APPENDIX E

TECHNICAL INFORMATION

THIS PAGE INTENTIONALLY LEFT BLANK

CONTENTS

E.1. DATA AND DOCUMENTS USED TO ESTABLISH BACKGROUND CONCENTRATIONS E-7

E.2. SITE-SPECIFIC EXPOSURE INFORMATION E-19
- E.2.1 PHASE I SITE INVESTIGATION RESULTS OF SURFACE WATER AND GROUNDWATER USERS SURVEY TO DETERMINE GROUNDWATER USE NEAR PGDP E-19
- E.2.2 SUMMARY OF AGRICULTURAL PRACTICES IN BALLARD COUNTY, KENTUCKY E-19
- E.2.3 SUMMARY OF AGRICULTURAL PRACTICES IN MCCRACKEN COUNTY, KENTUCKY E-21
- E.2.4 AREA OF CROP LAND IN BALLARD AND MCCRACKEN COUNTY, KENTUCKY E-22
- E.2.5 RECREATIONAL USE OF BAYOU AND LITTLE BAYOU CREEKS NEAR PGDP E-22
- E.2.6 ANNUAL HARVESTS OF TURKEYS AND DEER IN MCCRACKEN AND BALLARD COUNTIES, KENTUCKY, AND WATERFOWL IN BALLARD COUNTY, KENTUCKY E-25
- E.2.7 USE OF EXPOSURE UNITS IN RISK CALCULATIONS AND REMEDIAL DECISIONS E-32

E.3. KENTUCKY REGULATORY GUIDANCE E-49

E.4. FLOWCHART FOR UNCERTAINTY MANAGEMENT FOR UNKNOWN AREAS OF CONTAMINATION E-51

E.5. COMPILED PARAMETERS FOR PROBABILISTIC RISK ASSESSMENTS E-55

E.6. LEAD-210 AT PGDP E-99

E.7. PAH CONTAMINATION AND ESTABLISHMENT OF REMEDIAL GOALS E-111

E.8. SITE-SPECIFIC SOIL SCREENING LEVELS AND SITE-SPECIFIC DILUTION ATTENUATION FACTORS AT THE PADUCAH GASEOUS DIFFUSION PLANT E-123

E.9. HUMAN HEALTH INFORMATION FOR THE PADUCAH VAPOR INTRUSION EVALUATION E-137

E.10. PERTINENT TOXICITY VALUES AND INFORMATION E-163

E.11. MEETING MINUTES FROM PADUCAH RISK ASSESSMENT WORKING GROUP E-167

E.12. ANTHROPOGENIC BACKGROUND AT PGDP E-233

E.13. PFAS ANTHROPOGENIC BACKGROUND AT PGDP E-249

ATTACHMENT E1: 1995 QUESTIONNAIRE AND RESPONSES REGARDING RECREATIONAL USAGE OF BAYOU AND LITTLE BAYOU CREEKS.....E1-1

ATTACHMENT E2: 2014 E-MAIL UPDATE REGARDING RECREATIONAL USAGE OF BAYOU AND LITTLE BAYOU CREEKS.....E2-1

FIGURES

E.1. Map of West Kentucky Wildlife Management Area....E-26
E.2. Map of West Kentucky Wildlife Management Area Horse Trails....E-27
E.3. Map of Ballard Wildlife Management Area....E-28
E.4. Wildlife Management Area Map Legend....E-29
E.5. Total Turkey Harvest in Ballard and McCracken Counties 2000–2016....E-30
E.6. Total Deer Harvest in Ballard and McCracken Counties 2000–2016....E-31
E.7. Lead-210 Decay Chain....E-99
E.8. Lead-210 Soil/Sediment Samples....E-100
E.9. Total PAH Concentrations by Depth....E-113
E.10. Total PAH in Surface (0-1 ft bgs) Soil/Sediment Samples....E-115
E.11. Total PAH Subsurface (1-10 ft bgs) Soil/Sediment Samples....E-117
E.12. Total PAH Deep Subsurface (>10 ft bgs) Soil/Sediment Samples....E-119
E.13. Probabilistic DAF Distribution....E-126

TABLES

E.1. Turkey Harvested on Public Land in Western Kentucky in 2016....E-30
E.2. Deer Harvested on Public Land in Western Kentucky in 2016....E-31
E.3. Waterfowl Counts in Ballard Wildlife Management Area....E-32
E.4. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment....E-102
E.5. Results of Filtering....E-106
E.6. Maximum Benzo(a)pyrene Concentrations by Sample Depth....E-112
E.7. Maximum Total PAHs by Depth....E-112
E.8. Modeling Matrix for Groundwater....E-127
E.9. Example Site-Specific and Default Inputs for Key COPCs....E-130
E.10. Vapor Intrusion Screening Levels (VISLs) for Analytes of Interest for PGDP—Commercial....E-139

THIS PAGE INTENTIONALLY LEFT BLANK

E.1. DATA AND DOCUMENTS USED TO ESTABLISH BACKGROUND CONCENTRATIONS

As early as the late 1950s, the U.S. Department of Energy (DOE) and its predecessor organization determined the importance of identifying background concentrations for metals and radionuclides in the environment. Routine monitoring programs were established for air and grass. In 1971, the monitoring program was expanded to include surface soil samples taken at four locations at the plant perimeter, with the only analyte being total uranium.

In 1973, the locations of sampling were changed from the perimeter locations mentioned herein to four locations five miles from the plant perimeter. The only analyte was total uranium. From 1975 until 1985, the environmental monitoring program for soils continued as described.

The environmental report for 1986 states that the analyte list for soil samples was expanded from only uranium to thorium-230, neptunium-237, plutonium-239, and isotopic uranium. Starting in 1988, the radionuclide analyte list for soil samples taken as part of the environmental monitoring programs was expanded to include total uranium, uranium-238, cesium-237, potassium-40, neptunium-237, plutonium-239, thorium-230, and technetium-99. Also, beginning in 1988, analyses were performed for 36 metals. Metals included in the analyte list were aluminum, antimony, arsenic, barium, beryllium, bismuth, calcium, cadmium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, niobium, phosphorus, potassium, ruthenium, silver, sodium, silicon, strontium, tantalum, thallium, thorium, tin, titanium, tungsten, vanadium, zinc, and zirconium.

PHASE I AND II SITE INVESTIGATIONS REFERENCE SAMPLING

In 1988, DOE and the U.S. Environmental Protection Agency (EPA) entered into a Consent Order that defined the mutual objectives of the EPA and DOE to study groundwater contamination and the threat of releases from the Paducah Gaseous Diffusion Plant (PGDP). A copy of that Consent Order can be found at the following link: https://eic.pad.pppo.gov/Search.aspx?accession=I-02004-0002.

As part of the effort to address the Consent Order, a Site Investigation was performed in two phases. The *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (ER/KY-4) was completed in 1991; and *Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/SUB/13B-97777C P-03/1991/1, was completed in 1992. During the completion of Phase I and II Site Investigations, the need for background or reference concentrations for inorganic analytes and reference activities radionuclides was recognized. To meet this need, the Site Investigations included the collection of soil samples from areas outside known plant influence. To establish reference activities for radionuclides, 33 surface soil samples (from 0 to 12 inches in depth) were collected from areas at least 5 miles east and southeast of PGDP in May and June of 1990. The analytes for this sampling effort included gross alpha and gross beta, neptunium-237, technetium-99, plutonium-239, thorium-230, uranium-238, uranium-234, and uranium-235.

To establish reference concentrations for inorganic and metals, five surface samples (from 0 to 6 inches in depth) were taken during the Phase II Site Investigation in areas near the PGDP, but outside areas suspected to be influenced by the plant operations. The metals included aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, cyanide, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium and zinc. A report entitled *Inorganic Soil and Groundwater Chemistry Near Paducah Gaseous Diffusion Plant; Paducah, Kentucky*, ORNL/TM-12897, was prepared and sent to the regulatory agencies for information purposes. While this

report was not prepared to establish background groundwater and soil concentrations, it did discuss potential background concentrations for soil and groundwater at PGDP.

In response to comments on *Soil and Groundwater Chemistry Near Paducah Gaseous Diffusion Plant; Paducah, Kentucky*, ORNL/TM-12897 (1996), DOE prepared another internal report with a more extensive evaluation of existing data (primarily data from the Phase I and II Site Investigations, entitled *Background Concentrations and Human Health Risk-based Screening Criteria for Metals in Soil at the Paducah Gaseous Diffusion Plant*, KY/EM-77&D1. The report contained data for 146 surface sampling locations and 597 samples for subsurface soils for metals analysis. The metals included all of those analyzed in the Phase II report with the exception of cyanide in surface and subsurface soils and thallium in subsurface soils. A consensuses of reviewers believed that the data evaluation in this report was not sufficient to establish background of metals in soil and requested that the document be revised.

In response, a revised report, *Background Concentrations and Human Health Risk-based Screening Criteria for Metals in Soil at the Paducah Gaseous Diffusion Plant*, DOE/OR/07-1417&D2, was prepared (DOE 1996). EPA conditionally approved this revised document. The conditions included the reanalysis of four metals including antimony, beryllium, cadmium, and thallium. Also in 1996, the Commonwealth of Kentucky accepted the revised report. The Commonwealth also called for additional sampling to verify the background concentrations of antimony, beryllium, cadmium, and thallium.

DOE issued the final revision of a work plan entitled *Project Plan for the Background Soils Project for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1414&D2 (DOE 1996). As described in this work plan, DOE was to verify with additional sampling the background concentrations for the four metals listed in the conditional approval letters for DOE/OR/07-1417&D2 and to determine the background concentrations of selected radionuclides.

DOE issued the final revision of the report for the background soils project entitled, *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1586&D2. In this report, the values selected by DOE as background concentrations for soil in the DOE/OR/07-1417 report were combined with the background concentrations analyzed for antimony, beryllium, cadmium, thallium, and selected radionuclides, and final background concentration data sets were established. This report included 15 surface soil and 41 subsurface soil sampling locations for the four metals listed above. In addition the significant radionuclides included cesium-137, neptunium-237, plutonium-239, plutonium-238, potassium-40, radium-226, strontium-90, technetium-99, thorium-228, thorium-230, thorium-232, uranium-238, uranium-234, and uranium-235. A variety of statistical methods as described in *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1586&D2, were used to evaluate the data and ultimately these data were used with data from previous investigations to establish the background values for soils at PGDP. The background values are presented in Appendix A.

INSERT Pages E-9 through E-17

INSERT Pages E-9 through E-17

INSERT Pages E-9 through E-17

INSERT Pages E-9 through E-17

INSERT Pages E-9 through E-17

INSERT Pages E-9 through E-17

INSERT Pages E-9 through E-17

INSERT Pages E-9 through E-17

INSERT Pages E-9 through E-17

THIS PAGE INTENTIONALLY LEFT BLANK

E.2. SITE-SPECIFIC EXPOSURE INFORMATION

This section of the appendix contains copies or excerpts of reports, memoranda, articles, and links to reports that are useful in developing exposure assessments for PGDP and justifying various assumptions made when completing risk assessments and analyses. These include the following:

- Site Investigation surface water and groundwater users survey to determine groundwater use near PGDP (CH2M HILL 1991);
- Summary of agricultural practices in Ballard County, Kentucky;
- Summary agricultural practices in McCracken County, Kentucky;
- Area of crop land in Ballard and McCracken Counties, Kentucky;
- Recreational use of Bayou and Little Bayou Creeks near PGDP;
- Annual harvests of geese, ducks, turkeys, and deer in McCracken and Ballard Counties, Kentucky; and
- Reports entitled, "Planning Issues for Superfund Site Remediation," and "Quantitative Decision Making in Superfund: A Data Quality Objectives Case Study," from *Hazardous Materials Control* regarding use of exposure units in risk calculations and remedial decisions.

E.2.1 PHASE I SITE INVESTIGATION RESULTS OF SURFACE WATER AND GROUNDWATER USERS SURVEY TO DETERMINE GROUNDWATER USE NEAR PGDP

A surface water and groundwater user's survey was conducted as part of the Site Investigation Phase I, and is included in the document's Appendix 2B-15 (CH2M HILL 1991). The appendix in its entirety can be found at the following link: https://eic.pad.pppo.gov/Search.aspx?accession=I-02300-0001 (part f). Appendix 2B-15 begins on page 276 of the pdf.

Because the Site Investigation Phase I is large, it is broken into several parts. Part "f" contains Appendix 2B-15. Click "View" at the left of the screen of the above link to see the document.

E.2.2 SUMMARY OF AGRICULTURAL PRACTICES IN BALLARD COUNTY, KENTUCKY

This section summarizes information obtained from a 2017 search of various public records to identify the parameters of agricultural practices in Ballard County, Kentucky.

Population. Population information for Ballard County is taken from http://www.city-data.com/county/Ballard_County-KY.html, accessed October 2017.

- 8,240 population (as of 2014)
- Size of family households: 1,179 2-persons; 552 3-persons; 405 4-persons; 157 5-persons; 52 6-persons; 27 7-or-more-persons

- Size of nonfamily households: 881 1-person; 131 2-persons; 5 3-persons; 6 4-persons; 1 5-persons; 1 6-persons

Agriculture in Ballard County. Agriculture information for Ballard County is taken from http://www.city-data.com/county/Ballard_County-KY.html, accessed October 2017.

- Average size of farms: 233 acres
- Average value of agricultural products sold per farm: $70,647
- Average value of crops sold per acre for harvested cropland: $213.68
- The value of nursery, greenhouse, floriculture, and sod as a percentage of the total market value of agricultural products sold: 0.18%
- The value of livestock, poultry, and their products as a percentage of the total market value of agricultural products sold: 55.27%
- Average total farm production expenses per farm: $60,366
- Harvested cropland as a percentage of land in farms: 63.59%
- Irrigated harvested cropland as a percentage of land in farms: 0.29%
- Average market value of all machinery and equipment per farm: $50,268
- The percentage of farms operated by a family or individual: 91.56%
- Average age of principal farm operators: 55 years
- Average number of cattle and calves per 100 acres of all land in farms: 8.31
- Milk cows as a percentage of all cattle and calves: 5.09%
- Corn for grain: 22,422 harvested acres
- All wheat for grain: 10,372 harvested acres
- Soybeans for beans: 39,814 harvested acres
- Vegetables: 15 harvested acres
- Land in orchards: 5 acres

Gardening. Gardening information was updated from a 1994 interview with the Agricultural Extension Agent of Ballard County. The current Ballard County Agricultural Extension Agent confirmed in December 2013 that most of the information is feasible; however, the percentage of the population with a garden has dropped considerably.

(1) Approximately 25–30% of the population have a garden
(2) Commonly grown garden vegetables are squash, corn, tomatoes, green beans, and peas
(3) The average garden site is one-fourth acre
(4) Approximately 0.1 to 0.2 pounds of garden grown vegetables are consumed per individual per day

(5) Approximately 80% of gardeners can their produce
(6) Growing season is April 5 to October 12: 4,560 hours

E.2.3 SUMMARY OF AGRICULTURAL PRACTICES IN MCCRACKEN COUNTY, KENTUCKY

This section summarizes information obtained from a 2017 search of various public records to identify the parameters of agricultural practices in McCracken County, Kentucky.

Population. Population information for McCracken County is taken from http://www.city-data.com/county/McCracken_County-KY.html, accessed October 2017.

- 65,316 population (as of 2014)
- Size of family households: 8,862 2-persons; 4,185 3-persons; 3,035 4-persons; 1,200 5-persons; 411 6-persons; 198 7-or-more-persons
- Size of nonfamily households: 8,993 1-person; 1,153 2-persons; 119 3-persons; 50 4-persons; 11 5-persons; 5 6-persons; 5 7-or-more-persons

Agriculture in McCracken County: Agriculture information for McCracken County is taken from http://www.city-data.com/county/McCracken_County-KY.html, accessed October 2017.

- Average size of farms: 161 acres
- Average value of agricultural products sold per farm: $29,777
- Average value of crops sold per acre for harvested cropland: $215.65
- The value of nursery, greenhouse, floriculture, and sod as a percentage of the total market value of agricultural products sold: 11.92%
- The value of livestock, poultry, and their products as a percentage of the total market value of agricultural products sold: 26.35%
- Average total farm production expenses per farm: $22,605
- Harvested cropland as a percentage of land in farms: 63.19%
- Irrigated harvested cropland as a percentage of land in farms: 0.21%
- Average market value of all machinery and equipment per farm: $34,300
- The percentage of farms operated by a family or individual: 96.80%
- Average age of principal farm operators: 55 years
- Average number of cattle and calves per 100 acres of all land in farms: 3.63
- Corn for grain: 9,160 harvested acres
- All wheat for grain: 3,899 harvested acres

- Soybeans for beans: 37,579 harvested acres
- Vegetables: 85 harvested acres
- Land in orchards: 122 acres

Gardening. Gardening information was updated from a 1994 interview with the Agricultural Extension Agent of McCracken County. The current McCracken County Agricultural Extension Agent confirmed in January 2014, that most of the information still is feasible; however, the percentage of the population with a garden has dropped considerably, as has the average garden size.

(1) Approximately 10% of the population have a garden.

(2) Common grown garden vegetables are squash, com, tomatoes, green beans, and lettuce.

(3) The average garden size is one-eighth acre.

(4) During harvest season (three months), approximately 2 pounds of garden grown vegetables are consumed per individual per day.

(5) Approximately all gardeners can their produce.

E.2.4 AREA OF CROP LAND IN BALLARD AND MCCRACKEN COUNTY, KENTUCKY

The following information is taken from USDA's National Agricultural Statistics Service in cooperation with the Kentucky Department of Agriculture. The information is available at the following web site, accessed October 2017:

http://www.nass.usda.gov/Statistics_by_State/Kentucky/Publications/State_Census_Summaries/Historical_Ag_Statistics/

	Harvested Acres	
Year	**Ballard**	**McCracken**
1982	80,133	45,870
1987	62,583	40,444
1992	69,662	36,450
1997	74,158	46,291
2002	71,870	54,003
2007	70,700	43,272
2012	78,427	41,832

E.2.5 RECREATIONAL USE OF BAYOU AND LITTLE BAYOU CREEKS NEAR PGDP

The usage information originally was provided by Charlie Logsdon, West Kentucky Wildlife Management Area (WKWMA) Supervisor, in November 1995, in response to a questionnaire sent to him by Fuller, Mossbarger, Scott, and May Engineers, Inc., of Lexington, Kentucky (see Attachment E1). The information was used by the United States Army Corps of Engineers to support a preliminary risk calculation for Bayou and Little Bayou Creeks that was completed in 1997. In response to a recommendation from the Paducah Risk Assessment Working Group (RAWG) in October 2013, the information was provided to Tim Kreher, the current WKWMA Manager, for review and update. Mr. Kreher returned the updated information to the RAWG on January 21, 2014. Mr. Kreher's e-mail to LeAnne Garner, chair of the Risk Assessment Working

Group, is included in Attachment E2.The information below provides a summary of the updated information.

E.2.5.1. Bayou Creek

1. What is the average number of visitors per year to Bayou Creek?

The number of visits by people using Bayou Creek specifically is estimated to be 225 visits. This is for a specific activity involving Bayou Creek, such as fishing. More people may be in the vicinity while using the WKWMA, but their use of Bayou Creek maybe for only an instant (i.e., using a log to cross Bayou Creek to hunt on the other side of the creek).

2. Of this number, how many are adults and how many are children?

Of the 225 visits of people using Bayou Creek, 150 are adults and 75 are children. This is an estimate based on our observations of people using the area.

3. Are most of your visitors repeat or one-time visitors on a yearly basis?

Most of these people would be one-time users; however, 10% of the total number of users could be classified as repeat users. The highest number of visits by one person specifically using Bayou Creek would probably be < 15.

4. What is the average time (hours) spent in Bayou Creek? Is there a difference in average time spent between adult and child usage?

The average time spent in Bayou Creek by users is unknown; however, the amount of time spent/trip would be similar to other activities. An estimate of the average number of hours spent/trip for activities were as follows: Quail hunting ~ 5, rabbit hunting ~ 5, bowhunting for deer ~ 5, duck hunting ~ 4, and raccoon hunting ~ 4. Raccoon hunting and duck hunting would be the activities most likely associated with Bayou Creek. There would be little, if any, difference between adult and child usage of the area.

Actual time spent in the creek may be cases where hunters cross one or both creeks by wading through shallow spots; in most cases, these people are wearing rubber boots or waders. When hunters do wade through the creeks, again it is a brief exposure of less than 30 seconds each time.

5. What are the common recreational usages in the area? What is the percentage breakdown of usages by the visitors (i.e., what percentage of visitors fish, hunt, hike, swim. etc.)?

WKWMA is used heavily by a wide variety of users. Annually, the estimated number of visits for the following activities are the following: fishing ~ 7,500 visits/year; hunting and dog training ~ 6,000-9,000; field trials ~ 2,250; hiking ~ 150; berry and nut picking ~ 300; driving through for a variety of reasons ~ 75,000.

There are brief exposures to both Bayou and Little Bayou Creeks by dog trainers riding horses where they cross the creek via the method of the horse and dog wading through the creek while the rider is mounted (i.e., the riders does not have contact with the water for the most part). Such crossings are brief, less than 10 seconds at a time. For activities involving Bayou Creek alone: fishing—225 (see Question 1).

6. What is the number of repeat visits per year by anyone individual or group of individuals? What is the average time spent (hours) in the area by the higher frequency visitors?

Refer to Questions 3 and 4.

7. For individuals who are fishing in the area, are they mostly bank fishing or wade fishing? Can you estimate the percentage breakdown between the two? What is the average time spent in the area by a fisherman?

