

**APPENDIX E**  
**ADDITIONAL INFORMATION**

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## **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: <http://www.paducaheic.com/media/32632/I-02004-0002-ARI52.PDF>.

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 consensus 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.

## **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: <http://www.paducaheic.com/media/45063/i-02300-0001f-ARI14.pdf>. Appendix 2B-15 begins on page 276 of the pdf.

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

This section summarizes information obtained from a 2013 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](http://www.city-data.com/county/Ballard_County-KY.html), accessed December 2013.

- 8,333 population (as of 2012)
- 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](http://www.city-data.com/county/Ballard_County-KY.html), accessed December 2013.

- 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: 39814 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 2013 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](http://www.city-data.com/county/McCracken_County-KY.html), accessed December 2013.

- 65,549 population (as of 2012)
- 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](http://www.city-data.com/county/McCracken_County-KY.html), accessed December 2013.

- 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: 9160 harvested acres
- All wheat for grain: 3899 harvested acres

- Soybeans for beans: 37579 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, corn, 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, published in June 2009. The information is available at the following Web sites, accessed December 12, 2013:

- [http://www.nass.usda.gov/Statistics\\_by\\_State/Kentucky/Publications/State\\_Census\\_Summaries/Historical\\_Ag\\_Statistics/BALLARD.pdf](http://www.nass.usda.gov/Statistics_by_State/Kentucky/Publications/State_Census_Summaries/Historical_Ag_Statistics/BALLARD.pdf)
- [http://www.nass.usda.gov/Statistics\\_by\\_State/Kentucky/Publications/State\\_Census\\_Summaries/Historical\\_Ag\\_Statistics/MCCRACKEN.pdf](http://www.nass.usda.gov/Statistics_by_State/Kentucky/Publications/State_Census_Summaries/Historical_Ag_Statistics/MCCRACKEN.pdf)

Year	Harvested Acres	
	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

#### **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 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 Risk Assessment Working Group 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 kgs 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.2.5.3 Annual Harvests of Turkeys, Deer, Geese, and Ducks in McCracken and Ballard Counties, Kentucky**

PGDP is surrounded by the WKWMA (Figure E.1). Additionally, several solid waste management units (SWMUs) (currently listed as no further action) are located in the Ballard Wildlife Management Area (Figure E.2). Figure E.3 provides a legend for features in the wildlife management areas. Both of these areas are home to hunting and fishing. Huntatable 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.4 and Table E.2 and Figure E.5 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 Wildlife Management Area during the 2010/2011 and 2011/2012 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 2013.

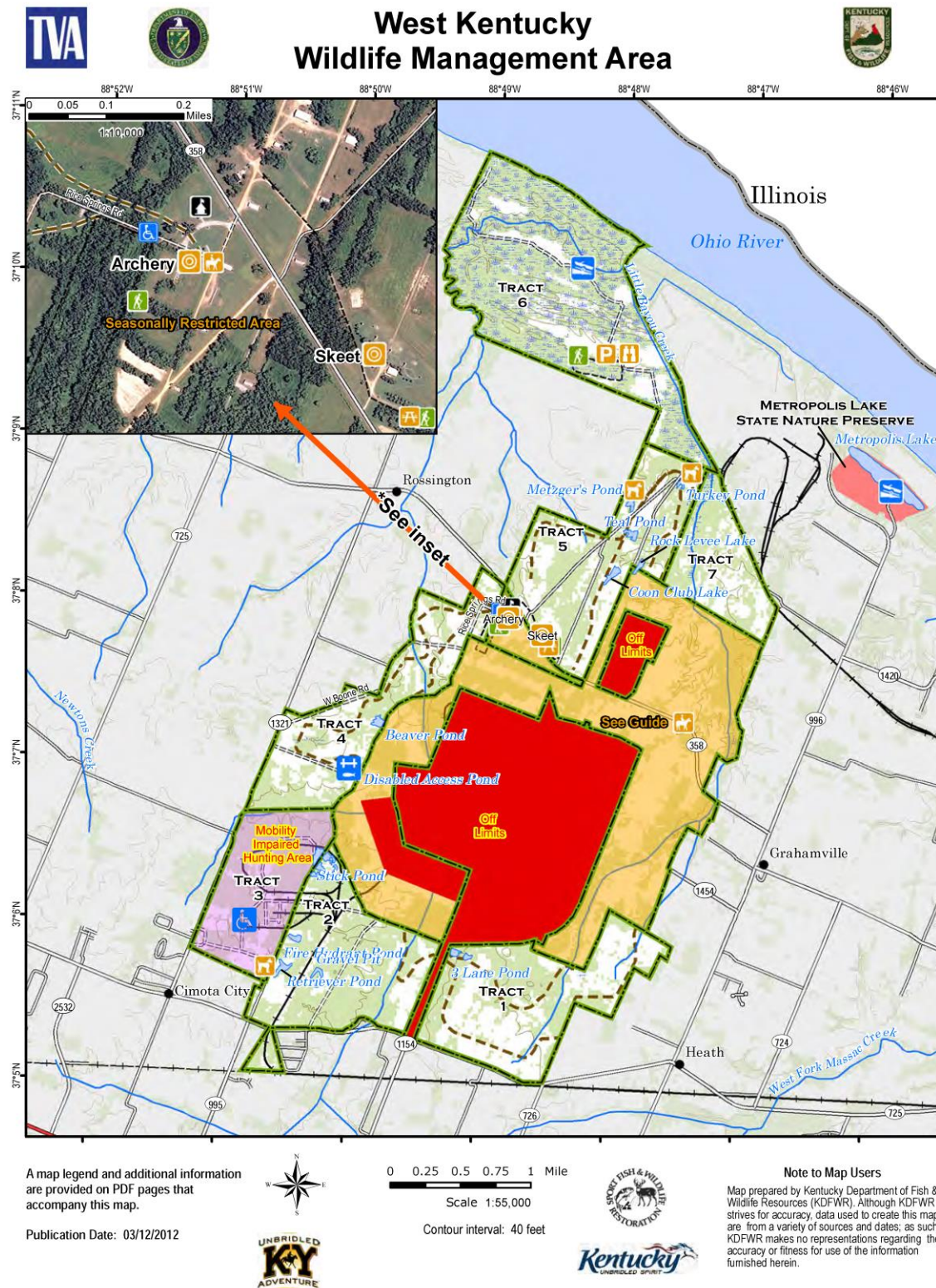
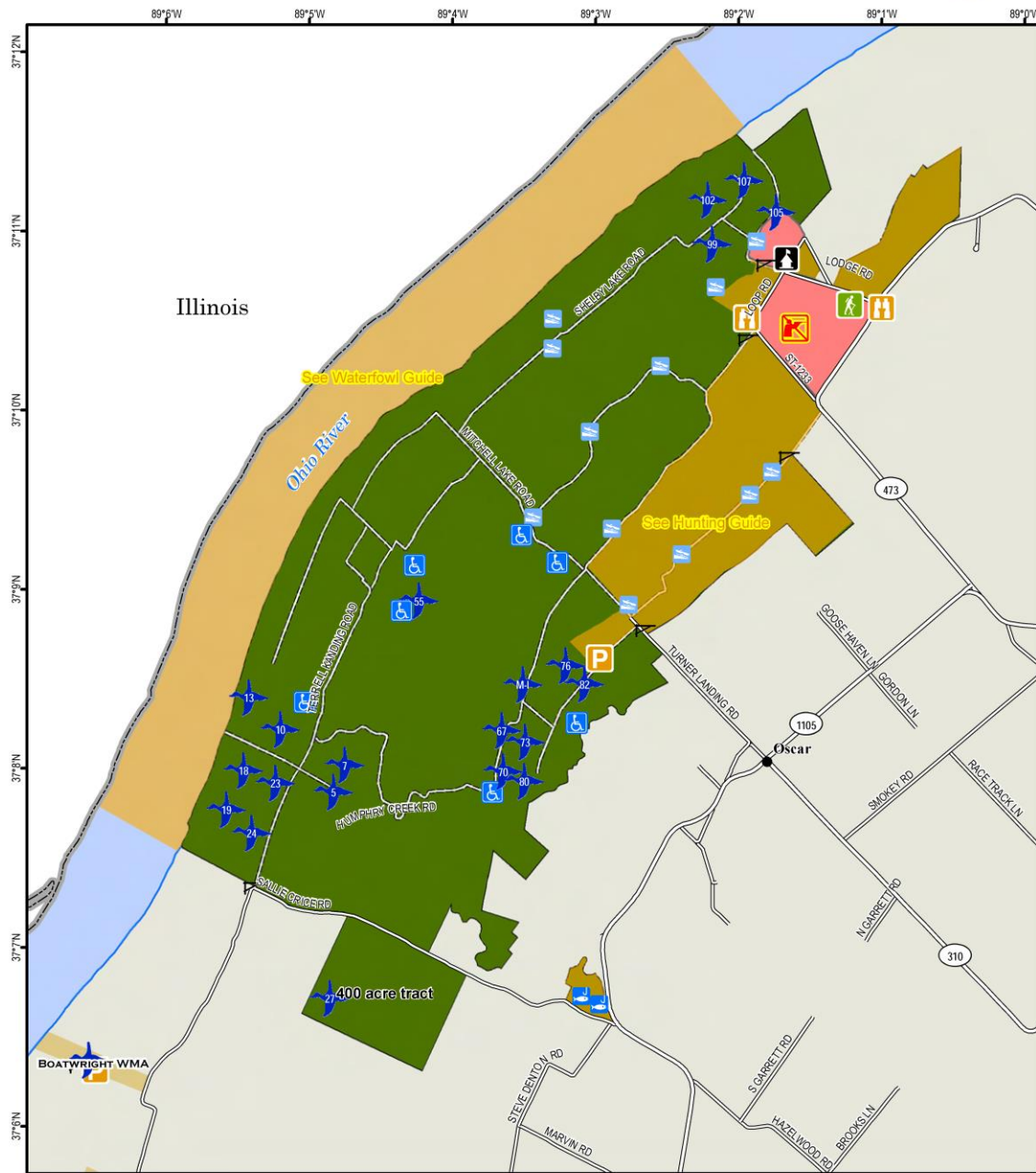


Figure E.1. Map of West Kentucky Wildlife Management Area

# Ballard Wildlife Management Area Index Map



A map legend and additional information are provided on PDF pages that accompany this map.

Publication Date: 9/03/2013



Scale 1:55,000  
Contour interval: 10 feet



## Note to Map Users

Map prepared by Kentucky Department of Fish & Wildlife Resources (KDFWR). Although KDFWR strives for accuracy, data used to create this map are from a variety of sources and dates; as such, KDFWR makes no representations regarding the accuracy or fitness for use of the information furnished herein.

Figure E.2. Map of Ballard Wildlife Management Area



## Wildlife Management Area Map Notes & Legend

### NOTE TO MAP USERS:

For most WMA maps the landscape is depicted using a combination of elevation contours, hillshading and a green tint indicating woodland areas that is derived from satellite imagery. On WMAs that are relatively small or have a history of surface mining aerial photography is used.

