combined to create a single source area 415 ft by 150 ft and 6 ft thick. Cobalt was detected in one boring, DPT99-001, at a depth between 1–17 ft bgs. A source area 440 ft by 500 ft and 3 ft thick was defined to encompass this sample. Lithium and strontium were identified as present in subsurface soils at SWMU 99. As with the surface soil sources, lithium and strontium source areas were defined to cover a 315-ft by 375-ft area in partially saturated zone 1 (the entire 40-ft interval) and in partially saturated zone 2 (the entire 17-ft thickness).

Table 5.5 provides the results of MEPAS modeling for SWMU 99. This table lists the maximum concentrations of each source contaminant (and, in the case of the radionuclides, its daughter products) expected to reach the two receptor locations. Results indicate that the Kellogg Building and leach fields are not contributors of trichloroethene contamination. The sampling conducted west of the Kellogg Building indicates that a source of radionuclide contamination may be contributing to groundwater contamination in the area near SS082-014. However, the MEPAS modeling indicates that the elevated technetium-99 concentrations in the UCRS soils in the vicinity of this boring will not result in RGA groundwater concentrations exceeding 900 pCi/L, the calculated maximum contaminant level (MCL) for technetium-99, at the fence or the DOE property boundary.

Table 5.5. MEPAS results for SWMU 99

Source	Constituent	PGDP security fence		DOE boundary property		Location of source relative to plant fence
		Potential maximum concentration (mg/L or pCi/L)	Time (years)	Potential maximum concentration (mg/L or pCi/L)	Time (years)	
Surface Soil	Aluminum	0	10001-20002	0	10001-20002	Outside
	Barium	0	10001-20002	0	10001-20002	Outside
	Benzo(b)fluoranthene	0	10001-20002	0	10001-20002	Inside
	Chromium	2.08E-18	9904-15654	1.081E-27	9950-15654	Outside
	Lithium	5.632	78.1	1.715E-2	89.7	Outside
	Neptunium-237	4.985	249	0.8428	356	Inside
	*Protactinium-233	4.985	249	0.8428	356	
	*Uranium-233	5.405E-3	249	1.306E-3	356	
	*Thorium-229	6.675E-5	266	2.168E-5	356	
	*Radium-225	6.673E-5	266	2.168E-5	356	
	*Actinium-225	6.671E-5	266	2.167E-5	356	
	Strontium	2.214	8952.5	3.581E-4	9898.6-11953	Outside
	Technetium-99	181	1570	0.2736	2247	Inside
	Uranium-234	0	7880-17881	0	8387-17881	Inside
	*Thorium-230	0	7880-17881	0	8387-17881	
	*Radium-226	0	7880-17881	0	8387-17881	
	Uranium-238	0	7861-17862	0	8367-17862	Inside
	*Thorium-234	0	7861-17862	0	8367-17862	
	*Uranium-234	0	7861-17862	0	8367-17862	
	*Thorium-230	0	7861-17862	0	8367-17862	
	*Radium-226	0	7861-17862	0	8367-17862	
	*Radon-222	0	7861-17862	0	8367-17862	
	*Lead-210	0	7861-17862	0	8367-17862	
	*Bismuth-210	0	7861-17862	0	8367-17862	
	*Polonium-210	0	7861-17862	0	8367-17862	

Table 5.5. (continued)

Source	Constituent	PGDP security fence		DOE boundary property		Location of source relative to plant fence
		Potential maximum concentration (mg/L or pCi/L)	Time (years)	Potential maximum concentration (mg/L or pCi/L)	Time (years)	
UCRS	Aluminum	0	10001-20002	0	10001-20002	Outside
	Chromium	9.397E-20	9904-15655	2.039E-26	9997-15655	Inside
	Cobalt	3.612E-5	9890-13140	2.433E-6	9919-13140	Inside
	Lithium	46.86	67	7.217E-1	95.5	Outside
	Neptunium-237	3.86E-2	300	6.887E-3	393	Inside
	*Protactinium-233	3.86E-2	300	6.887E-3	393	
	*Uranium-233	5.052E-5	300	1.179E-5	393	
	*Thorium-229	7.087E-7	300	2.162E-7	393	
	*Radium-225	7.085E-7	300	2.162E-7	393	
	*Actinium-225	7.083E-7	300	2.161E-7	393	
	Plutonium-239	1.229E-10	9948-13948	2.410E-19	9904-13948	Inside
	Strontium	3.782	8952.5	6.118E-4	9899-15655	Outside
	Uranium-238	0	7861-17862	0	8367-17862	Inside
	*Thorium-234	0	7861-17862	0	8367-17862	
	*Uranium-234	0	7861-17862	0	8367-17862	
	*Thorium-230	0	7861-17862	0	8367-17862	
	*Radium-226	0	7861-17862	0	8367-17862	
	*Radon-222	0	7861-17862	0	8367-17862	
	*Lead-210	0	7861-17862	0	8367-17862	
	*Bismuth-210	0	7861-17862	0	8367-17862	
	*Polonium-210	0	7861-17862	0	8367-17862	

* Daughter products are denoted with an asterisk.
Distance to plant fence and property boundary: If source is located inside fence, distances of 700 ft and 4800 ft, respectively, were used.
If source is located outside fence, distances of 10 ft and 4500 ft, respectively, were used.

5.4.2 SWMU 193

Two model layers, one partially saturated and one saturated, were delineated at SWMU 193. The partially saturated layer includes the loess deposits making up HU1; the permeable but discontinuous sand and gravel lenses of the UCRS (HU2), and a silty clay aquitard HU3 (1–68 ft bgs). The saturated layer consists of the RGA (HU4 and HU5) and extends from 68 ft to 93 ft bgs. A cross-section showing the depths of these layers at the unit is presented in Fig. B.8 in Appendix B of Vol. 4. The travel distance from the source to each downgradient exposure point is 3000 ft to the PGDP security fence and 7400 ft to the DOE property boundary.

Surface and subsurface soil data provided by the WAG 28 RI and the Northeast Plume Investigation (comprised of the site evaluation of SWMUs 193 and 194 and the Groundwater Phase IV Investigation—DOE 1995a) were used to develop the source terms and inventories for the site contaminants. Three metals (chromium, lithium, and strontium) and one organic [benzo(g,h,i)perylene] were identified as present above screening levels in surface soils at SWMU 193. No background values are available for lithium and strontium at the PGDP, so all detected values were used to develop their source volumes. Because lithium and strontium were widespread across the unit, their source areas were assumed to be equal to the total SWMU area. Chromium was detected above screening levels in one boring (DPT193-023). A rectangular source area 250 ft by 250 ft was used for modeling chromium in surface soils. The more mobile form of chromium (chromium VI) was modeled to provide the most conservative results. Benzo(g,h,i)perylene is not included in the chemical database for MEPAS and so could not be modeled.

MEPAS source terms were also developed for several subsurface soil contaminants. Seven metals were detected above screening levels in the partially saturated zone. The three metals aluminum, lithium, and strontium were detected throughout the SWMU 193 area and so were assumed to be present across the entire SWMU and to extend throughout most of model layer 1 to the top of the HU3 unit (60 ft). Another UCRS soil contaminant, cadmium, was detected above screening levels in one boring, 193-2, at a depth of 15.5 ft bgs. It was assumed to be present at its maximum detected concentration (13.2 mg/kg) in a 440-ft by 440-ft area encompassing the boring. Chromium (maximum 398 mg/kg) was detected above screening levels in three borings (193-1, 193-5, and DPT193-049) in the 15- to 23-ft interval. Hence, a rectangular source area (2400 ft by 1960 ft) surrounding these three borings was used to model chromium in partially saturated layer 1. Cobalt was detected above screening levels in one boring, DPT193-036, at a sample depth of 2–5 ft bgs. The source was defined as a rectangular area 240 ft by 260 ft and 3 ft thick. Manganese was detected above screening levels at depths between 2–10 ft bgs in two borings, DPT193-033 and DPT193-036. The manganese source was assumed to be 8 ft thick and to extend around these borings in a rectangular area 920 ft by 640 ft. It was assumed that all site contaminants were distributed homogeneously at their maximum detected concentrations across their source areas. The results of the MEPAS modeling for SWMU 193 are presented in Table 5.6. These results indicate no significant sources of groundwater contamination are present at the unit.

5.4.3 SWMU 194

The former leach fields associated with SWMU 194 are located above the slope of the Porters Creek Clay terrace. None of the borings drilled at SWMU 194 were extended beyond approximately 30 ft bgs, so lithologic logs for deep borings located in the surrounding area were used to develop the conceptual site model. Two model layers (one partially saturated and one saturated) were delineated at SWMU 194 (see Fig. B.9 in Appendix B of Vol. 4). The partially saturated layer extends to a depth of 55 ft bgs and includes the loess deposits making up HU1, the permeable and discontinuous sand and gravel lenses of the Terrace Gravel and of the UCRS (HU2), and a thin, silty clay aquitard HU3.

Table 5.6 MEPAS results for SWMU 193

Source	Constituent	PGDP security fence		DOE boundary property	
		Potential maximum concentration (mg/L)	Time (years)	Potential maximum concentration (mg/L)	Time (years)
Surface Soil	Chromium	2.018E-3	5929	1.194E-3	7961
	Lithium	2.085	45.8	1.169	60.3
	Strontium	2.524E-1	9854-10834	1.546E-4	9846-13283
UCRS	Aluminum	0	1-10,001	0	1-10,001
	Cadmium	0	879-10001	0	9990-10001
	Chromium	3.803	5929	2.133	7744
	Cobalt	3.562E-2	939	2.083E-2	1281
	Lithium	38.05	48.8	38.09	69.8
	Manganese	5.11	2655	3.651	3624
	Strontium	7.453	9854-10834	4.565E-3	9846-13283

The saturated layer includes the RGA and extends from an average depth of 55 ft to 85 ft bgs. The travel distances from the source to each downgradient exposure point are 10 ft to the PGDP security fence and 8700 ft to the DOE property boundary. (SWMU 194 is located outside the security fence, so a small, non-zero value was used.) The direction of groundwater flow was assumed to be to the north (Davis et al. 1973).

The WAG 28 RI soil data and data from the 1995 SE at SWMU 194 (DOE 1995b) were used to develop the source terms and inventories for the SWMU 194 site contaminants. Four metals were identified as present above screening levels in subsurface soils: lithium, strontium, aluminum, and chromium. No background values are available for lithium and strontium at PGDP, so all detected values were used to develop their source volumes. Because lithium and strontium were widespread across the area (detected in 15 and 16 samples, respectively), their source areas were assumed to be equal to the total SWMU area and to extend beneath the terrace gravel to a depth of 40 ft bgs (top of HU3). Aluminum was detected above screening levels in three samples in boring DPT194-010 at depths between 2 and 15 ft bgs. A 250-ft by 250-ft source area, centered around the boring and extending from 1 to 17 ft bgs, was used for modeling aluminum. Chromium was detected above screening levels at depths between 15 and 30 ft bgs in five samples from four borings at the unit: 194-02, 194-03, DPT194-10, and DPT194-11. A rectangular source area 650 ft by 710 ft and extending from 11 ft to 40 ft bgs in the partially saturated layer was used for modeling chromium. The more mobile form of chromium (chromium VI) was modeled to provide the most conservative results. It was assumed that all four contaminants were distributed homogeneously at their maximum detected concentrations across their source areas. The results of the MEPAS modeling conducted for SWMU 194 are presented in Table 5.7. These results indicate that no significant sources of groundwater contamination are present at the SWMU 194 leach fields.

5.4.4 AOC 204

The conceptual site model for AOC 204 is based on lithologic logs for shallow borings installed during the WAG 28 investigation and on logs for deep borings installed in the area during the Groundwater Phase IV investigation (DOE 1995a). Figure B.10 in Appendix B of Vol. 4 presents a geologic cross section used to delineate the model layers. Three model layers (two partially saturated and one saturated) were delineated at AOC 204. These layers include the loess deposits making up HU1 and the permeable but discontinuous sand and gravel lenses of the UCRS (HU2) (1–52 ft); the silty clay

Table 5.7. MEPAS results for SWMU 194

Source	Constituent	PGDP security fence		DOE boundary property	
		Potential maximum concentration (mg/L)	Time (years)	Potential maximum concentration (mg/L)	Time (years)
UCRS	Aluminum	0	0-10,001	0	0-10,001
	Chromium	72.4	3,783	0.17	7728
	Lithium	67	19.7	7.57	52
	Strontium	10.5	55.81	5.167E-4	9924-11832

aquitard designated HU3 (52–67 ft); and the sandy gravel deposits of the RGA (67–95 ft). The travel distances from the source to each downgradient exposure point are 10 ft to the PGDP security fence and 4500 ft to the DOE property boundary located to the east. (AOC 204 is located outside the security fence, so a small, non-zero value was used.)

Subsurface soil data were provided by the WAG 28 RI as well as by historical investigations conducted in the AOC 204 area in 1995 (DOE 1995b). For the WAG 28 data collected at AOC 204, no soil contaminants exceeded the screening levels. However, historical groundwater and soil data indicate that there is subsurface trichloroethene contamination located within the boundaries of AOC 204. The likely source was believed to be a small historical spill in Outfall 011 (DOE 1995b). Based on the historical data at Borings 204-19, 204-15, and 204-20, one subsurface contaminant, trichloroethene, was retained for MEPAS modeling at AOC 204. The previous sampling at AOC 204 found trichloroethene at a maximum concentration of 123 μg/kg in the soil at Boring 204-19. Earlier investigations concluded the trichloroethene source had a small areal extent, approximately 100 ft by 100 ft, and extended to a depth of 30 ft (DOE 1995b). The source used for the MEPAS modeling at AOC 204 is larger than this to encompass all three borings while allowing for the rectangular-shaped source area required by the model. The source covers an area of 445 ft by 345 ft and extends to a depth of 35 ft.