Most, if not all, would be bank fishermen. Most of the fishing would occur at three points: (1) where the iron bridge in Tract 4 crosses Bayou Creek, (2) where the collapsed bridge in Tract 4 crosses Bayou Creek (by weir constructed by PGDP), and (3) where the concrete crossing bridges Bayou Creek in Tract 6. While it may occur, no wade fishing has been observed. No actual data are available, but should be similar to the length of visits noted in Question 4.

8. Is there a harvestable fish population in Bayou Creek? If there is, is there enough to support subsistence fishing (i.e., 0.284 kg of meat flesh/meal) for one person to eat 128 meals a year? If not, how much fish, and how often could a person best expect to harvest a meal for consumption?

There is a harvestable fish population in Bayou Creek. A person potentially could expect to catch 0.284 kg of fish on a regular basis; however, this is assuming that the person is not culling (throwing back extremely small fish). The frequency of being able to catch 0.248 kg of fish would increase as one approaches the mouth of Bayou Creek. Also, the only way the creek could support 128 meals a year is if there were a major influx of fish from the Ohio River. This does occur when there is a backwater. During the backwater periods, catches of 50 to several hundred pounds of catfish can be taken (this has been observed) on trotlines. This would not be indicative of risks associated with the plant.

Fishing activity in the creeks rarely is observed outside of the portion that crosses through TVA-owned property near where the creeks join and meet the Ohio River (referred to as Tract 6 of the WKWMA).

E.2.5.2. Little Bayou Creek

1. What is the average number of visitors per year to Little Bayou Creek?

The number of people visiting Little Bayou Creek essentially is zero, with the exception of PGDP personnel and a few fishermen (maybe 30 visits annually) who fish a large beaver pond above the outfalls of the plant. A few people (bowhunters and dog trainers) may cross the creek occasionally, but these visits would be brief (the majority would be measured in seconds or minutes). Field trial galleries do cross the creek (over a large dirt-covered culvert) north of McCaw Road; however, they do not enter the creek, and the whole process takes seconds.

2. Of this number, how many are adults and how many are children?

The visitors would be adults.

3. Are most of your visitors repeat or one-time visitors on a yearly basis?

Refer to Bayou Creek Question 3 (Section E.2.5.1). Visitors to Little Bayou Creek would be repeat users, probably less than 15 visits per year, and most of them fall into the brief encounter scenario described in Question 1.

4. What is the average time (hours) spent in Little Bayou? Is there a difference in average time spent between adult and child usage?

Most encounters with Little Bayou Creek would be measured in seconds. Fishermen who use the beaver pond above the outfalls may fish on average 3 hours.

5. What are the common recreational usages in the area? What is the percentage breakdown of usages by the visitors (i.e. what percentage of visitors fish, hunt, hike, swim, etc.)?

See Bayou Creek Question 5 (Section E.2.5.1).

6. What is the number of repeat visits per year by anyone individual or group of individuals? What is the average time spent (hours) in the area by the higher frequency visitors?

Field trials that cross the creek may occur 12–15 weekends of the year. Most of the participants would be repeat users. The sum of all the encounters with Little Bayou Creek would be measured in minutes for the most frequent user, and most would cross the creek only on the culvert and dirt crossings.

7. For individuals who are fishing in the area, are they mostly bank fishing or wade fishing? Can you estimate the percentage breakdown between the two? What is the average time spent in the area by a fisherman?

All fishermen in the beaver pond would be bank fishermen because the pond is too deep to wade.

8. Is there a harvestable fish population in Little Bayou? If there is, is there enough to support subsistence fishing (i.e., 0.284 kilograms of meat flesh/meal) for one person to eat 128 meals a year? If not, how much fish, and how often could a person best expect to harvest a meal for consumption?

Other than the beaver pond above the outfalls, it would be nearly impossible to catch 0.284 kg of fish from Little Bayou Creek. There is a fish population, but most would fall in the minnow category and are not desirable by fishermen. In the beaver pond, it would be possible to catch this amount, but it would not support subsistence fishing (128 meals/year).

E.2.6 ANNUAL HARVESTS OF TURKEYS AND DEER IN MCCRACKEN AND BALLARD COUNTIES, KENTUCKY, AND WATERFOWL IN BALLARD COUNTY, KENTUCKY

PGDP is surrounded by the WKWMA (Figures E.1 and E.2). Additionally, several solid waste management units (SWMUs) (currently listed as no further action) are located in the Ballard Wildlife Management Area (WMA) (Figure E.3). Figure E.4 provides a legend for features in the WMAs. Both of these areas are home to hunting and fishing. Huntable populations of turkey, deer, dove, squirrel, rabbits, and quail exist in the area. Migratory geese and ducks also are abundant in the area. Table E.1 and Figure E.5 and Table E.2 and Figure E.6 show the hunting statistics for turkey and deer in western Kentucky.

The figures and tables within this subsection include additional information regarding wildlife harvests of turkey and deer recorded by Kentucky's telecheck program. Additionally, the reported inventories of ducks and geese found in the Ballard WMA during the 2015/2016 and 2016/2017 hunting seasons are presented in Table E.3. Maps and information regarding game were taken from the Kentucky Department of Fish and Wildlife Resources web site, http://fw.ky.gov accessed in October 2017.

Figure E.1. Map of West Kentucky Wildlife Management Area

Figure E.2. Map of West Kentucky Wildlife Management Area Horse Trails

Figure E.3. Map of Ballard Wildlife Management Area

Figure E.4. Wildlife Management Area Map Legend

Table E.1. Turkey Harvested on Public Land in Western Kentucky in 2016[a]

Public Land	Male	Female	Total	Archery	Firearm	Muzzle loader	Crossbow
Ballard WMA	23	1	24	0	24	0	0
Beechy Creek WMA	2	0	2	0	2	0	0
Boatwright WMA	7	0	7	0	7	0	0
Clarks River National Wildlife Refuge	19	3	22	0	21	1	0
Coil Estate WMA	1	0	1	0	1	0	0
Doug Travis WMA	14	4	18	1	17	0	0
Jones-Keeney WMA	1	0	1	0	1	0	0
Kaler Bottoms WMA	6	0	6	00	6	0	0
Kentucky Lake WMA	3	0	3	0	3	0	0
Lake Barkley WMA	11	0	11	0	11	0	0
Land Between the Lakes National Recreational Area	54	0	54	0	54	0	0
Livingston County WMA and State Natural Area	9	2	11	1	10	0	0
Obion Creek WMA	4	0	4	0	4	0	0
Ohio River Islands WMA	0	0	0	0	0	0	0
Pennyrile State Forest	21	0	21	0	21	0	0
Reelfoot National Wildlife Refuge	0	0	0	0	0	0	0
Tradewater WMA	1	0	1	0	1	0	0
West Kentucky WMA	32	2	34	1	33	0	0
Winford WMA	0	0	0	0	0	0	0
Totals	208	12	220	3	216	1	0

[a] Numbers are indicative of telechecked game (http://app.fw.ky.gov/harvestweb/TurkeyPublicLandRegion.aspx, accessed 10/6/2017). Both spring and fall hunting seasons are included.

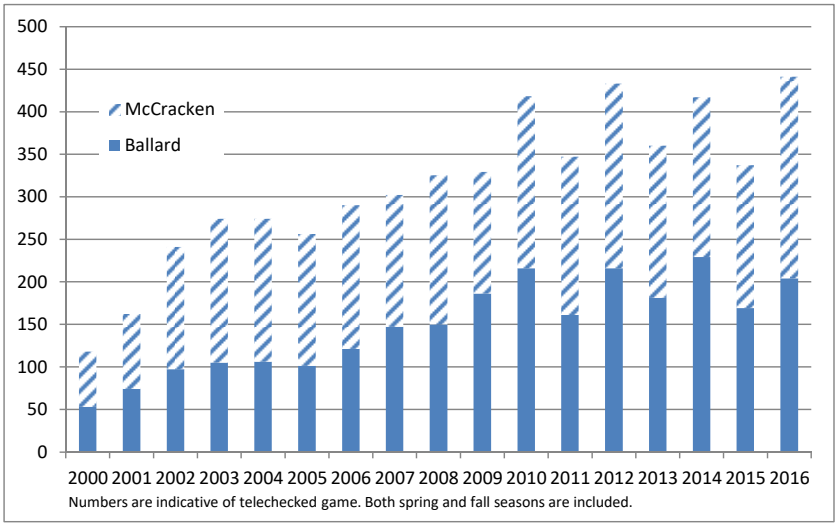


Figure E.5. Total Turkey Harvest in Ballard and McCracken Counties 2000–2016

Table E.2. Deer Harvested on Public Land in Western Kentucky in 2016[a]

Public Land	Male	Female	Total	Archery	Firearm	Muzzle loader	Crossbow
Ballard WMA	24	26	50	17	33	0	0
Beechy Creek WMA	12	9	21	3	18	0	0
Boatwright WMA	25	15	40	2	36	1	1
Clarks River National Wildlife Refuge	79	94	173	20	139	13	1
Coil Estate WMA	0	0	0	0	0	0	0
Doug Travis WMA	17	14	31	3	26	2	0
Jones-Keeney WMA	6	3	9	1	7	1	0
Kaler Bottoms WMA	11	18	29	3	25	1	0
Kentucky Lake WMA	37	28	65	6	55	3	1
Lake Barkley WMA	45	47	92	8	65	17	2
Land Between the Lakes National Recreational Area	168	61	229	57	155	15	2
Livingston County WMA and State Natural Area	34	32	66	11	5	49	1
Obion Creek WMA	19	23	42	4	37	1	0
Ohio River Islands WMA	1	1	2	0	2	0	0
Pennyrile State Forest	22	18	40	37	1	1	1
Reelfoot National Wildlife Refuge	0	0	0	0	0	0	0
Tradewater WMA	1	4	5	4	1	0	0
West Kentucky WMA	15	27	42	40	0	0	2
Winford WMA	3	0	3	0	3	0	0
Totals	**519**	**420**	**939**	**216**	**608**	**104**	**11**

[a]Numbers are indicative of telechecked game (http://app.fw.ky.gov/harvestweb/deerpubliclandregion.aspx, accessed 10/6/2017).

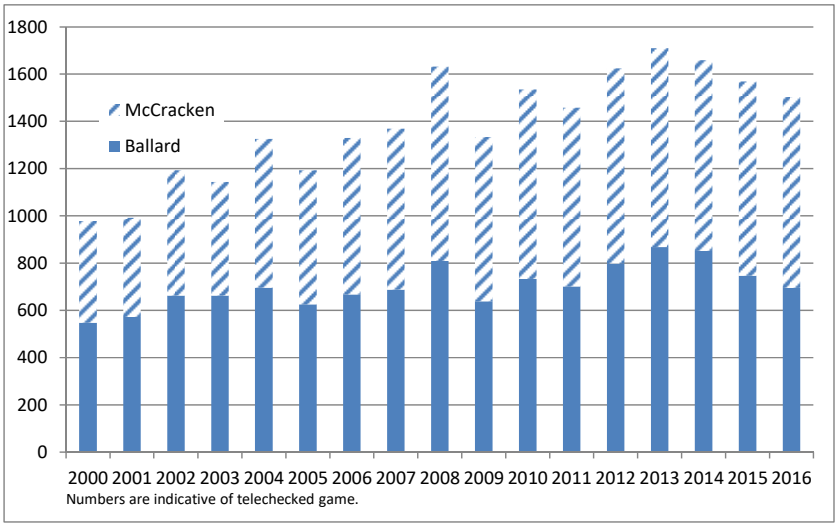


Figure E.6. Total Deer Harvest in Ballard and McCracken Counties 2000–2016

Table E.3. Waterfowl Counts in Ballard Wildlife Management Area

Date	Population Count		Harvest			Date	Population Count		Harvest		
	Ducks	Geese	Ducks	Canada Geese	Other Geese		Ducks	Geese	Ducks	Canada Geese	Other Geese
12/16/2015	43,000	2,600	19	0	1	12/7/2016	35,900	65	85	2	1
12/17/2015	43,000	2,600	16	0	0	12/8/2016	35,900	65	72	3	0
12/18/2015	43,000	2,600	24	0	0	12/9/2016	35,900	65	27	0	0
12/19/2015	41,500	500	26	0	0	12/10/2016	35,900	65	17	0	1
12/20/2015	41,500	500	28	0	0	12/11/2016	35,900	65	70	0	0
12/30/2015						12/14/2016	60,672	120	45	0	0
12/31/2015						12/15/2016	60,672	120	6	0	0
1/1/2016						12/16/2016	60,672	120	19	2	0
1/2/2016						12/17/2016	60,672	120	88	2	0
1/3/2016						12/18/2016	60,672	120	78	0	0
1/6/2016						12/21/2016	64,122	564	55	0	0
1/7/2016	No counts on					12/22/2016	64,122	564	62	0	0
1/8/2016	waterfowl due to		WMA closed			12/23/2016	64,122	564	56	0	0
1/9/2016	flood waters					12/28/2016	54,000	350	73	2	2
1/10/2016						12/29/2016	54,000	350	50	2	0
1/13/2016						12/30/2016	54,000	350	41	0	0
1/14/2016						12/31/2016	54,000	350	80	2	0
1/15/2016						1/4/2017	22,500	350	49	0	0
1/16/2016						1/5/2017	22,500	350	40	0	0
1/17/2016						1/6/2017	22,500	350	0	0	1
1/27/2016			93	1	0	1/7/2017	22,500	350	5	0	0
1/28/2016			104	1	4	1/8/2017	22,500	350	2	0	0
1/29/2016			86	2	4	1/11/2017	55,000	600	61	1	6
1/30/2016			114	0	0	1/12/2017	55,000	600	62	0	3
1/31/2016			110	0	2	1/13/2017	55,000	600	88	0	6
						1/14/2017	55,000	600	31	0	0
						1/15/2017	55,000	600	57	1	2
						1/18/2017	41,500	150	53	0	0
						1/19/2017	41,500	150	20	0	0
						1/20/2017	41,500	150	21	0	0
						1/21/2017	41,500	150	57	0	0
						1/22/2017	41,500	150	44	0	2
						1/25/2017	39,000	480	22	0	1
						1/26/2017	39,000	480	20	0	1
						1/27/2017	39,000	480	51	0	2
						1/28/2017	39,000	480	40	6	0
						1/29/2017	39,000	480	71	0	0
						2/4/2017	30,010	415	62	0	3
						2/5/2017	30,900	415	50	0	1

E.2.7 USE OF EXPOSURE UNITS IN RISK CALCULATIONS AND REMEDIAL DECISIONS

According to two reports ("Planning Issues for Superfund Site Remediation" and "Quantitative Decision Making in Superfund: A Data Quality Objectives Case Study," from *Hazardous Materials Control*) received by the risk analysis section, industrial workers range 0.5 acres per day. This area is where the worker may be exposed to contamination. This area is called an exposure unit. For risk assessment purposes, it is reasoned that an exposure unit of 0.5 acres is consistent with the activities at PGDP. Exposure was weighted based on the size of the SWMU and the 0.5-acre exposure units. If the size of the SWMU was smaller than the 0.5-acre exposure unit, then the fraction was introduced into the chronic daily intake equation. The fraction, however, cannot exceed 1. Copies of the two reports are provided as references.

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-46

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

INSERT Pages E-33 through E-47

THIS PAGE INTENTIONALLY LEFT BLANK

E.3. KENTUCKY REGULATORY GUIDANCE

Copies of regulatory guidance listed below previously have been presented in this chapter. This regulatory guidance is available in Appendix E, of *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1, Human Health*, DOE/LX/07-0107&D2/R8/V1 (DOE 2017). Several guidance documents also are available online.

- Kentucky Risk Assessment Guidance, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, June 8, 2002.
  https://eec.ky.gov/Environmental-Protection/Waste/superfund/Documents/KY%20Risk%20Assessment%20Guidance%20_Final_.pdf

- Kentucky Guidance for Ambient Background Assessment, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, January 8, 2004.
  https://eec.ky.gov/Environmental-Protection/Waste/superfund/Documents/Kentucky%20Guidance%20for%20Ambient%20Background%20Assessment.pdf

- Kentucky Guidance for Groundwater Assessment Screening, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, January 15 2004.
  https://eec.ky.gov/Environmental-Protection/Waste/superfund/Documents/GroundwaterAssessmentScreening.pdf

- Trichloroethylene Environmental Levels of Concern, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, April 2004.
  Guidance is not available online. See https://www.epa.gov/iris for additional information.

THIS PAGE INTENTIONALLY LEFT BLANK

E.4. FLOWCHART FOR UNCERTAINTY MANAGEMENT FOR UNKNOWN AREAS OF CONTAMINATION

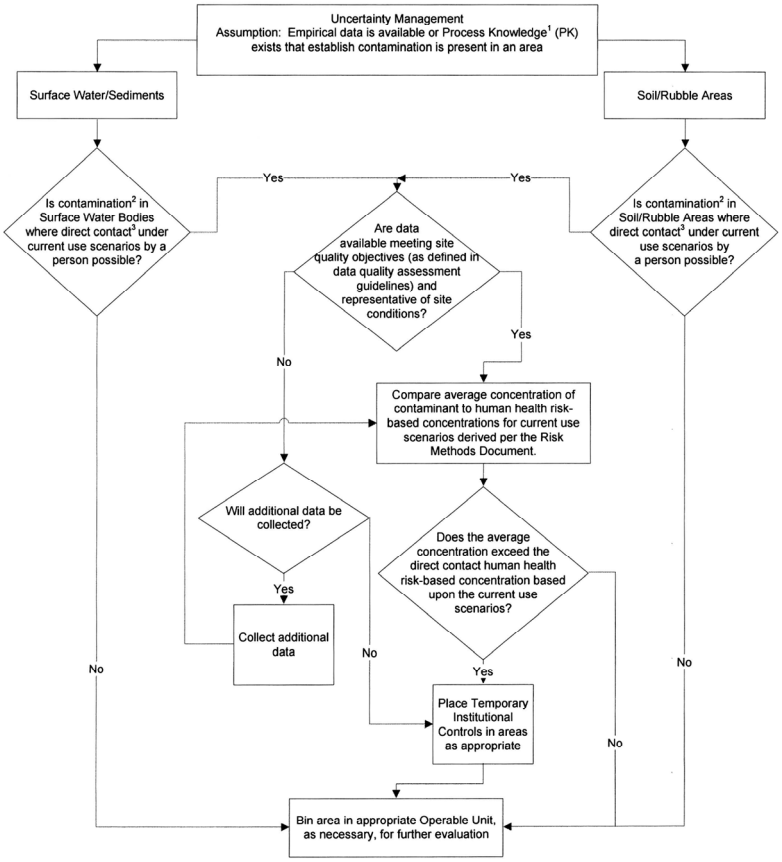
The annotated flowchart presented in this section was provided to KDWM under cover letter from the DOE Paducah Site Lead on April 1, 2008, (PPPO-02-130-08) as a condition to be met for DOE to receive an Environmental Indicator of "Yes" with regard to the Government Performance and Results Act milestone of having human exposures under control. The flowchart applies to newly identified areas of contamination that may be identified in the future on DOE-owned property licenses for use at PGDP, which are outside the controlled area and not currently assigned to an operable unit under the Federal Facility Agreement (FFA). The flowchart describes the uncertainty management for nonworker exposures associated with DOE-owned property described above.

THIS PAGE INTENTIONALLY LEFT BLANK

Enclosure

Flow Chart for Uncertainty Management

This flowchart applies to newly identified areas of contamination that may be identified in the future on DOE-owned property licensed for use at the Paducah Gaseous Diffusion Plant, which are outside the controlled area and not currently assigned to an operable unit under the federal Facility Agreement. The flowchart describes uncertainty management for non-worker exposures associated with DOE-owned property described above.



1 "Process Knowledge" is defined as information identifying releases from past or current processes at the PGDP.

2 "Contamination" is defined in the Risk Methods Document as the presence of a constituent at a concentration greater than background.

3 "Direct contact" is exposure by a human to environmental medium [i.e., surface soil, sediment, debris (e.g., rubble), and surface water] through ingestion, dermal contact, inhalation (particulates and vapors), or external exposure.

Enclosure
(Cont)

Further Explanation of Flow Chart Steps

Uncertainty Management Assumption: Empirical data is available or Process Knowledge[1] (PK) exists that establish contamination is present in an area	This flowchart applies to newly identified areas of contamination that may be identified in the future on DOE-owned property licensed for use at the Paducah Gaseous Diffusion Plant, which are outside the controlled area and not currently assigned to an operable unit under the federal Facility Agreement. The flowchart describes uncertainty management for non-worker exposures associated with DOE-owned property described above. Sufficient data or credible Process Knowledge must exist for this process to be activated.
Is contamination[2] in Surface Water Bodies or Soil/Rubble Areas where direct contact[3] under current use scenarios by a person possible?	Contamination definition is identified in Footnote 2. This process focuses on areas of surface soil, sediment, debris (e.g., rubble), and surface water that are located in the licensed area and available for direct contact exposure. Examples of exposure scenarios are riding horses or ATVs in the creek and bank areas, walking or hiking through wildlife habitat, or hunting.
Are data available meeting site quality objectives (as defined in data quality assessment guidelines) and representative of site conditions?	An evaluation of the available data will be performed to determine if data are of sufficient quality to be used for risk assessment. Additional data may be collected to determine appropriate protective actions.
Compare average concentration of contaminant to human health risk-based concentrations for current use scenarios derived per the Risk Methods Document.	Average concentrations from existing data will be compared to the human health risk-based concentrations. Risk-based concentrations used will be based on guidance in the current site Risk Methods Document.
Place Temporary Institutional Controls in areas as appropriate	Temporary institutional controls may vary depending on the nature of contamination. DOE may place temporary institutional controls under CERCLA, perform a maintenance action, or post under 10 *CFR* 835.
Bin area in appropriate Operable Unit, as necessary, for further evaluation	DOE, EPA, and KY will determine the appropriate Operable Unit under which the area may be placed for future evaluation in accordance with the FFA. These agencies will determine if immediate actions such as sampling or removal actions are warranted based on potential risk and exposure to the public.