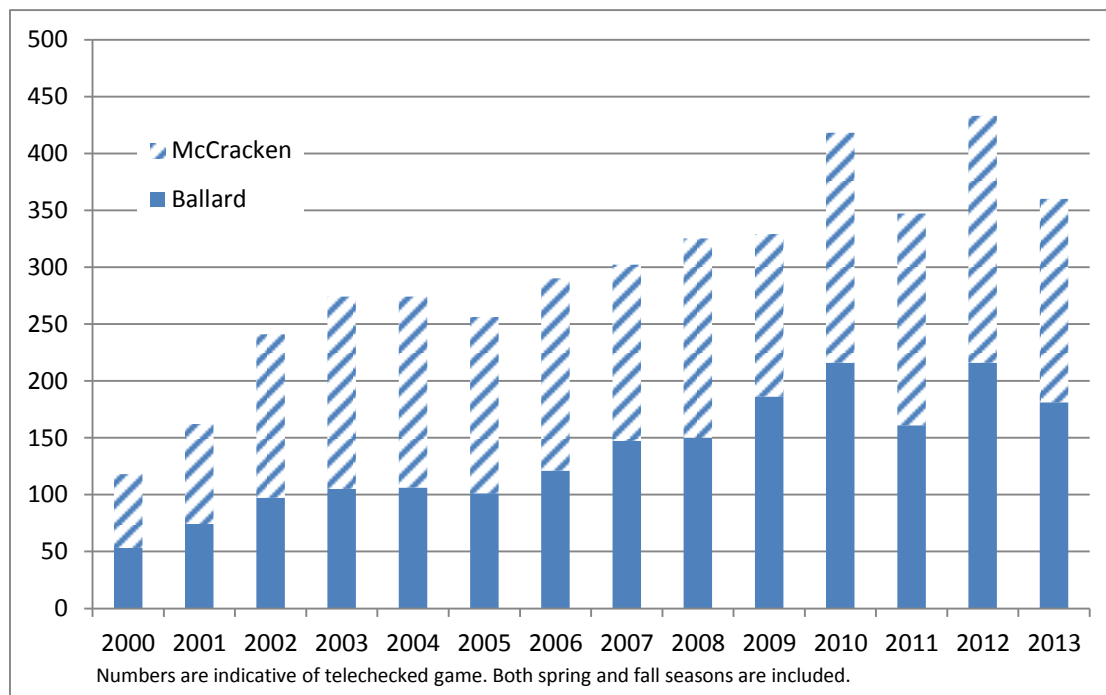


**Figure E.3. Wildlife Management Area Map Legend**

**Table E.1 Turkey Harvested on Public Land in Western Kentucky in 2013<sup>a</sup>**

Public Land	Male	Female	Total	Archery	Firearm	Muzzleloader	Crossbow
Ballard WMA	15	0	15	0	15	0	0
Beechy Creek WMA	2	0	2	0	2	0	0
Boatwright WMA	2	0	2	0	2	0	0
Clarks River NWR	19	2	21	0	20	1	0
Coil Estate WMA	3	0	3	0	3	0	0
Doug Travis WMA	9	0	9	0	9	0	0
Jones-Keeney WMA	2	0	2	0	2	0	0
Kaler Bottoms WMA	3	0	3	0	3	0	0
Kentucky Lake WMA	4	0	4	1	2	1	0
Lake Barkley WMA	16	0	16	1	15	0	0
Land Between The Lakes NRA	56	2	58	3	55	0	0
Livingston County WMA and SNA	2	1	3	0	3	0	0
Obion Creek WMA	1	0	1	0	1	0	0
Ohio River Islands WMA	0	0	0	0	0	0	0
Pennyrile State Forest	31	1	32	0	32	0	0
Reelfoot NWR	3	0	3	0	3	0	0
Tradewater WMA	2	0	2	0	2	0	0
West Kentucky WMA	18	2	20	2	18	0	0
Winford WMA	0	0	0	0	0	0	0
<b>Totals</b>	<b>188</b>	<b>8</b>	<b>196</b>	<b>7</b>	<b>187</b>	<b>2</b>	<b>0</b>

<sup>a</sup> Numbers are indicative of telechecked game (<http://app.fw.ky.gov/harvestweb/TurkeyPublicLandRegion.aspx> accessed 5/23/2014). Both spring and fall hunting seasons are included.



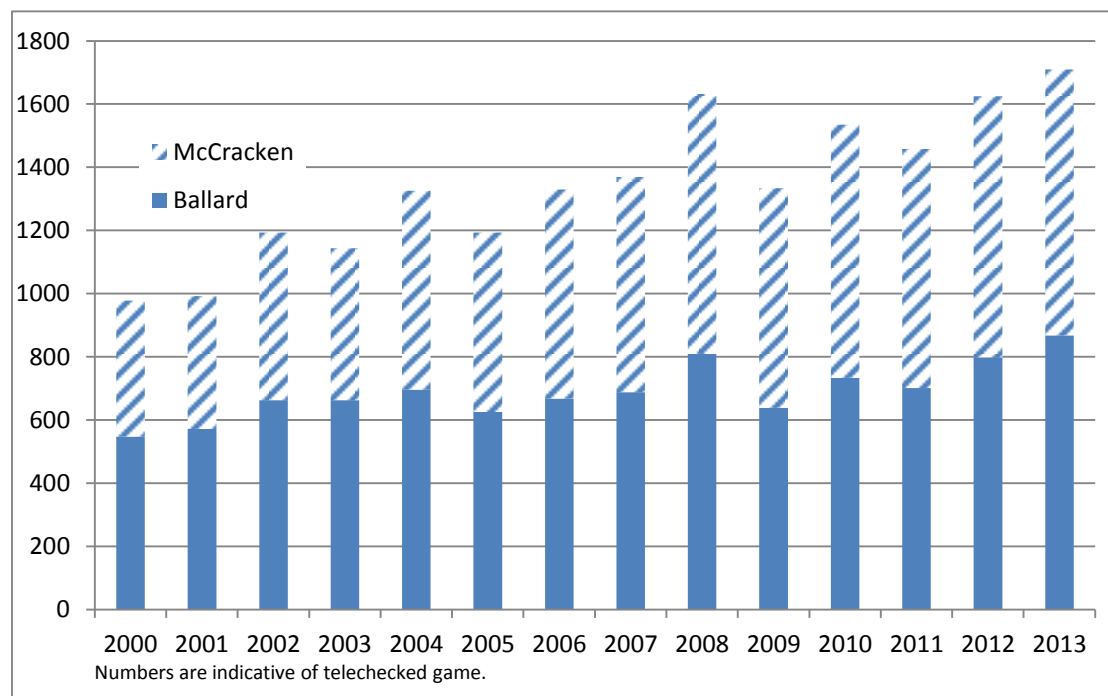
**Figure E.4. Total Turkey Harvest in Ballard and McCracken Counties 2000–2013**

**Table E.2 Deer Harvested on Public Land in Western Kentucky in 2013<sup>a</sup>**

Public Land	Male	Female	Quota	Total	Archery	Firearm	Muzzleloader	Crossbow
Ballard WMA	21	30	35 <sup>b</sup>	86	16	30	5	0
Beechy Creek WMA	6	11	not available	17	3	11	3	0
Boatwright WMA	24	36	not available	60	7	43	8	2
Clarks River NWR	62	65	not available	127	16	105	5	1
Coil Estate WMA	1	1	not available	2	0	1	1	0
Doug Travis WMA	18	17	not available	35	3	26	6	0
Jones-Keeney WMA	7	4	not available	11	1	7	3	0
Kaler Bottoms WMA	19	17	not available	36	7	29	0	0
Kentucky Lake WMA	27	23	not available	50	4	39	4	3
Lake Barkley WMA	41	39	not available	80	21	57	1	1
Land Between The Lakes NRA	129	102	not available	231	183	27	4	17
Livingston County WMA and SNA	30	21	not available	51	7	7	37	0
Obion Creek WMA	24	16	not available	40	4	36	0	0
Ohio River Islands WMA	3	0	not available	3	0	3	0	0
Pennyrite State Forest	23	22	not available	45	26	15	0	4
Reelfoot NWR	0	0	not available	0	0	0	0	0
Tradewater WMA	3	2	not available	5	2	1	2	0
West Kentucky WMA	18	28	28 <sup>b</sup>	74	36	2	0	8
Winford WMA	4	3	not available	7	2	3	2	0
<b>Totals</b>	<b>460</b>	<b>437</b>	<b>63<sup>b</sup></b>	<b>897</b>	<b>338</b>	<b>442</b>	<b>81</b>	<b>36</b>

<sup>a</sup>Numbers are indicative of telechecked game (<http://app.fw.ky.gov/harvestweb/deerpubliclandregion.aspx> accessed 5/23/2014).

<sup>b</sup>Quota deer hunt numbers from Kentucky Department of Fish and Wildlife Resources (KDWFR) 5/23/2014.



**Figure E.5. Total Deer Harvest in Ballard and McCracken Counties 2000–2013**

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

Date	Population Count		Harvest			Date	Population Count		Harvest		
	Ducks	Geese	Ducks	Canadas	Other		Ducks	Geese	Ducks	Canadas	Other
12/8/2010	57,000	3000	34	0	0	12/7/2011	21,000	100	Ballard closed due to flooding		
12/9/2010	57,000	3000	19	0	0	12/8/2011	21,000	100	Ballard closed due to flooding		
12/10/2010	57,000	3000	36	0	0	12/9/2011	21,000	100	Ballard closed due to flooding		
12/11/2010	57,000	3000	139	1	0	12/10/2011	21,000	100	Ballard closed due to flooding		
12/12/2010	57,000	3000	172	4	0	12/11/2011	21,000	100	Ballard closed due to flooding		
12/15/2010	57,000	3000	67	0	0	12/14/2011	16,000	100	Ballard closed due to flooding		
12/16/2010	57,000	3000	105	1	0	12/15/2011	16,000	100	Ballard closed due to flooding		
12/17/2010	57,000	3000	33	0	0	12/16/2011	16,000	100	Ballard closed due to flooding		
12/18/2010	107,700	4800	31	3	1	12/17/2011	16,000	100	Ballard closed due to flooding		
12/19/2010	107,700	4800	23	5	2	12/18/2011	16,000	100	Ballard closed due to flooding		
12/22/2010	107,700	4800	96	2	1	12/21/2011	52,000	1,000	112	0	0
12/23/2010	107,700	4800	68		0	12/22/2011	52,000	1,000	72	0	0
12/24/2010	107,700	4800	63	3	1	12/23/2011	52,000	1,000	56	0	0
12/25/2010	NA	NA	NA	NA	NA	12/24/2011	52,000	1,000	56	0	0
12/26/2010	54,000	14000	234	5	16	12/25/2011	52,000	1,000	Ballard closed for Christmas		
12/29/2010	54,000	14,000	68	0	3	12/28/2011	20,000	500	58	0	0
12/30/2010	54,000	14,000	71	0	1	12/29/2011	20,000	500	38	0	1
12/31/2010	54,000	14,000	49	1	0	12/29/2011	43,000	200	44	0	0
1/1/2011	58,000	52,000				12/30/2011	23,000	500	59	0	0
1/2/2011	58,000	52,000	54	7	3	12/31/2011	23,000	5,000	20	0	0
1/5/2011	58,000	52,000	88	5	53	1/1/2012	Closed		Closed		
1/6/2011	58,000	52,000	62	4	2	1/4/2012	23,000	100	58	0	1
1/7/2011	58,000	52,000	32	3	4	1/5/2012	23,000	100	32	0	0
1/8/2011	58,000	52,000	75	3	3	1/6/2012	23,000	100	7	0	0
1/9/2011	81,000	11,000	19	1	3	1/7/2012	32,000	200	33	0	0
1/12/2011	81,000	11,000	46	2	20	1/8/2012	32,000	200	8	0	1
1/13/2011	81,000	11,000	4	0	0	1/11/2012	32,000	100	77	0	3
1/14/2011	81,000	11,000	11	4	12	1/12/2012	32,000	100	123	0	2
1/15/2011	81,000	11,000	16	0	2	1/13/2012	32,000	100	26	1	2
1/16/2011	58,000	12,500	13	0	0	1/14/2012	79,000	300	31	2	3
1/19/2011	58,000	12,500	97	0	10	1/15/2012	79,000	300	10	0	1
1/20/2011	58,000	12,500	112	2	9	1/18/2012	79,000	1,000	81	1	3
1/21/2011	58,000	12,500	14	0	2	1/19/2012	79,000	1,000	52	0	0
1/22/2011	58,000	12,500	34	1	5	1/20/2012	79,000	1,000	47	0	1
1/23/2011	65,155	3,105	32	3	0	1/21/2012	79,000	1,000	65	0	0
1/26/2011	65,155	3105	122	4	5	1/22/2012	41,000	500	59	0	2
1/27/2011	65,155	3105	108	2	4	1/25/2012	41,000	500	78	0	1
1/28/2011	65,155	3105	98	0	1	1/26/2012	41,000	500	71	0	3
1/29/2011	65,155	3105	88	4	3	1/27/2012	41,000	500	50	0	1
1/30/2011	44,500	3,000	113	2	10	1/28/2012	43,000	200	75	0	1

#### E.2.5.4 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.



# PLANNING ISSUES FOR SUPERFUND SITE REMEDIATION



Randall T. Ryti  
Dean Neptune

One function of the Superfund program is to assess the risk posed by hazardous waste sites. Sites that merit inclusion on the National Priorities List (NPL) are analyzed intensively through the Remedial Investigation/Feasibility Studies (RI/FS) process, which provides estimates of the risk posed by the site and the cost of cleanup. In this article we will review the planning issues for RI/FS through a case study of a specific Superfund site—a former transformer storage and rehabilitation facility in North Carolina.

The planning process used for this example is the Data Quality Objectives (DQO) process, which consists of the following steps: define the problem, define the question, define the data needs (the domain and decision rule), and define the data performance for the main question (1,2).

The planning approach is flexible; we have successfully



Abandoned  
drums located  
behind the  
"burn shed" at  
the site



applied the DQO process to two other Superfund sites. This site differed in the complexity of the problem, as well as the time frame within the Superfund assessment and cleanup process. We have observed that using the DQO process has not increased the resources expended (either time or money). Indeed, the process has resulted in substantial savings at a dioxin site in Missouri (3,4).

Another advantage of the planning process is that data collection can be focused. If one or a few contaminants are of interest, then more specific tests can be used. The planning process also sets goals for data collection, so that a criterion for the adequacy of data collection can be specified. The question of "how much is enough" develops naturally during the planning process.