Results of the MEPAS modeling are presented in Table 5.8. The MEPAS modeling indicates that trichloroethene concentrations in the UCRS soils at AOC 204 will not result in RGA groundwater concentrations exceeding MCLs at the DOE property boundary. MEPAS cannot accurately assess the trichloroethene concentration in RGA groundwater at the PGDP security fence. Because it is a flux boundary condition model, it tends to overestimate concentrations under near-field conditions (i.e., when the receptor location is too close to the source). The maximum concentration presented in Table 5.8 thus represents a conservative estimate of the maximum concentration reaching the PGDP security fence. More information concerning development of the trichloroethene source term can be found in Appendix B of Vol. 4.

Table 5.8 MEPAS results for AOC 204

Source	Constituent	PGDP security fence		DOE boundary property	
		Potential maximum concentration (μg/L)	Time (years)	Potential maximum concentration (μg/L)	Time (years)
UCRS	Trichloroethene	14,280*	110.5	3.66	163

*At the security fence, the computed maximum concentration is greater than the designated initial concentration at the source of 1.428E-04 μg/L. The current receptor is located too close to the source, creating a near-field condition that cannot be properly assessed by a flux boundary condition model. Concentrations have been truncated to the initial dissolved concentration because of near-field conditions.

6. RESULTS OF BASELINE RISK ASSESSMENT

In 1999, DOE conducted an RI/RCRA Facility Investigation for WAG 28. WAG 28 includes SWMUs 99, 193, and 194 and AOC 204 at the PGDP in Paducah, Kentucky. SWMUs 99 and 193 were further subdivided into units based upon area and historical use (99a, 99b, 193a, 193b, and 193c.) The overall purpose of this investigation was to determine the presence, nature, and extent of contamination at SWMUs 99a, 99b, 193a, 193b, 193c, and 194 and AOC 204. The primary focus of the RI was to collect sufficient information about surface soil, subsurface soil, and the shallow groundwater of the UCRS contamination to support an assessment of risks to human health and the environment and the selection of remedial actions to reduce these risks. In addition, contamination in the RGA and McNairy Formation groundwater was characterized to determine if contamination in the sites acted as a secondary source of contamination to groundwater. The sites that were assessed for risk to human health and the environment were SWMUs 99a, 99b, 193a, 193b, 193c, and 194 and AOC 204.

SWMU 99a, site of the former C-745 Kellogg Buildings, is located along the eastern edge of PGDP, south of Building C-360, immediately north of Tennessee Avenue, and west of Patrol Road 3. The buildings were constructed in 1951 as support facilities during construction of the PGDP cascade facilities. Degreasing operations using trichloroethene possibly occurred on this site. The total area is approximately 2.4 acres.

SWMU 99b, a former septic tank and leach field used by the Kellogg Buildings, is thought to be located immediately outside the east guard house of the plant. The tank and associated leach field were connected to the Kellogg Buildings by a vitreous clay drain line approximately 350–400 ft southeast of the building site in the gravel parking lot east of Patrol Road 3. The suspected location is situated under a gravel-covered parking area between the contractor staging area to the north and AOC 204 to the south. The total area is approximately 0.3 acres.

SWMU 193a, the former Millwright Shop, is the outside perimeter of Building C-333 located in the northwestern portion of SWMU 193, north of Michigan Avenue, and west of 13th Street. The shop is no longer standing, and all that remains is a concrete pad. The area is drained by the plant storm drain system, which eventually exits the plant through KPDES Outfall 009. The total area is approximately 17.4 acres.

SWMU 193b, the former Pipe Fabrication Shop, is the outside northern perimeter of Building C-333 located in the northern portion of SMWU 193. The area is drained by the plant storm drain system, which eventually exits the plant through KPDES Outfall 009. The total area is approximately 4.3 acres.

SWMU 193c is located on the south side of the Building C-333. The site formerly consisted of temporary buildings used during the construction of PGDP, including the electrical warehouse, general warehouse, sheet metal shop, light and heavy equipment shops, acetylene shop, paint shop, civil engineering testing laboratory, filling station, and steel fabrication shop. A leach field was located in the southwest corner of the site. The leach field consists of 4-in. drain tiles in shallow soil. Currently, the site is used to store UF_6 cylinders. The site is bound on the north by Michigan Avenue, on the south by Patrol Road 4, on the east by 21st Street, and on the west by Patrol Road 5. The area is drained by the plant storm drain system, which eventually exits the plant through KPDES Outfall 011. The total area is approximately 87.0 acres.

SWMU 194 is located in the southwest portion of the plant directly outside the security fence. SWMU 194 was the site of the administrative portion of the McGraw construction facilities and consisted of an administration building (105,500 ft^2), cafeteria (10,200 ft^2), security guard headquarters (5,360 ft^2), hospital (4,480 ft^2), purchasing building (12,000 ft^2), paper and stationary warehouse (3,900 ft^2), a boiler house, and two leach fields located west of Hobbs Road. All of the buildings have been demolished. The site is bound on the north by Curlee Road, on the south by Patrol Road 4, on the east by Patrol Road 5, and extends west of Hobbs Road. The total area is approximately 41.7 acres.

AOC 204 is located on the eastern side of PGDP and bound on the north and south by KPDES Outfalls 010 and 011 and on the east and west by Dyke Road and the security fence. It is suspected that AOC 204 was used as a staging area or construction debris burial ground associated with the original construction of the plant. The surface of AOC 204 is undulating, with elevations ranging from 364 to 382 ft above mean sea level. The area is covered with heavy vegetation and a young stand of trees. A small ditch (approximately 4 ft wide and 3 ft deep) is situated across the mound from north to south. The total area is approximately 11.3 acres.

This baseline risk assessment utilizes information collected during the recently completed RI of WAG 28 and the results of previous risk assessments for sites in WAG 28 to characterize the baseline risks posed to human health and the environment from contact with contaminants in soil and groundwater. In addition, this baseline risk assessment uses results of fate and transport modeling (MEPAS) to estimate the baseline risks posed to human health and the environment through contact with media impacted by contaminants migrating off site from the various sources in WAG 28. Baseline risks are those that may be present now or in the future in the absence of corrective or remedial actions.

Consistent with regulatory guidance and agreements contained in the approved human health risk assessment methods document (DOE 1996), the BHHRA evaluates scenarios that encompass current use and several hypothetical future uses of the WAG 28 sites and the areas to which contaminants may migrate. The following scenarios are assessed:

- Current on-site industrial—direct contact with surface soil (0–1 ft below ground surface)
- Future on-site industrial—direct contact with surface soil and use of groundwater drawn from aquifers below WAG 28
- Future on-site excavation scenario—direct contact with surface and subsurface soil (0–15 ft below ground surface)
- Future on-site recreational user—ingestion of game exposed to contaminated surface soil
- Future on-site rural resident—direct contact with surface soil, use of groundwater drawn from aquifers below WAG 28, and ingestion of vegetables grown in this area
- Off-site rural resident—use of groundwater drawn from aquifers at the PGDP fence boundary

Also consistent with regulatory guidance and the strategy for the ecological risk assessment of source units (DOE 1993, EPA 1998a), the baseline ecological risk assessment (BERA) evaluates risks under both current and potential future conditions to several nonhuman receptors that may come into contact with contaminated media at or migrating from sources in WAG 28.

Not every medium was present for the assessment of every land use for each of the sites assessed for risks to human health, The land uses and media assessed for risks to human health for each site in WAG 28 are presented in Table 6.1. Table 6.2 indicates the scenarios for which human health risk exceeds de minimis levels. Tables 6.3–6.9 summarize the risk characterization results for each site.

Table 6.1. Land uses and media assessed for WAG 28 sites

Land use Scenario	Location						
	SWMU 99a	SWMU 99b	SWMU 193a	SWMU 193b	SWMU 193c	SWMU 194	AOC 204
Current on-site industrial worker							
Surface soil	X		X	X	X		
Current terrestrial biota			X				
Future on-site industrial worker							
Surface soil	X		X	X	X		
RGA groundwater	X	X	X	X	X		X
McNairy groundwater	X		X	X	X		
Future on-site excavation worker							
Surface and subsurface soil	X	X	X	X	X	X	X
Future on-site recreational user							
Soil (game)	X		X	X	X		
Future on-site rural resident							
Surface soil	X		X	X	X		
RGA groundwater	X	X	X	X	X		X
McNairy groundwater	X		X	X	X		
Off-site rural resident							
Groundwater	X	X	X	X	X		X
Future terrestrial biota	X		X	X	X		

Notes: Scenarios that were assessed in this baseline risk assessment are marked with an "X."

Information collected during the WAG 28 RI will also be used in the plant-wide BHHRA and BERA for PGDP. These assessments will be completed at a future date as discussed in *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-1207&D2) (DOE 1998a).

Major conclusions and observations of the BHHRA and BERA are presented in the following paragraphs.

6.1 GENERAL

For all sites, the cumulative human health excess lifetime cancer risk (ELCR) and systemic toxicity exceed the accepted standards of the KDEP and the EPA for one or more scenarios when assessed using default exposure parameters. The scenarios for which risk exceeds de minimis levels [i.e., a cumulative ELCR of 1E-6 or a cumulative hazard index (HI) of 1] are summarized in Table 6.2. This information is taken from the risk summary tables (see Tables 6.3–6.9), which present the cumulative risk values for each scenario, the COCs, and the pathways of concern (POCs).

Table 6.2. Scenarios for which human health risk exceeds de minimis levels

Scenario	Site						
	SWMU 99a	SWMU 99b	SWMU 193a	SWMU 193b	SWMU 193c	SWMU 194	AOC 204
Systemic toxicity[a]							
Current industrial worker							
Exposure to soil	–	NA	–	X[b]	X[c]	NA	NA
Future industrial worker							
Exposure to soil	–	NA	–	X[b]	X[c]	NA	NA
Exposure to RGA groundwater	X[d]	X[b]	X[b]	X[b]	X[b]	NA	X[b]
Exposure to McNairy groundwater	X[b]	NA	X[b]	–	X[d]	NA	NA
Future on-site resident[a]							
Exposure to soil	X[b]	NA	X[b]	X[b]	X[d]	NA	NA
Exposure to RGA groundwater	X[d]	X[b]	X[b]	X[b]	X[b]	NA	X[b]
Exposure to McNairy groundwater	X[b]	NA	X[b]	X[b]	X[d]	NA	NA
Off-site resident							
Exposure to groundwater[e]	X[e]	–	X[e]	–	X[e]	X[e]	X[e]
Future recreational user[a]							
Exposure to soil	–	NA	–	–	X[c]	NA	NA
Future excavation worker							
Exposure to soil	X[d]	–	–	X[b]	X[d]	X[c]	–
Excess lifetime cancer risk							
Current industrial worker							
Exposure to soil	X	NA	X	X	–	NA	NA
Future industrial worker							
Exposure to soil	X	NA	X	X	–	NA	NA
Exposure to RGA groundwater	X	X	X	X	X	NA	X
Exposure to McNairy groundwater	X	NA	X	–	X	NA	NA
Future on-site resident[f]							
Exposure to soil	X	NA	X	X	–	NA	NA
Exposure to RGA groundwater	X	X	X	X	X	NA	X
Exposure to McNairy groundwater	X	NA	X	X	X	NA	NA
Off-site resident							
Exposure to groundwater[e]	–	–	–	–	–	–	X[e]
Future recreational user[f]							
Exposure to soil	X	NA	X	–	–	NA	NA
Future excavation worker							
Exposure to soil	X	X	X	X	X	X	X

Notes: Scenarios where risk exceeded benchmark levels (HI of 1/ELCR of 1E-6) are marked with an "X."
Scenarios where risk did not exceed a benchmark level are marked with a "–."
"NA" indicates that the scenario/land use combination is not appropriate.

[a] For the future recreational user and the future on-site rural resident, the results for a child are presented.
[b] These scenarios are of concern even though lead was not detected.
[c] If contribution from lead is not considered, the total HI falls below 1, and the scenario is not of concern.
[d] Lead is present, and the scenario is of concern whether or not the element is included in the assessment.
[e] Based on the results of contaminant transport modeling, "X" indicates that the location contains a source of unacceptable off-site contamination.
[f] For excess lifetime cancer risk regarding the future recreational user and the future on-site rural resident, the valves are for lifetime exposure.