E.5. COMPILED PARAMETERS FOR PROBABILISTIC RISK ASSESSMENTS

A probabilistic risk assessment (PRA) of migration of contaminants to groundwater was conducted for the *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant*, *Paducah, Kentucky*, DOE/OR/07-2180&D2/R1 (June 2007). The parameters used in that modeling effort were presented in Attachment 2 of Appendix F of the site investigation report. This set of parameter values is appropriate for use in modeling for other PRAs, though the information on these values should be reviewed during the PRA development to ensure the assumptions made in setting the values are appropriate for each site being evaluated. Parameter values should be modified, if necessary, to reflect conditions for the individual site under consideration.

THIS PAGE INTENTIONALLY LEFT BLANK

Appendix F, Attachment 2, of the *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2180&D2/R1.

INPUT PARAMETERS FOR PROBABILISTIC MODELING

1. INTRODUCTION

Probabilistic (stochastic) modeling was performed for the trichloroethene (TCE) sources at (Solid Waste Management Unit (SWMU) 1 and the C-720 Building areas in order to understand better the uncertainties in the transport modeling for these sources, to estimate the likely TCE concentrations at the points of exposure (POEs) using the most likely input parameters, and to determine the error bounds on the predicted TCE concentrations. This modeling was based upon the nature and extent discussion in the Site Investigation (SI) Report and the transport modeling results completed earlier.

The fate and transport modeling was performed using Spatial Analysis/Decision Assistance (SADA) software (UT 2002); Crystal Ball® (Decisioneering, Inc. 2000), an add-in to Microsoft Excel®; Seasonal Soil Compartment Model (SESOIL) (GSC 1996, Bonazountas and Wagner 1984); and Analytical Transient One-, Two-, and Three-Dimensional Simulation Model (AT123D) (GSC 1998, Yeh 1981). The key input parameters for the modeling were developed using SADA and Crystal Ball®, while the modeling itself was performed using SESOIL and AT123D.

2. INPUT PARAMETERS

The input parameters for the modeling were in two groups: fixed and variable. The values of the fixed parameters were from earlier work (DOE 2003). The values of the variable parameters were set considering earlier work and employing a probabilistic method. This was done by developing a distribution for each variable parameter and sampling the distribution using the Monte Carlo sampling technique provided in Crystal Ball®.

3. PARAMETER DISTRIBUTIONS

Several distributions were considered when selecting the best distribution for each of the variable input parameters. A general discussion of each distribution considered is provided below.

1. **Triangular Distribution:** This distribution is used to describe a variable with known minimum, maximum, and most likely values (Decisioneering, Inc. 2000). Three conditions underlying this distribution are as follows:

    - The minimum value of the variable is fixed.
    - The maximum value of the variable is fixed.

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

INSERT Pages E-58 through E-98

E.6. LEAD-210 AT PGDP

Lead-210 is a radioactive form of lead, having an atomic weight of 210. It is one of the last elements created by the radioactive decay of the isotope uranium-238 (see Figure E.7). Lead-210 forms naturally in the sediments and rocks that contain uranium-238, as well as in the atmosphere, a by-product of radon gas. Within 10 days of its creation from radon, lead-210 falls out of the atmosphere. It accumulates on the surface of the earth where it is stored in soils, lake and ocean sediments, and glacial ice. The lead-210 eventually decays into a non-radioactive form of lead. Lead-210 has a half-life of 22.3 years and is a significant source of beta radiation (USGS 2012; EPA 2012).[1]

Lead-210 is not an easy analysis to perform and typically is not included in a regular gamma radiological scan; it has a peak at 46 KeV and requires a thin window detector and an efficiency curve using a standard with lead-210. Therefore, historical data was reviewed to ensure the analysis was necessary. Because lead-210 is found significantly down the decay chain for uranium-238 through radon-222, activities performed over the past 60 years at PGDP cannot have resulted in PGDP-sourced lead-210.

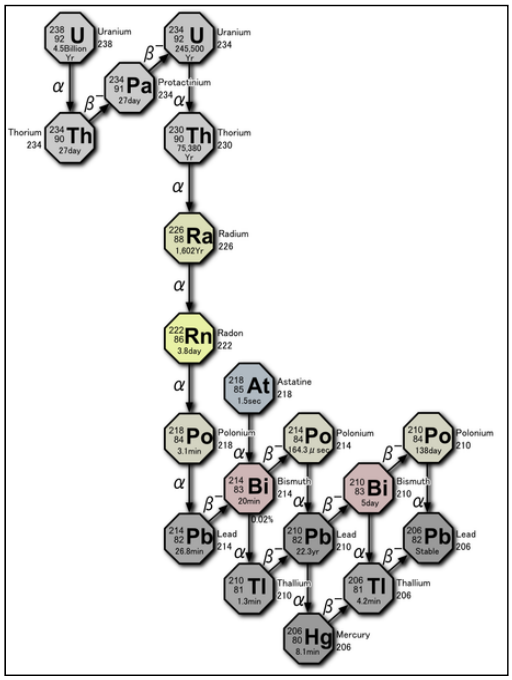
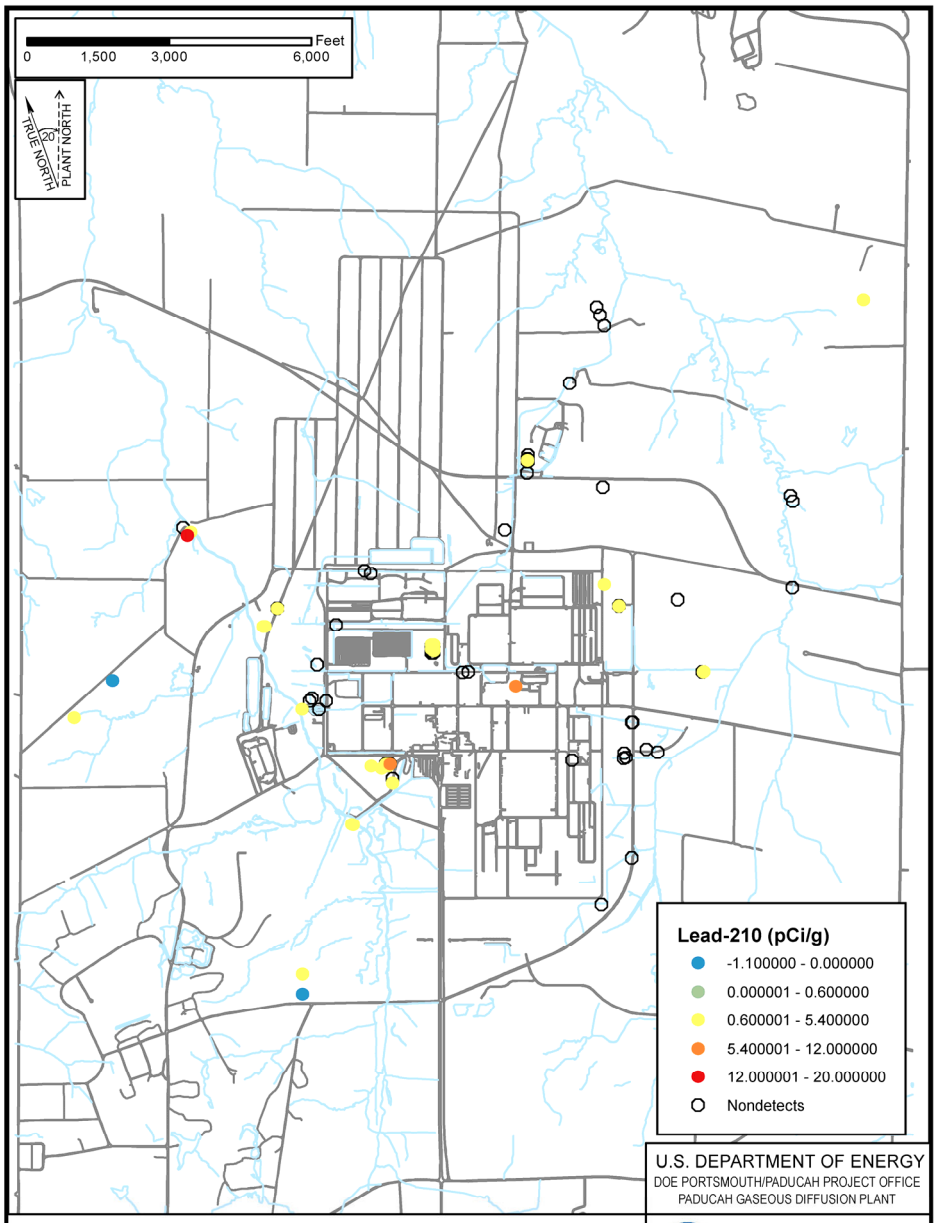


Figure E.7. Lead-210 Decay Chain

Available PGDP lead-210 data was plotted to estimate an approximate background value. This map is shown in Figure E.8. Because the majority of the available data is historical, data quality is not certain; however, it appears that the higher lead-210 activities within the PGDP boundaries are at background values.



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

Figure E.8. Lead-210 Soil/Sediment Samples

LATA Environmental Services of Kentucky, LLC

Figure No. Lead-210_Soil.mxd
DATE 11-01-2012

Data indicate higher levels of lead-210 inside the PGDP boundary at SWMU 222, although radium-226 was not reported for the majority of these samples. The one sample that had radium-226 reported had a significant difference in activity between the radium-226 and its ingrowth radionuclides, lead-214 and bismuth-214. If radium-226 is truly at 11 pCi/g, as reported in that sample, and the analysis was conducted properly (ingrowth for 30 days in a sealed container), the lead-214 and bismuth-214 activity should have equaled the radium-226 activity. Under these analysis conditions the activity of lead-210 would not be in secular equilibrium with radium-226. The fact that the lead-210 is elevated in the samples suggests a possible separate source of lead-210 rather than ingrowth. Lead-210, which has a 22-year half-life, is included in the list of short-lived radionuclides associated with radium-226 for completeness, as this isotope and its short-lived decay products typically are present with radium-226.

After processing, radionuclides with half-lives of less than one year will reestablish equilibrium conditions with their longer-lived parent radionuclides within several years. For this reason, at processing sites what was once a single, long decay series (for example the series for uranium-238) may be present as several smaller decay series headed by the longer-lived decay products of the original series (that is, headed by uranium-238, uranium-234, thorium-230, radium-226, and lead-210 in the case of uranium-238). Each of these sub-series can be considered to represent a new, separate decay series. Understanding the physical and chemical processes associated with materials containing uranium, thorium, and radium is important when addressing associated radiological risks.

Detected lead-210 results available for PGDP were listed alongside radium-226 and uranium-238 results in Table E.4. Lead-210 would be expected to be in equilibrium (i.e., similar activity results) with uranium-238 for instances of natural uranium. Lead-210 would be expected to be in equilibrium with radium-226 for instances of enriched uranium. No split samples are available; however, a surrogate to a “split” could be simply looking at the uranium-238 to lead-210 ratio in samples, where available. For example, if lead-210 is a true contaminant, then it should exceed the uranium-238 level, when the uranium-238 is at background in at least some samples.

A further check of the available data was performed by filtering the activity results against minimum detectable activities and counting uncertainties. The only samples that passed both checks are shown in Table E.5. Recent Soils Operable Unit (OU) soils data passed both checks.

Table E.4. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
194-01,02	301043	9	LOCK	20.00	0.02			Yes					No	0.60		0.10		Yes
JP-0092	DOJ1-99-0092		PGDP	14.55	18.18	29.10	29.10	No	0.77	0.31	1.53	1.53	No	4386.00	4.20	89.00	1117.00	Yes
194-01,02	301048	20	LOCK	12.00	0.05			Yes					No	1.30		0.16		Yes
SWMU222-4	2010-53093[a]		KYRAD	10.60	2.05	1.03		Yes					No	27.80	1.62	1.12		Yes
SWMU222-4	2010-53093		KYRAD	10.60	2.05	1.03		Yes					No	27.80	0.03	2.33		Yes
SWMU222-5	2010-53094[b]		KYRAD	8.60	1.47	0.76		Yes					No	32.30	0.04	2.66		Yes
SWMU222-1	2010-53090[b]		KYRAD	8.44	1.71	0.87		Yes					No	23.70	0.13	2.10		Yes
194-01,02	301044	11.33	LOCK	8.00	0.03			Yes					No	0.61		0.11		Yes
SWMU222-2	2010-53091[b]		KYRAD	6.98	1.41	0.71		Yes					No	22.10	0.04	1.94		Yes
SWMU222-3	2010-53092[b]		KYRAD	6.81	1.14	0.61		Yes					No	16.70	0.03	1.51		Yes
SOU195-120A	2010-51253[a]	1	KYRAD	6.57	9.25	3.83		No	2.53	2.08	0.94		Yes	3.94	2.41	1.36		Yes
SOU195-014C	2010-51264[a]	10	KYRAD	6.01	5.28	2.16		Yes	1.44	1.27	0.57		Yes	2.25	0.93	0.84		Yes
194-01,02	301047	18.6	LOCK	5.40	0.00			Yes					No	0.90		0.13		Yes
SWMU222-1	2010-52457[b]		KYRAD	4.92	0.82	0.41		Yes					No	31.30	0.05	3.59		Yes
JP-0160	DOJ1-99-0160		PGDP	4.31	1.79	2.11	2.28	Yes	0.71	1.64	1.42	1.42	No	2.70	0.93	0.52	1.41	Yes
BCBOKYRAD01	2010-50535[a]		KYRAD	4.27	0.46	0.25		Yes	2.35	0.87	0.39		Yes	2.22	0.47	0.22		Yes
LBC2L020	LBCSOSU2S1-04	1	STLMO	4.20	2.00		1.70	Yes	0.80	0.21		0.25	Yes	3.90	1.50		1.40	Yes
RSO3	110013[c]		STLMO	3.90	1.90	1.90		Yes					No					No
JP-0152	DOJ1-99-0152		PGDP	3.76	5.96	7.52	7.52	No	0.84	0.12	1.69	1.69	No	208.00	0.04	3.30	42.00	Yes
H01,05,15	301025	0.7	LOCK	3.70	0.00			Yes					No	0.96		0.10		Yes
SOU195-014A	2010-51258[a]	10	KYRAD	3.56	5.07	2.13		No	1.40	1.10	0.50		Yes	1.54	0.90	0.79		Yes
RSO3	110012[c]		STLMO	3.50	1.40	1.20		Yes					No					No
BC5KYRAD01	2010-50537[a]		KYRAD	3.43	0.36	0.21		Yes	2.06	0.71	0.32		Yes	1.37	0.32	0.15		Yes
C12,18,19	301012[d]	2	LOCK	3.20	0.00			Yes					No	0.97		0.09		Yes
A10	PLDJNSA10-01SO	2.5	PGDP	3.10	5.90	6.20	6.20	No	0.16	0.07	0.01	0.08	Yes	6.60	0.05	0.35	0.89	Yes
LBC2L015	LBCSOSU2S1-03	1	STLMO	3.00	2.90		2.40	Yes	1.21	0.26		0.30	Yes	1.25	0.01		0.18	Yes
JP-0161	DOJ1-99-0161		PGDP	2.92	1.93	2.07	2.10	Yes	0.83	0.17	1.66	1.66	No	2.30	1.02	0.51	3.21	No
SOU200-004	2010-51270[a]	4	KYRAD	2.81	5.18	2.19		No	2.51	1.31	0.61		Yes	1.48	0.88	1.19		Yes
F04,02,29	301005	0.8	LOCK	2.80	0.00			Yes					No	0.82		0.08		Yes
SOU195-120C	2010-51252[a]	1	KYRAD	2.70	0.62	0.32		Yes	1.67	0.90	0.41		Yes	1.02	0.52	0.29		Yes
K008-AIP-RP	030301	0	STLMO	2.70	1.20	1.10		Yes					No	1.71	0.33	0.98		Yes
C07,08,09	301013[d]	0.9	LOCK	2.70	0.00			Yes					No	1.04		0.09		Yes
NST2S04	BJC2041SS	8	PGDP	2.65	2.40	2.50	2.60	Yes	2.43	0.33	4.85	4.85	No	4.11	1.24	0.66	2.11	Yes
SOU222-001	2010-51277[a]	0.5	KYRAD	2.57	0.59	0.76		Yes	11.10	1.30	0.71		Yes	19.62	0.76	0.65		Yes
BCBOKYRAD02	2010-50536[a]		KYRAD	2.51	0.71	0.33		Yes	7.18	1.17	0.56		Yes	10.26	0.87	0.46		Yes
F12,20,22	301004	1.5	LOCK	2.46	0.00			Yes					No	0.90		0.08		Yes
H04,06,09	301023	0.8	LOCK	2.45	0.00			Yes					No	0.84		0.09		Yes
JP-0019	DOJ1-99-0017		PGDP	2.44	16.16	4.87	10.54	No	1.06	0.29	2.11	2.11	No	2270.00	9.14	16.30	609.00	Yes
C12,18,19	301011[d]	0.8	LOCK	2.40	0.00			Yes					No	1.06		0.10		Yes
196-03,04	301038	6.67	LOCK	2.40	0.00			Yes					No	0.80		0.12		Yes
C01,10,24	301017[d]	0.7	LOCK	2.30	0.00			Yes					No	0.95		0.10		Yes
F05,07,17	301008	1.6	LOCK	2.20	0.00			Yes					No	0.86		0.09		Yes
C07,08,09	301015[d]	0.9	LOCK	2.09	0.00			Yes					No	1.00		0.10		Yes

Table E.4. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
JP-0046	DOJ1-99-0046		PGDP	2.07	1.91	2.03	2.00	Yes	0.70	0.13	1.40	1.40	No	13.90	1.00	1.43	4.00	Yes
A2	PLDJNSA2D-01SO	8.5	PGDP	2.00	6.00	4.10	4.10	No	0.59	0.13	1.10	1.10	No	0.77	0.24	0.39	1.37	No
H04,06,09	301022	2.6	LOCK	1.90	0.00			Yes					No	1.01		0.10		Yes
F12,20,22	301001	0.8	LOCK	1.90	0.00			Yes					No	0.90		0.08		Yes
SOU195-014A	2010-51256 [a]	4	KYRAD	1.89	5.01	2.14		No	1.55	1.16	0.52		Yes	1.12	0.93	1.18		No
F04,02,29	301006	1.5	LOCK	1.85	0.00			Yes					No	0.82		0.08		Yes
JP-0160	DOJ1-99-0177		PGDP	1.84	2.62	3.68	3.68	No	0.65	0.12	1.30	1.30	No	2.01	0.91	1.08	3.57	No
K008-AIP-RP	030303	0	STLMO	1.80	1.10	1.30		Yes	0.80	0.30	0.28		Yes	2.30	0.30	1.10		Yes
C02,03,20	301019 [d]	0.7	LOCK	1.80	0.00			Yes					No	1.03		0.10		Yes
BC5KYRAD02	2010-50538 [a]		KYRAD	1.74	0.90	0.42		Yes	2.01	1.56	0.70		Yes	0.69	0.93	0.55		Yes
194-05,06	301039	9	LOCK	1.72	0.00			Yes					No	0.79		0.12		Yes
194-03,04	301045 [e]	16	LOCK	1.68	0.00			Yes					No	1.06		0.14		Yes
A2	PLDJNSA2-02SO	11.5	PGDP	1.60	6.60	3.30	4.40	No	1.10	0.18	2.20	2.20	No	1.69	0.86	1.03	3.04	No
F01,21,23	301009	0.8	LOCK	1.60	0.00			Yes					No	0.92		0.08		Yes
C02,03,20	301020 [d]	3	LOCK	1.59	0.00			Yes					No	1.00		0.09		Yes
H01,05,15	301026	2.6	LOCK	1.57	0.00			Yes					No	0.87		0.08		Yes
C07,08,09	301014 [d]	2.1	LOCK	1.56	0.00			Yes					No	0.94		0.08		Yes
JP-0157	DOJ1-99-0157		PGDP	1.56	4.07	3.11	3.11	No	0.90	0.16	1.80	1.80	No	108.00	1.80	2.95	29.10	Yes
JP-0113	DOJ1-99-0115		PGDP	1.54	1.60	1.68	1.69	No	0.49	0.12	0.97	0.97	No	6.02	0.88	1.33	3.23	Yes
C07,08,09	301016 [d]	2.1	LOCK	1.51	0.00			Yes					No	0.91		0.08		Yes
H04,06,09	301021	0.8	LOCK	1.50	0.00			Yes					No	0.94		0.10		Yes
F12,20,22	301003	1.5	LOCK	1.50	0.00			Yes					No	0.92		0.09		Yes
K008-AIP-RP	030302	0	STLMO	1.49	1.20	0.82		Yes					No	0.76	0.26	0.56		Yes
BC14KYRAD	2010-50539 [a]		KYRAD	1.49	0.68	0.32		Yes	1.94	1.52	0.67		Yes	1.64	0.70	0.40		Yes
JP-0075	DOJ1-99-0075		PGDP	1.48	4.62	2.97	2.97	No	1.24	0.16	2.48	2.48	No	14.80	1.54	2.05	6.04	Yes
194-03,04	301036 [e]	8	LOCK	1.48	0.00			Yes					No	0.80		0.12		Yes
H02,10,18	301027	0.7	LOCK	1.44	0.00			Yes					No	1.00		0.11		Yes
F12,20,22	301002	0.8	LOCK	1.40	0.00			Yes					No	0.93		0.09		Yes
SOU195-014A	2010-51257 [a]	7	KYRAD	1.38	0.70	0.32		Yes	2.12	1.07	0.49		Yes	1.11	0.58	0.38		Yes
JP-0090	DOJ1-99-0090		PGDP	1.37	2.21	2.74	2.74	No	0.77	0.14	1.55	1.55	No	22.00	0.02	0.75	3.30	Yes
OUTFALL10-1	WC02-242	4	PORTS	1.36	0.67	0.68	0.68	No	0.94	0.32	0.22	0.37	No	0.67	0.05	0.12	0.21	Yes
SOU195-014C	2010-51262 [a]	4	KYRAD	1.31	0.79	0.36		Yes	2.30	1.59	0.71		Yes	0.49	0.97	0.46		Yes
JP-0062	DOJ1-99-0062		PGDP	1.31	2.95	2.61	2.61	No	0.71	0.13	1.41	1.41	No	4.01	1.17	1.62	3.02	Yes
F01,21,23	301010	1.6	LOCK	1.26	0.00			Yes					No	0.82		0.08		Yes
SWMU222-4	2010-52458 [a]		KYRAD	1.25	0.48	0.22		Yes					No	1.52	0.44	0.29		Yes
JP-0163	DOJ1-99-0163		PGDP	1.22	2.94	2.45	2.45	No	0.97	0.23	1.93	1.93	No	3.23	1.36	0.78	1.76	Yes
NST2S02	BJC2021SS	3	PGDP	1.20	2.87	2.41	2.41	No	0.64	0.18	1.28	1.28	No	104.00	0.31	3.50	21.00	Yes
194-01,02	301040	6.75	LOCK	1.20	0.00			Yes					No	0.79		0.12		Yes
194-05,06	301050	17.5	LOCK	1.20	0.00			Yes					No	0.71		0.11		Yes
SOU195-014	2010-51255 [a]	10	KYRAD	1.20	0.88	0.36		Yes	1.89	1.50	0.67		Yes	0.74	0.97	0.51		Yes
SOU195-014B	2010-51260 [a]	7	KYRAD	1.17	0.64	0.30		Yes	2.25	0.91	0.43		Yes	0.79	0.56	0.35		Yes
194-05,06	301042	11.5	LOCK	1.17	0.00			Yes					No	0.72		0.11		Yes
H03,07,13	301029	0.7	LOCK	1.10	0.00			Yes					No	1.10		0.12		Yes