### Site history

The site is a former transformer storage and rehabilitation facility located on 4.8 acres of swampy terrain. The site lies within the 100 year floodplain of the Cape Fear River. Rebuilding of transformers was discontinued in 1982, but storage of transformers continued until 1986 when the site was abandoned. The initial sampling in 1978 found chlorobenzene in the well water on the site. Adjacent residences were placed on city water at that time. In 1979, PCBs were found in both the soil and well water, but no other action was taken. An Emergency Removal Action (ERA) was conducted in 1984 to remove contaminated soil. Sampling after the ERA detected PCBs at up to 140 ppm in the sub-surface soil.

The United States Environmental Protection Agency (EPA) Region 4 is administering the assessment and cleanup activities at the site. Discussions with the Region indicated that there were two phases to these activities. In Phase 1, the short list of contaminants of concern (COCs) and the general location of these COCs are determined. In Phase 2, the locations of the COCs are determined more precisely and the costs of various remedial alternatives are estimated. Through the steps of the DQO process, these general statements were refined and quantitative error tolerances were specified.

### Phase 1

Discussion with EPA Region 4 indicated that Phase 1 of the assessment should answer two questions: What is the list of COCs at the Carolina Transformer site, and what is the x, y and z location of these contaminants?

Determining the list of COCs and the spatial scale of the contamination are essentially interrelated. For example, a "hot spot" of dioxin at a concentration of 10 ppb, but only in a few grams of soil at one location is not a threat to human health. Thus a contaminant causes concern if it exists above a specific concentration over an area where exposure is possible.

What logic can be used to define the area and concentration that makes a particular contaminant a concern? One approach is to compute the concentration and exposure area from a risk perspective. A second approach is to consider the way that the contaminant came to be distributed on the site.

EPA policy puts an acceptable risk level between 1 in 10,000 and 1 in 10,000,000 additional cancers (5). In this case, Region 4 decided that an acceptable risk is an additional 1 in 1,000,000 cancer incidence.

For PCBs in soil, the likely exposure route is through ingestion of contaminated soil. Exposure scenarios were investigated for adult workers on the site or children trespassers.

A risk scenario is based on assumptions about the absorption rate of the contaminant, the soil ingestion rate, and the length of the exposure. For example, a 70 kg adult is assumed to absorb 30% of the PCBs ingested. Adults are assumed to ingest a total of 100 mg of soil per day. These PCBs accumulate over 30 years, where the worker is present at the site 5 days a week for 50 weeks a year. Based on laboratory models and these exposure assumptions, an additional one in one million risk is equivalent to a PCB concentration of 1 ppm in the soil. For children trespassers, the end concentration is roughly the same, although the assumptions are different.

Over what area is this exposure accumulated? Some construction workers work over (and thus integrate exposure) an area of 1/2 acre. Children playing on a baseball field would also cover about 1/2 acre. We define an exposure unit (EU) as 1/2 acre. Since exposure is integrated over a large area (1/2 acre), small "hot spots" are only important if the overall average in a 1/2 acre area is greater than 1 ppm.

The preceding scenario was based on ingestion of surface soil. Based on CFR guidelines (an ARAR for PCBs), subsurface soil can be backfilled with clean soil if the concentration of PCBs are less than 10 ppm at a depth of 10 inches; thus <1 ppm PCBs is acceptable

for soil in the 0-10 in. layer, and <10 ppm PCBs is acceptable below 10 in.

The likely source of the contamination was from leaking transformers. Thus a "hot spot" could result from a single leaking transformer. The Region decided that a leaking transformer would likely result in a 10 ft by 10 ft footprint. This implies that the smallest area that should need remediation is also a 10-ft square. The spatial scale is now bounded between 100 ft<sup>2</sup> and 22,500 ft<sup>2</sup>. (1/2 acre). What concentration of PCBs in 100 ft<sup>2</sup> would result in an average of 1 ppm over 1/2 acre? If the remainder of the 1/2 acre were clean, then a single hot spot would have to measure more than 225 ppm for that EU to pose an unacceptable risk.

The main goal of Phase 1 is to define the list of COCs for the site and estimate the risk posed to the public. To address these goals, some information on the spatial distribution of the contaminants must be collected. Based on the historical use of the site and aerial photos, the site was divided into three areas: administration, operations and storage; PCB contamination was expected to be lowest in administration, intermediate in storage, and highest in operations. This stratification should lead to a more precise estimate of the average PCB concentration on the site. The list of COCs was confirmed on a subset of samples submitted for the full scan analysis. Region 4 had expected that PCBs would be the sole COC on the site. The initial data also indicated that PCBs were much greater than 1 ppm in the surface soil. If these expectations are met, then the data collected in Phase 1 will only have to describe the general location of PCBs across the site.

Because no reliable information on the distribution of PCBs and the presence of other contaminants was available, a pilot study was recommended. In the case that the problem was truly as simple as described above, the pilot study could give enough information to lead to the second phase of the RI/FS.

Before describing the development of the pilot and the results obtained, let us consider the decision rule and the data quality required in Phase 1. The decision is to find if any area of the Carolina Transformer site poses an unacceptable health risk to the public. The data quality for the decision are the acceptable probabilities of making a positive or false negative errors. A positive is where the actual risk posed by the site is less than 1 in 1,000,000 addi-



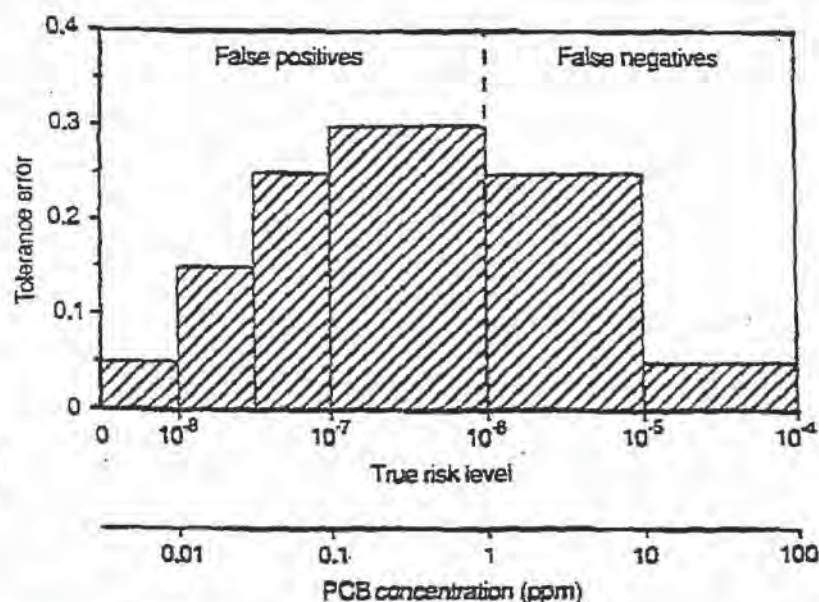
TABLE 1

## Assumptions about the site used to design the pilot

Sub-unit	Area/ acres	Probability 10' x 10' is contaminated	Number of samples
Administration	0.75	0.05	5
Storage	1.5	0.25	15
Operations	0.75	0.50	25

FIGURE 1

## "Discomfort curve," or acceptable error rate for decision



nal cancers, but the risk is measured as being greater than 1 in 1,000,000 additional cancers. The consequences of a false positive are that resources (time and money) are diverted to sites that do not pose a significant risk. The possible consequences of a false negative (actual risk posed by the site is greater than 1 in 1,000,000 additional cancers but is measured as less) are additional cancers. Region 4 stated their quantitative discomfort with various magnitudes of false negatives and false positives (Figure 1).

The pilot survey was designed by using simple assumptions about the site. Based on the historical activities at the site, PCBs were assumed to be the most important (or only) contaminants on the site. Thus the Region agreed to run most of the soil samples through a quick-turn-around (QT) analysis procedure for PCBs. In addition to providing results more quickly, the QT method was also less expensive per analysis than the total contaminant list (TCL) scan (\$150 vs.

\$1250). Based on the amount of data collected in other RI/FS Phase 1 surveys, approximately 45 QT soil samples could be analyzed. This amount is based on \$30,000 total for Phase 1 analyses; spending one-half of the total in the pilot at \$350 per analysis. An additional 10 samples were run by the TCL method to search for other contaminants. The 45 QT samples were allocated based on simple assumptions of the distribution of PCBs. PCB presence or absence was assumed to follow a binomial distribution on the scale of 10 ft by 10 ft areas (with no spatial correlation beyond 10 ft). The probability of presence was assumed to vary according to the sub-units of the site (Table 1).

The TCL samples taken in the pilot confirmed that PCBs were the only significant COC. The QT samples showed that the magnitude of PCB concentration did vary in the predicted manner among the three sub-units of the site. Table 2 shows these concentrations.

The concentration of PCBs was vari-

able both within and between sub-units of the site. For example, stations close to a hot spot (e.g., 10 ppm) were not likely to measure 10 ppm. The spatial pattern of PCBs fits a "hot spot model"; the contamination is located in a binomial fashion, either contaminated or not contaminated. The most important result is that 41 of 45 samples were greater than 1 ppm PCBs; nearly the entire site is a "hot spot" from a risk perspective. Thus the initial assumptions about the frequency of "hot spots" were not correct.

Because the pilot identified PCBs as the only significant contaminant, we can restate the decision as: do any 1/2-acre areas of the site exceed 1 ppm PCBs? What is the approximate location of the contaminated soil? The Region had two options at this point: accept the results of the pilot survey for Phase 1, or conduct a Phase 1 survey where the number of samples is based on the results of the pilot.

Based on the laboratory measurement error for PCBs and the spatial sampling variation, the number of samples taken in the pilot did not meet all of the error constraints set by the Region. The false negative error rate for the Phase 1 decision based on the pilot data was slightly larger than the rate specified by the discomfort curve (7.5% vs. 5%). The advantage of accepting the pilot for the Phase 1 results is that Phase 2 can be started more quickly. False negatives are not important, since all 1/2 acre units were positives (i.e., PCBs > 1 ppm), the Region decided to accept the results of the pilot in making the preliminary risk assessment for the site.

## Phase 2

The purpose of the Phase 2 RI/FS survey is to define the location of the contamination and the cleanup costs. The cleanup costs are based on two components: a per unit volume cost and the total volume to remediate. The per volume remedial cost is dependent on the particular remedial sequence selected (for example: excavation, incineration, disposal, and back-filling with clean soil). We assume that the per volume remedial cost can be estimated exactly, so the only error is in the estimate of the volume of soil to be remediated. Thus the total volume can be computed from the location estimate.

EPA policy states that the cost should be estimated to within +30% and -50% of the actual RD/RA cost. To simplify the problem, the Region wanted the Phase 2 survey to be designed to estimate the



cleanup cost to within 30% with 90% or greater probability. An obvious difficulty is that sub-surface contamination must be estimated before the surface soil is remediated. A simplifying assumption is that two discrete soil layers will be sampled. Soil above 1 ppm PCBs in the top 10 in. and soil below 10 in. and containing more than 10 ppm PCBs will be remediated.

The data resolution needed for the location question is dependent on the spatial distribution of the contaminant within the exposure units (EU) (1/2 acres units in this example). Should an all-or-none approach be used for EU cleanup, or should remediation units (RUs) be defined as sub-units of EUs? In some cases, the additional sampling is cost-effective in that a "surgical" cleanup can

TABLE 2  
Results of the pilot survey

Sub-unit	Mean concentration (standard deviation, n)	Median
Administration	7.5 (10.7, 5)	1.1
Storage	19.3 (21.4, 15)	11.3
Operations	34.7 (24.5, 25)	32.4

approach (see Ref. 6 for additional examples; contact Dean Neptune for details on the simulations). Based on cost considerations, Region 4 selected 50 ft by 50 ft (about 1/18th acre) as the remedial unit size. This design has a cost of about \$50,000 for sampling and laboratory analyses.

Each EU (or 1/2 acre) contains a three

PCB concentration varied over four orders of magnitude in both soil layers. There was greater contamination in the 0-2 in. layer on average, as compared with the 8-10 in. layer (compare Figures 2,3). But in 13 of 61 RUs the 8-10 in. layer was more contaminated (in many locations, by an order of magnitude) than the 0-2 in. layer. We would expect that PCBs would ordinarily migrate slowly down through the soil profile, without some kind of mechanical disturbance (or churning) of the soil. To what extent the soil was churned as a result of the operations at the facility or by the actions taken during the Emergency Removal Action is not known.

To estimate the volume of contaminated soil, the following cleanup strategy (Figure 4) was developed. It was based on the depth that can be excavated by a backhoe (about 8 ft) and the two cleanup criteria. The surface soil is considered to be clean if the PCB concentration is less than 1 ppm. An excavated area can be backfilled with clean soil if the PCB concentration is less than 10 ppm at a depth below 10 inches. Three different depths are excavated (8, 10 or 16 in.), or no soil is removed based on the PCB concentration (Table 4). The total amount of soil to be excavated is estimated at 5389 yd<sup>3</sup>.