Table 6.3. Summary of human health risk characterization for SWMU 99a without lead as a COPC

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	3.1E-4	Beryllium Benzo(a)pyrene Benzo(b)anthracene Benzo(b)fluoranthene Cesium-137 Dibenz(a,h)anthracene Indeno(1,2,3-cd)pyrene Neptunium-237 Uranium-238	70 6 1 1 3 3 1 9 5	Incidental ingestion Dermal contact External exposure	2 81 17	HI < 1	–	–	–	–
Future industrial worker at current concentrations (soil only)	3.1E-4	Beryllium Benzo(a)pyrene Benzo(b)anthracene Benzo(b)fluoranthene Cesiuim-137 Dibenz(a,h)anthracene Neptunium-237 Uranium-238	70 6 1 1 3 3 9 5	Incidental ingestion Dermal contact External exposure	2 81 17	HI < 1	–	–	–	–
Future industrial worker at current concentrations (RGA groundwater only)	5.6E-4	1,1-Dichloroethene Arsenic Beryllium Trichloroethene Radon-222	14 5 38 8 35	Incidental ingestion Dermal contact Inhalation of vapors/particles	44 12 43	5.11	Aluminum Arsenic Chromium Iron Manganese Trichloroethene Vanadium	2 4 10 15 8 42 14	Ingestion Dermal contact Inhalation of vapors/particles	73 15 12
Future industrial worker at current concentrations (McNairy groundwater only)	7.6E-5	1,1-Dichloroethene Carbon tetrachloride Trichloroethene	61 2 37	Ingestion Dermal contact Inhalation of vapors/particles	52 10 38	1.64	*cis*-1,2-Dichloroethene Trichloroethene Carbon tetrachloride	11 84 4	Ingestion Dermal contact Inhalation of vapors/particles	53 17 29
Future child rural resident at current concentrations (soil only)	NA	NA	NA	NA	NA	17.2	Barium Beryllium Chromium PCB-1016 PCB-1254 Pyrene Zinc	19 4 28 18 26 < 1 4	Ingestion Dermal contact Ingestion of vegetables	1 18 81

Table 6.3. (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future child rural resident at current concentrations (RGA groundwater only)	NA	NA	NA	NA	NA	97.3	1,1-Dichloroethene Aluminum Arsenic Barium Beryllium Chromium *cis*-1,2-Dichloroethene Cobalt Copper Iron Lithium Manganese Mercury Nickel Trichloroethene Vanadium Zinc	1 1 2 < 1 < 1 5 < 1 < 1 < 1 9 < 1 3 < 1 < 1 68 6 < 1	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	26 2 51 21
Future child rural resident at current concentrations (McNairy groundwater only)	NA	NA	NA	NA	NA	53.1	1,1-Dichloroethene Carbon tetrachloride *cis*-1,2-Dichloroethene Trichloroethene	1 5 13 80	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	11 1 73 15
Future adult rural resident at current concentrations (soil only)	> 1E-2*	Beryllium Benz(a)anthracene Benzo(a)pyrene Benzo(a)fluoranthene Cesium Chrysene Dibenz(a,h)anthracene Indeno(1,2,3-cd)pyrene Neptunium-237 PCB-1016 PCB-1254 PCB-1260 Technetium-99 Thorium-234 Uranium-234 Uranium-238	< 1 < 1 < 1 < 1 < 1 < 1 < 1 < 1 < 1 < 1 < 1 < 1 96 < 1 < 1 < 1	Ingestion Dermal Contact External Exposure Ingestion of vegetables	< 1 < 1 < 1 99	5.05	Barium Beryllium Chromium PCB-1016 PCB-1254 Zinc	19 3 25 20 28 4	Dermal contact Ingestion of vegetables	12 88

Table 6.3. (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult rural resident at current concentrations (RGA groundwater only)	5.6E-3	1,1-Dichloroethene Arsenic Beryllium bis(2-Ethylhexyl)phthalate Trichloroethene Radon-222 Technetium-99	40 4 26 < 1 11 9 9	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	24 3 45 28	28.3	1,1-Dichloroethene Aluminum Arsenic Barium Beryllium Chromium *cis*-1,2-Dichloroethene Iron Lithium Manganese Nickel Trichloroethene Vanadium	1 2 3 < 1 < 1 7 < 1 11 < 1 4 1 59 9	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	37 4 36 23
Future adult rural resident at current concentrations (McNairy groundwater only)	1.7E-3	1,1-Dichloroethene Carbon tetrachloride Trichloroethene	75 1 24	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	12 1 70 17	13.3	1,1-Dichloroethene *cis*-1,2-Dichloroethene Carbon tetrachloride Trichloroethene	1 13 5 80	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	18 3 60 19
Future child recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	HI < 1	–	–	–	–
Future teen recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	HI < 1	–	–	–	–
Future adult recreational user at current concentrations (soil only)	2.7E-6	Dibenz(a,h)anthracene	38	Ingestion of venison Ingestion of rabbit Ingestion of quail	11 72 11	HI < 1	–	–	–	–

Table 6.3. (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future excavation worker at current concentrations	2.1E-4	Aldrin	< 1	Ingestion	21	1.46	2-Nitroaniline	8	Ingestion	13
		Arsenic	5	Dermal contact	63		Antimony	35	Dermal contact	83
		Benz(a)anthracene	< 1	Inhalation of vapors/particles	< 1		Chromium	16	Inhalation of vapors/particles	3
		Benzo(a)pyrene	11				Manganese	14		
		Benzo(b)fluoranthene	1	External exposure	16		Aluminum	6		
		Beryllium	35				Arsenic	5		
		bis(2-chloroethyl)ether	< 1				Barium	3		
		Cesium-137	3				Beryllium	2		
		Dibenz (a,h) anthracene	7				Cadmium	2		
		Dieldrin	< 1							
		Hexachlorobenzene	1							
		Indeno (1,2,3-cd) pyrene	< 1							
		Neptunium-237	11							
		N-nitroso-di-n-propylamine	8							
		Thorium-234	< 1							
		Toxaphene	< 1							
		Uranium-234	< 1							
		Uranium-238	7							

Notes: NA = ECLR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
none = ELCR or HI is above the benchmark, but no COCs or POCs fulfill the selection criteria.
ND = No Data (no samples were taken from the medium under consideration).
– = There are no COCs or POCs.
* = The ELCR is approximate because the linearized multistage model returns imprecise values at risks > 1E-2.

Table 6.4. Summary of human health risk characterization for SWMU 99b without lead as a COPC

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future industrial worker at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future industrial worker at current concentrations (RGA groundwater only)	2.6E-4	Radon-222 Trichloroethene	47 53	Ingestion Dermal contact Inhalation of vapors/particles	31 12 57	7.00	Chromium Trichloroethene	3 94	Ingestion Dermal contact Inhalation of vapors/particles	54 19 26
Future industrial worker at current concentrations (McNairy groundwater only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future child rural resident at current concentrations (soil only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future child rural resident at current concentrations (RGA groundwater only)	NA	NA	NA	NA	NA	208	Barium Chromium Iron Manganese Trichloroethene	< 1 1 < 1 < 1 98	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	12 2 71 15
Future child rural resident at current concentrations (McNairy groundwater only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future adult rural resident at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future adult rural resident at current concentrations (RGA groundwater only)	2.3E-3	Radon-222 Trichloroethene	13 87	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	19 4 58 20	52.9	Barium Chromium Iron Manganese Trichloroethene	< 1 2 < 1 < 1 97	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	20 4 58 18

Table 6.4. (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult rural resident at current concentrations (McNairy groundwater only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future child recreational user at current concentrations (soil only)	NA/ND	NA/ND	NA/ND	NA/ND	NAND	ND	ND	ND	ND	ND
Future teen recreational user at current concentrations (soil only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future adult recreational user at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future excavation worker at current concentrations	2.1E-4	Arsenic Beryllium	7 93	Ingestion Dermal contact Inhalation of vapors/particles	5 95 < 1	HI < 1	–	–	–	–

Notes: NA = ECLR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
none = ELCR or HI is above the benchmark, but no COCs or POCs fulfill the selection criteria.
ND = No Data (no samples were taken from the medium under consideration).
– = There are no COCs or POCs.

Table 6.5. Summary of human health risk characterization for SWMU 193a without lead as a COPC

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	1.5E-5	Benzo(a)pyrene Dibenz(a,h)anthracene	60 31	Dermal contact Ingestion	97 4	HI < 1	–	–	–	–
Future industrial worker at current concentrations (soil only)	1.5E-5	Benzo(a)pyrene Dibenz(a,h)anthracene	60 31	Dermal contact Ingestion	97 4	HI < 1	–	–	–	–
Future industrial worker at current concentrations (RGA groundwater only)	2.6E-5	Pentachlorophenol Technetium-99 Trichloroethene 1,1-Dichloroethene bis(2-Ethylhexyl)phthalate	45 6 42 3 3	Ingestion Dermal contact Inhalation	48 42 9	1.64	Iron Trichloroethene Fluoride	62 33 4	Ingestion Dermal contact Inhalation of vapors/particles	82 9 9
Future industrial worker at current concentrations (McNairy groundwater only)	1.1E-6	none	–	None	–	4.69	Iron *cis*-1,2-Dichloroethene	94 6	Ingestion Dermal contact Inhalation of vapors/particles	96 2 2
Future child rural resident at current concentrations (soil only)	NA	NA	NA	NA	NA	6.25	Chromium	99	Dermal contact Ingestion of vegetables	40 59
Future child rural resident at current concentrations (RGA groundwater only)	NA	NA	NA	NA	NA	28.6	Fluoride Iron Trichloroethene *cis*-1,2-Trichloroethene	2 39 58 < 1	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	32 1 43 24
Future child rural resident at current concentrations (McNairy groundwater only)	NA	NA	NA	NA	NA	59.9	*cis*-1,2-Dichloroethene Iron Trichloroethene	17 82 < 1	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	51 < 1 13 36
Future adult rural resident at current concentrations (soil only)	7.1E-4	Benz(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenz(a,h)anthracene Indeno(1,2,3-cd)pyrene	4 60 1 31 4	Ingestion Dermal contact Ingestion of vegetables	< 1 6 93	1.66	Chromium	99	Dermal contact Ingestion of vegetables	29 70

Table 6.5. (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult rural resident at current concentrations (RGA groundwater only)	2.4E-3	1,1-Dichloroethene bis-(2-Ethylhexyl) phthalate Pentachlorophenol Technetium-99 Trichloroethene	1 < 1 2 90 7	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	3 1 4 92	8.69	Fluoride Iron Trichloroethene	2 49 48	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	43 2 29 25
Future adult rural resident at current concentrations (McNairy groundwater only)	4.1E-4	Technetium-99 Trichloroethene Uranium-238	98 < 1 < 1	Ingestion Inhalation of vapors/particles Ingestion of vegetables	1 < 1 99	21.2	*cis*-1,2-Dichloroethene Iron	12 87	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	59 < 1 7 33
Future child recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	HI < 1	–	–	–	–
Future teen recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	HI < 1	–	–	–	–
Future adult recreational user at current concentrations (soil only)	3.6E-6	Benzo(a)pyrene Dibenz(a,h)anthracene	35 59	Ingestion of venison Ingestion of rabbit Ingestion of quail	31 57 12	HI < 1	–	–	–	–
Future excavation worker at current concentrations	1.7E-4	Beryllium Benzo(a)pyrene Dibenz(a,h)anthracene	91 5 3	Ingestion Dermal contact	4 96	HI < 1	–	–	–	–

Notes: NA = ECLR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
none = ELCR or HI is above the benchmark, but no COCs or POCs fulfill the selection criteria.
ND = No Data (no samples were taken from the medium under consideration).
– = There are no COCs or POCs.

Table 6.6. Summary of human health risk characterization for SWMU 193b without lead as a COPC

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	5.1E-4	Beryllium	100	Ingestion Dermal contact	< 1 100	5.25	Beryllium Chromium Vanadium	3 60 37	Dermal contact	100
Future industrial worker at current concentrations (soil only)	5.1E-4	Beryllium	100	Ingestion Dermal contact	< 1 100	5.25	Beryllium Chromium Vanadium	3 60 37	Dermal contact	100
Future industrial worker at current concentrations (RGA groundwater only)	4.4E-5	1,1-Dichloroethene Carbon tetrachloride Trichloroethene	16 8 74	Ingestion Dermal contact Inhalation of vapors/particles	59 18 23	1.74	Carbon tetrachloride Trichloroethene	8 90	Ingestion Dermal contact Inhalation of vapors/particles	52 19 29
Future industrial worker at current concentrations (McNairy groundwater only)	< 1E-6	–	–	–	–	HI < 1	–	–	–	–
Future child rural resident at current concentrations (soil only)	NA	NA	NA	NA	NA	66.7	Beryllium Chromium Vanadium	3 68 30	Ingestion Dermal contact Ingestion of vegetables	< 1 46 53
Future child rural resident at current concentrations (RGA groundwater only)	NA	NA	NA	NA	NA	55.5	1,1-Dichloroethene Acetone Carbon tetrachloride *cis*-1,2-Dichloroethene Trichloroethene	< 1 1 9 < 1 88	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	11 2 73 15
Future child rural resident at current concentrations (McNairy groundwater only)	NA	NA	NA	NA	NA	2.69	*cis*-1,2-Dichloroethene Trichloroethene	53 47	Ingestion Inhalation of vapors/particles Ingestion of vegetables	11 71 17
Future adult rural resident at current concentrations (soil only)	3.0E-3	Beryllium	100	Ingestion Dermal contact Ingestion of vegetables	1 50 49	17.3	Beryllium Chromium Vanadium	2 69 28	Dermal contact Ingestion of vegetables	34 65
Future adult rural resident at current concentrations (RGA groundwater only)	1.0E-3	1,1-Dichloroethene Carbon tetrachloride bis(2-Ethylhexyl)phthalate Technetium-99 Trichloroethene	20 5 < 1 29 46	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	14 2 40 44	13.9	Acetone Carbon tetrachloride *cis*-1,2-Dichloroethene Trichloroethene	1 9 < 1 88	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	18 3 60 18

Table 6.6. (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult rural resident at current concentrations (McNairy groundwater only)	1.2E-5	Trichloroethene	100	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	22 4 50 23	HI < 1	–	–	–	–
Future child recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	HI < 1	–	–	–	–
Future teen recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	HI < 1	–	–	–	–
Future adult recreational user at current concentrations (soil only)	< 1E-6	–	–	–	–	HI < 1	–	–	–	–
Future excavation worker at current concentrations	1.7E-4	Beryllium	100	Ingestion Dermal contact	2 98	1.75	Chromium Vanadium	59 37	Dermal contact Ingestion	97 3

Notes: NA = ECLR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
none = ELCR or HI is above the benchmark, but no COCs or POCs fulfill the selection criteria.
ND = No Data (no samples were taken from the medium under consideration).
– = There are no COCs or POCs.