Table E.4. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
H03,07,13	301029	0.7	LOCK	1.10	0.00			Yes					No	1.10				Yes
SOU195-006	2010-51265 [a]	7	KYRAD	1.09	0.73	0.33		Yes	2.13	1.16	0.53		Yes	0.86	0.57	0.34		Yes
SOU195-025	2010-51250 [a]	7	KYRAD	1.09	0.84	0.38		Yes	2.41	1.65	0.73		Yes	1.05	0.72	0.52		Yes
SOU195-014B	2010-51261 [a]	10	KYRAD	1.08	0.96	0.43		Yes	1.46	1.45	0.64		Yes	0.77	0.69	0.44		Yes
SOU200-009	2010-51275 [a]	4	KYRAD	1.08	5.15	2.23		No	1.87	1.32	0.60		Yes	1.08	0.93	0.88		Yes
H02,10,18	301028	3	LOCK	1.07	0.00			Yes					No	0.92		0.08		Yes
JP-0162	DOJ1-99-0162		PGDP	1.05	1.94	2.10	2.10	No	0.84	0.16	1.67	1.67	No	1.63	0.91	0.47	2.29	No
194-03,04	301041 [c]	12	LOCK	1.04	0.00			Yes					No	0.81		0.12		Yes
SOU200-005	2010-51271 [a]	4	KYRAD	1.04	0.89	0.40		Yes	2.15	1.57	0.70		Yes	1.64	0.99	0.64		Yes
SOU195-014C	2010-51263 [a]	7	KYRAD	1.03	1.04	0.46		No	1.73	1.32	0.59		Yes	0.90	0.75	0.45		Yes
SOU195-025	2010-51251 [a]	10	KYRAD	1.02	0.77	0.35		Yes	1.91	1.46	0.66		Yes	1.17	1.07	0.62		Yes
JP-0091	DOJ1-99-0091		PGDP	1.01	2.08	2.02	2.02	No	0.82	0.14	1.64	1.64	No	12.70	1.24	1.72	3.82	Yes
NST1S01	BJC1011SS	2.5	PGDP	1.01	3.31	2.02	2.02	No	0.65	0.19	1.29	1.29	No	65.90	1.87	2.87	18.00	Yes
SOU200-008	2010-51274 [a]	4	KYRAD	1.01	0.70	0.32		Yes	1.88	1.18	0.53		Yes	1.01	0.56	0.32		Yes
H04,06,09	301024	2.6	LOCK	1.00	0.00			Yes					No	0.94		0.09		Yes
OUTFALL10-1	WC02-242D	4	PORTS	0.99	0.63	0.64	0.65	No	0.87	0.29	0.25	0.31	No	0.68	0.07	0.13	0.46	Yes
SOU195-014B	2010-51259 [a]	4	KYRAD	0.99	0.92	0.41		Yes	1.62	1.32	0.59		Yes	0.93	0.99	0.56		Yes
JP-0018	DOJ1-99-0016		PGDP	0.96	4.68	1.92	2.81	No	0.64	0.14	1.28	1.28	No	188.00	0.05	2.30	32.00	Yes
OUTFALL10-2	WC02-243	4	PORTS	0.96	0.68	0.63	0.64	No	0.82	0.31	0.28	0.31	No	0.63	0.02	0.13	0.21	Yes
SOU200-006	2010-51272 [a]	4	KYRAD	0.95	0.66	0.30		Yes	2.67	1.09	0.51		Yes	0.94	0.57	0.38		Yes
SOU200-001	2010-51267 [a]	4	KYRAD	0.94	0.83	0.37		Yes	2.73	1.33	0.61		Yes	1.06	0.70	0.39		Yes
SOU200-010	2010-51276 [a]	4	KYRAD	0.89	0.94	0.42		No	1.75	1.47	0.65		Yes	0.76	0.69	0.36		Yes
SOU195-006	2010-51266 [a]	10	KYRAD	0.88	0.78	0.35		Yes	1.98	1.52	0.68		Yes	1.51	0.98	0.63		Yes
JP-0081	DOJ1-99-0081		PGDP	0.87	1.43	1.75	1.75	No	0.61	0.11	1.22	1.22	No	3.60	0.01	0.17	0.47	Yes
SOU200-003	2010-51269 [a]	4	KYRAD	0.86	0.92	0.41		No	2.22	1.27	0.57		Yes	0.74	0.69	0.50		Yes
JP-0015	DOJ1-99-0013		PGDP	0.81	1.66	1.62	1.62	No	0.62	0.13	1.23	1.23	No	3.16	0.82	1.25	1.99	Yes
H03,07,13	301030	3	LOCK	0.80	0.00			Yes					No	0.83		0.08		Yes
NST1S03	BJC1031SS	12	PGDP	0.79	1.55	1.59	1.59	No	0.80	0.18	1.60	1.60	No	0.66	0.04	0.11	0.13	Yes
JP-0080	DOJ1-99-0080		PGDP	0.73	1.91	1.46	1.46	No	0.82	0.15	1.64	1.64	No	2.39	0.94	0.47	3.33	No
SOU195-014	2010-51254 [a]	7	KYRAD	0.71	0.74	0.33		No	1.72	1.50	0.66		Yes	0.54	0.70	0.44		Yes
LBC2L005	LBCSOSU2S1-01	1	STLMO	0.70	2.20		1.30	No	1.40	0.15		0.30	Yes	3.12	16.80	9.24		No
SOU200-007	2010-51273 [a]	4	KYRAD	0.69	0.78	0.35		No	2.12	1.68	0.75		Yes	1.16	0.90	0.41		Yes
JP-0110	DOJ1-99-0110		PGDP	0.67	8.67	1.34	5.33	No	0.81	0.19	1.61	1.61	No	626.00	4.72	8.10	168.00	Yes
SOU200-002	2010-51268 [a]	4	KYRAD	0.65	0.62	0.28		Yes	2.10	0.94	0.44		Yes	1.08	0.56	0.33		Yes
JP-0057	DOJ1-99-0057		PGDP	0.65	1.60	1.30	1.30	No	0.28	0.09	0.56	0.56	No	7.97	0.78	1.14	4.06	Yes
JP-0097	DOJ1-99-0097		PGDP	0.62	1.70	1.25	1.25	No	0.76	0.13	1.52	1.52	No	2.58	0.77	1.04	3.71	No
JP-0066	DOJ1-99-0066		PGDP	0.60	2.87	1.21	1.85	No	0.85	0.14	1.70	1.70	No	4.81	1.22	1.63	3.47	Yes
JP-0082	DOJ1-99-0082		PGDP	0.60	2.74	1.20	1.67	No	1.29	0.18	2.58	2.58	No	20.00	0.02	0.75	3.30	Yes
194-03,04	301046 [c]	21	LOCK	0.60	0.00			Yes					No	1.18		0.16		Yes
JP-0061	DOJ1-99-0061		PGDP	0.60	2.19	1.20	1.41	No	0.33	0.08	0.66	0.66	No	6.32	0.76	1.00	0.16	Yes
JP-0013	DOJ1-99-0011		PGDP	0.55	2.26	1.11	1.36	No	0.83	0.15	1.66	1.66	No	17.30	0.97	1.38	4.86	Yes
JP-0063	DOJ1-99-0063		PGDP	0.54	2.50	1.09	1.64	No	0.65	0.12	1.29	1.29	No	1.00	0.01	0.10	0.16	Yes
JP-0087	DOJ1-99-0088		PGDP	0.47	5.67	0.94	3.46	No	0.77	0.13	1.54	1.54	No	138.00	2.54	4.19	53.00	Yes

Table E.4. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

		Depth	Lab	Lead-210 (pCi/g)					Radium-226 (pCi/g)					Uranium-238 (pCi/g)				
Station	Sample ID	(ft bgs)	Code	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?
A10	PLDJNSA10-02SO	8.5	PGDP	0.34	5.70	0.69	3.60	No	0.49	0.12	0.98	0.98	No	1.91	0.79	0.42	3.26	No
ISOCSOFFST	ISOCSBKGR08-01	0	PGDP	0.34	1.04	0.68	0.68	No					No	1.58	0.47	0.25	0.33	Yes
NST2S03	BJC2031SS	15	PGDP	0.31	2.30	0.61	1.39	No	0.99	0.19	1.98	1.98	No	19.80	0.08	0.79	3.00	Yes
JP-0112	DOJ1-99-0114		PGDP	0.27	1.38	0.54	0.85	No	0.67	0.11	1.34	1.34	No	7.50	0.01	0.37	1.10	Yes
JP-0060	DOJ1-99-0060		PGDP	0.22	2.13	0.44	1.40	No	0.13	0.04	0.16	0.26	No	8.24	0.85	1.26	3.40	Yes
C01,10,24	301018 [d]	2.8	LOCK	0.20	0.00			Yes					No	1.03		0.09		Yes
NST2S05	BJC2052SS	12.5	PGDP	0.17	1.28	0.35	0.78	No	0.52	0.14	1.03	1.03	No	1.21	0.20	0.32	1.70	No
JP-0100	DOJ1-99-0100		PGDP	0.09	1.44	0.18	0.89	No	0.72	0.12	1.44	1.44	No	1.48	0.67	0.39	2.08	No
NST1S02	BJC1021SS	2.5	PGDP	0.06	2.53	0.13	1.54	No	0.57	0.19	1.15	1.15	No	29.70	1.38	2.18	8.27	Yes
JP-0016	DOJ1-99-0014		PGDP	0.00	1.81	0.01	1.10	No	0.57	0.12	1.13	1.13	No	8.80	0.04	0.35	1.20	Yes
196-01,02	301037	7	LOCK	0.00 [f]	0.00			No					No	0.82		0.12		Yes
JP-0164	DOJ1-99-0164		PGDP	-0.01	1.86	0.01	1.15	No	0.69	0.15	1.38	1.38	No	1.84	0.92	0.45	2.57	No
NST2S01	BJC2011SS	2	PGDP	-0.13	1.73	0.25	1.06	No	0.57	0.16	1.14	1.14	No	8.11	0.91	1.35	2.56	Yes
JP-0045	DOJ1-99-0045		PGDP	-0.29	2.68	0.58	1.76	No	0.58	0.12	1.15	1.15	No	6.00	0.01	0.23	0.77	Yes
JP-0016	DOJ1-99-0014DUP		PGDP	-0.29	1.76	0.59	1.08	No	0.52	0.12	1.05	1.05	No	11.00	0.02	0.37	1.40	Yes
JP-0087	DOJ1-99-0087		PGDP	-0.43	5.27	0.86	3.23	No	0.65	0.12	1.30	1.30	No	126.00	2.33	3.83	48.30	Yes
JP-0071	DOJ1-99-0071		PGDP	-0.75	5.45	1.50	3.40	No	2.78	0.26	5.56	5.56	No	19.00	1.98	2.46	7.68	Yes
BGS194-04	301049	24	LOCK	-0.80	0.01			No					No	0.76		0.12		Yes
JP-0085	DOJ1-99-0085		PGDP	-0.86 [f]	6.72	1.72	4.14	No	0.80	0.15	1.60	1.60	No	160.00	3.01	5.07	61.80	Yes
F05,07,17	301007	1	LOCK	-1.10 [f]	0.00			No					No	0.93		0.08		Yes
A10	PLDJNSA10-03SO	9	PGDP	-1.20	31.00	2.50	18.00	No	0.14	0.20	0.00	0.06	No	326.00	4.61	7.56	125.00	Yes
JP-0072	DOJ1-99-0072		PGDP	-1.31	9.10	2.62	5.58	No	6.88	0.41	13.75	13.75	No	87.00	0.24	2.80	21.00	Yes
JP-0111	DOJ1-99-0112		PGDP	-1.99	6.10	3.99	3.99	No	0.84	0.17	1.69	1.69	No	317.00	0.67	11.00	68.00	Yes
JP-0076	DOJ1-99-0076		PGDP	-2.04	6.16	4.07	4.07	No	2.19	0.23	4.38	4.38	No	69.00	2.28	3.26	26.70	Yes
NST2S05	BJC2051SS	12.5	PGDP	-2.12	12.77	4.25	7.90	No	5.15	1.39	10.30	10.30	No	11.10	1.90	3.14	4.33	Yes
JP-0077	DOJ1-99-0077		PGDP	-2.71	5.02	5.42	5.42	No	1.47	0.17	2.94	2.94	No	56.00	0.21	1.80	11.00	Yes
A2	PLDJNSA2-01SO	8.5	PGDP	-2.90	6.20	5.80	5.80	No	0.65	0.14	1.30	1.30	No	1.24	0.26	0.44	2.14	No
JP-0152	DOJ1-99-DUP1		PGDP	-2.91	6.47	5.83	5.83	No	0.87	0.13	1.73	1.73	No	393.00	0.69	12.00	120.00	Yes
JP-0111	DOJ1-99-0111		PGDP	-2.99	6.03	5.98	5.98	No	0.91	0.17	1.81	1.81	No	365.00	0.13	4.50	63.00	Yes
JP-0151	DOJ1-99-0151		PGDP	-4.78	8.89	9.57	9.57	No	0.54	0.13	1.07	1.07	No	365.00	3.25	5.42	140.00	Yes
JP-0150	DOJ1-99-0150		PGDP	-10.07	12.75	20.14	20.14	No	0.79	0.18	1.58	1.58	No	599.00	4.88	8.14	230.00	Yes
JP-0153	DOJ1-99-0153		PGDP	-19.47	14.31	38.93	38.93	No	0.32	0.17	0.64	0.64	No	1921.00	3.50	50.00	617.00	Yes

Yellow shading indicates sample analysis by the Kentucky Radiation Health Branch Laboratory.
Blue shading indicates a detected lead-210 result for samples other than those analyzed by the Kentucky Radiation Health Branch.
TPU = total propagated uncertainty
Lab Codes are the following: LOCK = Lockheed Engineering & Science Co., Las Vegas, NV; KYRAD = Kentucky Radiation Health Branch; PGDP = USEC-Paducah Gaseous Diffusion Plant; PORTS = USEC-Portsmouth Plant; STLMO = Severn Trent, Earth City, Missouri
[a] The uranium-238 results was reported by the lab as thorium-234/uranium-238.
[b] The maximum uranium-238 result was used for comparison.
[c] This sample is not plotted in Figure 2, the coordinates place the sample in Illinois. The available coordinates are likely incorrect.
[d] This sample is not plotted in Figure 2, no coordinates are available.
[e] This sample is not plotted in Figure 2, the coordinates place the sample in Ballard County, which is outside the scale of the map.
[f] This results is set as a nondetect because the reported result is less than the minimum detectable activity (MDA).

Table E.5. Results of Filtering

Method	Chemical	Date Collected	MDA	Lab Code	Lab Sample ID	Media	Rad Error	Result	Lab Qualifier	Station	Units	Val Qualifier	Greater Than DL	Less Than DL	Pass cut
DNT	Lead-210	7/31/2006	152.1	KYRAD	2006-51812	SW	133.1	529.9		A-Composite	pCi/L	X	529.9		529.9
DNT	Lead-210	7/21/2004	139	KYRAD	2004-51807	SW	120.4	557.4		A-Composite	pCi/L	=	557.4		557.4
DNT	Lead-210	7/9/2003	86.13	KYRAD	2003-06373	SW	77.85	213.2		A-Composite	pCi/L	=	213.2		213.2
DNT	Lead-210	12/8/2006	141.6	KYRAD	2006-53149	SW	156.5	1469		A-Composite	pCi/L	X	1469		1469
DNT	Lead-210	7/18/2005	96.2	KYRAD	2005-51647	SW	176.1	661.4		A-Composite	pCi/L	X	661.4		661.4
DNT	Lead-210	5/26/2006	116	KYRAD	2006-51119	SW	126.8	1605		A-Composite	pCi/L	X	1605		1605
Gamma Spec	Lead-210	2/2/2007	159.2	KYRAD	2007-50161	SW	276.5	692.8	U	A-Composite	pCi/L	U	692.8		692.8
DNT	Lead-210	10/27/2005	105.5	KYRAD	2005-52609	SW	124.9	1707		A-Composite	pCi/L	X	1707		1707
Gamma Spec	Lead-210	6/4/2007	174.2	KYRAD	2007-51252	SW	107	1284		A-Composite	pCi/L	=	1284		1284
DNT	Lead-210	10/13/2004	99.77	KYRAD	2004-52643	SW	143.4	309.4		C-Composite	pCi/L	=	309.4		309.4
DNT	Lead-210	3/9/2005	173.9	KYRAD	2005-50440	SW	189.5	2593		C-Composite	pCi/L	=	2593		2593
DNT	Lead-210	5/11/2005	144.7	KYRAD	2005-51034	SW	82.96	514		A-Composite	pCi/L	X	514		514
DNT	Lead-210	6/9/2004	147.5	KYRAD	2004-51367	SW	77.57	1714		A-Composite	pCi/L	=	1714		1714
Gamma Spec	Lead-210	4/3/2007	180.9	KYRAD	2007-50606	SW	97.97	1719	U	A-Composite	pCi/L	U	1719		1719
Gamma Spec	Lead-210	11/19/2007	168	KYRAD	2007-52795	SW	123.9	274.7	J	A-Composite	pCi/L	J	274.7		274.7
DNT	Lead-210	1/10/2005	138.2	KYRAD	2005-50023	SW	147.8	1210		C-Composite	pCi/L	X	1210		1210
Gamma Spec	Lead-210	2/22/2007	275.7	KYRAD	2007-50293	SW	160.8	2222	U	C-Composite	pCi/L	U	2222		2222
DNT	Lead-210	1/3/2006	299	KYRAD	2005-53157	SW	285.5	881.4		C-Composite	pCi/L	X	881.4		881.4
DNT	Lead-210	3/9/2005	173.9	KYRAD	2005-50440	SW	189.5	2593		C-Composite	pCi/L	X	2593		2593
DNT	Lead-210	12/20/2004	173.3	KYRAD	2004-53235	SW	237	832.2		C-Composite	pCi/L	=	832.2		832.2
Gamma Spec	Lead-210	4/25/2007	128.9	KYRAD	2007-50839	SW	138.1	1185		C-Composite	pCi/L	=	1185		1185
DNT	Lead-210	12/14/2006	533.1	KYRAD	2006-53330	SW	283.4	3222	U	ATC746K	pCi/L	X	3222		3222
DNT	Lead-210	9/11/2006	149.7	KYRAD	2006-52207	SW	130.7	594		B-Composite	pCi/L	X	594		594
Gamma Spec	Lead-210	6/25/2007	154.2	KYRAD	2007-51454	SW	85.39	1936	U	B-Composite	pCi/L	U	1936		1936
DNT	Lead-210	9/22/2004	112.7	KYRAD	2004-52430	SW	121.2	368.1		B-Composite	pCi/L	=	368.1		368.1
DNT	Lead-210	10/13/2004	146.1	KYRAD	2004-52679	SW	126.1	664.9		D2-Composite2	pCi/L	=	664.9		664.9
DNT	Lead-210	12/24/2003	80.3	KYRAD	2003-08104	SW	79.66	233		D2-Composite2	pCi/L	=	233		233
DNT	Lead-210	3/2/2006	67	KYRAD	2006-50341	SW	43.39	102.5		B-Composite	pCi/L	X	102.5		102.5
Gamma Spec	Lead-210	4/3/2007	183.7	KYRAD	2007-50628	SW	95.3	2502	U	B-Composite	pCi/L	U	2502		2502
DNT	Lead-210	7/18/2005	129.3	KYRAD	2005-51670	SW	96.29	1306		B-Composite	pCi/L	X	1306		1306
DNT	Lead-210	1/10/2005	225.3	KYRAD	2005-50022	SW	113.8	3492		B-Composite	pCi/L	X	3492		3492
DNT	Lead-210	8/31/2004	106.9	KYRAD	2004-52253	SW	92.05	604.6		D-Composite	pCi/L	=	604.6		604.6
DNT	Lead-210	6/30/2004	138.7	KYRAD	2004-51697	SW	127.6	575.8		D2-Composite2	pCi/L	=	575.8		575.8
DNT	Lead-210	10/27/2005	115.4	KYRAD	2005-52720	SW	122.4	1419		F-Composite	pCi/L	X	1419		1419
Gamma Spec	Lead-210	11/29/2010	1.61	KYRAD	2010-53281	SW	0.894	974	U	C-613	pCi/L	U	974		974
DNT	Lead-210	11/17/2005	152.4	KYRAD	2005-52866	SW	106.8	1269		D-Composite	pCi/L	X	1269		1269
Gamma Spec	Lead-210	2/2/2007	126.9	KYRAD	2007-50240	SW	224.8	490.7	U	F-Composite	pCi/L	U	490.7		490.7
DNT	Lead-210	12/13/2006	532.5	KYRAD	2006-53325	SW	282.9	3226	U	BBCDG	pCi/L	X	3226		3226
DNT	Lead-210	10/27/2005	2017	KYRAD	2005-52676	SW	2740	9532		D1-Composite	pCi/L	X	9532		9532
DNT	Lead-210	9/14/2005	130.7	KYRAD	2005-52307	SW	55.96	169.4		D1-Composite	pCi/L	X	169.4		169.4
DNT	Lead-210	12/13/2006	5867	KYRAD	2006-53326	SW	3802	7905	U	BBCROSS	pCi/L	X	7905		7905
DNT	Lead-210	7/5/2006	315.2	KYRAD	2006-51734	SW	293.3	612.9	R	BBCUG	pCi/L	X	612.9		612.9
DNT	Lead-210	8/25/2005	592.4	KYRAD	2005-52201	SW	312.6	3755		BBCUG	pCi/L	X	3755		3755