In the Administration area, 6 of 16 RUs (62.5%) were greater than 1 ppm in the 0-2 in. layer, and in the Operations/Storage all 46 RUs measured greater than 1 ppm in the 0-2 in. layer. These numbers are similar to the assumptions used in the volume estimation design computations (50% contaminated assumed for Administration and 90% contaminated assumed for Operations/Storage).

Fifteen quality assessment (QA) samples were analyzed. The QA samples were laboratory sub-samples of the core composites. The relative standard deviation of these QA samples was 15%, excluding one outlier.

#### Discussion

The goal of Superfund program is to



**Large electrical transformers  
at the site—a former  
transformer rehabilitation  
and storage facility**

remove hot spots of contamination (4). At a dioxin contaminated site in Missouri, the lowest total cost for sampling and cleanup was for RUs that were 1/24th the size of EUs (4). But in the present case, the pilot data indicated that there was little local pattern in the contamination, and that PCBs were nearly uniformly above 1 ppm. Field sampling and laboratory analysis costs were estimated for four sizes of RUs (1/2 acre, 1/8 acre, 1/18 acre, and 1/32 acre). Designs were evaluated by a Monte Carlo simulation

by three grid of RUs. Partial RUs (containing less than 1250 ft<sup>2</sup>) are lumped with an adjacent RU. Sixty-two RUs were sampled in the legal boundaries of the site. Two soil samples were taken: a 0-2 in. sample that represented the 0-8 in. soil layer, and a 8-10 in. sample that represented the 8-16 in. soil layer. For each layer, 14 grab samples were taken in the Administration area, and 4 grabs elsewhere (Storage/Operations). The grabs were homogenized, and a single aliquot was bagged for laboratory analysis. Each aliquot contained enough material for four laboratory analyses. Two laboratory analyses were made of each aliquot in the Administration area and one analysis elsewhere.

The results of the Phase 2 RI/FS survey showed that PCBs are highly variable over the site (Table 3).



remediate sites that pose an unacceptable health hazard. Because resources are limited, the Superfund program must be able to rank sites and to rank the hazards within sites. The information for these rankings becomes more detailed at each step in the process. Three main questions about sites are: Does the site pose a hazard? What remedial plan will remove the hazard? How will I verify the site is "clean?"

The Data Quality Objectives (DQO) process provides a way for managers to define a general question about a site that is later refined to a quantitative decision rule. The other parallel effort in the DQO process is to define error tolerances. The initial error tolerances are qualitative, and these are later quantified. These two components (decision rule and error tolerances), are the building blocks for a statistically-based design.

In the case of the North Carolina transformer site, the managers in Region 4 asked for the lowest cost designs that would meet their error tolerances for selected cleanup unit (RU) sizes. They were able to compare the cost of these surveys against a survey that would estimate the volume of soil that was contaminated. In this way they could balance the importance of these main questions in the Phase 2 survey.

The advantage of the DQO process is that the decision constraints (the decision rule and the error tolerances) are based on the initial responses of the decision-maker. The decision-maker can see how different ways of stating the decision rule can have profound implications on the proposed survey design. Where no proposed sampling design is within budget, then the decision-maker has the option to either increase the budget or modify some of the constraints (look at larger RUs).

### Conclusions

We have shown that the Data Quality Objectives process can help define questions and the data quality in ways that can lead to statistically-based sampling designs. The DQO process allowed Region 4 to collect the right data at the right time. It should be noted that at each step from the pilot survey to the Phase 1 design, and finally for the Phase 2 study design, the question was further clarified and more information was gathered about PCB distribution across the site. One problem with the Superfund program in general has been to decide when enough data has been collected.

TABLE 3  
Results of Phase 2 survey

Soil layer	Median	Range		Number of RUs	
		low	high	<1 ppm	<10 ppm
0-2" <sup>1</sup>	21	0.4	2500	3	21
8-10" <sup>2</sup>	7.25	0.2	1100	18	36

<sup>1</sup> n=62

<sup>2</sup> n=61, one RU was concrete below the top 8"

FIGURE 2  
PCB concentrations in 0-2 in. soil layer

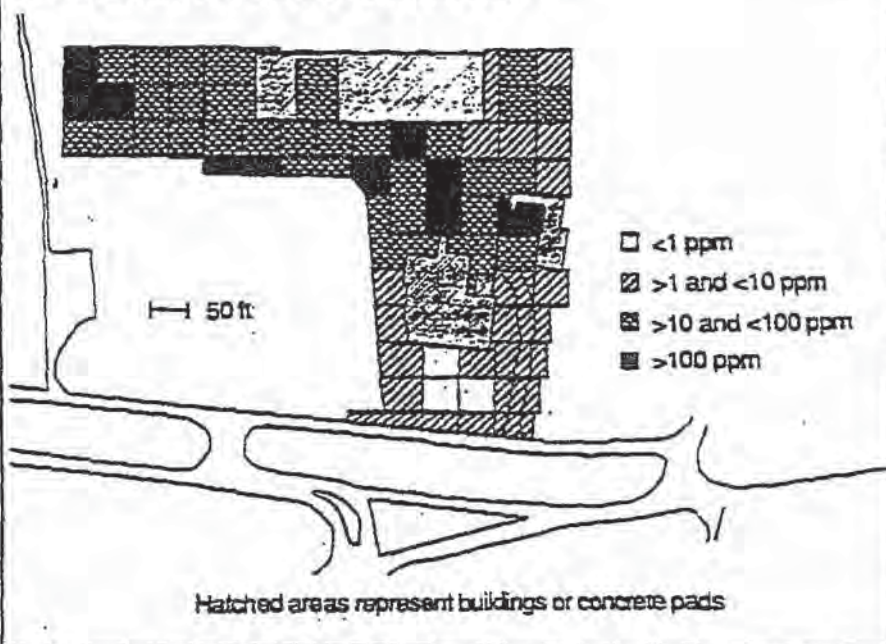
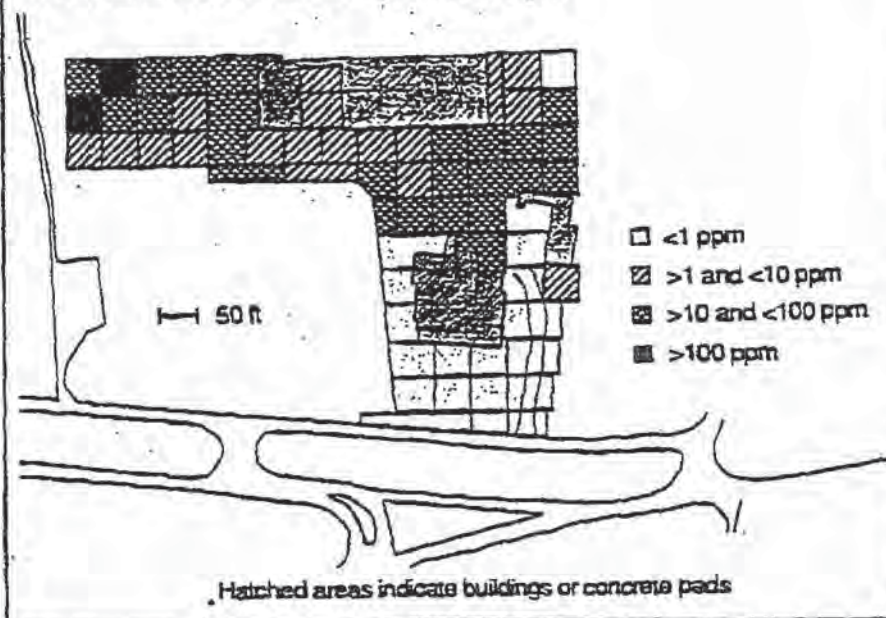


FIGURE 3  
PCB concentrations in 8-10 in. soil layer







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TABLE 4

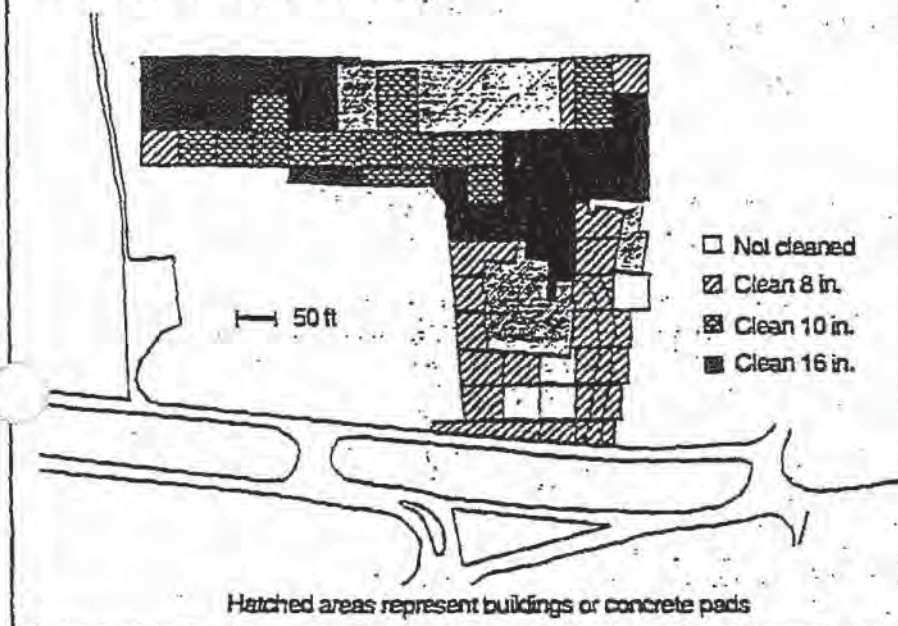
## Summary of cleanup strategy

Soil depth and concentration	Depth to excavate	Number of RUs	Volume cubic yards
0-2" <1 ppm	0"	3	—
8-10" <1 ppm	8"	18	969
8-10" <10 ppm	10"	18	1297
8-10" >10 ppm <sup>1</sup>	16"	22	3123

<sup>1</sup> These RUs need to be sampled at 16-18" to verify PCBs are <10 ppm

FIGURE 4

## Cleanup strategy for the site



It is through the steps of the DQO process that the data user specifies the stopping point (the decision rule with error tolerances).

## Acknowledgments

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## References

- (1) Neptune, D. and Blacker, S.M. Applying Total Quality principles to Superfund planning. I. Upfront planning in Superfund. American Society for Quality Control. Seventeenth Annual National Energy Division Conference, Tucson, Arizona, Sept. 1990.
- (2) Neptune, D., E.P. Brantley, M.J. Messner, and D.L. Michael. Quantitative

decision making in Superfund. Hazardous Materials Control 3(3):18-27, May/June 1990.

(3) Fairless, B. Applying Total Quality principles to Superfund planning. II. DQOs in Superfund: A dioxin case study. American Society for Quality Control. Seventeenth Annual National Energy Division Conference, Tucson, Arizona, Sept. 1990.

(4) Rytli, R.T. Applying Total Quality principles to Superfund planning. III. Evaluation of design alternatives for a Superfund site. American Society for Quality Control. Seventeenth Annual National Energy Division Conference, Tucson, Arizona, Sept. 1990.


(5) US Environmental Protection Agency. Superfund public health evaluation manual. EPA/540/1-861060. Oct. 1986.

(6) Klee, A.J. MOUSE (Modular Oriented Uncertainty System): A computerized uncertainty analysis system. EPA/600/S8-89/102. 1990.

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# Quantitative Decision Making in Superfund:

## A Data Quality Objectives C A S E S T U D Y

**W**hat type and quality of data are needed to answer key questions and how do we know when we have enough? Data quality objectives (DQOs) offer decision makers a tool to answer both questions. DQOs provide a qualitative and quantitative framework around which data collection surveys are designed, and can serve as performance criteria for assessing ongoing or completed remedial investigation/feasibility studies (RI/FSs). DQOs allow remedial project managers to make decisions based on RI/FS data with a predetermined and acceptable level of confidence.

Here we present a case study demonstrating the practicality and benefits of using the DQO process as an up-front planning tool for designing RI/FS data collection activities. The RI/FS decision maker and technical support staff (typically including environmental toxicologists and field and laboratory scientists) must work together to develop DQOs and associated RI/FS survey designs. With these individuals in mind, this article illustrates the issues raised during the DQO process, and demonstrates how the process can help resolve them at a Superfund site before an RI survey design is developed.

Development of DQOs involves a step-wise planning process (see box, "Data quality objectives") that may be applied to any problem involving the collection and use of environmental data (1). We begin the DQO process by carefully stating the environmental problem to be addressed or the decision to be made; then we identify the information required to select an appropriate course of action and carefully articulate the specific role data will play in making the selection. Specifications regarding the type of data needed, the way data will be used, and

the desired degree of certainty in conclusions to be derived from the data are then developed through an iterative process that involves the decision maker and data generators (technical support staff).