Table 6.7. Summary of human health risk characterization for SWMU 193c without lead as a COPC

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	< 1E-6	–	–	–	–	HI < 1	–	–	–	–
Future industrial worker at current concentrations (soil only)	< 1E-6	–	–	–	–	HI < 1	–	–	–	–
Future industrial worker at current concentrations (RGA groundwater only)	1.0E-5	Trichloroethene	100	Ingestion Dermal contact Inhalation of vapors/particles	59 23 18	1.46	1,2-Dichloroethene Trichloroethene	65 35	Ingestion Dermal contact Inhalation of vapors/particles	60 7 33
Future industrial worker at current concentrations (McNairy groundwater only)	4.2E-4	1,1-Dichloroethene 1,2-Dichloroethane Arsenic Beryllium Carbon tetrachloride Tetrachloroethene Radon-222 Vinyl chloride	3 < 1 15 54 < 1 < 1 11 16	Ingestion Dermal contact Inhalation of vapors/particles	71 15 14	9.92	Aluminum Antimony Arsenic Cadmium Chromium Iron Manganese Vanadium	4 33 4 10 6 20 3 16	Ingestion Dermal contact	86 14
Future child rural resident at current concentrations (soil only)	NA	NA	NA	NA	NA	3.04	Chromium Zinc	91 9	Dermal contact Ingestion of vegetables	37 62
Future child rural resident at current concentrations (RGA groundwater only)	NA	NA	NA	NA	NA	80.7	1,2-Dichloroethene Trichloroethene	80 20	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	7 < 1 48 45

Table 6.7. (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future child rural resident at current concentrations (McNairy groundwater only)	NA	NA	NA	NA	NA	103	1,1,2-Trichloroethane 1,1-Dichloroethene 1,2-Dichloroethane Aluminum Antimony Arsenic Barium Benzene Beryllium Cadmium Carbon tetrachloride Chromium Chloroform *cis*-1,2-Dichloroethene Cobalt Iron Manganese Molybdenum Nickel *trans*-1,2-Dichloroethene Trichloroethene Silver Uranium Vanadium	< 1 < 1 < 1 4 33 4 < 1 < 1 < 1 7 2 5 < 1 < 1 < 1 21 2 1 < 1 < 1 < 1 < 1 < 1 14	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	56 4 4 37
Future adult rural resident at current concentrations (soil only)	< 1E-6	–	–	–	–	HI < 1	–	–	–	–
Future adult rural resident at current concentrations (RGA groundwater only)	1.5E-4	Trichloroethene	100	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	22 4 50 23	22	1,2-Dichloroethene Trichloroethene	82 18	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	11 < 1 36 52

Table 6.7. (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult rural resident at current concentrations (McNairy groundwater only)	4.0E-3	1,1,2-Trichloroethane 1,1-Dichloroethene 1,2-Dichloroethane Arsenic Benzene Beryllium Bromodichloromethane Carbon tetrachloride Chloroform Polychlorinated biphenyl Radon-222 Tetrachloroethene Trichloroethene Vinyl chloride	< 1 8 < 1 14 < 1 39 < 1 < 1 < 1 < 1 3 < 1 < 1 34	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	41 4 16 39	38.5	Aluminum Antimony Arsenic Barium Benzene Beryllium Cadmium Carbon Tetrachloride Chromium Iron Manganese Molybdenum Nickel Silver Vanadium	4 33 4 < 1 < 1 < 1 8 1 5 21 3 1 < 1 1 14	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	62 5 2 31
Future child recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	HI < 1	–	–	–	–
Future teen recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	HI < 1	–	–	–	–
Future adult recreational user at current concentrations (soil only)	< 1E-6	–	–	–	–	HI < 1	–	–	–	–
Future excavation worker at current concentrations (soil only).	1.7E-4	Beryllium	100	Ingestion Dermal contact	2 98	2.09	Chromium Iron Manganese Vanadium	28 31 17 14	Ingestion Dermal contact	12 88

Notes: NA = ECLR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
none = ELCR or HI is above the benchmark, but no COCs or POCs fulfill the selection criteria.
ND = No Data (no samples were taken from the medium under consideration).
– = There are no COCs or POCs.

Table 6.8. Summary of human health risk characterization for SWMU 194 without lead as a COPC

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future industrial worker at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future industrial worker at current concentrations (RGA groundwater only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future industrial worker at current concentrations (McNairy groundwater only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future child rural resident at current concentrations (soil only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future child rural resident at current concentrations (RGA groundwater only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future child rural resident at current concentrations (McNairy groundwater only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future adult rural resident at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future adult rural resident at current concentrations (RGA groundwater only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future adult rural resident at current concentrations (McNairy groundwater only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 6.8. (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future child recreational user at current concentrations (soil only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future teen recreational user at current concentrations (soil only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future adult recreational user at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future excavation worker at current concentrations	3.1E-4	Beryllium	100%	Ingestion Dermal contact	2 98	HI < 1	–	–	–	–

Notes: NA = ECLR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
none = ELCR or HI is above the benchmark, but no COCs or POCs fulfill the selection criteria.
ND = No Data (no samples were taken from the medium under consideration).
– = There are no COCs or POCs.

Table 6.9. Summary of human health risk characterization for AOC 204 without lead as a COPC

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future industrial worker at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future industrial worker at current concentrations (RGA groundwater only)	1.3E-3	1,1-Dichloroethene PCB-1254 PCB-1260 Polychlorinated biphenyls Tetrachloroethene Trichloroethene	13 6 14 43 21 3	Ingestion Dermal contact Inhalation of vapors/particles	40 53 8	33.3	1,2-Dichloroethane PCB-1254 Tetrachloroethene Trichloroethene	2 88 4 5	Ingestion Dermal contact Inhalation of vapors/particles	43 55 2
Future industrial worker at current concentrations (McNairy groundwater only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future child rural resident at current concentrations (soil only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future child rural resident at current concentrations (RGA groundwater only)	NA	NA	NA	NA	NA	279	1,1-Dichloroethane 1,1-Dichloroethene *cis*-1,2-Dichloroethene PCB-1254 Tetrachloroethene Trichloroethene	9 1 < 1 66 5 19	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	35 18 21 27
Future child rural resident at current concentrations (McNairy groundwater only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future adult rural resident at current concentrations (soil)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 6.9. (continued)

Receptor	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult rural resident at current concentrations (RGA groundwater only)	> 1E-2*	1,1-Dichloroethene PCB-1254 PCB-1260 Polychlorinated biphenyls Tetrachloroethene Trichloroethene Vinyl chloride	33 6 7 38 11 3 < 1	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	19 12 28 41	102	1,1-Dichloroethane 1,1-Dichloroethene PCB-1254 Tetrachloroethene Trichloroethene	6 1 74 5 13	Ingestion Dermal contact Inhalation of vapors/particles Ingestion of vegetables	39 25 11 24
Future adult rural resident at current concentrations (McNairy groundwater only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future child recreational user at current concentrations (soil only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future teen recreational user at current concentrations (soil only)	NA/ND	NA/ND	NA/ND	NA/ND	NA/ND	ND	ND	ND	ND	ND
Future adult recreational user at current concentrations (soil only)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Future excavation worker at current concentrations	1.1E-6	none	–	none	–	HI < 1	–	–	–	–

Notes: NA = ECLR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
none = ELCR or HI is above the benchmark, but no COCs or POCs fulfill the selection criteria.
ND = No Data (no samples were taken from the medium under consideration).
– = There are no COCs or POCs.
* = The ELCR is approximate because the linearized multistage model returns imprecise values at risks > 1E-2.

The conceptual model defined in the approved WAG 28 work plan (DOE 1998b) defined the potential sources of contamination in SWMU 194 and AOC 204 as being contained within subsurface soil (i.e., drain fields and buried debris pile). Consequently surface soils are not impacted and did not require an ecological evaluation to be performed.

Lack of quality habitat in the industrial setting of WAG 28 sites within the fence boundaries limits exposure of ecological receptors at most sites under current conditions (with the exception of SWMU 193a). However, an assessment of potential risks in the future, assuming conditions change so that suitable habitat becomes available for ecological receptors, was conducted. Several contaminants in surface soils were found to be at concentrations greater than levels that are protective of future nonhuman receptors. Tables 6.10 and 6.11 summarize these chemicals of potential ecological concern (COPECs).

6.2 BHHRA—SPECIFIC

As a measure of the threat of systemic toxicological effects arising through contact with contaminated media at WAG 28, values for HIs were, for the most part, greater than 1000 when lead was retained as a COPC. However, such high values are related to the use of a provisional reference dose (RfD) provided by KDEP, an approach that may overemphasize the potential threat of this contaminant. Accordingly, in this assessment, HIs for all receptor/land use combinations were routinely calculated with lead both included and excluded from the determinations, thereby permitting an evaluation of the overall threat to human health of other contaminants at WAG 28 for sites where lead is present.

In an effort to reduce the uncertainty surrounding the assessment of systemic toxicity at sites at WAG 28 where lead is present, two further analytical approaches are included in this risk assessment. Risks to exposed children were estimated using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model, and the reasonable maximum exposure (RME) concentrations of lead in soil and groundwater samples were compared to KDEP and EPA screening values.

Applying the biokinetic model for lead indicates that the concentration of the element in McNairy Formation groundwater at SWMU 193c (250 µg/L) and in RGA groundwater at SWMU 99a (81.3 µg/L) result in a greater than 5 percent probability of a child having blood lead levels greater than 10 µg/dL (84 percent probability for SWMU 193c/McNairy and 38 percent for SWMU 99a/RGA). These findings are consistent with the respective lead-driven HIs of 278,000 and 90,600, as calculated for a future on-site resident child exposed to contaminants in these aquifers.

The RME lead concentrations in SWMU 193c/McNairy and SWMU 99a/RGA are also greater than the KDEP and EPA screening level concentrations for this element (4 and 15 µg/L, respectively). Therefore, when these findings are considered together, there is qualitative agreement on the potential hazards of prevailing lead concentrations in the groundwater at these sites.

Where the element was detected in surface or subsurface soil, lead-driven HIs of greater than 1000 contrast with very low probabilities (< 0.02 percent) of children having blood levels greater than 10µg/dL, as determined by the IEUBK model. Furthermore, lead concentrations in subsurface soil at SWMUs 99a, 193c and 194 do not exceed the soil screening values specified by either agency. However, as illustrated in Exhibit 1.39, the concentration of lead in surface soil at SWMU 193c exceeds the KDEP benchmark but not that of EPA (20 < 24.9 < 400 mg/kg).

Because the risks calculated using the provisional lead RfD are so uncertain, all observations presented in Tables 6.3–6.9 exclude the quantitative contribution from lead.

6.2.1 Exposure Routes

When the major contributions of each applicable exposure route to the overall risk or hazard posed by all sites in WAG 28 are considered, dermal contact appears to contribute the largest proportion of the threat from contact with soil. This observation holds good irrespective of toxicological endpoint (i.e., systemic toxicity or carcinogenicity) and is also irrespective of the applicable land use scenario. However, a significant portion of the threat to the on-site resident from soil constituents comes also from ingestion of vegetables grown in contaminated soil.

By contrast, a plurality of the hazard or cancer risk arising from contact with contaminants in groundwater comes from ingestion, again irrespective of toxicological endpoint. However, inhalation of vapors (while showering and/or during household use) and ingestion of vegetables irrigated with contaminated groundwater make significant contributions to the overall hazard or risk to an on-site resident.

6.2.2 Contaminants of Concern

A measure of the relative importance of different media contaminants to the overall hazard and risk that arises from contact with soil and groundwater may be obtained by ranking by occurrence the priority COCs across WAG 28 as a whole. When all sites are considered, the priority COCs contributing 10 percent or more to the total HI or ELCR at one or more of the sites can be ranked according to the number of sites at which the contaminant was a priority COC (Table 6.10).

Table 6.10. Frequency of occurance of contaminants of concern

Soil samples			
beryllium	(6/7)	iron	(1/7)
chromium	(4/7)	technetium-99	(1/7)
PAHs	(2/7)	neptunium-234	(1/7)
PCBs	(2/7)	barium	(1/7)
vanadium	(2/7)	1,1-dichloroethene	(1/7)
manganese	(2/7)	tetrachloroethene	(1/7)
antimony	(1/7)	trichloroethene	(1/7)
Groundwater samples			
trichloroethene	(6/6)	PCBs	(1/6)
cis-1,2-dichloroethene	(3/6)	tetrachloroethene	(1/6
1,1-dichloroethene	(3/6)	PCB-1254	(1/6)
radon-222	(3/6)	antimony	(1/6)
iron	(3/6)	cadmium	(1/6)
technetium-99	(2/6)	chromium	(1/6)
beryllium	(2/6)	pentachlorophenol	(1/6)
vanadium	(2/6)	arsenic	(1/6)
1,2-dichloroethene	(1/6)	uranium-238	(1/6)
vinyl chloride	(1/6)		

6.2.3 Scenario Hazards and Risks

The overall extent of the threats of systemic toxicity or induction of carcinogenicity presented by sites in WAG 28 is indicated by the ranges of SWMU-specific HIs and ELCRs that were calculated for each primary on-site receptor (Table 6.11). Also listed are the number of sites for each receptor/land use combination in which the overall ELCR is greater than 1E-4 or where the HI is greater than 1.