Table E.5. Results of Filtering (Continued)

Method	Chemical	Date Collected	MDA	Lab Code	Lab Sample ID	Media	Rad Error	Result	Lab Qualifier	Station	Units	Val Qualifier	Greater Than DL	Less Than DL	Pass cut
DNT	Lead-210	12/8/2006	141.1	KYRAD	2006-53231	SW	155.1	1554		D1-Composite	pCi/L	X	1554		1554
Gamma Spec	Lead-210	6/4/2007	171.1	KYRAD	2007-51333	SW	99.26	406.2		D1-Composite	pCi/L	=	406.2		406.2
DNT	Lead-210	8/13/2004	135.7	KYRAD	2004-52111	SW	137.5	621.3		F-Composite	pCi/L	=	621.3		621.3
Gamma Spec	Lead-210	11/29/2010	51.1	KYRAD	2010-53280	SW	23.7	230	U	K001	pCi/L	U	230		230
DNT	Lead-210	1/26/2005	152	KYRAD	2005-50163	SW	150	482.9		F-Composite	pCi/L	X	482.9		482.9
DNT	Lead-210	1/26/2005	152	KYRAD	2005-50163	SW	150	482.9		F-Composite	pCi/L	=	482.9		482.9
DNT	Lead-210	7/16/2002	437.6	KYRAD	2002-06663	SW	256.7	27660		D2-Composite	pCi/L	=	27660		27660
DNT	Lead-210	9/14/2005	110.6	KYRAD	2005-52329	SW	55.95	146.3		D2-Composite	pCi/L	X	146.3		146.3
DNT	Lead-210	11/20/2006	267.2	KYRAD	2006-53106	SW	283.2	843		G-Composite	pCi/L	X	843		843
DNT	Lead-210	12/22/2006	230.8	KYRAD	2006-53421	SW	148.8	2500		G-Composite	pCi/L	X	2500		2500
DNT	Lead-210	8/31/2004	107.1	KYRAD	2004-52318	SW	90.23	526		G-Composite	pCi/L	=	526		526
DNT	Lead-210	7/31/2006	150.7	KYRAD	2006-51871	SW	132.9	446.9		D2-Composite	pCi/L	X	446.9		446.9
DNT	Lead-210	11/20/2006	113.4	KYRAD	2006-53074	SW	73.27	265.4		D2-Composite	pCi/L	X	265.4		265.4
DNT	Lead-210	7/21/2004	137.2	KYRAD	2004-51947	SW	144	342.6		G-Composite	pCi/L	=	342.6		342.6
DNT	Lead-210	5/26/2006	159.3	KYRAD	2006-51229	SW	79.65	2701		D2-Composite	pCi/L	X	2701		2701
DNT	Lead-210	8/25/2005	599	KYRAD	2005-52191	SW	424.1	1900		K010	pCi/L	X	1900		1900
DNT	Lead-210	6/1/2005	237.4	KYRAD	2005-51358	SW	260.6	1634		G-Composite	pCi/L	X	1634		1634
Gamma Spec	Lead-210	4/3/2007	182	KYRAD	2007-50729	SW	96.81	2054	U	G-Composite	pCi/L	U	2054		2054
DNT	Lead-210	12/14/2006	537.4	KYRAD	2006-53312	SW	285.4	3298	U	K011	pCi/L	X	3298		3298
DNT	Lead-210	6/16/2005	539.3	KYRAD	2005-51401	SW	366.8	865.9		K012	pCi/L	X	865.9		865.9
DNT	Lead-210	8/23/2005	589.5	KYRAD	2005-52186	SW	491.7	2210		L14	pCi/L	X	2210		2210
DNT	Lead-210	12/14/2006	539.1	KYRAD	2006-53316	SW	286.2	3332	U	K015	pCi/L	X	3332		3332
Gamma Spec	Lead-210	11/29/2010	685	KYRAD	2010-53280	SW	274	4070	U	L4	pCi/L	U	4070		4070
DNT	Lead-210	12/14/2006	7379	KYRAD	2006-53321	SW	4801	11210	U	LBC@McCaw	pCi/L	X	11210		11210
Gamma Spec	Lead-210	5/11/2010	0.838952	KYRAD	2010-51250	SO	0.375929	1.0877436		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.774856	KYRAD	2010-51251	SO	0.352924	1.0153096		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.622129	KYRAD	2010-51252	SO	0.323104	2.7034682		SOU195-120C	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	9.25275	KYRAD	2010-51253	SO	3.831	6.5693666	U	SOU195-120A	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.738264	KYRAD	2010-51254	SO	0.327648	0.7087367	U	SOU195-014	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.87614	KYRAD	2010-51255	SO	0.357205	1.1963452		SOU195-014	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	5.00644	KYRAD	2010-51256	SO	2.14186	1.8868582	U	SOU195-014A	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.69731	KYRAD	2010-51257	SO	0.323468	1.3837602		SOU195-014A	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	5.07442	KYRAD	2010-51258	SO	2.12668	3.5576405	U	SOU195-014A	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	0.919572	KYRAD	2010-51259	SO	0.410998	0.9908741		SOU195-014B	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.643217	KYRAD	2010-51260	SO	0.297765	1.1705553		SOU195-014B	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.963233	KYRAD	2010-51261	SO	0.42696	1.0807067		SOU195-014B	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.786643	KYRAD	2010-51262	SO	0.364651	1.3145335		SOU195-014C	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	1.03762	KYRAD	2010-51263	SO	0.457097	1.0294589	U	SOU195-014C	pCi/g	U			
Gamma Spec	Lead-210	5/12/2010	5.28305	KYRAD	2010-51264	SO	2.15693	6.0068083	J	SOU195-014C	pCi/g	J			
Gamma Spec	Lead-210	5/12/2010	0.727831	KYRAD	2010-51265	SO	0.330025	1.0930592		SOU195-006	pCi/g	=			
Gamma Spec	Lead-210	5/12/2010	0.779156	KYRAD	2010-51266	SO	0.351511	0.8835402		SOU195-006	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.832552	KYRAD	2010-51267	SO	0.370699	0.9368339		SOU200-001	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.616779	KYRAD	2010-51268	SO	0.276128	0.6544536		SOU200-002	pCi/g	=			

Table E.5. Results of Filtering (Continued)

Method	Chemical	Date Collected	MDA	Lab Code	Lab Sample ID	Media	Rad Error	Result	Lab Qualifier	Station	Units	Val Qualifier	Greater Than DL	Less Than DL	Pass cut
Gamma Spec	Lead-210	5/5/2010	0.918867	KYRAD	2010-51269	SO	0.405092	0.8584913	U	SOU200-003	pCi/g	U			
Gamma Spec	Lead-210	5/5/2010	0.894012	KYRAD	2010-51271	SO	0.401519	1.0366496		SOU200-005	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.662666	KYRAD	2010-51272	SO	0.300982	0.9515829		SOU200-006	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	0.777267	KYRAD	2010-51273	SO	0.346092	0.6884684	U	SOU200-007	pCi/g	U			
Gamma Spec	Lead-210	5/5/2010	0.695554	KYRAD	2010-51274	SO	0.31533	1.0058769		SOU200-008	pCi/g	=			
Gamma Spec	Lead-210	5/5/2010	5.14907	KYRAD	2010-51275	SO	2.22839	1.0775268	U	SOU200-009	pCi/g	U			
Gamma Spec	Lead-210	5/5/2010	0.942465	KYRAD	2010-51276	SO	0.415427	0.8905683	U	SOU200-010	pCi/g	U			
Gamma Spec	Lead-210	4/27/2010	0.590492	KYRAD	2010-51277	SO	0.763757	2.571285		SOU222-001	pCi/g	=			
Gamma Spec	Lead-210	9/2/2010	0.816	KYRAD	2010-52457	SO	0.406	4.92		SWMU222-1	pCi/g	=			
Gamma Spec	Lead-210	9/2/2010	0.475	KYRAD	2010-52458	SO	0.221	1.25		SWMU222-4	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.71	KYRAD	2010-53090	SO	0.869	8.44		SWMU222-1	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.41	KYRAD	2010-53091	SO	0.709	6.98		SWMU222-2	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.14	KYRAD	2010-53092	SO	0.607	6.81		SWMU222-3	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	2.05	KYRAD	2010-53093	SO	1.03	10.6		SWMU222-4	pCi/g	=			
Gamma Spec	Lead-210	11/4/2010	1.47	KYRAD	2010-53094	SO	0.757	8.6		SWMU222-5	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.838952	KYRAD	2010-51250	SO	0.375929	1.0877436		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.774856	KYRAD	2010-51251	SO	0.352924	1.0153096		SOU195-025	pCi/g	=			
Gamma Spec	Lead-210	5/11/2010	0.622129	KYRAD	2010-51252	SO	0.323104	2.7034682		SOU195-120C	pCi/g	=			

DNT = Analytical methods was not transmitted.
Gamma Spec = Gamma Spec
KYRAD = Kentucky Radiation Health Branch Laboratory
SW = surface water
X = no 3rd party validation was performed
U = not detected above the MDA
R = result rejected
"=" = result accepted by 3rd party validation

Lead-210 is the daughter of polonium-214 that is a member of the uranium-238 decay chain. Lead-210 is reported at background levels of 1-2 pCi/g in at least one facility (http://www.lrb.usace.army.mil/Portals/45/docs/FUSRAP/DaytonIII/day3-si-2004-12.pdf, Table 2). Please see Tables E.4 and E.5 for the Kentucky Radiation Health Branch (RHB) lead-210 analysis. Only data with a sample specific minimum detectable concentration (MDC) of less than 1 pCi/g were included in the analysis. Based on the data provided by the RHB for lead-210, the background would be in the 1-2 pCi/g range for lead-210 at PGDP.

The no action levels [i.e., 1E-6 values calculated using Risk Assessment Information System (RAIS) and Paducah-specific parameters] are as follows:

- Resident—0.661 pCi/g,
- Industrial worker—7.62 pCi/g, and
- Outdoor worker—1.08 pCi/g.

Based on information provided by TestAmerica to LATA Environmental Services of Kentucky, LLC, the MDC obtained by liquid scintillation (LS) is approximately 5 pCi/g. TestAmerica indicates this is the target MDC by LS; however, this MDC can be lower, if necessary. TestAmerica's target MDC by gamma spectroscopy is the same, 5 pCi/g, but it could vary. TestAmerica indicates that "Lead-210 is a low energy radionuclide on the gamma spec and there could be interferences from other radionuclides and samples with sufficient activity. This could raise the MDA."

Soil analysis by the Kentucky RHB using gamma spectroscopy and a thin window high purity germanium (HPGe) detector, however, achieved an MDC of approximately 1 pCi/g for lead-210 (employing the 46 KeV line for lead-210). Using gamma spectroscopy with the appropriate thin window HPGe detector an MDC of 1 pCi/g is achievable without interference from other radionuclides. In fact, lead-210 is used in calibration standards for thin window HPGe detectors. Gamma spectroscopy, using these thin window HPGe detectors and incorporation of lead-210 into the calibration standard, provides a significant improvement in efficiency in the region less than 59 KeV. Because the analysis of lead-210 by gamma spectroscopy uses the 46 KeV line energy, thin window HPGe detectors are the preferred detectors for analysis of lead-210 by gamma spectroscopy. Achieving a 1 pCi/g MDC for soil analysis is fully supported by the Kentucky RHB data for lead-210 analysis. Because there is no requirement for sample dissolution and separation from other radionuclides, gamma spectroscopy using a thin window HPGe detector would be the preferred method for analysis of lead-210 in soil.

Because analysis of lead-210 by LS requires dissolution of the media in this case soil, it would be preferable to use gamma spectroscopy in order to eliminate concerns regarding complete dissolution of the sample.

With the equipment used by the United States Enrichment Corporation (USEC) laboratory, gamma spectroscopy analysis for lead-210 was not possible because the two primary energy lines are below the analytical laboratory normal energy calibration range. It would require the purchase of a new calibration mixture to include the Pb-210 lines at 46 KeV. The analytical laboratory only has one manual detector that can measure in the x-ray region, so output would be limited.

Lead-210 was included as part of the standard gamma scan for radiological analysis by TestAmerica during the Soils OU project. The MDC for lead-210 was approximately 30 pCi/g. This MDC is protective of a worker at a risk of 1E-5.

The ingrowth of lead-210 from uranium-238 is blocked at uranium-234. Due to the long ingrowth period from uranium-234 to lead-210, it is unlikely that, at the present time, ingrowth of lead-210 from the uranium used in the uranium enrichment processes at PGDP contributes to presence of lead-210 as a potential contaminant/risk at PGDP.

Independent analysis of lead-210 is not necessary on a routine basis. The need for the analysis of radionuclides, such as lead-210, not related to natural uranium and recycled uranium enrichment by the gaseous diffusion process at PGDP should be assessed on project by project basis.

[1] EPA 2012. *Lead-210*, accessed from http://www.epa.gov/radiation/glossary/termjklm.html in 2012.

USGS 2012. *^{210}Pb (lead 210) Dating*, accessed from http://gec.cr.usgs.gov/archive/lacs/lead.htm in 2012.

E.7. PAH CONTAMINATION AND ESTABLISHMENT OF REMEDIAL GOALS

E.7.1. IDENTIFICATION OF THE PROBLEM

Due to the nature of polycyclic aromatic hydrocarbons (PAHs), as described in the Toxicological Profile for PAHs,[1] the presence of PAHs in PGDP in some soils and sediments (e.g., along roads, including roadside ditches, and around buildings) may not be directly related to PGDP releases, but rather from other on- or off-site site activities, including airborne deposition of PAHs that result from the incomplete burning of oil, gas, wood, garbage, or other organic substances or deposition due to the use of rubber, asphalt, crude oil, coal tar, creosote, and roofing tar. The most common source of PAHs in the environment currently is deposition of automobile exhaust.[2] Thus, in evaluating risk/hazard at PGDP SWMUs/areas of concern under the FFA, there is a potential for PAHs not associated with PGDP releases to be identified as a risk driver, potentially leading to the development of disagreements on appropriate cleanup decisions.[3]

The on-site Surface Water Operable Unit (SWOU) contaminated sediment project provides an example of the aforementioned problems. As discussed in the SWOU (on-site) contaminated sediment Engineering Evaluation/Cost Analysis (EE/CA), [9] PAHs were determined not to be good candidates to verify cleanup because PAHs were detected above cleanup criteria at random locations due to their sources. To address PAH contamination in on-site sediments, other contaminants of concern (COCs) found to be co-located with PAHs [i.e., polychlorinated biphenyls (PCBs) and uranium] were used to verify cleanup.

E.7.2. DISCUSSION

Varying approaches have been used to address the presence of PAHs as risk drivers by DOE. At the Oak Ridge Reservation, an early document proposed that DOE manage PAHs as if they were wholly associated with background;[4] however, currently at the Oak Ridge Reservation, PAHs are being addressed on a case-by-case basis and anthropogenic sources are considered. At the Portsmouth Gaseous Diffusion Plant,[2] DOE proposed remediation of PAHs in areas where (1) the source has been determined to be contributed to by past plant operations or treatment, storage, and disposal activities; and (2) concentrations are sufficiently high that the acceptable risk range of 1E-4 to 1E-6 is exceeded.[5]

Commonwealth of Kentucky guidance indicates that parking lots, paved areas, areas within 3 ft of a roadway, railroad tracks, railway areas, storm drains, or ditches presently or historically receiving industrial or urban runoff should not be sampled when determining background, in part due to the potential for PAHs to be present in these areas.[3,6] Kentucky Revised Statutes exclude emissions from the engine exhaust of a motor vehicle from the definition of a release;[7] therefore, remediation of the widespread low concentrations of PAHs, when linked to such sources (e.g., automobile exhaust and asphalt), should not be considered.

As part of the baseline human health risk assessment (BHHRA) process at PGDP, the potential risks posed by PAHs are included in the quantitative BHHRA. In evaluating methods to address unacceptable risk/hazard, the nature of the PAHs and the potential non-PGDP sources will be considered as uncertainties when identifying risk drivers requiring action and when analyzing alternatives to manage site risk. This evaluation will include consideration of the following:

- PAHs are a group of chemicals formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances. PAHs are constituents of rubber, asphalt, coal, crude oil, coal tar, creosote, and roofing tar.

- PAH media concentrations in some areas (e.g., along roads and in roadside ditches) may increase over time in the absence of identifiable releases from PGDP processes.

- PAHs currently in the environment will degrade over time; however, the rate of degradation is unknown and depends upon the site conditions, including the medium in which PAHs are present and the location of the environmental medium.

Of the PAH chemicals considered to be carcinogenic, benzo(a)pyrene is believed to be the most potent. In a database search at PGDP in October 2017, there were 563 detected benzo(a)pyrene results, out of 5,224 analyzed environmental soil and sediment samples. Table E.6 summarizes these benzo(a)pyrene results and indicates that the highest concentrations of the PAH are in surface soils.

Table E.6. Maximum Benzo(a)pyrene Concentrations by Sample Depth

Sample Depth (ft)	Maximum Benzo(a)pyrene Concentration (mg/kg)
0-1	6,100
2-4	3.9
4-8	8.6
8-12	0.95
>12	0.98

Toxicity equivalence factors (TEFs) are used to calculate Total PAHs.[8] The method to calculate Total PAHs using TEFs is described in Section 3.3.3.2 (Step 8) of the Paducah Risk Methods Document. As described there, detected concentrations of each carcinogenic PAH in each sample are multiplied by the carcinogenic PAH's TEF. Also, for carcinogenic PAHs not detected in a sample, the minimum detection limit for the PAH is multiplied by the carcinogenic PAH's TEF. The products for detected and non-detected PAHs are then summed to derive Total PAHs. The carcinogenic PAHs considered in these calculations are benzo(a)pyrene; benz(a)anthracene; benzo(b)fluoranthene; benzo(k)fluoranthene; chrysene; dibenz(a,h)anthracene; and indeno(1,2,3-cd)pyrene.

Table E.7 summarizes the maximum concentrations of Total PAHs detected in surface (0–1 ft), subsurface (1–10 ft), and deep subsurface soils (> 10 ft) at PGDP (as defined by the Paducah Risk Methods Document).[8] Figure E.9 summarizes the range of concentrations of Total PAHs detected in soil at the PGDP as found in PEGASIS. This figure provides a comparison to the no action level (ELCR = 1E-06) and action level (ELCR = 1E-04) for the industrial worker. These values are 0.643 mg/kg and 64.3 mg/kg, respectively. Figures E.10 through E.12 illustrate the location of these Total PAHs by depth.