When applied to Superfund sites, the DQO process provides a quantitative basis for designing rigorous, defensible, and cost-effective remedial investigations. The DQO planning process recognizes that decision making in Superfund is driven by risks to public health and that the uncertainty in decisions will be affected by the type and quality of data collected. The focus on planning, as presented here, is consistent with ideas developed as part of Superfund's endeavor to streamline its remedial process (2).

The case study was developed cooperatively by EPA's Region IV Waste Management Division and Environmental Services Division, and the Quality Assurance Management Staff. Our study involved a retrospective application of the DQO process to an actual Superfund site that had already been studied and the remedial investigation design already implemented. (The RI designs reported here were not actually implemented.) By using a completed site, Region IV expects to compare and contrast the DQO process with the current approach to planning such investigations. All decisions regarding the DQOs were made by Region IV personnel, just as they would for other sites where RIs are planned. We chose an actual site for several reasons: to avoid a purely hypothetical exercise; to ensure that realistic issues were confronted; and to facilitate an objective assessment of the practicality of implementing the DQO process for Superfund problems. Here we report the results of our planning efforts, following the generic structure illustrated in the box "Data quality objectives."

### Problem statement

The starting point for any planning process is gathering background information on the specific problem at hand. The site addressed in this case study was used for storing and burning railroad ties and creosote-soaked timbers (3) (see photo). Information collected at various times (e.g., during previous site studies and during the Superfund site listing process) suggested that a logical exposure scenario consistent with future use of the site includes site workers and visitors as hazard targets.

Toxicologists determined that the exposure route of greatest concern for these targets is direct ingestion of contaminated surface soils; other routes of exposure are not addressed in the case study. Existing data from preliminary investigations and site visits also suggested that while several contaminants are to be expected in such surface soils, the most toxic are polycyclic aromatic hydrocarbons (PAHs) associated with creosote.

### Decisions and decision elements

The key decision posed by the RI/FS is: "What remedial actions, if any, must be taken to reduce the risk posed by the site to an acceptable level?" A logical starting point, and the focus of this study, is to determine whether the site poses an unacceptable risk in its current state—whether it is a problem.

The next step is to work logically toward increasingly specific and hence focused questions that will require environmental data for resolution. We know that PAH contamination of soil is the most likely source of public health risk from the site. Thus, the element of interest can be restated as a question: "Which, if any, surface soil areas have PAHs at concentrations that pose an unacceptable risk to the hazard targets?"



### Domain and logic statement

The next step was to determine the concentrations of PAHs that, if present over some defined area, would pose an unacceptable risk. This approach to the problem raised three related questions:

- What level of public health risk from this site is acceptable to the remedial project manager?
- What concentration of PAHs is associated with the acceptable level of risk, given reasonable assumptions about target exposure?
- What is the smallest area on the site over which we can reasonably assume

that the targets' exposure to contaminants may occur?

Addressing these issues required assumptions about the population at risk (people), their activities, exposure routes, and the risks associated with specific contaminants. Recognizing that the number of samples ultimately collected at a site depends in part on the smallest area of concern, we focused attention on defining the size of this area first, and then dealt with the issues of acceptable risk and corresponding concentrations.

To divide the site into discrete areas for study in a manner consistent with our in-

terest in controlling risk, assumptions about exposure and activity patterns were used to define an area called an "exposure unit" (EU). An EU is the area over which people are expected to integrate exposure when routinely working at or visiting the site (see white grid on site photo).

A separate decision will be made for each EU: if an area is found to contain PAHs at a concentration that poses an unacceptable risk, that EU (and thus the site) will be considered a problem. Further investigations and remedial alternatives will address only the EUs found to

### Data quality objectives

To build total quality into data operations, EPA quality assurance management staff have developed a planning tool for assuring that key planning steps are taken in a thoughtful, methodical manner. This tool, known as the Data Quality Objectives (DQO) process, begins with a careful statement of the environmental problem and produces a design for collecting the information needed to make an informed decision with a desired degree of confidence. The stepwise structure of the DQO process is to:

- state the problem, then
- identify decisions that address the problem, then
- select elements or factors that affect the decision, then
- specify the domain of the decision.
- Then develop a logic statement.
- establish constraints on uncertainty, and, finally,
- optimize the design for data collection.

The DQO process provides a logical, objective, and quantitative framework for finding an appropriate balance between the time and resources that will be used to generate the product (data) and the quality of that product.

DQOs enable EPA to develop, optimize, and evaluate statistically valid sampling and analysis designs that achieve the constraints on uncertainty. In general several options are developed for a range of costs that will generate the type and quality of data required to make a reliable decision. In the final step of the DQO process, the decision maker selects the design option that best fits his or her needs.



contain PAHs at concentrations posing unacceptable risks. If no such EUs are found, then a "no-action" alternative may be appropriate for the entire site.

Superfund risk assessment guidance stresses the importance of considering future land use and related reasonable exposure scenarios (4). According to the National Utility Contractor's Association, people working at or visiting a site such as this, where light industrial equipment is operated, would typically work within or traverse an area roughly one-half acre in size (about 2,000 m<sup>2</sup>) on a given day (5). This is the area in which people can be expected to receive their daily dose of contamination. In a very real sense, people "sample" surface soil contaminants over this half-acre; hence the average concentration of contaminants over each half-acre is a meaningful basis for assessing risk. Thus, for this site, a half-acre area of soil is an EU. Since a separate estimate of the average surface soil concentration will be generated for each EU, and a separate decision made about whether each EU poses an unacceptable risk, the EU defines the spatial domain of the decision.

Based on discussions of the potential risks posed by the site, the EPA Region IV remedial staff decided that remedial action should be taken if the site (i.e., any EU at the site) poses an increased cancer risk greater than 10<sup>-4</sup>. The 10<sup>-4</sup> risk level is therefore the decision point between acceptable and unacceptable risk. This decision point is consistent with EPA's policy that 10<sup>-4</sup> and 10<sup>-7</sup> is the range for acceptable risk limits (6). (Note: The 10<sup>-4</sup> level was used specifically for this case study and does not necessarily reflect EPA Region IV policy or standard practice for other sites.)

We used exposure assumptions and standard Superfund risk equations (6) to determine the surface soil contaminant concentration that corresponds to a risk level of 10<sup>-4</sup>. Region IV typically treats total PAHs as though the sole contaminant is benzo[a]pyrene, the most toxic of the PAH family of compounds. This approach is conservative in that it will generally overestimate the risk posed by total PAHs. Risk calculations indicate that an EU is a problem (i.e., presents a 10<sup>-4</sup> increased risk of cancer) when the average PAH concentration in the EU is at or above 122 ppm.

A "logic statement" is a concise quantitative summary of how data will be used to reach a decision. The logic statement follows directly from the formulation of the problem above.

Data collected during the remedial investigation will be used to determine the average surface soil concentration of PAHs within each half-acre. Average PAH concentrations will be compared to the risk-derived concentration of concern, 122 ppm, to determine which, if any, surface soil EUs have PAHs at concentrations that would pose an unacceptable risk.

If an EU has an unacceptable average PAH concentration  $\geq 122$  ppm, then further study should be undertaken to develop a list of remedial alternatives. This "if-then" logic statement will be applied for each of the EUs, and any EU posing an unacceptable risk will need to be remediated.

#### Constraints on uncertainty

If the estimates of average PAH concentration within EUs are inaccurate, decisions about whether an EU poses unacceptable risk may be incorrect. The remedial investigation should be designed to limit the probability of incorrect decisions to an acceptable level. After the logic statement was specified, the project manager developed constraints on uncertainty, expressed as acceptable false positive and false negative error rates. These are shown in Figure 1. The y-axis provides the acceptable error rates (probability of making an incorrect decision) given various possible true risk levels, shown on the upper x-axis.

Acceptable error rates were not assigned in the 61–122-ppm range be-

cause the manager considered either decision would acceptable in this range. The error rates expressed in Figure 1 provided the statistician with quantitative constraints to be used in developing survey designs, which specify the number, location, and type of samples needed in the remedial investigation.

Stated in terms of the risk-based decision point, decisions about EUs may be incorrect in two ways:

The first type of error occurs when it is decided that an EU does not pose an unacceptable risk when, in fact, the risk posed by the EU exceeds 10<sup>-4</sup>. This is a false negative error. If the investigation leads to this false conclusion, the project manager may stop further investigations at the EU and people eventually may be exposed to unacceptable risks. The seriousness of this type of error, and therefore the project manager's desire to avoid it, becomes greater as the true level of risk gets larger and larger. To help the manager establish limits on false negatives, a toxicologist was consulted to assess the consequences for three ranges of incremental risk, all of which exceed 10<sup>-4</sup>:

- $1.0 \times 10^{-4}$  to  $5.0 \times 10^{-4}$ ;
- $5.0 \times 10^{-4}$  to  $1.0 \times 10^{-3}$ ; and
- above  $1.0 \times 10^{-3}$ .

After carefully considering the human health consequences, the project manager assigned acceptable probabilities for failing to detect a problem if the risk posed by the EU is actually within each of the above ranges (shown in the right-hand portion of Figure 1). The manager



expressed differing levels of acceptable error rates for the three risk ranges. These error rates (probabilities), which reflect the manager's increasing desire to avoid false negative errors at higher and higher contaminant concentrations, are the maximum acceptable rates established for this type of error. Notice that the manager desired lower false negative rates when the true risk is above  $1.0 \times 10^{-3}$  because the consequences to the public and to workers on-site are potentially much more serious than the consequences associated with the other ranges of risk.

The second type of error occurs when it is decided that an EU poses an unacceptable risk when, in fact, the risk posed by the EU is less than  $10^{-4}$ . This is a false positive error. If data collected during the remedial investigation lead to this false

conclusion, the manager will decide, unnecessarily, to continue to study the EU. New data may eventually reveal that an EU is not a problem, and hence, correct the false positive error. Otherwise, unnecessary remedial action will be taken. A false positive error results in wasted time, money, and effort on EUs that are actually not a problem. The manager consulted with the toxicologist and site engineers to assess the consequences of such error for three risk ranges, all of which are below  $10^{-4}$ :

- below  $5 \times 10^{-6}$ ;
- $5.0 \times 10^{-6}$  to  $1.0 \times 10^{-5}$ ; and
- $1.0 \times 10^{-5}$  to  $5.0 \times 10^{-5}$ .

The project manager stated that the remedial investigation should be designed to have a low probability of false positives when very low risk levels exist at an EU

(e.g., when the EU is "clean"). The manager was willing to tolerate higher probabilities of false positives for risk levels near the threshold. The manager assigned acceptable probabilities for determining when an EU is a problem when in reality it is not for each of the above ranges (shown in the left-hand portion of Figure 1). These values are the acceptable rates for this type of error.

Risk equations (6) were used to determine the PAH concentrations that correspond to the risk ranges for which acceptable error rates had been defined. These concentrations are shown on the lower x-axis in Figure 1.

The logic statement, discussed earlier, indicated that we want to conclude that an EU is a problem if the true average PAH concentration in the EU is  $>122$  ppm. Figure 1 indicates that the project manager is willing to accept a 0.15 probability or less for making an incorrect decision at true concentrations of 122 ppm. It also indicates the manager's desire to avoid developing remedial alternatives for EUs that have PAH concentrations below 61 ppm. The figure specifies that for PAH concentrations falling between 122 ppm and 61 ppm, the manager will accept either decision (indicated by the grey region in Figure 1).

Because the project manager is indifferent about the decision in the range of 61–122 ppm, but wants to limit the probability of a false negative at 122 ppm or above, our original question was refined as follows: "Which, if any, surface soil EUs have an average PAH concentration above 61 ppm?" At 122 ppm and above, the manager has specified the false negative error rates that are acceptable. At values below 61 ppm, the manager also specified the false positive error rates that are acceptable. The qualitative and quantitative criteria established for addressing this question are the DQOs for the remedial investigation, and will focus the statistician's search for an optimal design (see box, "DQOs for case study").