Table 6.11 Range of values for hazards and risks

		ELCR	
Receptor	**Medium**	**Range of Values**	**Sites > 1E-4**
Future on-site resident	Groundwater	1.5E-2–4.1E-4	10/10
	Soil	1.4E-1–1.1E-9	3/4
Future on-site worker	Groundwater	1.3E-3–8.4E-7	9/10
	Soil	5.1E-4–1.7E-10	2/4
Future excavation worker	Subsurface soil	3.1E-4–1.1E-6	6/7
		HI	
Receptor	**Medium**	**Range of Values**	**Sites > 1**
Future on-site resident	Groundwater	278,000–2.69	10/10
	Soil	247,000–6.25	4/4
Future on-site worker	Groundwater	25,100–< 0.1	9/10
	Soil	3620–0.432	2/4
Future excavation worker	Subsurface soil	250–< 0.1	4/7

These data clearly demonstrate that for both the default "worst-case" scenario (future on-site resident) and the most likely future receptor (industrial worker), most sites had HIs and ELCRs greater than the EPA's ranger of concern.

When considered in detail, the most plausible future use scenario, future industrial worker, has total HIs and ELCRs exceeding de minimis levels at all sites except SWMU 194, for which this scenario/land use combination did not apply. As discussed in the BHHRA, the future industrial land use scenario is identical to the current industrial land use scenario except that the future industrial land use scenario also evaluates use of RGA and McNairy groundwater. Addition of groundwater as a medium of exposure adds significantly to the risk for this scenario. If groundwater contribution is removed from the risk totals, the primary pathways are identical to the current industrial use scenario.

The driving contaminants contributing to more than 10 percent of total HIs for the future industrial worker at SWMU 99a (excluding lead) in RGA groundwater are trichloroethene, chromium, iron, and vanadium with ingestion as the primary pathway. The driving contaminant contributing to more than

10 percent of total HIs at SWMU 99b is trichloroethene with ingestion as the primary pathway. The driving contaminants contributing to more than 10 percent of total HIs at SWMU 193a are iron and trichloroethene with ingestion as the primary pathway. The driving contaminants contributing to more than 10 percent of total HIs at SWMU 193b is trichloroethene with ingestion as the primary pathway. The driving contaminants contributing to more than 10 percent of total HIs at SWMU 193c are 1,2-dichloroethene and trichloroethene with ingestion as the primary pathway. The driving contaminants contributing to more than 10 percent of total HIs at AOC 204 are PCBs with dermal contact and ingestion as the primary pathways.

The driving contaminants contributing to more than 10 percent of total ELCR for the future industrial worker exposed to RGA groundwater at SWMU 99a are 1,1-dichloroethene, beryllium, and radon-222 with incidental ingestion and inhalation of vapors and particulates as the primary pathways. The driving contaminants contributing to more than 10 percent of total ELCR at SWMU 99b are trichloroethene and radon-222 with inhalation as the primary pathway. The driving contaminants contributing to more than 10 percent of total ELCR at SWMU 193a are pentachlorophenol and trichloroethene with ingestion and dermal contact as the primary pathways. The driving contaminants contributing to more than 10 percent of total ELCR at SWMU 193b are trichloroethene and 1,1-dichloroethene with ingestion as the primary pathway. The driving contaminant contributing to more than 10 percent of total ELCR at SWMU 193c is trichloroethene with ingestion as the driving pathway. The driving contaminants contributing to more than 10 percent of total ELCR at AOC 204 are PCBs, trichloroethene, and 1,1-dichloroethene with dermal contact as the primary pathway.

The COCs for analytes migrating from sources in WAG 28 soil and groundwater as determined by risk estimates for off-site residential groundwater users are chromium, lithium, manganese, strontium, technetium-99, and trichloroethene.

6.3 BERA—SPECIFIC

The conceptual model defined in the approved WAG 28 work plan (DOE 1998b) defined the potential sources of contamination in SWMU 194 and AOC 204 as being contained within subsurface soil (i.e., drain fields and buried debris pile). This is also the case for SWMU 99b. Consequently surface soils were not expected to be impacted and did not require an ecological evaluation to be performed.

Lack of quality habitat in the industrial setting of WAG 28 sites within the fence boundaries limits exposure of ecological receptors at most sites under current conditions (with the exception of SWMU 193a). However, an assessment of potential risks in the future, assuming conditions change so that suitable habitat becomes available for ecological receptors, was conducted. Several contaminants in surface soil were found to be at concentrations greater than levels protective of future nonhuman receptors. Table 6.12 and 6.13 summarize these COPECs.

Chemical and radionuclide contaminants were evaluated for surface soil from SWMUs 99a, 193a, 193b, and 193c. Detectable concentrations that exceeded background were evaluated for the potential of inducing adverse ecological effects to a representative set of receptor species that potentially could inhabit the WAG 28 area. Tables 6.12 and 6.13 summarize COPECs that were identified based on the results of screening contaminant concentrations against ecological benchmarks.

Six nonradionuclide COPECs, all inorganics, exceed background and benchmarks for at least one receptor group (Table 6.12). The inorganics are boron, barium, chromium, lead, vanadium, and zinc. However, chromium and lead are near background levels (maximum of 1.05 and 1.53× background, respectively). Confidence in the benchmarks for boron and chromium is low. Potential risks from chromium are largely based on the conservative assumption that chromium is present as the more toxic chromium(VI) rather than the more likely chromium(III). However, chromium exceeds benchmarks for plants and soil invertebrates at all four sites with the highest concentrations occurring at SWMUs 99a and 193b. Barium is only a potential concern for plants at SWMU 99a, and the concern is driven by a maximum detected concentration more than an order of magnitude higher than other detects in that SWMU. Lead is only a concern for plants in SWMU 193c, but the lead concentration is near background levels. Zinc is a potential concern for plants at SWMU 193c and plants and soil invertebrates at SWMU 99a, but as with lead, concentrations are near background levels. Vanadium is a potential concern for plants and wildlife at SWMU 193b. The potential for adverse effects to ecological receptors exposed to chemicals in surface soil from WAG 28 sites is low.

Estimated doses from exposure to radionuclides in soil are below recommended dose rate limits for all receptors at all sites except for plant and soil invertebrates at SWMU 99a, in which technetium-99 is the radionuclide of concern.

The purpose of this assessment was to evaluate the potential for unacceptable adverse effects on ecological receptors at WAG 28. For sites within the fence boundaries, under current conditions, complete exposure pathways are not expected for terrestrial biota except at SWMU 193a, and even this area is within the industrialized portion of the plant. Thus, this evaluation focuses on hypothetical future exposures, assuming loss of industrial controls and buildings and development of a larger area of suitable habitat. Analytes that are retained as COPECs may require further study to determine whether adverse ecological effects are likely if decisions for remedial actions are based on ecological concerns. Uncertainty concerning the future condition, the bioavailability or form of various metals (e.g., boron, barium, chromium, lead, vanadium, and zinc), and use of only one line of evidence (comparison of exposures to single chemical toxicity values) may have lead to an overestimate of potential future ecological risks.

The following paragraphs and Tables 6.12 and 6.13 summarize analytes of potential concern and receptors potentially at risk should future exposures occur.

6.3.1 SWMU 99a

While chromium and zinc exceed benchmarks for plants and soil invertebrates and barium exceeds benchmarks for plants, potential risks to plant and soil invertebrate communities from future exposure to surface soil at this site appear low. The barium risk is due to a location (Station 099014) where the concentration is more than an order of magnitude higher than at other stations. Zinc is near background levels and results in low exceedances of benchmarks. There is considerable uncertainty in the benchmark for chromium, which tends to be based on the more toxic chromium(VI) rather than the more likely chromium(III).

Estimated doses from exposure to radionuclides in soil are below recommended dose rate limits for wildlife, but dose rates for plants and soil invertebrates are higher than the recommended dose rate limit of 1 rad /day. Technetium-99 is the radionuclide of concern based on its occurrence in a single sample.

6.3.2 SWMU 193a

Risks to terrestrial receptors are not expected from current or future exposures at this site. No radionuclides are detected, and only chromium, for which toxicological benchmark are likely highly conservative, exceeds levels of potential concern for plants and soil invertebrates.

6.3.3 SWMU 193b

Potential future risks from exposure of plants, soil invertebrates, and wildlife to chromium or vanadium were identified. While there is considerable uncertainty associated with the benchmarks available for chromium, concentrations of both chromium and vanadium are elevated relative to other areas in WAG 28.

6.3.4 SWMU 193c

Potential future risks from exposure of plants to boron, chromium, lead, and zinc and exposure of soil invertebrates to chromium are identified, but there is considerable uncertainty associated with the benchmarks available for boron and chromium. Lead and zinc are near background levels, and chromium concentrations are lower at this site than in other areas in WAG 28.

Table 6.12. Summary of chemicals with maximum detected or reasonable maximum exposure concentrations resulting in ecological hazard quotients greater than 1.0 for one or more nonhuman receptor groups

Site	Receptor group	Boron	Barium	Chromium	Lead	Vanadium	Zinc
SWMU 193a	Plants[a]			26.5[b]			
	Soil invertebrates			66.2			
SWMU 193b	Plants			88.7		32.5	
	Soil invertebrates			222.0			
	Terrestrial wildlife[c,d]					1.24	
SWMU 193c	Plants	200.0		12.0	1.35		1.85
	Soil invertebrates			30.0			
SWMU 99a	Plants		4.94	45.7			3.26
	Soil invertebrates			114.0			1.63

[a] Plant and soil invertebrate values are based on maximum detected concentrations.
[b] Values in cells are hazard quotients.
[c] Terrestrial wildlife values are based on reasonable maximum exposure concentrations.
[d] Estimated daily doses for wildlife were below LOAELs at SWMUs 193a, 193c, and 99a.

Table 6.13. Estimated dose rates (mrad/day) and hazard indices for terrestrial biota exposed to radionuclides in soil

SWMU[a]	Radionuclide	Freq. of detection	RMA[b]	Max. detect	Plants[c]	Soil inverts[c,e]	Vole[d,e]	Shrew[d,e]	Mouse[d,e]	Weasel[d,e]
SWMU 99a	Cesium-137	3/16	1.06E+00	1.90E+00	1.13E-02	8.37E-02	1.86E-02	2.24E-02	1.85E-02	2.14E-02
SWMU 99a	Neptunium-237	1/1	1.28E+01	1.28E+01	4.58E-01	7.80E-01	8.82E-02	1.14E-01	8.73E-02	8.76E-02
SWMU 99a	Technetium-99	3/16	4.61E+02	2.65E+03	1.04E+03	1.06E+03	9.08E-02	9.10E-02	9.08E-02	2.94E-04
SWMU 99a	Thorium-234	1/16	2.16E+01	5.30E+01	1.51E-02	2.58E+00	1.23E-02	1.23E-02	1.23E-02	1.24E-02
SWMU 99a	Uranium-234	1/1	1.64E+01	1.64E+01	1.84E+00	5.05E+00	2.73E-02	2.73E-02	2.73E-02	3.56E-02
SWMU 99a	Uranium-238	1/1	5.17E+01	5.17E+01	5.17E+00	1.67E+01	1.06E-01	1.06E-01	1.06E-01	1.29E-01
	Total (mrad/day)				1.05E+03	1.08E+03	2.50E-01	3.72E-01	3.42E-01	2.86E-01
	Hazard index[f]				1.05E+00	1.08E+00	2.50E-03	3.72E-03	3.42E-03	2.86E-03

[a] No radionuclides were detected from SWMU 193a or 193b.

[b] RMA = Reasonable Maximum Activity. This is the lower of the UCL95 and maximum detected activities.

[c] Estimated dose rates for plants and soil invertebrates are based on maximum detected activities.

[d] Estimated dose rates for wildlife receptors are based on RMAs.

[e] Soil inverts = soil invertebrates; vole = meadow vole; shrew = short-tailed shrew; mouse = white-footed mouse; weasel = long-tailed weasel.

[f] HIs for plants and soil invertebrates represent the total dose rate divided by the recommended dose rate limit of 1 rad/day. HIs for wildlife receptors represent the total dose rate divided by the recommended dose rate limit of 100 mrad/day.

7. CONCLUSIONS

7.1 INTRODUCTION

This section presents conclusions about the hydrogeologic setting, contaminant sources, contaminant migration pathways, affected environmental media, human health risk assessment, and ecological risk assessment at the four WAG 28 sites. These conclusions are drawn from known site conditions, the nature and extent of contamination, the fate and transport of contaminants, and the risk to human health and the ecological communities associated with the identified contaminants.