Table E.7. Maximum Total PAHs by Depth

Sample Depth (ft)	Maximum Total PAH Concentration (mg/kg)
Surface (0–1)	8,750
Subsurface (1–10)	11.4
Deep Subsurface (> 10)	1.46

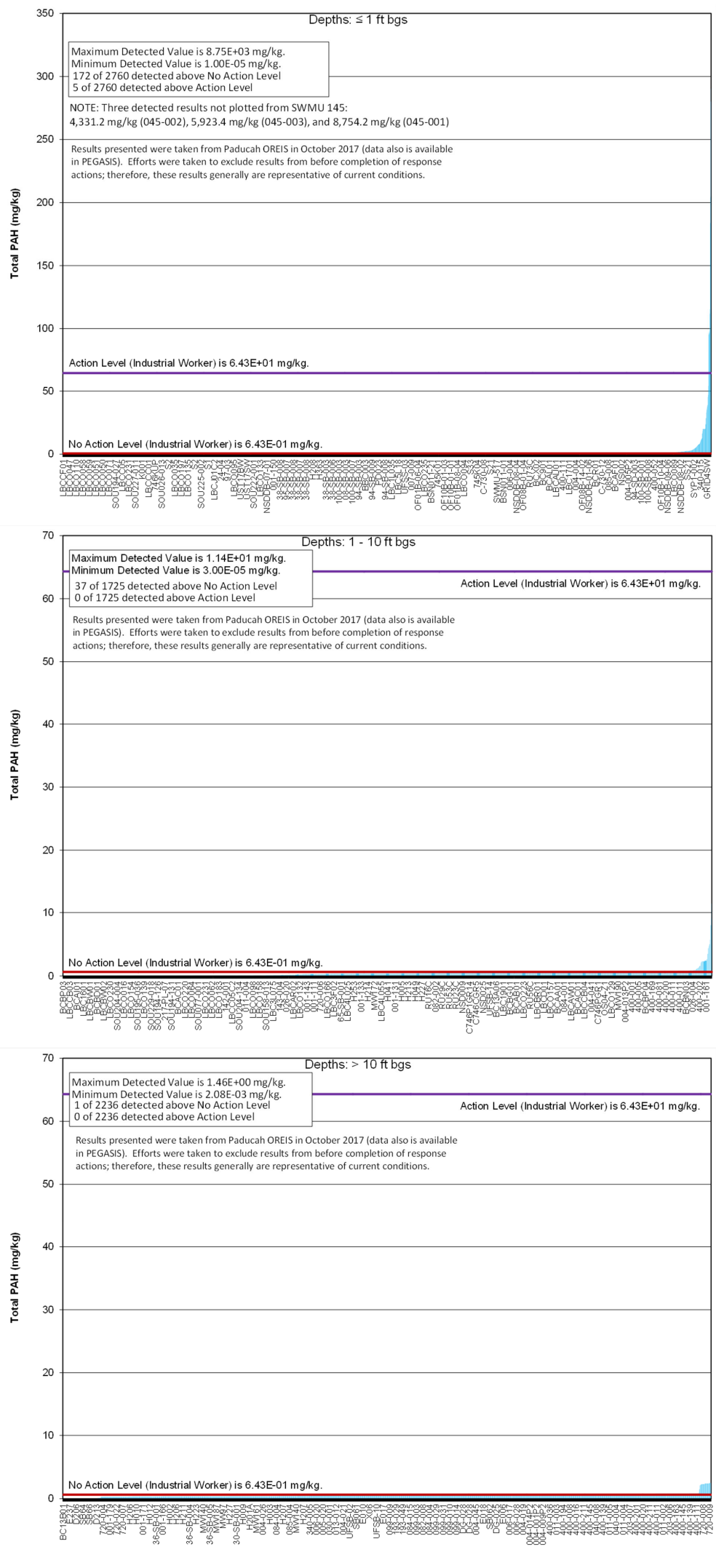


Figure E.9. Total PAH Concentrations by Depth

THIS PAGE INTENTIONALLY LEFT BLANK

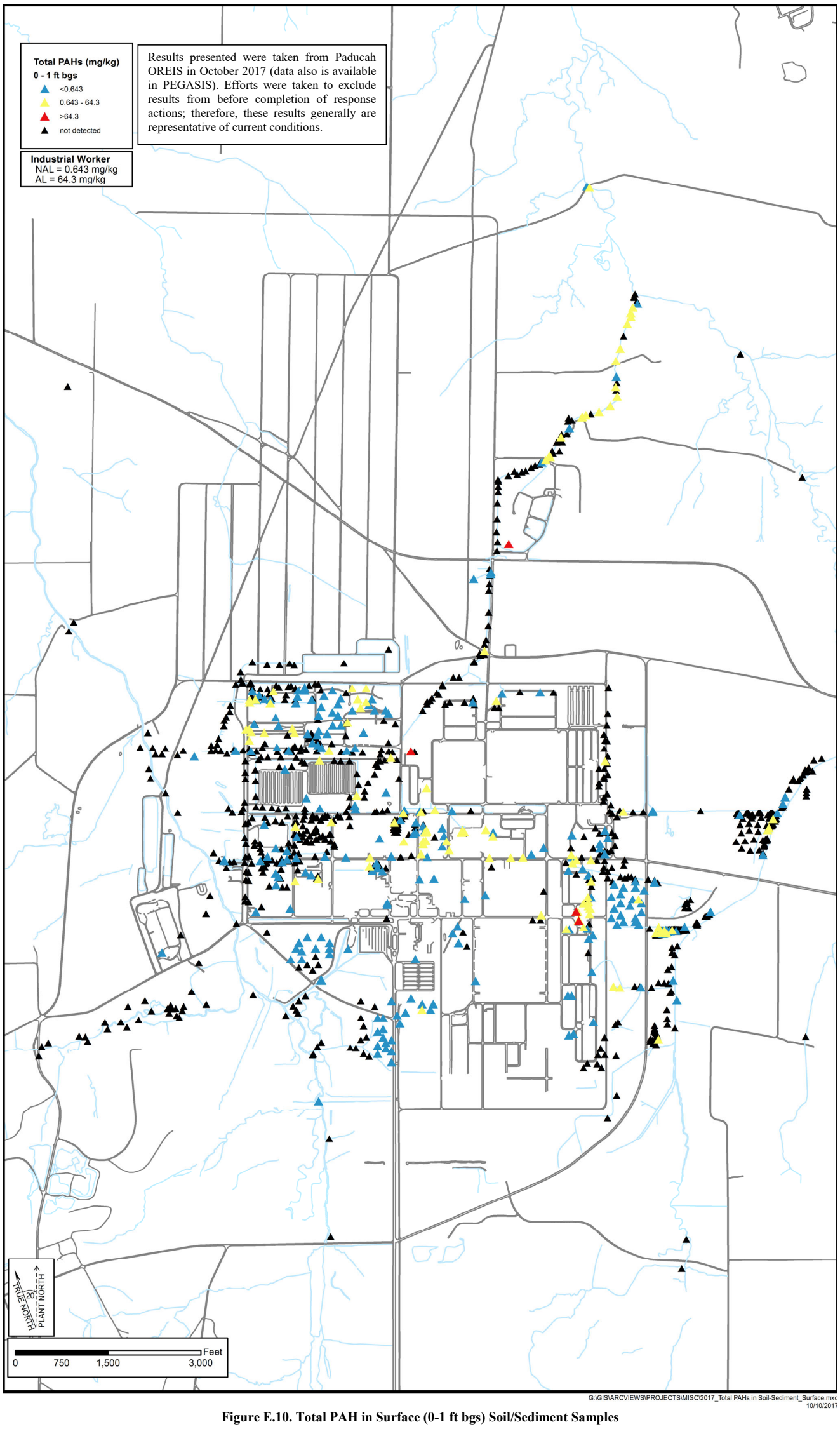


Figure E.10. Total PAH in Surface (0-1 ft bgs) Soil/Sediment Samples

THIS PAGE INTENTIONALLY LEFT BLANK

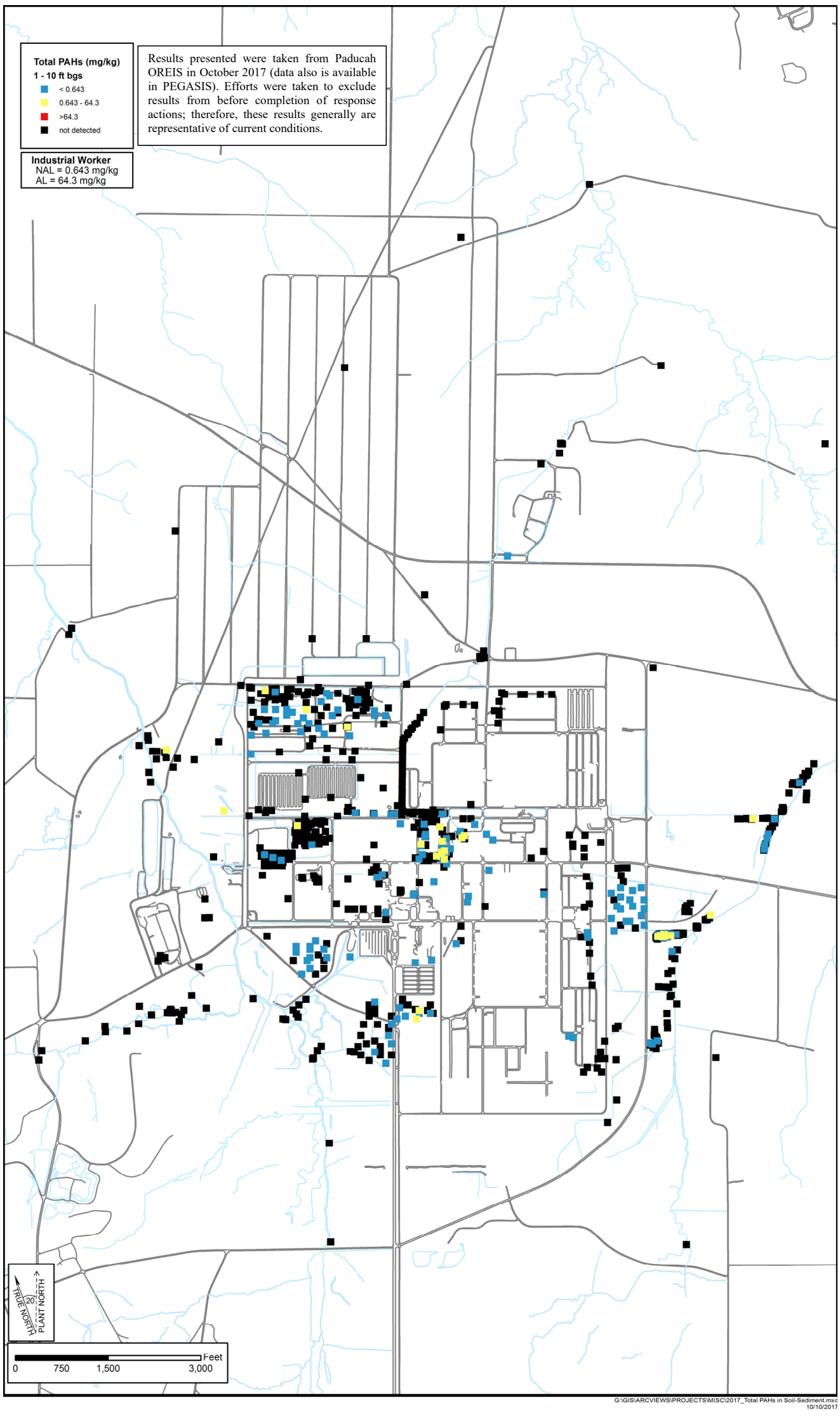


Figure E.11. Total PAH Subsurface (1-10 ft bgs) Soil/Sediment Samples

THIS PAGE INTENTIONALLY LEFT BLANK

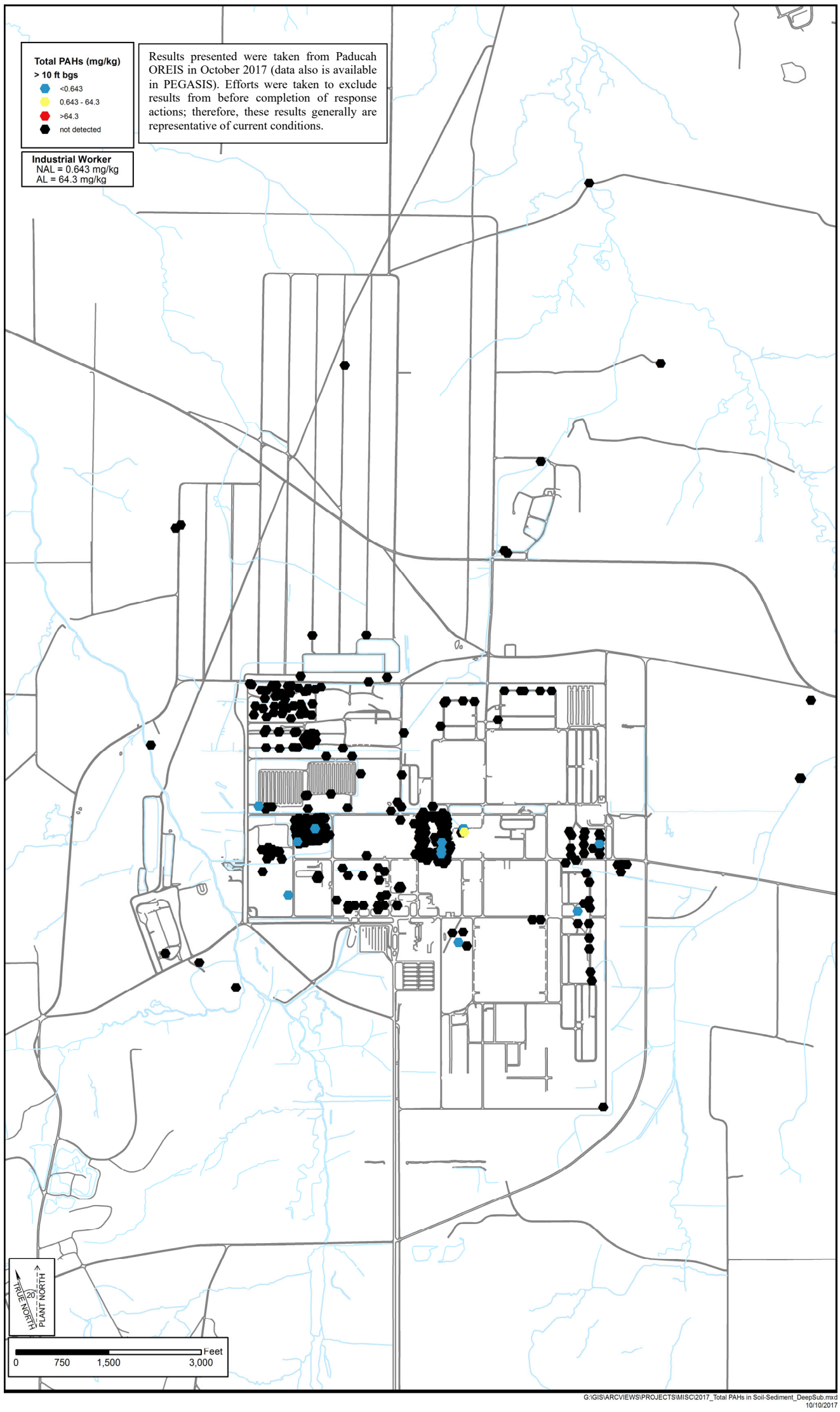


Figure E.12. Total PAH Deep Subsurface (>10 ft bgs) Soil/Sediment Samples

THIS PAGE INTENTIONALLY LEFT BLANK

The Observations section of BHHRAs address uncertainties associated with the presence of PAHs, and the feasibility study (FS) includes discussions ensuring that remedial actions appropriately address the uncertainties associated with the presence of residual concentrations of PAHs.

E.7.3. SUMMARY

In evaluating risk/hazard at PGDP, the need to sample for PAHs and the evaluations of PAH sampling results will be determined on a case-by-case basis to incorporate uncertainties concerning the presence of PAHs into the risk management process. This will include ***quantitative*** evaluation of the risk/hazard presented by PAHs in the BHHRA when PAHs are sampled for, consistent with the Paducah Risk Methods Document.[8] Subsequently, the BHHRA will discuss the uncertainties associated with the presence of PAHs, and these uncertainties will be combined with risk characterization in the Observations section. The FS will manage these uncertainties and incorporate regulatory requirements to ensure that potential exposure to residual PAHs in environmental media is addressed appropriately.

[1]Agency for Toxic Substances and Disease Registry [ATSDR 1995] (see http://www.atsdr.cdc.gov/toxprofiles/tp69.pdf).

[2]*Risk Management Considerations for Polycyclic Aromatic Hydrocarbon Contamination at the Portsmouth Gaseous Diffusion Plant*, POEF-ER-4616&D1, January 27, 1995.

[3]E-mail correspondence among FFA parties.

[4]*Final Report on the Background Soil Characterization Project at the Oak Ridge Reservation, Oak Ridge, Tennessee; Volume 1, Results of Field Sampling Program*, DOE/OR/01-1175/V1, October 1993.

[5]"Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (OSWER Directive 9355.0-30) April 22, 1991.

[6]Kentucky Guidance for Ambient Background Assessment, January 8, 2004, Natural Resources and Environmental Protection Cabinet.

[7]Kentucky Revised Statute 224.01-400 (1) (b).

[8]Draft *Risk Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0107&D2/R9, December 2017.

[9]*Engineering Evaluation/Cost Analysis for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0012&D2, August 2008.

THIS PAGE INTENTIONALLY LEFT BLANK

E.8. SITE-SPECIFIC SOIL SCREENING LEVELS AND SITE-SPECIFIC DILUTION ATTENUATION FACTORS AT THE PADUCAH GASEOUS DIFFUSION PLANT

E.8.1. IDENTIFICATION OF THE PROBLEM

U.S. Environmental Protection Agency (EPA) provides guidance for calculating risk-based, site-specific, soil screening levels (SSLs) for contaminants in soil that may be used to identify areas needing further investigation at National Priorities List sites (EPA 1996a; EPA 1996b; EPA 2002). SSLs are risk-based concentrations derived from equations combining exposure information assumptions with EPA toxicity data. SSLs may be developed for the direct exposure pathways (e.g., incidental ingestion, dermal contact, particulate inhalation, and inhalation of volatiles) based on excess lifetime cancer risk for carcinogens or on hazard quotients for noncarcinogens; or. SSLs may be developed for the indirect exposure pathway of soil to groundwater migration and subsequent ingestion of contaminated groundwater. This paper looks only at these SSLs for soil to groundwater migration.

Contaminant concentrations are attenuated by adsorption and degradation as soil leachate moves through soil and groundwater. In the aquifer, dilution by groundwater further reduces concentrations before contaminants reach receptor points (i.e., drinking water wells). This reduction through dilution in concentration can be expressed as a dilution attenuation factor (DAF), defined as the ratio of soil leachate concentration to receptor point concentration. A DAF of 1 corresponds to a situation where there is no dilution or attenuation of a contaminant (i.e., when the concentration in the receptor well is equal to the soil leachate concentration). On the other hand, higher DAF values correspond to a large reduction in contaminant concentration from the contaminated soil to the receptor well (EPA 1996a).

In order to facilitate agreement with respect to use of SSLs and DAFs at Paducah Gaseous Diffusion Plant (PGDP), the Federal Facility Agreement (FFA) Managers decided that the Groundwater Modeling Working Group (MWG) would develop a white paper for inclusion in the Risk Methods Document to provide guidance on development of site-specific SSLs and site-specific DAFs to be implemented when scoping projects.

E.8.2. BACKGROUND

E.8.2.1 HYDROGEOLOGY OF THE PADUCAH SITE

PGDP is located in the Jackson Purchase region of western Kentucky, approximately 10 miles west of Paducah, Kentucky, and 3.5 miles south of the Ohio River. Buried Pleistocene fluvial deposits of the ancestral Tennessee River unconformably overlie Cretaceous marine sediments at a depth of approximately 100 ft directly beneath and north of the Paducah Site. The bottom Pleistocene fluvial deposits consist of a gravel unit that ranges in thickness from 30 ft to 50 ft, with the top of the unit encountered at a general depth of 60 ft below ground surface (bgs) at the Site. This gravel unit is the primary member of the uppermost aquifer beneath the Paducah Site and north to the Ohio River—the Regional Gravel Aquifer (RGA). The RGA is the main conduit for groundwater flow to the north, where groundwater discharges to the Ohio River, and the main pathway for off-site contaminant plume migration. A thick sequence of silts and fine sands, comprising the Upper Continental Recharge System (UCRS), overlies the RGA.

E.8.2.2 USE OF SSLS AND DAF AT THE PADUCAH SITE

The maximum UCRS soil concentrations that are protective of RGA groundwater quality, SSLs, are determined by combining the DAF (unitless) calculations with contaminant-specific distribution coefficients (K_d) (units of volume/mass).

RGA groundwater flows are much higher relative to UCRS groundwater flows; thus, mixing the two waters will result in much lower RGA groundwater contaminant concentrations relative to the initial UCRS groundwater contaminant concentrations. The reduction in groundwater concentrations in the RGA is proportional to the ratio of the volume of RGA groundwater to contaminated UCRS groundwater. The DAF calculates the impact on the concentration from the relative rates of vertical migration of contaminated UCRS water and horizontal migration of RGA groundwater to yield a concentration of the blended water.

To complete the evaluation, the K_d of the constituent must be factored into the analysis. K_d represents the ratio of contamination adhered to soil particles (the source zone) relative to that dissolved in groundwater (as the soil leachate).

Starting with a target-acceptable RGA groundwater contaminant concentration [i.e., maximum contaminant levels (MCLs) or site-specific risk based concentrations, etc.] and assuming that the receptor point concentration is below the source area in the RGA, the maximum acceptable UCRS groundwater contaminant concentration can be calculated using a DAF value. When this result is combined with the applicable K_d for the UCRS and for the contaminant, this calculation will yield the SSL, the maximum-acceptable UCRS soil contaminant concentration that is protective of RGA groundwater quality at the target concentration.