### Design and optimization

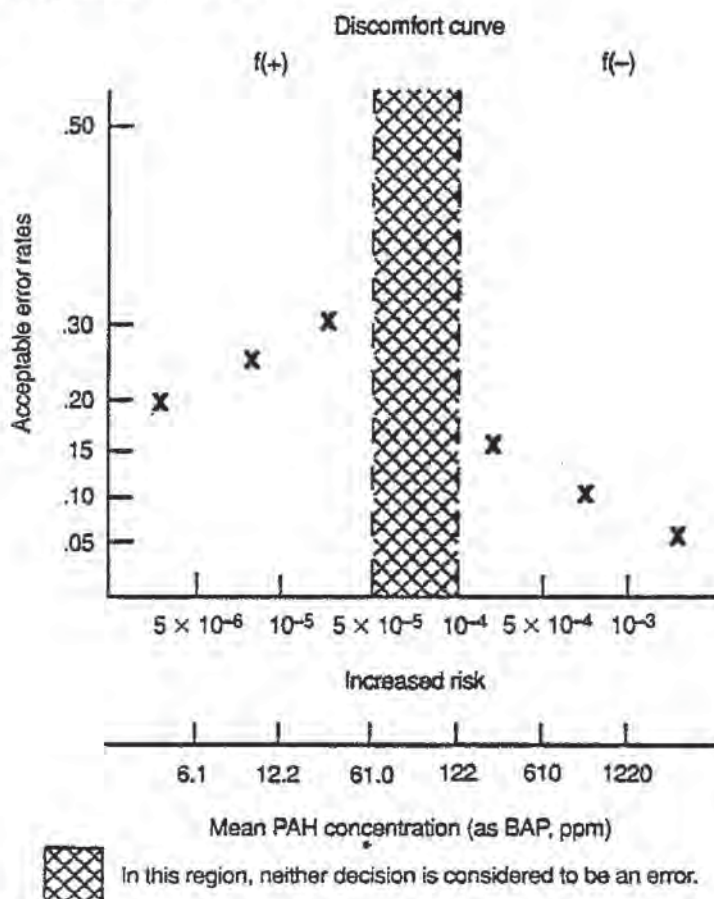
After the DQOs were established, a statistician applied conventional techniques to explore and evaluate various designs for data collection. The statistician was asked to design a survey that, first, would attempt to identify any EUs that have average PAH concentrations  $>61$  ppm; and second, would be subject to error rates no greater than those specified in the DQO statement from the project manager.

One concern the statistician noted was



FIGURE 1

## Acceptable limits for decision error



Workers collect soil samples at the Superfund site

that any attempt to divide the site into spatially distinct, uniform exposure units for testing runs the risk of missing an unacceptably contaminated area which lies across two or more EUs. This weakness is more than offset by two conservative measures included earlier: the assumption that the only PAH present is benzo[a]pyrene (the most toxic of the PAHs), and the decision to test for concentrations above 61 ppm when concern for false negative errors begins above 122 ppm.

The statistician framed the if-then logic statement as a statistical test that would allow us to determine whether PAHs within an EU are greater than 61 ppm, and began the search for designs that would control the decision uncertainty to the levels specified in the DQOs. To develop a statistically based sampling and analysis plan (the design), the statistician needed rough estimates of the spatial pattern and variability of the distribution of contaminant concentrations within EUs. He also required an estimate of the additional variability that would be introduced through the process of taking samples and analyzing them in the laboratory. Finally, since the statistician was asked to find the least expensive design that meets all the DQOs (the optimal solution), estimates of the costs of taking and analyzing a sample were required.

Since prior data on average PAHs across half-acre units were not available, the statistician used prior data from ran-

## DQOs for case study

**Decision:** Determine whether sections of the site pose unacceptable risks to human health or the environment and require remediation.

**Domain:** Exposure units are half-acre areas of surface soils. (Temporal aspects of the domain are not at issue because the contaminant of concern at this site is stable, not mobile.)

**Logic statement:** If the mean PAH concentration in an exposure unit exceeds 122 ppm ( $10^{-4}$  risk), then the exposure unit will require remediation.

## Uncertainty constraints

PAH risk range	Concentration range (ppm)	Acceptable probability for false positives (%)
Below $5 \times 10^{-6}$	Below 6.1	20
$5 \times 10^{-6}$ to $1 \times 10^{-5}$	6.1–12.2	25
$1 \times 10^{-5}$ to $5 \times 10^{-5}$	12.2–61	30
PAH risk range	Concentration range (ppm)	Acceptable probability for false negatives (%)
$1 \times 10^{-4}$ to $5 \times 10^{-4}$	122–610	15
$5 \times 10^{-4}$ to $1 \times 10^{-3}$	610–1,220	10
Above $1 \times 10^{-3}$	Above 1,220	5



dom samples of surface soils across the site (Figure 2). The statistician assumed that point-by-point spatial variability of PAHs within half-acre EUs was identical to the point-by-point variability of samples taken across the entire site, without grouping into half-acre units. This is probably a conservative assumption, since it is likely that there is some degree of similarity within EUs as compared to points that are more widely separated.

These data indicated the form of the distribution of contaminant concentrations (in this case a log-normal distribution) and provided the basis for estimating the variability of contaminant concentrations across the site. An estimate of the most probable total variance (on a log scale) is  $\sigma_1^2 = 1.64$  (24 degrees of freedom). Quality control data from analyses of PAHs, using the same analytical methods as those used to generate historical data for this site, indicate that analytical imprecision is on the order of 25% relative standard deviation. If the statistician had determined the historical data were not suitable for estimating the distribution and variability of concentrations within EUs, a pilot study would have been required to obtain these estimates.

Using the above information and the approximate per-sample costs of sampling (\$80) and analysis (\$800), the statistician began to evaluate various statistical sampling designs that would allow us to achieve the desired control over uncertainty. Recall that uncertainty is measured in terms of the probability of reaching an incorrect conclusion about whether an EU is a problem, i.e., the probability of false positives and false negatives. Among the options considered were uniform random sampling across the site, systematic sampling, stratified sampling, and sample compositing within each EU. After considering these options, the statistician recommended an approach that uses a compositing technique in which 10 or more scoops of soil, taken randomly within each EU, are combined, homogenized, and subsampled for analysis. When the potential difficulties and errors introduced through mixing and subsampling were recognized, five soil scoops were considered to be an efficient, practical number that could be combined routinely.

A statistical evaluation of several different designs, presented in Table 1, led to the following conclusions:

First, the expected performance data indicate that two survey designs have favorable cost and acceptable performance (i.e., were expected to meet or

FIGURE 2

# Frequency distribution of soil PAH concentrations

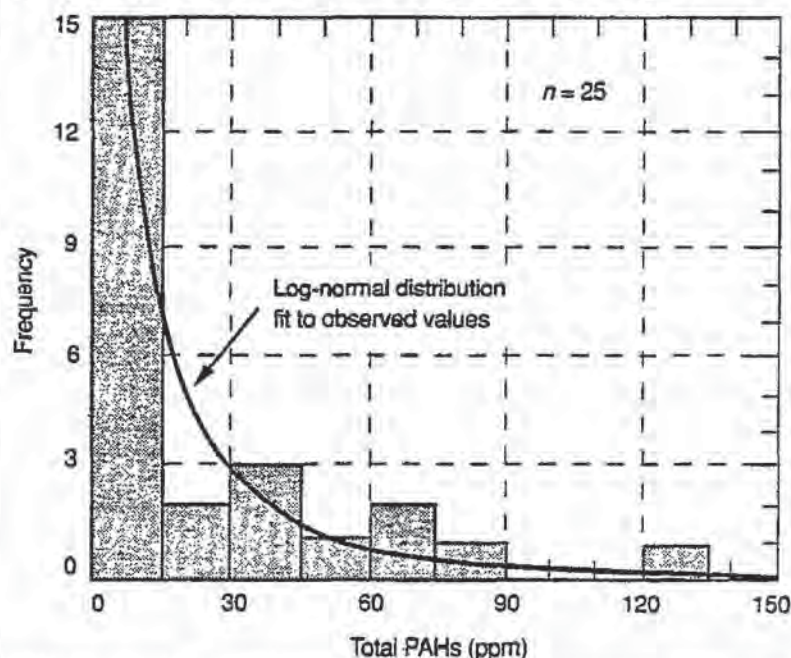


TABLE 1

## Results of initial power calculations

No. scoops /analysis	No. analyses/EU	Cost /EU (\$)	Probability of error <sup>a</sup>
1	4	3,520	.53
3	5	5,200	.15
4	2	2,240	.27
4	3	3,360	.18
4	4	4,480	.12
5	2	2,400	.20
5	3	3,600	.11

<sup>a</sup>When  $\mu = 122$  ppm and  $\alpha = .30$ .

Note:  $\alpha$  = probability of concluding EU is a problem when  $\mu$  is 61 ppm.

come close to meeting the 0.15 acceptable false negative and 0.3 false positive error rates specified over the range of important concentrations). The most favorable designs involved compositing five scoops per analytical sample. One design required the analysis of two composited samples per EU, while the other required three. Our notation for these designs are (5,2) and (5,3), respectively.

Second, compositing five scoops transformed the underlying log-normal

distribution into one that is more like a normal distribution in shape. A computer simulation was needed to assess more accurately the anticipated performance of the two designs, i.e., the "power" or capability of each design to detect EUs with PAH concentrations above the criterion. (Details on the statistical evaluation may be obtained by writing author Dean Neptune.)

The (5,2) and (5,3) designs were evaluated by simulation to determine how



well they can be expected to perform at the critical values of 122 and 61 ppm, and at other concentrations higher and lower than these values. The rough estimates of performance in Table 1 were based on the assumption that the distribution of total PAHs was log-normal with a total variability of 1.64. The true variability of concentrations within EUs may prove to be greater or less than this estimate. To determine the effect that more or less variability might have on reaching a correct conclusion with either of these designs, the performance of each design was evaluated at three different levels of total variability: 1.64 (most probable—our estimate of variability based on historical data), 1.00 (assumes less variability—a lower 95% confidence limit on the historical estimate), and 3.17 (assumes more variability—an upper 95% confidence limit on the historical estimate).

Figures 3 and 4 show the results of the simulations presented as expected performance curves. The shaded regions of the two figures are areas in which the constraints on uncertainty—control on false negative and false positive error rates—are achieved. In the region between 61 and 122 ppm, the shaded area shows that any amount of error can be tolerated. The shaded regions above 122 and below 61 ppm are those for which the error rates are of concern. A design performance curve that lies entirely in the shaded regions would satisfy all the DQOs (see box, "DQOs for the case study").

The figures show that the two designs can be expected to perform similarly and to achieve most of the constraints on uncertainty (most of the curve appears in the shaded region). If variability is 1.64, the figures reveal that both designs fail slightly when the true average PAH concentrations are between 50 and 60 ppm. Neither of the designs is likely to meet uncertainty constraints if the total variability is high (3.17). Points labeled "A" and "B" are slightly outside the regions of desired performance. Points labeled "A" are of concern if the variability is lower than we anticipate (1.00). Points labeled "B" are of concern if the variability is greater than we anticipate (3.17). Thus, if we use either the (5,2) or (5,3) design, and the variability of PAH concentrations within an EU is substantially lower or higher than assumed (1.64), we can expect slightly higher error rates than specified by the DQOs.

Considering the conservative measures built into the designs, the project manager determined that failing to meet

uncertainty constraints at these specific points is not serious. Finally, because the design (5,2) represents a 33% cost savings over the (5,3) design, and its ability to achieve the uncertainty constraints is approximately equal to that of the (5,3) design, the (5,2) design was recommended for the remedial investigation.

### Summary

The data quality objectives produced in the manner described do much more

than simply guide the survey design. The DQOs provide a focused decision statement, boundaries on the domain of interest (the EU), an "if-then" logic statement that specifies how data will be used in the decision, and constraints on the amount of uncertainty (limits on both false positives and false negatives) acceptable. They provide the information needed to ensure that the number of samples per EU is adequate and the sampling and analysis methods used will provide the



FIGURE 3

## Results of simulation for the (5,2) design

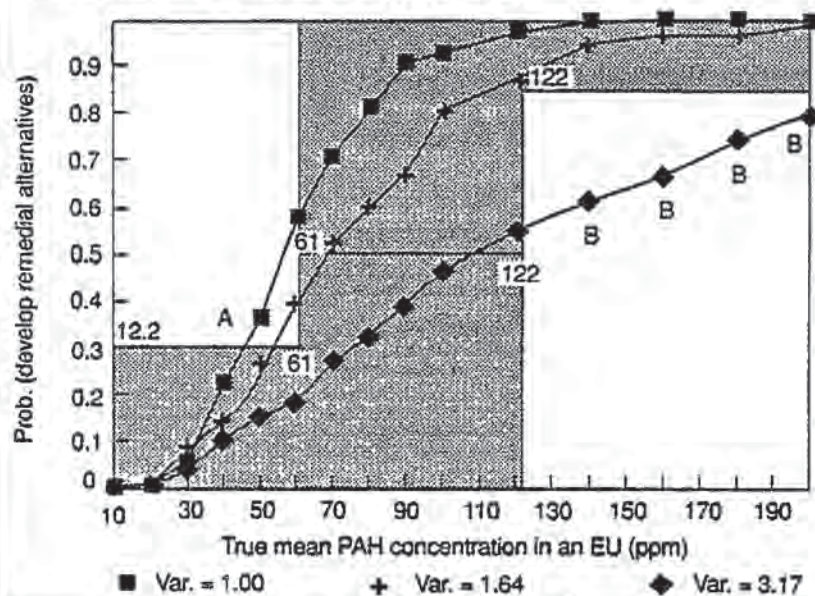
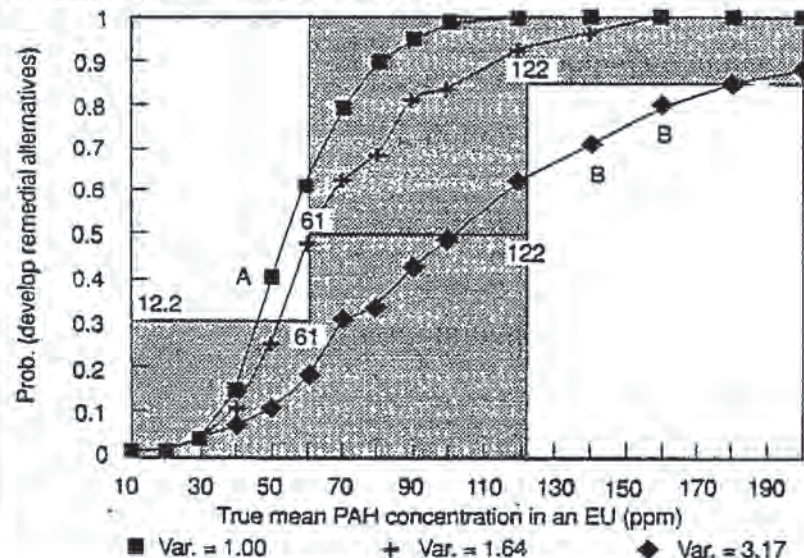


FIGURE 4

## Results of simulation for the (5,3) design



quality of data required to support decisions with the desired certainty. The most important benefits of this approach are that the decisions regarding Superfund site remediation can be made at the desired level of certainty, and that the project manager has specific quantitative criteria for deciding how much data is enough.