7.1.1 Major Findings of Contaminant Distribution

The WAG 28 RI found the following major contaminant distribution:

- Impact to all media from releases as a result of past activities at SWMUs 99, 193 and 194 has been minimal. No contaminant release was documented from AOC 204 (the construction debris pile).
- Isolated occurrences of elevated levels of metals were detected at three of the four sites.
- Two potential contaminant sources have been identified near SWMU 99. The first is related to a storm drain that may underlie the Classified Scrap Yard. Shallow soils adjacent to this drain contained elevated activities of several radionuclides. The second includes radiological contaminated material stored in the Classified Scrap Yard and Cylinder Storage Area that may have impacted the surrounding surface soils.
- Shallow soils at SWMU 193 do not contain significant concentrations of any VOAs and, therefore, the areas investigated within the SWMU are not a source for trichloroethene contamination present in the underlying RGA Northeast Plume. Additionally, the concentration of trichloroethene in RGA groundwater in the vicinity of the Millwright Shop was found to have significantly decreased since 1994, indicating that the contaminated groundwater plume has migrated downgradient of the area.
- Isolated occurrences of SVOAs (primarily PAHs) were detected at several surface locations within SWMU 193.
- Several metals were detected at elevated levels at SWMU 194. These metals may have been derived from the leach field formerly located at the site.
- The results of the WAG 28 RI at AOC 204 indicate that the construction debris pile is not a source of trichloroethene contamination in the underlying RGA Northeast Plume. The findings of the WAG 28 RI support the earlier assumption that the surface drainage system at Outfall 011 is one source for this contamination.
- Groundwater data indicate that vertical migration from RGA into the underlying McNairy Formation is not a significant contaminant migration pathway.

7.1.2 Hydrogeologic Setting

During the WAG 28 RI process, data were gathered on the stratigraphy and hydrogeologic conditions at each of the four sites. Because of the proximity of the investigated sites, the basic subsurface geology and hydrogeology were found to be similar among the areas studied. However, locally, the position of an erosional surface known as the Porters Creek Terrace Slope results in significant changes in both the stratigraphy and hydrogeology. Several of the DQO questions that were developed during the WAG 28 Work Plan development stage concern the physical and chemical properties and stratigraphy of the geologic units at each of the sites. To eliminate redundancy, these related DQO questions are addressed here in a single section. Significant variation in the subsurface environment among the sites is, however, emphasized.

What is the stratigraphy (and physical and chemical properties) of the soil and water?

Three primary units are encountered in the subsurface at WAG 28. These are, in ascending order: the McNairy Formation, the RGA, and the UCRS. The McNairy Formation is predominantly gray lignitic clays and silts that subcrop at approximately 100 ft bgs. The McNairy sediments are overlain by 40–45 ft of porous and permeable, coarse-grained sands and chert gravels of the RGA. The RGA is in turn overlain by a fining-upward sequence of gravels, sands, silts, and clays that comprise the UCRS. Sands and gravels within the UCRS are typically fine-grained, poorly sorted, and occur as laterally discontinuous lenses within a matrix of finer-grained material.

Southwest and east of PGDP, post-Eocene erosion has resulted in the formation of an important subsurface feature known as the Porters Creek Terrace. The Porters Creek Terrace Slope dips toward the north, and as a result the sediments of the RGA and UCRS are truncated against the terrace face. Locally, a thin layer of gravel, sand, or loess is developed above this erosional surface south of the terrace slope (Clausen et al. 1992a).

At PGDP, the UCRS averages approximately 55–60 ft in thickness, and the water table is typically encountered at approximately 45–50 ft bgs. As a result, most of the UCRS sediments are within the vadose zone, whereas the RGA and McNairy Formations are below the water table.

The physical and chemical properties of the subsurface soil and the depth to the water table at WAG 28 play an important role in the migration and distribution of contaminants in the subsurface. Releases at any of the WAG 28 sites would have occurred within the upper few feet of soil in the clay-rich upper UCRS soil.

The most common contaminants identified at the WAG 28 sites were metals. The downward mobility of these metal ions would be expected to be inhibited by the low permeability of the clay-rich UCRS soil and by absorption processes. However, the UCRS sediments are not an aquitard, and leaching of contaminants and downward migration of precipitation toward the RGA, although retarded, would be expected to be a contaminant dispersion pathway at each of the sites investigated. Because most of the UCRS sediments are within the vadose zone and because of the lack of laterally continuous sands within the UCRS, conduits for long-distance lateral migration of contaminants in the shallow subsurface would not be expected to be a significant contaminant distribution process.

Downward migrating contaminated fluids that reached the water table (the RGA) would then be incorporated into the RGA groundwater and transported laterally to the east-northeast as part of the Northeast Plume. Because the McNairy Formation has a lower permeability than the overlying RGA sediments and because groundwater flow typically will follow the path of least resistance, mixing of the contaminated RGA groundwater in the Northeast Plume with the deeper McNairy flow system has not been extensive. As a result, McNairy groundwater samples collected during the WAG 28 RI were found to be relatively uncontaminated.

Areas located on the terrace south of PGDP, such as SWMU 194 and the south end of SWMU 193, are underlain by continental gravels and sands. Where "terrace gravels" overlie Eocene sands, the units function as one hydrogeologic unit with a range of hydraulic conductivities similar to the RGA (Phillips and Douthitt 1993).

7.2 WAG 28 SWMU/AOC SPECIFIC DQO QUESTIONS

The primary DQO questions that were developed during scoping of the work plan have been grouped into like categories and are addressed individually for each of the three SWMUs investigated and for AOC 204.

7.2.1 SWMU 99 (former Kellogg Building Location)

What are the potential contaminants? What are the plant processes that contributed to the contamination? When did the release(s) occur?

It is known that the former Kellogg Building was utilized for pipe fabrication during its 5 years (1951–1955) of operation, but information is limited on other specific activities that may have been performed at the site. It is possible that degreasing operations using trichloroethene were conducted at the site. Leach fields that were connected to the Kellogg Building by a clay pipe also represent a potential release site at SWMU 99. No releases are known from SWMU 99, but spills and leaks may have occurred. Presently SWMU 99 is occupied by the Classified Materials Scrap Yard and Cylinder Storage Area.

What are the contaminants and activities at the source? What are the areas and volumes of the source zones? What are the contaminant distributions and concentrations?

Several metals were detected in the surface and subsurface soils at SWMU 99. Possible site-related metal contaminants that could have originated from leaks or spills associated with operations of the Kellogg Building include barium, cobalt, chromium, and lead. However, only isolated occurrences of these metals at relatively low concentrations (less than twice screening levels) were documented in the surface and subsurface. A conservative estimate of the maximum volume of soil impacted by metals contamination is slightly more than 1,800,000 ft^3.

Low levels of technetium-99 radioactivity were detected in the surface soil at SWMU 99. A conservative estimate of the maximum volume of surface soil impacted by technetium-99 is approximately 104,000 ft^3.

Shallow subsurface soil containing elevated levels of technetium-99 (maximum concentration 2650 pCi/g), other radionuclides, and PCBs was found adjacent to a storm drain outside the boundary of SWMU 99. Although the origin of the drainpipe is unknown, the pipe appears to trend toward the Classified Scrap Yard (SWMU 16), and it is believed that the drain system may have collected surface runoff from the SWMU. The pipe is currently sealed off, but the impacted soil represents a potential source for leaching of contaminants to the groundwater. The full extent of contamination associated with the drainpipe has not been defined.

What are the past, present, and future release mechanisms? What are the contaminant migration trends? What are the past, present, and future migration pathways? What are the effects of underground utilities and plant operations on migration pathways?

Past releases at SWMU 99 include isolated spills and leaks that may have occurred in association with historical activities at the Kellogg Building. Activities at the Kellogg Building were terminated in 1955 and, therefore, do not present the potential for current or future releases.

A drainpipe of unknown origin located outside SWMU 99 appears to trend toward the site and it is believed that this drain system may have collected surface runoff from SWMU 16 (located within SWMU 99). Releases to the subsurface soil and perhaps to surface water via the backfill adjacent to this abandoned plant storm drain may have served as a conduit for the migration of contaminants in the past.

The storm drain is currently sealed off, and continued releases through the pipe should not occur in the future. A soil sample collected from within the pipe indicated that contaminants are not present at significant levels, and migration to surface water would be expected to be miminal. Migration of contaminants to the surface water or subsurface along the backfill could, however, represent an ongoing process.

SWMU 99 is presently utilized as a Classified Materials Scrap Yard and a Cylinder Storage Area. Material stored in these areas is probably the source of the low levels of technetium-99 observed in the surface soils and in the backfill material adjacent to the abandoned storm drain. The lack of other contaminants detected in the site surface and subsurface soils during the WAG 28 RI suggests that no other releases are currently occurring at SWMU 99.

What is the role of the UCRS in contaminant transport? To what area is the dissolved-phase plume migrating?

UCRS groundwater near SWMU 99 contains low concentrations of trichloroethene and its associated daughter products at several locations. Elevated technetium-99 activities were also present in several of the UCRS water samples. The highest technetium-99 activity was from a boring located south (upgradient) of SWMU 99.

The lack of trichloroethene and technetium-99 in UCRS soils at SWMU 99 indicates that the contaminated UCRS groundwater may have migrated into the vicinity of SWMU 99 from a source to the south of the former Kellogg Building. The distribution of trichloroethene and technetium-99 in the RGA near SWMU 99 at levels that are significantly above the concentrations reported from the overlying UCRS groundwater suggests that the source for both of these constituents is also located upgradient of SWMU 99.

7.2.2 SWMU 193 (former McGraw Construction Facility)

What are the potential contaminants? What are the plant processes that contributed to the contamination? When did the release(s) occur?

No historical releases have been documented from the operation of the McGraw Construction Facility. Based on the history of the site, which was used as a staging area for construction of PGDP, waste such as volatiles and metals may have been released to the environment. Operations were discontinued at the site before the end of the 1950s, and the facilities have been removed. Based on the presence of trichloroethene in RGA groundwater, it was suspected that a source for the chlorinated solvent existed at SWMU 193.

What are the contaminants and activities at the source? What are the areas and volumes of the source zones? What is the contaminant distribution and concentration?

During the WAG 28 RI several metals, including aluminum, chromium, manganese, cobalt, and lead were detected at levels above screening values in the surface and subsurface soil at SWMU 193. Most of the occurrences of elevated metals concentrations were from isolated detections.

All detections of aluminum were at concentrations only slightly above background levels and are considered to be within the range of expected variability for naturally occurring soils. Isolated detections of cobalt, manganese, chromium, and lead during the WAG 28 RI and cadmium during an earlier investigations may represent small spills or leaks. Chromium was detected at a maximum of 88.7 mg/kg in the surface soil at the Schulman Pipe Fabrication Shop and at 85.8 mg/kg in the subsurface at the Millwright Shop. Cobalt, manganese, and cadmium were present only in the subsurface at the leach fields in the southern part of the SWMU.

What are the past, present, and future release mechanisms? What are the contaminant migration trends? What are the past, present, and future migration pathways? What are the effects of underground utilities and plant operations on migration pathways?

Releases of metals to the surface may have occurred at the Schulman Pipe Fabrication Shop and at the Millwright Shop during building of PGDP in the 1950s. None of these facilities are currently in operation and are not considered to be potential current or future release points. Metals may also have been released to the subsurface from the leach fields located in the southern half of SWMU 193. Because of the isolated occurrence of metals contamination, no migration pathway has been identified. Clay-rich soils, such as the UCRS sediments, would be expected to inhibit mobility of metals in the subsurface.

What is the role of the UCRS in contaminant transport? To what area is the dissolved-phase plume migrating?

The UCRS water level is generally present at a depth of 50 or more feet bgs on the north side of SWMU 193. Only five water samples could be collected from the UCRS at SWMU 193 during the WAG 28 RI because of the slow recharge rate of the UCRS and the local absence of water-bearing zones. Contaminants reported from the UCRS samples included low levels of trichloroethene and degradation products and low activities of several radionuclides RGA groundwater samples collected from SWMU 193 contained trichloroethene and degradation products, uranium-235, and technetium-99 at levels above screening criteria. Because neither trichloroethene nor radionuclides were present in the overlying UCRS soil at SWMU 193, the source for the contaminants in the RGA groundwater in the area of the Millwright Shop and Schulman Pipe Fabrication Shop cannot be attributed to leaching of overlying contaminated soil.

7.2.3 SWMU 194 (Leach Fields)

What are the potential contaminants? What are the plant processes that contributed to the contamination? When did the release(s) occur?

SWMU 194 encompasses the leach fields that served the administration building of the former McGraw Construction Facility. Undocumented releases may have occurred during construction of PGDP in the early 1950s. Based on previous investigations, metals such as chromium, cadmium, and lead may have been released to the subsurface at the leach fields.

What are the contaminants and activities at the source? What are the area and volumes of the source zones? What is the contaminant distribution and concentration?

Chromium was detected at maximum concentrations that were less than twice screening levels in two samples from SWMU 194. Although the vertical extent of the impacted soil has not been defined, a maximum distribution for impacted soils as currently defined by the distribution of chromium in the subsurface has been calculated as 13,383,500 ft^3.

What are the past, present, and future release mechanisms? What are the contaminant migration trends? What are the past, present, and future migration pathways? What are the effects of underground utilities and plant operations on migration pathways?

Metal contaminants detected at SWMU 194 represent isolated releases of metal-bearing fluids to the shallow subsurface through the leach field that serviced the former McGraw Administrative Building. Because of the low mobility of metals in clay-rich soil, the area impacted would be expected to be relatively small and confined to the upper few tens of feet of soil. The leach field has been out of service for over 40 years, and all associated structures have been removed. Current and future releases from SWMU 194 are, therefore, not likely.

What is the role of the UCRS in contaminant transport? To what area is the dissolved-phase plume migrating?