E.8.3. HISTORICAL USE OF SSLS AT THE PADUCAH GASEOUS DIFFUSION PLANT

E.8.3.1 EARLY PROJECTS

Prior to the use of site-specific soil-to-groundwater SSLs, projects used background and risk-based screening levels from the site Risk Methods Document. The following are example projects.

- SWMU 2 Data Summary Interpretation Report (DOE 1997)
- WAG 6 Remedial Investigation (RI) (DOE 1998a)
- WAG 27 RI (DOE 1999a)

Other site RIs screened media analyses against EPA-derived SSLs using a DAF of 20. The following projects used this approach.

- WAGs 9 & 11 Site Evaluation (DOE 1999b)
- WAG 28 RI (DOE 2000a)
- WAG 3 RI (DOE 2000b)

The SWMUs 7 and 30 RI used EPA SSLs at a DAF of 1 to screen chemicals or radionuclides of potential concern (COPCs) prior to fate and transport modeling using Seasonal Soil Model (SESOIL) (DOE 1998b). The Southwest Plume Site Investigation (SI) Report provided SSLs at DAFs of 1 and 20 for volatile organic compounds (DOE 2007).

E.8.3.2 SOUTHWEST PLUME FFS

Following the Southwest Plume SI Report, the Southwest Plume Focused Feasibility Study (FFS) (DOE 2011) used deterministic modeling [SESOIL/Analytical Transient 1-, 2-, 3-Dimensional Simulation of Waste Transport in the Aquifer System (AT123D)] and site-specific values of attenuation and migration factors to evaluate remediation goals for protection of groundwater for trichloroethene (TCE) and its break-down products for the Oil Landfarm (SWMU 1) and the C-720 area.

The Southwest Plume FFS calculated a DAF of 59. Cleanup goals of 0.073 and 0.075 mg/kg for TCE at SWMU 1 and C-720, respectively, were calculated (using an MCL of 5 µg/L as a target-acceptable RGA groundwater contaminant concentration). Site-specific values used in the calculations are shown in Tables C.9 and C.10 of the FFS (DOE 2011).

E.8.3.3 SOILS OU RI

Based on expected minimum and maximum RGA hydraulic conductivity (K) (0.03 to 1.09 cm/s), RGA gradient (i) (1.84E-04 to 2.98E-03 m/m), and UCRS infiltration (I) (0.0679 to 0.1964 m/yr) values, DAF values for the Soils Operable Unit (OU) ranged between 5 and 139 (DOE 2013). The parameter distributions, with the exception of I, were developed for probabilistic evaluation of soil cleanup remediation goals for SWMU 1 and the C-720 Building (DOE 2007; DOE 2011). For the soil remediation goal probabilistic evaluation, I was held constant. For this probabilistic evaluation, I was assumed to range linearly between 2.64 inches/yr and 7.64 inches/yr (0.067 m/yr and 0.194 m/yr) (DOE 2013).

Limiting the maximum hydraulic conductivity value to 1,500 ft/d, to reflect the expected lower hydraulic conductivity values found beneath the PGDP, the maximum DAF was calculated at 68. To develop a better understanding of the potential DAF distribution, a probabilistic evaluation was performed. The evaluation predicted mean, median, minimum, and maximum DAF values of 52, 33, 3, and 366, respectively. Evaluation of the probabilistic DAF distribution (Figure E.13) shows that lower DAF values occur more frequently than higher DAF values with the most frequently occurring DAF being between 11 and 20.

DAF values for the Soils OU ranged between 5 and 139 (DOE 2013).

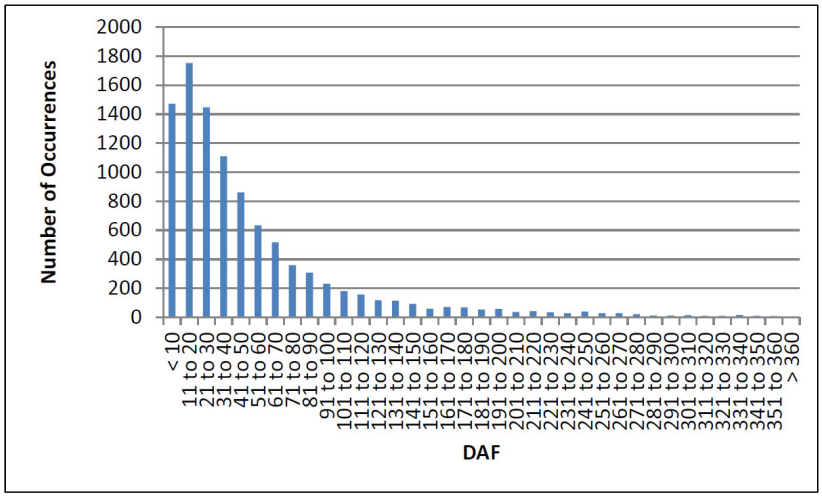


Figure E.13. Probabilistic DAF Distribution

Deterministic evaluation of typical PGDP site conditions predicted a DAF of 58 for the Soils OU RI. Minimum and maximum deterministic predicted DAF values were 5 and 139, respectively. The DAF of 58 derived with the expected values for hydraulic parameters was used to support screening of the Soils OU results to identify those SWMUs/AOCs where constituents might present an impact to groundwater.

E.8.4. DISCUSSION

E.8.4.1 RISK METHODS DOCUMENT MODELING MATRIX

Based on guidance presented in Section 3.3.4.3 "Quantification of Exposure" of the Risk Methods Document (DOE 2017a), to determine if fate and transport modeling is needed, the maximum soil concentrations (or activities for radionuclides) at the source (over all depths) for each analyte are compared to the appropriate groundwater protection preliminary remediation goal (PRG). If the maximum soil concentration exceeds the groundwater protection PRG, then future concentrations in groundwater will be modeled. Models to be used to determine future concentrations and activities at the source and in groundwater will be based on the modeling matrix presented in Table E.8 (from Table 1 DOE 2017a). Tier 1 values are existing sets of screening levels used for the initial screening of a site. Tier 2 values also are used for scoping, but account for more specific estimates of model parameters than the default Tier 1 values. Tiers 3 and 4 values are derived by models used primarily with site–specific values for site decision making.

Table E.8. Modeling Matrix for Groundwater

	Values for Soil to Protect Groundwater	Model	Point of Exposure	Notes
INVESTIGATION DOCUMENTS	Tier 1 (Used for scoping)	SSLs and/or RESidual RADioactivity (RESRAD)	At source unit	Value to be used for initial scoping, use DAF of 1 for SSLs, unless site-specific values are available. Groundwater protection value based on residential use and targets of 1E-6, 0.1, and 1 for risk, hazard, and radiological dose, respectively. If site-specific DAF values are used, then need to justify these values. The depth of water needs to be considered in the calculation.
		Vapor intrusion model	At source unit	Initial vapor intrusion model will use default values.
	Tier 2 (Used for scoping)	SESOIL and/or RESRAD	At source unit	Includes source delimitation. Recognize SESOIL limitations when modeling inorganic COPCs—refine K_ds.
DECISION DOCUMENTS	Tier 3 (Enhanced modeling used in decision documents if needed)	SESOIL and RESRAD suite of codes (including RESRAD-OFFSITE) with AT123D	At source unit and at downgradient points (Industrialized area, DOE property boundary, creek, river)	Uses source delimitation and refined K_ds from above. Use values from this effort to set initial cleanup levels. On the Terrace (southern portion of PGDP), different points of exposure will apply.
	Tier 4 (Enhanced modeling used in decision and design documents if needed)	Source modeling and three-dimensional finite-difference groundwater model (MODFLOW/MT3D/ RT3D)	At source unit and at downgradient points appropriate to the selected remedy	To be used to refine cleanup levels (if needed). May be especially important to set monitoring goals. On the Terrace (southern portion of PGDP), different points of exposure will apply.

(Table from DOE 2017a)

E.8.4.2 METHODOLOGY FOR DEVELOPMENT OF TIER 1 SSLS FOR GROUNDWATER PROTECTION

SSLs[1] will be calculated using EPA guidance (i.e., EPA 1996a; EPA 1996b; EPA 2002). EPA guidance is appropriate for calculating SSLs corresponding to target leachate contaminant concentrations in the zone of contamination. Inputs to the calculations will use project-specific data, when available, to guide selection of values for variables of the SSL and DAF calculations, as appropriate. If necessary, additional data may be collected if determined during project scoping.

For nonradionuclides, soil to groundwater SSLs in the Risk Methods Document are calculated from the equation below. This methodology follows EPA guidance in EPA 1996b.

$$SSL = C_w \times DAF \times \left(K_d + \left(\frac{\theta_w + \theta_a H'}{\rho_b}\right)\right)$$

Where:

Variable	Explanation	Recommended Input
C_w	Target groundwater concentration (mg/L)	MCLs or resident/child resident no action level.
DAF	dilution attenuation factor (unitless)	See equation below.
K_d	soil-water partition coefficient (L/kg)	For inorganics: Chemical-specific (RAIS default, unless project-specific value is available). For organics: $K_d = K_{oc} \times f_{oc}$
K_{oc}	soil organic carbon-water partition coefficient (L/kg) K_{oc} is the determinant for each organic chemical's effective distribution coefficient	Chemical-specific (RAIS default, unless project-specific value is available). See also equation shown for K_d.
f_{oc}	fraction organic carbon in soil (unitless)	0.002 (RAIS default), unless project-specific value is available. (NOTE: Paducah-specific values range 0.0002 to 0.005. Most projects have location-specific values available.[a])
θ_w	water-filled soil porosity (Lwater/Lsoil)	0.3 (RAIS default), unless project-specific value is available. [NOTE: Paducah-specific values of total porosity are from the WAG 6 RI data set (DOE 1998a). Water filled soil porosity ranges between 0.37 for shallow water table settings and 0.30 for deep water table settings.[b]]
θ_a	air-filled soil porosity (Lair/Lsoil)	0.13[c] (EPA 1996b), unless project-specific value is available. (NOTE: Paducah-specific values are 0.0 for shallow water table settings and 0.07 for deep water table settings.[d])
ρ_b	dry soil bulk density (kg/L)	1.5 (RAIS default), unless project-specific value is available. (NOTE: Paducah-specific value is 1.7.[e])
H'	dimensionless Henry's law constant	Chemical-specific (RAIS default).

[a] Fraction organic carbon in soil typically can be found on the Paducah Site's Environmental Geographic Analytical Spatial Information System as Total Organic Carbon (TOC).
[b] The water-filled soil porosity 0.37 value represents 100 % water saturation and the 0.30 value represents 80% water saturation.
[c] Although the default value for air-fill soil porosity is 0.13, much lower values are representative of the near-saturated, fine-grained soils of the Paducah Site.
[d] The air-filled soil porosity 0.0 value represents 100 % water saturation and the 0.07 value represents 80% water saturation.
[e] $\rho_b = [1.00\text{-}0.37\ (\theta_{total})] \times 2.65$ kg/L (soil particle specific gravity)

[1] These SSLs are developed as Tier 1 values. Using more sophisticated modeling (e.g., SESOIL) to develop Tier 2 values also is consistent with EPA guidance.

For radionuclides, soil to groundwater SSLs are calculated from the equation below. This methodology also follows EPA guidance in EPA 1996b, since Henry's law constant is not applicable.

$$SSL = C_w \times DAF \times \frac{\left(K_d + \left(\frac{\theta_w}{\rho_b}\right)\right)}{1{,}000}$$

Where:

Variable	Explanation	Recommended Input
C_w	Target groundwater concentration (pCi/L)	MCLs or resident/child resident no action level.
DAF	dilution attenuation factor (unitless)	See equation below.
K_d	soil-water partition coefficient (L/kg)	Radionuclides: values are from DOE 2003 and DOE 2012.
θ_w	water-filled soil porosity (L/L)	0.3 (RAIS default), unless project-specific value is available. (NOTE: Paducah-specific value is 0.37.)
ρ_b	dry soil bulk density (kg/L)	1.5 (RAIS default), unless project-specific value is available. (NOTE: Paducah-specific value is 1.7.)

DAF calculation utilizes EPA guidance and the following equations (EPA 1996a).

$$DAF = 1 + \frac{Kid}{IL}$$

Where:

Variable	Explanation	Recommended Input
i	horizontal hydraulic gradient (m/m)	Project-specific value.
d	mixing zone depth (m)	See equation below.
I	infiltration rate (m/yr)	Range of values taken from DOE 2017b.
L	length of source area parallel to groundwater flow (m)	Project-specific value (maximum distance across the source area in a direction parallel to RGA groundwater flow).
K	aquifer hydraulic conductivity (m/yr)	Project-specific value taken from within range of values in DOE 2017b.

The equation for calculating the aquifer mixing zone depth, d:

$$d = \left(0.0112L^2\right)^{0.5} + d_a\left\{1 - e^{\left[\frac{(-LI)}{(Kid_a)}\right]}\right\}$$

Where:

Variable	Explanation	Recommended Input
i	horizontal hydraulic gradient (m/m)	Project-specific value.
d_a	aquifer thickness (m)	Average of values for project-specific area taken from most recent KRCEE database.
I	infiltration rate (m/yr)	Range of values taken from DOE 2017b.
L	length of source area parallel to groundwater flow (m)	Project-specific value.
K	aquifer hydraulic conductivity (m/yr)	Project-specific value taken from within range of values in DOE 2017b.

An example comparison of site-specific and default inputs for key COPCs is shown in Table E.9.

Table E.9. Example Site-Specific and Default Inputs for Key COPCs

Key COPC	Site-Specific			Default		
	DAF	K_d L/kg	SSL mg/kg or pCi/g	DAF	K_d L/kg	SSL[a] mg/kg or pCi/g
TCE	59[b]	7.52E-02[b]	7.30E-02[b]	20[e]	1.21E-01[f]	3.58E-02[e]
1,1-DCE	59[b]	5.20E-02[b]	1.30E-01[b]	20[e]	6.36E-02[f]	5.02E-02[e]
cis-1,2-DCE	59[b]	2.88E-02[b]	6.00E-01[b]	20[e]	7.92E-02[f]	4.12E-01[e]
trans-1,2-DCE	59[b]	3.04E-02[b]	1.08E+00[b]	20[e]	7.92E-02[f]	6.26E-01[e]
Vinyl chloride	59[b]	1.52E-02[b]	3.40E-02[b]	20[e]	4.34E-02[f]	1.38E-02[e]
Tc-99	58[c]	2.00E-01[d]	2.12E+01[c]	20[e]	2.00E-01[e]	1.52E-01[e]
U-238	58[c]	6.68E+01[d]	2.64E+02[c]	20[e]	6.68E+01[e]	8.04E-01[e]

[a] SSL is based on MCL for the organics and resident NAL for the radionuclides.
[b] DOE 2011, for SWMU 1 area, using site-specific foc.
[c] DOE 2013.
[d] DOE 2003.
[e] DOE 2017a.
[f] RAIS 2017. https://rais.ornl.gov/, accessed November 27, using K_{oc} × foc where foc is 0.002.

E.8.5. SUMMARY

Site-specific SSLs and site-specific DAFs will be developed collaboratively during project scoping by the FFA parties. If adequate site-specific data (of known and sufficient quality and quantity) are not available to support these calculations, SSLs developed using DAFs of 1 and 20 will be used for screening, consistent with EPA guidance (EPA 1996a). For the purposes of this paper, it is the intent of the FFA parties that "site" is a project-level term and does not refer to larger areas of consideration such as the facility, the plant, the Superfund Site or site-wide.

The method to be used in developing site-specific SSLs and site-specific DAFs is presented in the attachment to this paper and will follow Section 4.2, "Methodology for Development of Tier 1 SSLs for Groundwater Protection."

E.8.6. REFERENCES

DOE 1997. *Data Summary Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/OR/07-1549&D1, February.

DOE 1998a. *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/OR/07-1727&D2, May.

DOE 1998b. *Remedial Investigation Report for Solid Waste Management Units 7 and 30 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/OR/07-1604&D2, January.

DOE 1999a. *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/OR/07-1777&D2, June.

DOE 1999b. *WAGs 9 and 11 Site Evaluation Report at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/OR/07-l 785&D2, June.

DOE 2000a. *Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/OR/07-1846&D2, August.

DOE 2000b. *Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/OR/07-1895&D1, September.

DOE 2003. *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/OR/07-2041&D2/R1, September.

DOE 2007. *Southwest Plume Site Investigation Report at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/OR/07-2180&D2/R1, June.

DOE 2011. *Revised Focused Feasibility Study for Solid Waste Management Units 1, 211A, and 211B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/LX/07-0362&D2, May.

DOE 2012. *Remedial Investigation/Feasibility Study Report for the CERCLA Waste Disposal Alternatives Evaluation at the Paducah Gaseous Diffusion Plant*, *Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/LX/07-0244&D1, May.

DOE 2013. *Soils Operable Unit Remedial Investigation Report at the Paducah Gaseous Diffusion Plant*, *Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, DOE/LX/07-0358&D2/R1, February.

DOE 2017a. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1. Human Health*, U.S. Department of Energy, Paducah, KY, DOE/LX/07-0107&D2/R8/V1, July.

DOE 2017b. *2016 Update of the Paducah Gaseous Diffusion Plant Sitewide Groundwater Flow Model*, U.S. Department of Energy, Paducah, KY, DOE/LX/07-2415&D2, July.

EPA (U.S. Environmental Protection Agency) 1996a. *Soil Screening Guidance: User's Guide*. OSWER 9355.4-23, Office of Solid Waste and Emergency Response, July.

EPA 1996b. *Soil Screening Guidance: Technical Background Document*. EPA/540/R95/128, Office of Solid Waste and Emergency Response, May.

EPA 2002. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. OSWER 9355.4-24, Office of Solid Waste and Emergency Response, December.

THIS PAGE INTENTIONALLY LEFT BLANK

ATTACHMENT

METHOD TO BE USED IN DEVELOPING SITE-SPECIFIC SSLS AND SITE-SPECIFIC DAFS

THIS PAGE INTENTIONALLY LEFT BLANK

SITE-SPECIFIC SSL AND SITE-SPECIFIC DAF

OBJECTIVE

The methodology will serve as a standard for determining site-specific soil screening levels (SSLs) for soil to groundwater migration and site-specific dilution attenuation factors (DAFs). While this guidance presents a standard method for determining site-specific SSLs and DAFs, deviations from this guidance are likely, and these deviations will be discussed on a case-by-case basis.

BASIS

In order to facilitate agreement with respect to use of SSLs and DAFs at the Paducah Site, the Federal Facility Agreement Managers decided that the Groundwater Modeling Working Group would develop a white paper for inclusion in the Risk Methods Document providing guidance on development of site-specific SSLs and site-specific DAFs to be implemented when scoping projects.

SITE-SPECIFIC SSL AND SITE-SPECIFIC DAF DEVELOPMENT GUIDANCE

This guidance applies to determining maximum Upper Continental Recharge System soil concentrations that are protective of Regional Gravel Aquifer groundwater quality, SSLs, by combining the DAF (unitless) calculations with contaminant-specific distribution coefficients (K_d) (units of volume/mass).

Requirements for this determination are inputs to the equations identified in Section 4.2, "Methodology for Development of Tier 1 SSLs for Groundwater Protection." Each variable will be documented as to its source. An assessment of each of these variables for use as project-specific inputs will be included. These parameters will be agreed to by all parties during scoping. Derivation using the equations will be clearly documented.

THIS PAGE INTENTIONALLY LEFT BLANK

E.9. HUMAN HEALTH INFORMATION FOR THE PADUCAH VAPOR INTRUSION EVALUATION

Information provided in Table E.10 is taken from several sources. It should be noted that according to the Occupational Safety & Health Administration (OSHA) website (https://www.osha.gov/dsg/annotated-pels/, accessed in January 2022), "OSHA recognizes that many of its permissible exposure limits (PELs) are outdated and inadequate for ensuring protection of worker health. Most of OSHA's PELs were issued shortly after adoption of the Occupational Safety and Health (OSH) Act in 1970, and have not been updated since that time. Since 1970, OSHA promulgated … new PELs for 16 agents, and standards without PELs for 13 carcinogens. Industrial experience, new developments in technology, and scientific data clearly indicate that in many instances these adopted limits are [also] not sufficiently protective of worker health. This has been demonstrated by the reduction in allowable exposure limits recommended by many technical, professional, industrial, and government organizations, both inside and outside the United States."

Additionally, the following information has been provided in this section:

- Information provided by EPA Region 4 for cis-1,2-DCE and trans-1,2-DCE screening levels.
- Information provided by EPA Region 4 regarding the basis of their use of the Agency for Toxic Substances and Disease Registry intermediate minimal risk levels.
- Excerpt of Agency for Toxic Substances and Disease Registry minimal risk levels updated March 2016.
- Excerpt of information from the Region 4 Scientific Support Section Vapor Intrusion Screening Tool.
- Information provided by Kentucky Risk Assessment Branch to support a project discussion on June 20, 2017.
- Archived Provisional Peer Reviewed Toxicity Values for *trans*-1,2-Dichloroethylene (withdrawn by EPA).