## References

- (1) Quality Assurance Management Staff. Development of Data Quality Objectives:

Description of Stages I and II." In *EPA Information Guide*; EPA: Washington, D.C., July 1986.

- (2) Environmental Protection Agency Office of Emergency and Remedial Response. "RI/FS Improvements Phase II, Streamlining Recommendations"; EPA: Washington, D.C., January 1989; OSWER Directive No. 9355.3-06.

- (3) Environmental Protection Agency. "Region IV Remedial Investigation Report for this Uncontrolled Hazardous Waste Site"; EPA: Washington, D.C., 1988.

- (4) Environmental Protection Agency. *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual*; EPA:

Washington, D.C., June 30, 1989; draft. Note: The calculations used to estimate reasonable maximum exposure in this case study are found in Reference 6.

(5) Connor, B., National Utility Contractor's Association, Arlington, Va., personal communication. Reasonableness of this estimate was confirmed by EPA ORD and Region IV risk assessment experts.

(6) Office of Emergency and Remedial Response. *Superfund Public Health Evaluation Manual*; OSWER/EPA: Washington, D.C., October 1986; EPA 540/1-86/060.

## Acknowledgments

The individuals listed below played a substantive role in the development of the DQOs for this hazardous waste site. Region IV used the planning issues raised through the DQO process to set survey design constraints (the DQOs) for the case study. The DQOs then were used as the basis for optimizing the possible survey designs for this site. The DQO process and its adaptation to Superfund planning issues for the remedial investigation/feasibility study was led by the quality assurance management staff, with DQO application support from Research Triangle Institute, Montana State University, and NUS Corp. The authors of this paper have summarized the outputs of a series of activities in which all of these individuals participated directly: James Pickett, Ph.D., and Randall Rytel, Ph.D., Montana State University; Robert Hubbard, NUS Corp.; Eugene P. Brantly, C. Andrew Clayton, Daniel I. Michael, Michael Messner, Research Triangle Institute; Elmer Akin, Meredith Anderson, William Bokey, Beverly Houston, David Kleusner, M.D. Lair, William Patton, EPA Region IV; Dean Neptune, Ph.D., EPA Headquarters quality assurance management staff.

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### **E.3. KENTUCKY REGULATORY GUIDANCE**

The following copies of regulatory guidance are presented in this chapter.

- Kentucky Risk Assessment Guidance, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, June 8, 2002.
- Kentucky Guidance for Ambient Background Assessment, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, January 8, 2004.
- Kentucky Guidance for Groundwater Assessment Screening, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, January 15 2004.
- Trichloroethylene Environmental Levels of Concern, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, April 2004.

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# **Kentucky Risk Assessment Guidance**

**June 8, 2002**



**Natural Resources and  
Environmental Protection Cabinet**

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## Section 1. Introduction

Risk assessment is a formalized process for evaluating the potential human health and ecological impacts based on the concentration of, exposure to, and toxicity of environmental contaminants. Risk assessment has been used in environmental decision-making since the process was outlined in a publication by the National Research Council – National Academy of Sciences (1983) Red Book. The United States Environmental Protection Agency (U.S. EPA) produced several guidance documents to assist in assessing risks (U.S. EPA, 1989; 1991).

Human health risk assessment, as outlined, is a four-part process. The first step, Data Collection and Evaluation, assesses the available data and identifies chemicals of potential concern (COPCs). The next part, Exposure Assessment, identifies potential receptors and calculates their exposure to the COPCs. Toxicity Assessment, the third process, quantifies the toxicity of the COPCs for carcinogenic and noncarcinogenic effects. The final step, Risk Characterization, is the calculation of the potential effects on the receptors identified in the Exposure Assessment, based on the toxicity of the chemicals identified in the Data Collection and Evaluation step.

Risk assessment procedures are used in several stages of site assessment and closure. During site scoping Preliminary Remediation Goals may be used to determine preferred detection limits and to screen initial data to focus on areas of concern. Data from Site Characterization are often screened against target risk-based concentrations (Preliminary Remediation Goals) to identify whether a baseline risk assessment or further evaluation is needed and, if so, which chemicals should be further assessed. Risk assessment is also used in setting remedial goals, and as an exit criterion for closure of remediation activities. Risk assessment is used as part of activities related to the Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Clean Water Act, and Clean Air Act.

This document details the application of risk assessment to environmental remediation. The document can be used to determine if site conditions are protective of human health and the environment, or that risks are reduced to acceptable levels through removal of contaminants or management. The risk-based procedures for the program are based on a tiered approach allowing for screening against default risk-based screening values in lower tiers and incorporating more site-related data in the higher tiers.

This document outlines the procedures for:

1. Comparing site data against risk-based screening values.
2. Preparing a baseline risk assessment to determine protectiveness of human health and the environment.
3. Evaluating when an ecological assessment is necessary
4. Evaluating when to compare site soil data to Soil Screening Levels for protection of groundwater.
5. Selecting remedial cleanup goals.

The following sections describe the process of evaluating the site data that were collected during the site characterization. The data must be representative and complete. If statistical procedures are used, a sufficient number of samples should be collected to meet the needs of those statistical tests. Human health risk assessment is described in Section 2.0. The subsections within Section 2.0 describe the application of risk assessment to the processes of environmental assessment and remediation including: tiered risk assessment, groundwater evaluation, risk management, selection of remedial goals, and presenting the results of the two tiers of risk assessment. Section 3.0 details the ecological risk assessment procedures.

## **Section 2. Human Health Risk Assessment**

This section provides methods for screening environmental data to identify Contaminants of Concern, performing screening and baseline risk assessment, evaluating groundwater, managing risks, and selecting remedial goals. Figures 1 and 2 outline the process for risk-based procedures for residential and commercial/industrial scenarios in environmental remediation. The remedial options listed in Figures 1 and 2 are those listed in KRS 224.01-400 (18)-(21).

Figure 1. Flowchart for Residential Cleanup Options

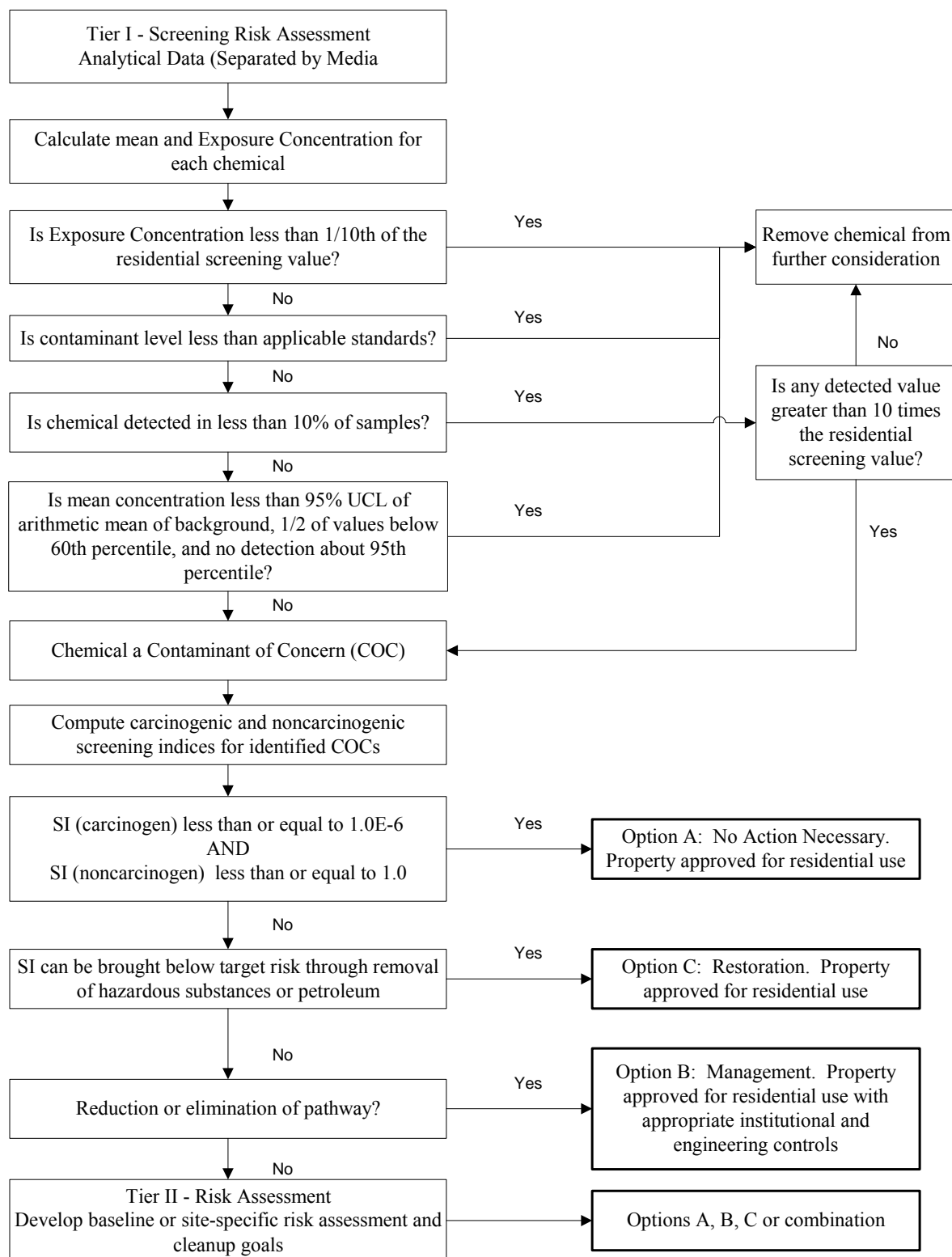
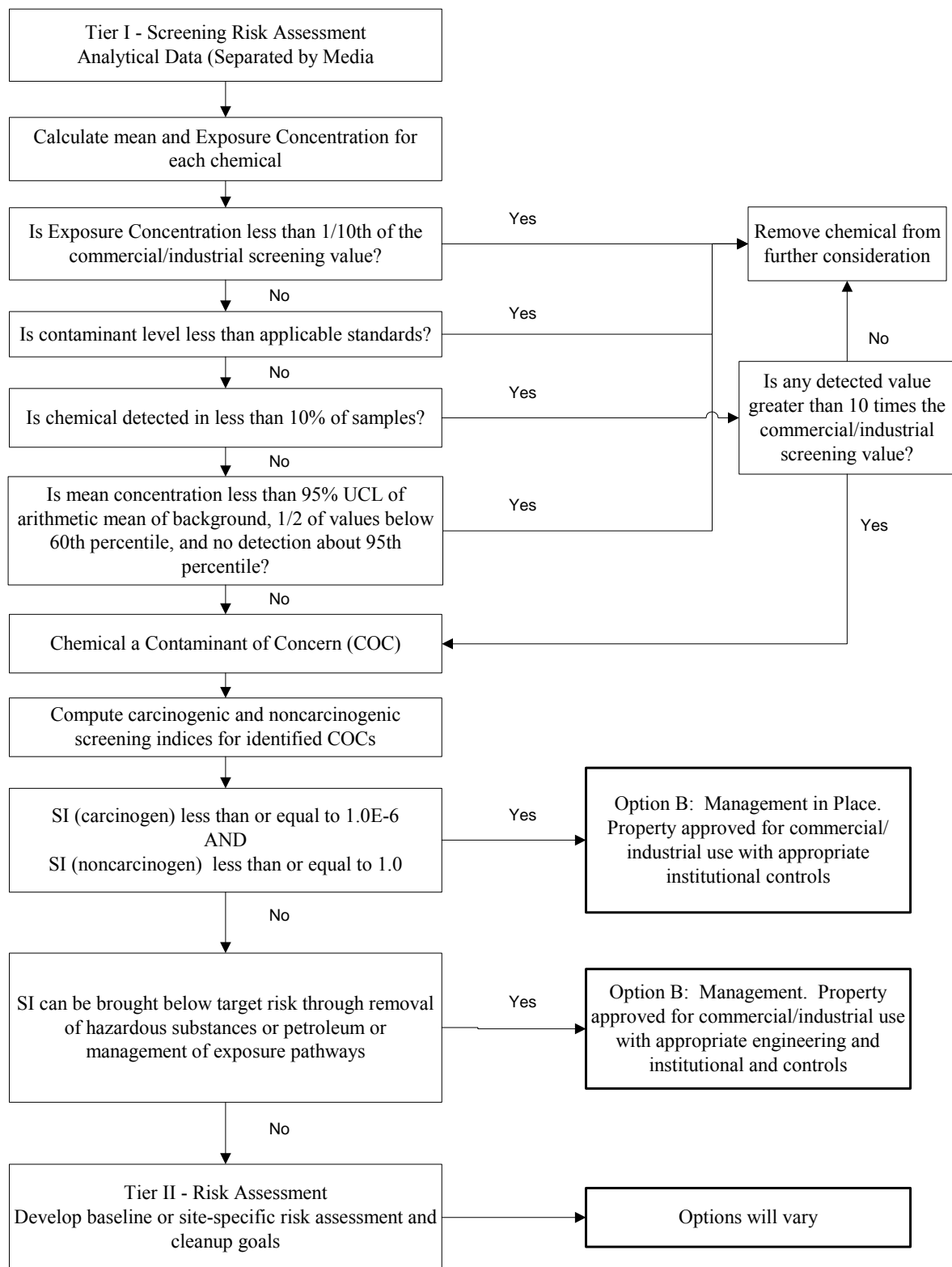