Because of the low mobility of metals in the subsurface, migration of metals to the UCRS groundwater at a depth of 50 feet bgs is not expected. Therefore, development of a dissolved-phase groundwater plume at SWMU 194 is unlikely.

7.2.4 AOC 204 (Construction Debris Pile)

What are the potential contaminants? What are the plant processes that contributed to the contamination? When did the release(s) occur?

No specific contaminants were identified for AOC 204 during the earlier site evaluation. Contaminants that may have been disposed of at the site may have included any common building materials used during construction of PGDP in the early 1950s.

What are the contaminants and activities at the source? What are the areas and volumes of the source zones? What is the contaminant distribution and concentration?

Historically, trichloroethene and trichloroethene-related compounds are the only contaminants that have been detected in the UCRS soil at AOC 204. The maximum concentration of trichloroethene detected was 123 µg/kg. Boring 204-15, drilled immediately adjacent to Outfall 011, was the only sampling point that exhibited VOAs in soil from the surface to the top of the UCRS groundwater. As the investigation moved away from this location and toward the center of AOC 204, the first occurrence of trichloroethene and related VOAs was not encountered until a depth of 15 ft bgs. The geometry of the identified contaminant zone suggests that the origin of the VOAs is due to infiltration and dispersion of VOA-bearing fluids that are sourced from surface water flow in Outfall 011.

What are the past, present, and future release mechanisms? What are the contaminant migration trends? What are the past, present, and future migration pathways? What are the effects of underground utilities and plant operations on migration pathways?

No releases from AOC 204 have been documented and, based on the fact that the debris pile has been inactive for over 40 years, no releases are expected in the future. VOA-impacted UCRS soil identified at AOC 204 is attributed to past infiltration and diffusion of contaminated surface water originating from the drainage system now known as Outfall 011.

What is the role of the UCRS in contaminant transport? To what area is the dissolved-phase plume migrating?

UCRS groundwater beneath AOC 204 has been impacted by VOA releases. The source for the contamination is believed to have been the downward percolation of VOA-bearing fluids from surface water flow in the Outfall 011 drainage system. Migration of UCRS contaminated water to the underlying RGA in the vicinity of AOC 204 may contribute to the VOA contamination known to be present in the RGA in the Northeast Plume.

7.3 BASELINE RISK ASSESSMENT

The decision rules for the WAG 28 RI are addressed individually for SWMUs 99, 193, and 194 and AOC 204 in Tables 7.1 through 7.4. Conclusions based on the DQO process and the risk-based decision rules indicate that risk from exposure to contaminated media exists at each of these sites. However, these risks do not pose an imminent or immediate threat to human health or the environment at any of the four locations. Risk-based analysis of data generated during the investigation indicates that response actions may be appropriate for impacted media at each of the four sites.

Table 7.1. WAG 28 SWMU 99-specific decision rules and conclusions

Decision rule	Conclusion	Comments
D1a: If the concentration of analytes found in the source zone may result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through contact with contaminated media, or if the concentration of analytes in the source zone may result in detrimental impacts to nonhuman receptors through contact with contaminated media as indicated by exceeding ecological screening criteria, and if the concentrations of analytes in the source zone are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise pursue a "no further action" decision (see D1b and D1c).	Direct contact with surface soil (at SWMU 99a) results in a cancer risk that exceeds de minimis levels for industrial workers. However, the likelihood of systemic toxicity effects does not exceed de minimis levels. Risks to the excavation worker exposed to contaminated subsurface soils exceed de minimis levels. Risks from potential use of the RGA as a drinking water source at the SWMU exceed de minimis levels for the industrial worker. Risks to nonhuman receptors are generally de minimis under current conditions. Additionally, the contaminant concentrations are such that risks may not exceed de minimis levels in the future.	Risks for the industrial worker from exposure to surface soil were greater than de minimis when the analysis was performed using default exposure parameters. When the assessment was performed using site-specific exposure parameters and reduced dermal absorption values for inorganic chemicals, the cancer risk remained above de minimis levels. Risks were greater than de minimis for the excavation worker when default exposure parameters were used. Furthermore, when the assessment was performed using site-specific exposure parameters, the risk remained greater than de minimis levels. Groundwater drawn from the RGA is not currently used at PGDP. No surface soil samples were taken from SWMU 99b. Risks to nonhuman receptors are driven by two hot-spot samples, one with a high concentration of barium and the other containing technetium-99. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1b: If concentrations of analytes found in the source zone exceed applicable or relevant and appropriate requirements (ARARs), evaluate actions that will bring contamination within the source zone into compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1c).	Concentrations in RGA groundwater exceed maximum contamination levels (MCLs) for some contaminants.	No chemical-specific ARARs are available for screening contaminant concentrations in sediment or soil. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1c: If contaminants found at the site are known to transform or degrade into chemicals that could lead to increased risks to human health or the environment or into chemicals for which there are ARARs, and if the concentrations of these contaminants may result in risks greater than those defined in D1a or concentrations greater than ARARs, then evaluate actions that will mitigate potential future risk or promote compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1b).	The organic COCs driving the risk from direct contact with groundwater at SWMU 99 may degrade into more toxic substances, potentially leading to increased risk and/or concentrations that may exceed chemical-specific ARARs.	Trichloroethene is a risk driver in RGA groundwater at SWMU 99.

Table 7.1. (continued)

Decision rule	Conclusion	Comments
D2a: If secondary sources are found, and if the concentrations of analytes within the secondary sources are found to potentially result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through contact with contaminated media at the unit, and if the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider secondary sources when making remedial decisions for the unit.	Secondary sources were identified. These secondary sources may continue to release contaminants to groundwater.	Beryllium is present in subsurface soil at SWMU 99.
D3a: If contaminants are found in the source zone, or if secondary sources are found, and are found to be migrating or may migrate from the source zone or from secondary sources at concentrations that may potentially result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through use of contaminated media at downgradient points of exposure, and the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider risk posed by migratory pathways when evaluating remedial alternatives for the unit (see D3b).	Multimedia transport modeling indicates that contaminants may be released from soils and secondary sources at SWMU 99, potentially resulting in risk to off-site residential groundwater users that could exceed de minimis levels at some point in the future. Pathway analysis performed as part of fate and transport modeling indicated that releases to surface water bodies are unlikely.	Lithium and manganese are SWMU-specific COCs (SWMU 99a) with potential to migrate to off-site groundwater in concentrations that may impact human health at some future time.
D3b: If contaminants are found in the source zone, or if secondary sources are found, and if these contaminants are found to be migrating or may migrate from the source zone or from the secondary sources at concentrations that exceed ARARs, then evaluate actions that will bring migratory concentrations into compliance with ARARs; otherwise, do not consider ARARs when examining migratory pathways during the evaluation of remedial actions (see D3a).	Multimedia transport modeling indicates that contaminants released from source soil at SWMU 99(a) will not result in concentrations in off-site groundwater that exceed MCLs.	
D4a: If Decision Rules D1a, D1b, D1c, D2a, D3a, or D3b indicate that remedial actions are needed, then evaluate response actions to mitigate risk in the source zone. (Refer to Sects. 5.11 and 5.12 of the WAG 27 Work Plan for discussions of possible response actions.)	Results for Decision Rules D1a, D1b, D1c, D2a, and D3a indicate that response actions are needed. Evaluations of response actions to mitigate risk in the source zone may be appropriate.	
D5a: If contaminants in the source zone are found to migrate to the RGA, then determine the contributions from the source zone to support future remedial actions for existing groundwater contamination in the groundwater integrator unit; otherwise, do not determine contributions.	Multimedia transport modeling to off-site locations was completed because contaminants were suspected of migrating to the RGA. This information will be considered when determining remedial actions for the Groundwater OU at PGDP.	Multimedia transport modeling was completed using MEPAS. A more sophisticated modeling tool may be appropriate when determining remedial actions for the Groundwater OU.

Table 7.1. (continued)

Decision rule	Conclusion	Comments
D5b: If contaminants in the source zone are found to migrate to the Surface Water Integrator Unit (i.e., Big and Little Bayou Creek and ditches discharging directly to regulated outfalls), then determine the contributions from the source zone to support future remedial actions for past releases to the Surface Water Integrator Unit; otherwise, do not determine contributions.	Pathway analysis performed as part of fate and transport modeling indicated that releases to surface water bodies are unlikely.	

General Conclusions for SWMU 99

1. Contamination is present in surface soil at SWMU 99 that may lead to risks to industrial workers exceeding de minimis levels. Per Decision Rule D4a, response actions to mitigate the risks from direct contact with this medium may be appropriate.
2. Contamination is present in subsurface soil at SWMU 99 that may lead to risks exceeding de minimis levels for unprotected excavation workers. Per Decision Rule D4a, response actions to mitigate risks from direct contact with this medium may be appropriate.
3. Contamination is present in RGA groundwater at SWMU 99 that may lead to risks exceeding de minimis levels for industrial workers. Additionally, results indicate that contamination present in soil and in secondary sources at concentrations could lead to continuing contamination of groundwater. Per Decision Rule D4a, response actions to mitigate the risks from direct contact with this medium and to address continued contaminant migration thereto might be appropriate.
4. SWMU 99 is not a source of contamination to surface water bodies, and suspected groundwater contaminant levels at points of exposure are expected to be less than regulatory values such as MCLs.

Table 7.2. WAG 28 SWMU 193-specific decision rules and conclusions

Decision rule	Conclusion	Comments
D1a: If the concentration of analytes found in the source zone may result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through contact with contaminated media, or if the concentration of analytes in the source zone may result in detrimental impacts to nonhuman receptors through contact with contaminated media as indicated by exceeding ecological screening criteria, and if the concentrations of analytes in the source zone are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise pursue a "no further action" decision (see D1b and D1c).	Risks from direct contact with surface soil exceed de minimis levels for industrial workers. Risks to the excavation worker exposed to contaminated soils exceed de minimis levels. Risks from potential use of the RGA as a drinking water source at the SWMU exceed de minimis levels for the industrial worker. Risks to nonhuman receptors are generally de minimis under current conditions. Additionally, contaminant concentrations are such that risks are unlikely to exceed de minimis levels in the future.	Risks to the industrial worker from exposure to surface soil were greater than de minimis when the analysis was performed using default exposure parameters. When the assessment was performed using site-specific exposure parameters and reduced dermal absorption values for inorganic chemicals, the cancer risk remained above de minimis levels at SWMUs 193a and 193b. Risks were greater than de minimis for the excavation worker when default exposure parameters were used. Furthermore, when the assessment was performed using site-specific exposure parameters, the cancer risk remained greater than de minimis levels (4.7E-4). Groundwater drawn from the RGA is not currently used at PGDP. Chromium is the primary risk driver for nonhuman receptors at SWMU 193. However, SWMUs 193b and 193c are largely covered with gravel and/or concrete, thereby offering no substantial habitat for ecological receptors. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1b: If concentrations of analytes found in the source zone exceed ARARs, then evaluate actions that will bring contamination within the source zone into compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1c).	Concentrations in RGA groundwater exceed MCLs for some contaminants.	No chemical-specific ARARs are available for screening contaminant concentrations in sediment or soil. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1c: If contaminants found at the site are known to transform or degrade into chemicals that could lead to increased risks to human health or the environment or into chemicals for which there are ARARs, and if the concentrations of these contaminants may result in risks greater than those defined in D1a or concentrations greater than ARARs, then evaluate actions that will mitigate potential future risk or promote compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1b).	COCs constituting primary risk drivers through direct contact with groundwater at SWMU 193 may degrade into more toxic substances, potentially leading to increased risk at concentrations that may exceed chemical-specific ARARs.	A range of chlorinated alkenes was detected in RGA groundwater at SWMU 193. Soil-specific risk drivers such as beryllium and chromium are unlikely to degrade.

Table 7.2. (continued)

Decision rule	Conclusion	Comments
D2a: If secondary sources are found, and if the concentrations of analytes within the secondary sources are found to potentially result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through contact with contaminated media at the unit, and if the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider secondary sources when making remedial decisions for the unit.	Secondary sources were identified. These secondary sources may continue to release contaminants to groundwater.	Beryllium and chromium are present in subsurface soil at SWMU 193.
D3a: If contaminants are found in the source zone, or if secondary sources are found, and are found to be migrating or may migrate from the source zone or from secondary sources at concentrations that may potentially result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through use of contaminated media at downgradient points of exposure, and the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider risk posed by migratory pathways when evaluating remedial alternatives for the unit (see D3b).	Multimedia transport modeling indicates that contaminants may be released from soils and secondary sources at SWMU 193, potentially resulting in risk to off-site residential groundwater users that could exceed de minimis levels at some point in the future. Pathway analysis performed as part of fate and transport modeling indicated that releases to surface water bodies are unlikely.	Priority COCs include chromium, lithium and manganese.
D3b: If contaminants are found in the source zone, or if secondary sources are found, and if these contaminants are found to be migrating or may migrate from the source zone or from the secondary sources at concentrations that exceed ARARs, then evaluate actions that will bring migratory concentrations into compliance with ARARs; otherwise, do not consider ARARs when examining migratory pathways during the evaluation of remedial actions (see D3a).	Multimedia transport modeling indicates that the contaminants released from soil at SWMU 193 will result in concentrations in off-site groundwater that exceed MCLs.	The model predicts a concentration in excess of the current MCL for chromium, a level arising from the subsurface soil levels of this contaminant at SWMU 193a.
D4a: If Decision Rules D1a, D1b, D1c, D2a, D3a, or D3b indicate that remedial actions are needed, then evaluate response actions to mitigate risk in the source zone. [Refer to Sects. 5.11 and 5.12 of the WAG 27 Work Plan (DOE 1998) for discussions of possible response actions.]	Results for Decision Rules D1a, D1b, D1c, D2a, D3a, and D3b indicate that response actions are needed. Evaluations of response actions to mitigate risk in the source zone may be appropriate.	
D5a: If contaminants in the source zone are found to migrate to the RGA, then determine contributions from the source zone to support future remedial actions for existing groundwater contamination in the groundwater integrator unit; otherwise, do not determine contributions.	Multimedia transport modeling to off-site locations was completed because contaminants were suspected of migrating to the RGA. This information will be considered when determining remedial actions for the Groundwater OU at PGDP.	Multimedia transport modeling was completed using MEPAS. A more sophisticated modeling tool may be appropriate when determining remedial actions for the Groundwater OU.