THIS PAGE INTENTIONALLY LEFT BLANK

Table E.10. Vapor Intrusion Screening Levels (VISLs) for Analytes of Interest for PGDP—Commercial

Chemical	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk via VI from Soil Source?	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk via VI from Groundwater Sources?	Indoor Air VISL (µg/m³) at TCR = 1E-06 or THQ = 1[a]	Toxicity Basis	Soil Gas VISL (µg/m³) at TCR = 1E-06 or THQ = 1[a]	Target Groundwater Concentration (µg/L) at TCR = 1E-06 or THQ = 1[a]	Occupational Exposure Limits[b]		
							OSHA PEL/TWA (µg/m³)	NIOSH REL/TWA (µg/m³)	ACGIH TLV/TWA (µg/m³)
	Cvp > Cia, target?	Chc > Cia, target?	Min (Cia, c; Cia, nc)	C or NC	Csg	Chc			
Chloroform	Yes	Yes	5.33E-01	C	1.78E+01	3.55E+00[c]	No PEL/TWA[d]	No REL/TWA[e]	4.88E+01
Dichloroethane, 1,1- (1,1-DCA)	Yes	Yes	7.67E+00	C	2.56E+02	3.34E+01	4.00E+05	4.00E+05	4.00E+05
Dichloroethylene, 1-1- (1,2-DCE)	Yes	Yes	8.76E+02	NC	2.92E+04	8.21E+02	No PEL/TWA	No PEL/TWA	2.00E+04
Dichloroethylene, 1,2-cis- (cis-1,2-DCE)	No Inhalation Toxicological Information	No Inhalation Toxicological Information	NVA[f,g], 3.50E+03	NC	N/A	N/A	7.93E+05	7.93E+05	7.93E+05
Dichloroethylene, 1,2-trans- (trans-1,2-DCE)	Yes	Yes	NVA[g], 3.50E+03	NC	N/A	N/A			
Mercury (elemental)[h]	Yes	Yes	1.31E+00	NC	4.38E+01	3.73E+00	1.00E+02	5.00E+01	2.5E+01
Trichloroethane, 1,1,1- (1,1,1-TCA)[i]	Yes	Yes	2.19E+04	NC	7.30E+05	3.11E+04	1.91E+06	No REL/TWA[j]	1.91E+06
Trichloroethylene (TCE)	Yes	Yes	2.99E+00	C	9.97E+01	7.43E+00	5.37E+05	1.34E+05[k]	5.37E+04
Vinyl Chloride (VC)	Yes	Yes	2.79E+00	C	9.29E+01	2.45E+00	2.56E+03	No REL/TWA	2.56E+03

ACGIH = American Conference of Governmental Industrial Hygienists
C = carcinogenic
Cia = concentration, indoor air
Chc = concentration, groundwater vapor
Csg = concentration, subslab and exterior soil gas concentration
Cvp = concentration, pure phase vapor
µg/m³ = micrograms per cubic meter

Table E.10. Vapor Intrusion Screening Levels (VISLs) for Analytes of Interest for PGDP—Commercial (Continued)

N/A = no value available
NC = noncarcinogenic
NIOSH = National Institute for Occupational Safety and Health
NVA = no VISL value available
REL = recommended exposure limit
STEL = short-term exposure limit
TCR = target risk for carcinogens
THQ = target hazard quotient for noncarcinogens
TWA = time-weighted average
VI = vapor intrusion
VISL = vapor intrusion screening level

[a] The agreed upon VISLs in the Paducah Gaseous Diffusion Plant Industrial Area Vapor Intrusion Preliminary Risk Assessment Report (DOE/LX/07-2471&D2) were calculated at a hazard quotient of 1 because this was a preliminary assessment and was not intended to be used for human health risk assessment. Projects should consider using reporting limits targeted to meet the hazard quotient of 0.1 to ensure usability for future risk assessment.
[b] Occupational exposure limits obtained from the OSHA Occupational Chemical Database (https://www.osha.gov/chemicaldata), accessed February 7, 2022. Values provided in units of parts per million were converted to units of µg/m^3 using the NIOSH online conversion calculator (https://wwwn.cdc.gov/niosh-oeb/resource/calculator), accessed February 7, 2022; based on 25°C and 1 atmosphere, and using molecular weight obtained from the OSHA Occupational Chemical Database.
[c] The maximum contaminant level (MCL) for total trihalomethanes in drinking water, of which, chloroform is a key component, is 80 µg/L.
[d] There is no OSHA PEL/TWA for chloroform; a ceiling peak PEL of 240,000 µg/m^3 has been established.
[e] There is no NIOSH REL/TWA for chloroform; a 60-minute STEL of 9,780 µg/m^3 has been established.
[f] The reference concentration for *trans*-1,2-DCE, was used as a surrogate to calculate the screening levels for *cis*-1,2,-DCE.
[g] Provisional value provided by EPA, as documented in Section E.9, because VISL value is not available.
[h] For an analyte to be considered a contaminant of potential concern for VI, the analyte must be toxic and sufficiently volatile to migrate from a subsurface source into a building at a concentration greater than its indoor air screening level. Elemental mercury is toxic and can be sufficiently volatile to exist in vapors at levels potentially harmful to human receptors; therefore, mercury must be present in subsurface media in elemental form to pose a VI risk. The majority of mercury, which is a common industrial contaminant and by-product of coal combustion, detected in groundwater or soils at PGDP is expected to be in the form of salts—not elemental mercury. Mercury has not been detected in site monitoring wells at concentrations greater than its groundwater VISL; therefore, mercury is not expected to be present in vapor form above trace concentrations. Indoor air in each building identified for VI sampling, however, was screened for mercury using a field meter as a protective measure based on its widespread detection in site soil.
[i] 1,1,1-TCA was included to be considered only when there is documented use within a facility.
[j] There is no NIOSH REL/TWA for 1,1,1-TCA; a 15-minute STEL of 1.90E+06 µg/m^3 has been established.
[k] Recommendation listed in *NIOSH Pocket Guide to Chemical Hazards*, Appendix C, Supplementary Exposure Limits, (https://www.cdc.gov/niosh/npg/nengapdxc.html), accessed February 2022.

Note:
The VISL values are taken from the VISL calculator (results generated, April 5, 2022, https://epa-visl.ornl.gov/cgi-bin/visl_search) derived for a commercial exposure scenario at a target excess cancer risk of 1.0E-06 and a target hazard quotient of 1.0. Per the VISL calculator, the commercial exposure scenario has a 70-year averaging time for carcinogens, a 25-year averaging time for noncarcinogens, an exposure duration of 25 years, an exposure frequency of 250 days/year, and an exposure time of 8 hours/day.

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

INSERT Pages E-141 through E-162

E.10. PERTINENT TOXICITY VALUES AND INFORMATION

The "BAF_{fish}" is the bioaccumulation factor for fish. EPA's "Waste and Cleanup Risk Assessment Glossary" defines it as the ratio of the concentration of a contaminant in an organism to the concentration in the ambient environment at steady state, where the organism can take in the contaminant through ingestion with its food as well as through direct contact. BAF_{fish} is not used in PRG derivation, but is presented in this table for reference only. The BAF_{fish} is in units of L/kg. Bioaccumulation factors for other organisms are available on the RAIS Web site and in *Risk Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0107&D2/R1, February 2011.

Chemical Abstract Number	Analyte	BAF_{fish}	BAF_{fish} Ref.
7429-90-5	Aluminum	5.00E+02	NCRP
7440-36-0	Antimony (metallic)	1.00E+02	NCRP
7440-38-2	Arsenic, Inorganic	3.00E+02	Wang
7440-39-3	Barium	4.00E+00	IAEA
7440-41-7	Beryllium and compounds	1.00E+02	NCRP
7440-42-8	Boron And Borates Only		
7440-43-9	Cadmium (Diet)	2.00E+02	NCRP
7440-43-9	Cadmium (Water)	2.00E+02	NCRP
7440-47-3	Chromium (Total)		
16065-83-1	Chromium(III), Insoluble Salts	2.00E+02	IAEA
18540-29-9	Chromium(VI)	2.00E+02	IAEA
7440-48-4	Cobalt	3.00E+02	IAEA
7440-50-8	Copper	2.00E+02	NCRP
16984-48-8	Fluoride		
7439-89-6	Iron	2.00E+02	NCRP
7439-92-1	Lead	3.00E+02	IAEA
7439-96-5	Manganese (Diet)	4.00E+02	IAEA
7439-96-5	Manganese (Non-diet)	4.00E+02	IAEA
7439-97-6	Mercury, Inorganic Salts	1.00E+03	NCRP
7439-98-7	Molybdenum	1.00E+01	NCRP
7440-02-0	Nickel Soluble Salts	1.00E+02	IAEA
7782-49-2	Selenium	2.00E+02	NCRP
7440-22-4	Silver	5.00E+00	IAEA94
7440-28-0	Thallium (Soluble Salts)	1.00E+04	NCRP
N/A	Uranium (Soluble Salts)	1.00E+01	IAEA
N/A	Vanadium and Compounds		
7440-66-6	Zinc and Compounds	1.00E+03	IAEA
83-32-9	Acenaphthene	7.55E+02	EPI
208-96-8	Acenaphthylene[a]	2.71E+02	EPI
107-13-1	Acrylonitrile	3.16E+00	EPI
120-12-7	Anthracene	1.80E+03	EPI
71-43-2	Benzene	4.27E+00	EPI
117-81-7	Bis(2-ethylhexyl)phthalate[b]	5.88E+02	EPI
75-27-4	Bromodichloromethane	9.70E+00	EPI
86-74-8	Carbazole	1.70E+02	EPI
56-23-5	Carbon Tetrachloride	7.40E+00	EPI
67-66-3	Chloroform	1.30E+01	EPI
75-71-8	Dichlorodifluoromethane (Freon-12)[b]	6.15E+00	EPI

Chemical Abstract Number	Analyte	BAF_{fish}	BAF_{fish} Ref.
75-34-3	Dichloroethane, 1,1-[b]	7.05E+00	EPI
107-06-2	Dichloroethane, 1,2-	4.40E+00	EPI
75-35-4	Dichloroethylene, 1,1-	1.30E+01	EPI
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	1.11E+01	EPI
156-59-2	Dichloroethylene, 1,2-*cis*-	1.11E+01	EPI
156-60-5	Dichloroethylene, 1,2-*trans*-	1.11E+01	EPI
60-57-1	Dieldrin	7.48E+03	EPI
1746-01-6	Dioxins/Furans, Total		
37871-00-4	~HpCDD		
38998-75-3	~HpCDF, 2,3,7,8-		
34465-46-8	~HxCDD, 2,3,7,8-		
55684-94-1	~HxCDF, 2,3,7,8-		
3268-87-9	~OCDD	1.31E+03	EPI
39001-02-0	~OCDF		
36088-22-9	~PeCDD, 2,3,7,8-		
57117-41-6	~PeCDF, 1,2,3,7,8-		
57117-31-4	~PeCDF, 2,3,4,7,8-		
1746-01-6	~TCDD, 2,3,7,8-	9.70E+04	EPI
51207-31-9	~TCDF, 2,3,7,8-	4.06E+03	EPI
100-41-4	Ethylbenzene	5.56E+01	EPI
206-44-0	Fluoranthene	3.63E+03	EPI
86-73-7	Fluorene	5.25E+02	EPI
118-74-1	Hexachlorobenzene	2.14E+04	EPI
91-20-3	Naphthalene	8.45E+01	EPI
88-74-4	Nitroaniline, 2-	1.00E+01	EPI
621-64-7	Nitroso-di-N-propylamine, N-	3.67E+00	EPI
87-86-5	Pentachlorophenol	5.96E+02	EPI
85-01-8	Phenanthrene[a]	2.51E+03	EPI
1336-36-3	Polychlorinated Biphenyls (high risk)	2.53E+04	EPI
1336-36-3	Polychlorinated Biphenyls (low risk)	2.53E+04	EPI
12674-11-2	~Aroclor 1016	9.14E+03	EPI
11104-28-2	~Aroclor 1221		
11141-16-5	~Aroclor 1232		
53469-21-9	~Aroclor 1242		
12672-29-6	~Aroclor 1248		
11097-69-1	~Aroclor 1254		
11096-82-5	~Aroclor 1260		
50-32-8	Polycyclic aromatic hydrocarbons (cPAH), Total Carcinogenic		
56-55-3	~Benz[a]anthracene	2.60E+02	EPI
50-32-8	~Benzo[a]pyrene	5.15E+03	EPI
205-99-2	~Benzo[b]fluoranthene	3.02E+03	EPI
207-08-9	~Benzo[k]fluoranthene	4.99E+03	EPI
218-01-9	~Chrysene	3.17E+03	EPI
53-70-3	~Dibenz[a,h]anthracene	9.60E+03	EPI
193-39-5	~Indeno[1,2,3-cd]pyrene	1.22E+04	EPI
129-00-0	Pyrene	1.51E+03	EPI
127-18-4	Tetrachloroethylene	5.20E+01	EPI
108-88-3	Toluene[b]	8.32E+00	EPI
71-55-6	Trichloroethane, 1,1,1-	5.00E+00	EPI
79-00-5	Trichloroethane, 1,1,2-	5.00E+00	EPI
79-01-6	Trichloroethylene	1.60E+01	EPI
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2- (Freon-113)[b]	4.96E+01	EPI
75-01-4	Vinyl Chloride	5.47E+00	EPI
1330-20-7	Xylene, Mixture		
108-38-3	Xylene, m-	1.48E+01	EPI
95-47-6	Xylene, o-	1.41E+01	EPI
106-42-3	Xylene, P-	1.48E+01	EPI

Chemical Abstract Number	Analyte	BAF_{fish}	BAF_{fish} Ref.
14596-10-2	Americium-241	3.00E+01	IAEA
10045-97-3	Cesium-137	2.00E+03	IAEA
13994-20-2	Neptunium-237	1.00E+01	IAEA
13981-16-3	Plutonium-238	4.00E+00	IAEA
15117-48-3	Plutonium-239	4.00E+00	IAEA
14119-33-6	Plutonium-240	4.00E+00	IAEA
14133-76-7	Tcchnetium-99	2.00E+01	IAEA
14269-63-7	Thorium-230	3.00E+01	IAEA
13966-29-5	Uranium-234	1.00E+01	IAEA
15117-96-1	Uranium-235	1.00E+01	IAEA
7440-61-1	Uranium-238	1.00E+01	IAEA

Information compiled from RAIS October 2016.
[a] Values for Acenaphthylene and Phenanthrene, if not available use toxicity factors for Acenaphthene.
[b] Analytes are not PGDP significant COPCs (Table 2.1), but are provided for project support.

Reference Codes:

EPI EPA's Estimation Programs Interface Suite.

IAEA International Atomic Energy Agency (IAEA) 1982, *Generic Models and Parameters for Assessing the Environmental Transfer of Radionuclides from Routine Releases. Exposures of Critical Groups*, Safety Series No. 57.

IAEA94 IAEA 1994, *Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments*, Technical Reports Series No. 364.

NCRP National Council on Radiation Protection and Measurements, *Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground.* Report No. 123, 1996.

Wang Wang, Y. Y., et al. 1993, *A Compilation of Radionuclide Transfer Factors for the Plant, Meat, Milk, and Aquatic Food Pathways and Suggested Default Values for the RESRAD Code*, ANL/EAIS/TM-103, Argonne National Laboratory, Argonne, IL, August.

THIS PAGE INTENTIONALLY LEFT BLANK

E.11. MEETING MINUTES FROM PADUCAH RISK ASSESSMENT WORKING GROUP

Notes from RAWG meetings held in 2000 through 2007 and minutes from RAWG quarterly meetings held from June 2012 through December 2016 are presented in Appendix E of *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1, Human Health,* DOE/LX/07-0107&D2/R8/V1 (DOE 2017). Meeting summaries from RAWG quarterly meetings held in 2017 are presented in Appendix E of *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1, Human Health,* DOE/LX/07-0107&D2/R9/V1 (DOE 2018). Meeting summaries from RAWG quarterly meetings held in 2018 are presented in Appendix E of *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1, Human Health,* DOE/LX/07-0107&D2/R10/V1 (DOE 2019). Meeting summaries from RAWG quarterly meetings held in 2019 are presented in Appendix E of *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1, Human Health,* DOE/LX/07-0107&D2/R11/V1 (DOE 2020). Meeting summaries from RAWG quarterly meetings held in 2020 are presented in Appendix E of *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1, Human Health,* DOE/LX/07-0107&D2/R12/V1 (DOE 2021). Meeting summaries from RAWG quarterly meetings held in 2021 are presented in Appendix E of *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1, Human Health,* DOE/LX/07-0107&D2/R13/V1 (DOE 2022). Meeting summaries from RAWG quarterly meetings held in 2022 are presented in Appendix E of *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1, Human Health,* DOE/LX/07-0107&D2/R14/V1 (DOE 2023). Meeting summaries from RAWG quarterly meetings held in 2023 are presented herein.

Deleted: 2

The meeting summaries presented herein, and within the annual updates to the Risk Methods Document since 2017, are provided for historical information to promote program consistency over time and facilitate succession planning. Meeting summaries may reflect document locations (e.g., table numbers) that have since been updated. The meeting summaries may not reflect information that currently is in the document.

INSERT the meeting summaries
(66 PAGES)

E.12. ANTHROPOGENIC BACKGROUND AT PGDP

The anthropogenic background white paper is presented herein.

THIS PAGE INTENTIONALLY LEFT BLANK

INSERT E.12.

E.13. PFAS ANTHROPOGENIC BACKGROUND AT PGDP

This white paper is planned to be developed in FY 2024 and included in the FY 2025 update to this document.

THIS PAGE INTENTIONALLY LEFT BLANK

ATTACHMENT E1

1995 QUESTIONNAIRE AND RESPONSES REGARDING RECREATIONAL USAGE OF BAYOU AND LITTLE BAYOU CREEKS

Deleted: Section Break (Next Page)

THIS PAGE INTENTIONALLY LEFT BLANK

ATTACHMENT E2

2014 E-MAIL UPDATE REGARDING RECREATIONAL USAGE OF BAYOU AND LITTLE BAYOU CREEKS

THIS PAGE INTENTIONALLY LEFT BLANK

Used with permission for inclusion in *Methods for Conducting Risk Assessment and Risk Evaluation at the Paducah Gaseous Diffusion Plant Paducah, Kentucky, Volume 1. Human Health.*

Garner, Leanne K (YLN)

From: Kreher, Timothy (FW) <Timothy.Kreher@ky.gov>
Sent: Tuesday, January 21, 2014 11:41 AM
To: Garner, Leanne K (YLN)
Subject: RE: Update of Recreational Use of Bayou and Little Bayou Creeks near PGDP

LeAnne,

I would concur with the numbers and estimates originally provided by Charlie Logsdon for the most part. I would suggest that there are brief exposures to both Little Bayou and Bayou Creeks by dog trainers riding horses where they cross the creek via the method of the horse and dog wading through the creek while the rider is mounted (i.e., the riders does not have contact with the water for the most part). Such crossings are brief, less than 10 seconds at a time. I would also suggest that there may be cases where hunters cross one or both creeks by wading through shallow spots, but in most cases these people are wearing rubber boots or waders, and I would not consider this a major source of exposure (?). When hunters do wade through the creeks, it is again a brief exposure of less than 30 seconds each time.

I would suggest increasing the **frequency** of visits / exposures by a factor of 1.5 for all of Charlie's answers to factor in increased use of the WMA.

I almost never see fishing activity in the creeks outside of the portion that crosses through TVA-owned property near where the creeks join and meet the Ohio River (what we refer to as Tract 6 of the WKWMA). As Charlie mentioned, the great majority of this fishing activity occurs when the Ohio River levels are elevated and have the creeks "backed up" with water from the river. I assume this also decreases the effects of any particular exposure during these instances.

Tim Kreher
Wildlife Biologist, Kentucky Department of Fish and Wildlife Resources
Doug Travis, Obion Creek, and West Kentucky Wildlife Management Areas
10535 Ogden Landing Road, Kevil, KY 42053
office 270-488-3233; cell 270-292-9010; fax 270-488-2589
email Timothy.Kreher@ky.gov

Confidentiality Notice:
This e-mail message, including any attachment, is for the sole use of the intended recipient(s) and may contain confidential information. Any unauthorized review, use, disclosure or distribution is strictly prohibited. If you are not the intended recipient, please contact the sender, by e-mail, and destroy all copies of the original message.

From: Garner, Leanne K (YLN) [mailto:Leanne.Garner@lataky.com]
Sent: Tuesday, January 21, 2014 8:52 AM
To: Kreher, Timothy (FW)
Subject: RE: Update of Recreational Use of Bayou and Little Bayou Creeks near PGDP

Any thoughts on this, Tim?
If there are no updates, I can just use to older information.

Thanks.

LeAnne

From: Garner, Leanne K (YLN)
Sent: Tuesday, January 07, 2014 8:56 AM
To: 'Timothy.Kreher@ky.gov'
Subject: RE: Update of Recreational Use of Bayou and Little Bayou Creeks near PGDP

Good morning, Tim!
I hope you had a good holiday!

We are updating the Risk Methods Document (the *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky Volume 1. Human Health*) with more current information.

Some of the information we are updating is "Recreational Use of Bayou and Little Bayou Creeks near PGDP." I have attached that information.
The entire document can be found here:
http://www.paducaheic.com/media/112385/ENV1.A-00440-ARI41.pdf

If you could, please look at the attached and let me know if you think any of the information needs updating.
If so, do you have that information?

I would appreciate any help you could give.

Thank you.

LeAnne Garner
Scientist
LATA Kentucky
leanne.garner@lataky.com
270-441-5436

The contents of this e-mail and any attachments are considered sensitive privacy information and may be protected by one or more legal privileges. If you are not the intended recipient, the sender prohibits you from disclosing, copying, distributing, sharing or otherwise using the contents of the e-mail or any attachment. If you have received this e-mail in error, please immediately notify the sender and delete the email and any attachments from your system. Thank you for your cooperation.

LATA Environmental Services of Kentucky, LLC