Table 7.2. (continued)

Decision rule	Conclusion	Comments
D5b: If contaminants in the source zone are found to migrate to the Surface Water Integrator Unit (i.e., Big and Little Bayou Creek and ditches discharging directly to regulated outfalls), then determine contributions from the source zone to support future remedial actions for past releases to the Surface Water Integrator Unit; otherwise, do not determine contributions.	Pathway analysis performed as part of fate and transport modeling indicated that releases to surface water bodies are unlikely.	
General Conclusions for SWMU 193 1. Contamination is present in surface soil at SWMU 193 that may lead to risks exceeding de minimis levels for industrial workers. Per Decision Rule D4a, response actions to mitigate the risks from direct contact with this medium may be appropriate. 2. Contamination is present in subsurface soil at SWMU 193 that may lead to risks exceeding de minimis levels for unprotected excavation workers. Per Decision Rule D4a, response actions to mitigate the risks from direct contact with this medium may be appropriate. 3. Contamination is present in RGA groundwater at SWMU 193 that may lead to risks exceeding de minimis levels for industrial workers. Additionally, results indicate that the contamination present in soil and in secondary sources at concentrations could lead to continuing contamination of groundwater. Per Decision Rule D4a, response actions to mitigate risks from direct contact with this medium and to address continued contaminant migration might be appropriate. 4. SWMU 193 is not a source of contamination to surface water bodies.		

DOE (U.S. Department of Energy). 1998. *Integrated Remedial Investigation/Feasibility Study Work Plan for the Waste Area Grouping 27 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1518&D3, Paducah, KY.

Table 7.3. WAG 28 SWMU 194-specific decision rules and conclusions

Decision rule	Conclusion	Comments
D1a: If the concentration of analytes found in the source zone may result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through contact with contaminated media, or if the concentration of analytes in the source zone may result in detrimental impacts to nonhuman receptors through contact with contaminated media as indicated by exceeding ecological screening criteria, and if the concentrations of analytes in the source zone are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise pursue a "no further action" decision (see D1b and D1c).	Risks to the excavation worker exposed to contaminated soils exceed de minimis levels for both carcinogenicity and systemic toxicity.	Risks were greater than de minimis for the excavation worker when default exposure parameters were used. Furthermore, when the assessment was performed using site-specific exposure parameters, cancer risk remained greater than de minimis levels (3.3E-4). No surface soil or groundwater samples were taken at this site. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1b: If concentrations of analytes found in the source zone exceed ARARs, then evaluate actions that will bring contamination within the source zone into compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1c).	Comparisons of contaminant levels to MCLs could not be made because no groundwater samples were taken at SWMU 194.	No chemical-specific ARARs are available for screening contaminant concentrations in sediment or soil. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1c: If contaminants found at the site are known to transform or degrade into chemicals that could lead to increased risks to human health or the environment or into chemicals for which there are ARARs, and if the concentrations of these contaminants may result in risks greater than those defined in D1a or concentrations greater than ARARs, then evaluate actions that will mitigate potential future risk or promote compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1b).	Contaminants in the subsurface soil at SWMU 194 will not degrade substantially to other, potentially toxic substances.	Beryllium is a primary risk driver at this SWMU.
D2a: If secondary sources are found, and if the concentrations of analytes within the secondary sources are found to potentially result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through contact with contaminated media at the unit, and if the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider secondary sources when making remedial decisions for the unit.	No secondary sources were identified at SWMU 194.	

Table 7.3. (continued)

Decision rule	Conclusion	Comments
D3a: If contaminants are found in the source zone or if secondary sources are found and are found to be migrating or may migrate from the source zone or from secondary sources at concentrations that may potentially result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through use of contaminated media at downgradient points of exposure, and the concentrations of analytes are greater than those that are expected to occur naturally in the environment, evaluate actions that will mitigate risk; otherwise, do not consider risk posed by migratory pathways when evaluating remedial alternatives for the unit (see D3b).	Multimedia transport modeling indicates that SWMU-specific contaminants have the potential to be released from soils at rates that will result in risks to off-site residential groundwater users exceeding de minimis levels. Pathway analysis performed as part of fate and transport modeling indicated that releases to surface water bodies are unlikely.	Chromium has the potential to migrate off site from this SWMU.
D3b: If contaminants are found in the source zone or if secondary sources are found, and if these contaminants are found to be migrating or may migrate from the source zone or from the secondary sources at concentrations that exceed ARARs, evaluate actions that will bring migratory concentrations into compliance with ARARs; otherwise, do not consider ARARs when examining migratory pathways during evaluation of remedial actions (see D3a).	Multimedia transport modeling indicates that the contaminants released from subsurface soil at SWMU 194 could result in concentrations in off-site groundwater that exceed MCLs.	Modeled amounts of chromium in the downgradient RGA exceed the MCL.
D4a: If Decision Rules D1a, D1b, D1c, D2a, D3a, or D3b indicate that remedial actions are needed, then evaluate response actions to mitigate risk in the source zone. [Refer to Sects. 5.11 and 5.12 of the WAG 27 Work Plan (DOE 1998) for discussions of possible response actions.]	Results for Decision Rules D1a, D3a, and D3b indicate that response actions are needed. Evaluations of response actions to mitigate risk in the source zone may be appropriate.	
D5a: If contaminants in the source zone are found to migrate to the RGA, determine contributions from the source zone to support future remedial actions for existing groundwater contamination in the groundwater integrator unit; otherwise, do not determine contributions.	Multimedia transport modeling to off-site locations was completed because contaminants were suspected of migrating to the RGA. This information will be considered when determining remedial actions for the Groundwater OU at PGDP.	Multimedia transport modeling was completed using MEPAS. A more sophisticated modeling tool may be appropriate when determining remedial actions for the Groundwater OU.
D5b: If contaminants in the source zone are found to migrate to the Surface Water Integrator Unit (i.e., Big and Little Bayou Creek and ditches discharging directly to regulated outfalls), determine contributions from the source zone to support future remedial actions for past releases to the Surface Water Integrator Unit; otherwise, do not determine contributions.	Pathway analysis performed as part of fate and transport modeling indicated that releases to surface water bodies are unlikely.	

General Conclusions for SWMU 194

1. Contamination in subsurface soil at SWMU 194 may lead to risks exceeding de minimis levels for unprotected excavation workers. Per Decision Rule D4a, response actions to mitigate risks from direct contact with this medium may be appropriate.
2. Results indicate that the contamination present in subsurface soil has the capacity to migrate to groundwater, with the potential for impacting the health of off-site receptors. Per Decision Rule D4a, response actions to mitigate the risks from direct contact with this medium and to address continued contaminant migration thereto might be appropriate.
3. SWMU 194 is not a source of contamination to surface water bodies.

DOE (U.S. Department of Energy). 1998. *Integrated Remedial Investigation/Feasibility Study Work Plan for the Waste Area Grouping 27 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1518&D3, Paducah, KY.

Table 7.4. WAG 28 AOC 204-specific decision rules and conclusions

Decision rule	Conclusion	Comments
D1a: If the concentration of analytes found in the source zone may result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through contact with contaminated media, or if the concentration of analytes in the source zone may result in detrimental impacts to nonhuman receptors through contact with contaminated media as indicated by exceeding ecological screening criteria, and if the concentrations of analytes in the source zone are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise pursue a "no further action" decision (see D1b and D1c).	Risks to the future on-site excavation worker exposed to contaminated soils at AOC 204 did not exceed de minimis levels for systemic toxicity, but did just exceed de minimis levels for an increase in cancer risk (1.1E-6). Risks from potential use of the RGA as a drinking water source at the SWMU exceed de minimis levels for the future industrial worker (ELCR of 1.3E-3 and a HI of 33.3).	Risks were greater than de minimis for the excavation worker when default exposure parameters were used. However, when the assessment was performed using site-specific exposure parameters, the cancer risk was less than de minimis levels (3.0E-7). Risks were greater than de minimis for the future industrial worker exposed to RGA groundwater when default exposure parameters were used. Furthermore, when the assessment was performed using site-specific exposure parameters, cancer risk and systemic toxicity remained above de minimis levels. Groundwater drawn from the RGA is not currently used at PGDP. No surface soil samples were taken from AOC 204. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1b: If concentrations of analytes found in the source zone exceed ARARs, then evaluate actions that will bring contamination within the source zone into compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1c).	Concentrations in RGA groundwater exceed MCLs for some contaminants.	No chemical-specific ARARs are available for screening contaminant concentrations in sediment or soil. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1c: If contaminants found at the site are known to transform or degrade into chemicals that could lead to increased risks to human health or the environment or into chemicals for which there are ARARs, and if the concentrations of these contaminants may result in risks greater than those defined in D1a or concentrations greater than ARARs, then evaluate actions that will mitigate potential future risk or promote compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1b).	A number of contaminants in the RGA groundwater at AOC 204 have the potential to degrade into other toxic substances that themselves might impact human health or be out of compliance with ARARs.	Chlorinated alkenes and PCB-1254 are the driving contaminants in RGA groundwater at AOC 204.
D2a: If secondary sources are found, and if the concentrations of analytes within the secondary sources are found to potentially result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through contact with contaminated media at the unit, and if the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider secondary sources when making remedial decisions for the unit.	No secondary sources were identified at AOC 204.	

Table 7.4. (continued)

Decision rule	Conclusion	Comments
D3a: If contaminants are found in the source zone or if secondary sources are found and are found to be migrating or may migrate from the source zone or from secondary sources at concentrations that may potentially result in a cumulative ECLR greater than 1E-6 or a cumulative HI greater than 1 through use of contaminated media at downgradient points of exposure, and the concentrations of analytes are greater than those that are expected to occur naturally in the environment, evaluate actions that will mitigate risk; otherwise, do not consider risk posed by migratory pathways when evaluating remedial alternatives for the unit (see D3b).	Multimedia transport modeling indicates that SWMU-specific contaminants could be released from soil at rates that will result in risks exceeding de minimis levels to off-site residential groundwater users.	Trichloroethene is a priority COC.
D3b: If contaminants are found in the source zone or if secondary sources are found, and if these contaminants are found to be migrating or may migrate from the source zone or from the secondary sources at concentrations that exceed ARARs, evaluate actions that will bring migratory concentrations into compliance with ARARs; otherwise, do not consider ARARs when examining migratory pathways during evaluation of remedial actions (see D3a).	Multimedia transport modeling indicates that the contaminants released from subsurface soil at AOC 204 could result in concentrations in off-site groundwater that exceed MCLs.	Trichloroethene is a priority COC.
D4a: If Decision Rules D1a, D1b, D1c, D2a, D3a, or D3b indicate that remedial actions are needed, evaluate response actions to mitigate risk in the source zone. [Refer to Sects. 5.11 and 5.12 of the WAG 27 Work Plan (DOE 1998) for discussions of possible response actions.]	Results for Decision Rules D1a, D1b, D1c, D3a, and D3b indicate that response actions are needed. Evaluations of response actions to mitigate risk in the source zone may be appropriate.	
D5a: If contaminants in the source zone are found to migrate to the RGA, determine contributions from the source zone to support future remedial actions for existing groundwater contamination in the groundwater integrator unit; otherwise, do not determine contributions.	Multimedia transport modeling to off-site locations was completed because contaminants were suspected of migrating to the RGA. This information will be considered when determining remedial actions for the Groundwater OU at PGDP.	Multimedia transport modeling was completed using MEPAS. A more sophisticated modeling tool may be appropriate when determining remedial actions for the Groundwater OU.
D5b: If contaminants in the source zone are found to migrate to the Surface Water Integrator Unit (i.e., Big and Little Bayou Creek and ditches discharging directly to regulated outfalls), determine contributions from the source zone to support future remedial actions for past releases to the Surface Water Integrator Unit; otherwise, do not determine contributions.	Pathway analysis performed as part of fate and transport modeling indicated that releases to surface water bodies are unlikely.	

General Conclusions for AOC 204

1. Contamination in subsurface soil at AOC 204 may lead to risks exceeding de minimis levels for unprotected excavation workers. Per Decision Rule D4a, response actions to mitigate risks from direct contact with this medium may be appropriate.
2. Contamination is present in RGA groundwater at AOC 204 that may lead to risks exceeding de minimis levels for future industrial workers. Additionally, results indicate that the contamination present in soil and in secondary sources at concentrations could lead to continuing contamination of groundwater. Per Decision Rule D4a, response actions to mitigate the risks from direct contact with this medium and to address continued contaminant migration thereto might be appropriate.
3. AOC 204 is not a source of contamination to surface water bodies.

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