Figure 2. Flowchart for Commerical/Industrial Cleanup Options



## Section 2.1. Tier I. Human Health Risk-Based Screening

This initial tier identifies which contaminants contribute significantly to the risks associated with the property and calculates the cumulative risk for all Contaminants of Concern (COCs). For this guidance, hazardous substance or petroleum shall have the meaning as defined in KRS 224.01-512. The screening-level risk assessment should be completed for residential land use as a baseline, and commercial or industrial land use if commercial or industrial use is part of the management plan. The following steps should be followed when completing a screening-level risk assessment for human health.

1. Segregate analytical data by medium. Further segregate soil data into surface (0-1 foot depth) and subsurface (greater than one foot depth).
2. Calculate 95% Upper Confidence Limit (UCL) of the arithmetic mean as described in U.S. EPA, 1992 (Supplemental Guidance to RAGS: Calculating the Concentration Term). Use all samples of the property and site(s). Use one-half of the detection limit for non-detect sample results. The Exposure Concentration shall be the lower of the 95% UCL of the arithmetic mean and the maximum detected value for that medium (and horizon, for soil). Calculate the mean of the site data for inorganic compounds in addition to the 95% UCL.
3. Compare the Exposure Concentration to  $1/10^{\text{th}}$  of the residential or commercial/industrial screening value, as appropriate. When screening, use the Total Chromium value for chromium, use carcinogenic effects for arsenic, and use Toxicity Equivalency Factors (TEFs) to calculate a Toxicity Equivalency Quotient (TEQ) for dioxins. Instead of  $1/10^{\text{th}}$  of the screening value for lead, use the Kentucky Lead Action Level of 50 mg/kg for soils for residential, and 400 mg/kg for commercial/industrial soils. Appendix E contains the KY Radiological Risk-Based Preliminary Remediation Goals, if applicable. Compare the Exposure Concentration to the following standards when applicable: Maximum Contaminant Levels (MCLs) for surface and ground water (401 KAR 8:250, 401 KAR 8:300, 401 KAR 8:400, 401 KAR 8:420), National Ambient Air Quality Standards (NAAQS) for air, and Surface Water Standards (401 KAR 5:031) for surface water.
4. Calculate the frequency of detection of the hazardous substance or petroleum constituent. Identify those compounds that are detected in at least 10 percent of the samples. If there is any detection above ten times the residential or commercial/industrial screening value, as

appropriate, then the hazardous substance or petroleum should remain a Contaminant of Concern (COC) regardless of the frequency of detection.

5. Compare the mean of the site data to the 95% UCL of background for inorganics. The background value shall be the generic statewide background number listed on Table G-2 in Appendix G, or site-specific background may be determined using the methods described in 401 KAR 100:100 Section 7 (6). In addition to the site mean being less than the 95% UCL of background, at least half of the samples should fall below the 60<sup>th</sup> percentile on Table G-2 or site-specific background, and no sample should exceed the 95<sup>th</sup> percentile listed on Table G-2 or site-specific background. The cabinet may approve other statistical methods proposed by the VERP applicant or party.
6. Produce a summary table that lists each hazardous substance or petroleum, site mean, Exposure Concentration, 1/10<sup>th</sup> of the screening value, frequency of detection (as a fraction), and, for inorganics, 95% UCL of the arithmetic mean of background. Include MCLs, Surface Water Standards, and NAAQS, if applicable. Identify those compounds as Contaminants of Concern (COCs) that exceeds the values in all applicable screens (i.e., is not eliminated by any screen). Highlight or denote with bold text the screen that eliminates the COC from further evaluation, if applicable. Table 1 is an example of the summary table for soil.

Table 1. Summary of Results of Tier I Screening

Hazardous Substance	Mean	Exposure Concentration	1/10 <sup>th</sup> Screening Value	Frequency of Detection	95% UCL of Background	COC?
Benzene	--	0.8 mg/kg	0.03 mg/kg	(8/30)	---	Yes
Arsenic	7.9 mg/kg	9.3 mg/kg	0.019 mg/kg	(24/30)	<b>9.4</b>	No

7. Segregate the COCs into carcinogens and noncarcinogens as described in the Preliminary Remediation Goals table in Appendix C. Radionuclides should be evaluated in the Tier I Screen using the screening values in Appendix E, if applicable. Calculate a Screening Index for all COCs by dividing the Exposure Concentration by the chemical-specific Preliminary Remediation Goal from Appendix C and summing the carcinogens and noncarcinogens:

$$\text{Screening Index (SI)} = \sum \frac{\text{Exposure Concentration } x}{\text{Screening Value } x} + \frac{\text{Exposure Concentration } y}{\text{Screening Value } y} + \frac{\text{Exposure Concentration } z}{\text{Screening Value } z} + \text{etc.}$$



For noncarcinogens, a Screening Index of less than 1.0 indicates that exposure to all noncarcinogenic contaminants, when summed, do not exceed a HQ of 1.0. Likewise the carcinogenic constituents should also use the SI approach and multiply the result by  $10^{-6}$  to determine the additive risk in the media. This approach should be used for all applicable media at a site and then summing the indices of the individual media. The VERP applicant or party may calculate a site-specific PRG for a Tier I risk assessment screen.

8. Present the results of the Screening Index in the risk assessment report (Section 2.6).
9. If the cumulative Screening Index (SI) exceeds 1.0 for noncarcinogens or  $1 \times 10^{-6}$  for carcinogens, a VERP Applicant or party should select the next course of action. They may select to complete a risk management plan (Section 2.4), initiate remedial action(s) (Section 2.5), or evaluate the risks further through a baseline risk assessment (Section 2.2).

#### Section 2.2. Tier II. Baseline Human Health Risk Assessment.

1. Based on the COCs that were identified in Tier I (Risk-Based Screening), conduct a baseline risk assessment.
2. Risk assessment guidance documents from the United States Environmental Protection Agency should be used in preparing the risk assessment. Primary guidance is the “Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual. (Part A)” (RAGS Part A) and RAGS Part B (U.S. EPA, 1989; 1991), the “Soil Screening Guidance: Technical Background Document” (U.S. EPA, 1996a), the “Soil Screening Guidance: Users Guide” (U.S. EPA, 1996b), the “Soil Screening Guidance for Radionuclides: Users Guide” (U.S. EPA, 2000), and the Supplemental Guidance to RAGS: Region 4 Bulletins (U.S. EPA, 2001c). Other supporting guidance documents should be used as needed.
3. Describe the collection of sampling data and the procedures used to evaluate the data that are included in the risk assessment. Evaluation is completed as described in RAGS Part A (U.S. EPA, 1989) and involves evaluating analytical methods, quality of data, quantitation limits, data qualifiers, and blanks.
4. Identify and calculate exposure to current and future receptors. Potential land uses should be identified including, but not limited to: residential, industrial, recreational, commercial, or

agricultural. The baseline risk assessment should address all current and potential future receptors including trespassers and residents. Exposure factors for common receptors are listed in Appendix A. Site-specific factors may be used, subject to cabinet approval. The factors and the rationale for their use should be documented in the risk assessment report.

5. Describe the toxicity of the COCs that were identified in Section 2.1. List the toxicity values that are associated with the COCs. The hierarchy for sources of toxicity values is: (1) U.S. EPA's Integrated Risk Information System (IRIS), (2) U.S. EPA's Health Effects Assessment Summary Tables (HEAST), (3) provisional values from U.S. EPA's National Center for Environmental Assessment (NCEA), and (4) Other sources. Other sources may include Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles, World Health Organization (WHO) documents, publications in the primary toxicological literature, or values withdrawn from IRIS or HEAST, with cabinet approval.
6. Calculate the risks associated with the receptors that were identified in Step 4.
7. Identify and describe the uncertainties associated with the risk assessment. Potential sources of uncertainty include COC selection, range of values for exposure parameters, characterization of the site, and interaction between chemicals (additivity, synergism). Uncertainty analysis is further discussed in RAGS Part A (U.S. EPA, 1989).

### Section 2.3. Groundwater Evaluation.

Groundwater data from monitoring wells are evaluated in Tier I and II risk evaluations. Recoverable water from soil borings can also be evaluated with groundwater numbers (Preliminary Remediation Goals, MCLs) as described in Section 2.1 and 2.2. If no groundwater monitoring data are available, or data are not adequate, then compare Exposure Concentration(s) for soil to the Soil Screening Level(s) from the Preliminary Remediation Goals table in Appendix C as described in 401 KAR 100:100 Section 5 (5). Radionuclides should be evaluated using the Soil Screening Levels in Appendix E, if applicable.

If the bottom two sampling intervals in the soil boring do not exceed the SSL, modified SSL, site-specific SSL, or subsurface background, then further groundwater evaluation of soil as a potential source for groundwater contamination is not necessary. If soil concentrations in the bottom two sampling intervals of the soil boring do exceed the Soil Screening Level, Modified SSLs, or site-specific SSLs for protection of groundwater resources, and subsurface background, then this indicates a need to manage for migration of contaminants to groundwater or for a

groundwater investigation. Submit a plan to assess and protect groundwater or provide site-specific information that contamination doesn't pose a threat to groundwater.

Identify if the site is in an area where contamination of a karst aquifer is possible, or the contaminant(s) could result in a dense non-aqueous phase liquid (DNAPL) layer, or any other circumstances exist that would indicate a higher potential for contamination of groundwater. If such conditions exist, submit a plan for groundwater assessment and protection.

#### Section 2.4. Management of Risks.

1. Property Use. Management of risks can be accomplished by ensuring that a property is only used by a certain receptor. For example, a property that meets criteria for commercial or industrial use, but not residential, must remain commercial or industrial. Alternate land uses can be evaluated by using commercial/industrial screening values in place of the residential screening values that were used in Section 2.1, or in a baseline risk assessment.
2. Physical and Institutional Controls. Management of risks can be accomplished if exposure to contaminated media is controlled using a combination of soil cover, restrictive covenants, dig restrictions, fencing, or other approved methods.
3. Submit Corrective Action Plan for approval as described in 401 KAR 100:100 Section 8.

#### Section 2.5. Selection of Remedial Goals.

1. The primary goals of remediation is protection of human health at the hazard index of 1.0 and the carcinogenic risk of  $1 \times 10^{-6}$  at the point of exposure, and protection of ecological health. Ecological risks are addressed in Section 3.0.
2. The primary goals of remediation do not excuse compliance with other applicable standards, such as the National Ambient Air Quality Standards and the surface water standards.
3. The intended use must be ensured through physical and institutional controls and described in the Corrective Action Plan. The risk-based Preliminary Remediation Goals are found in the Appendix C table or derived based on approved receptor-specific values. Remedial goals

for radionuclides will be developed on a site-specific basis in consultation with the Kentucky Cabinet for Health Services. Generic inorganic background values are listed in Appendix G or may be derived using the guidance in 401 KAR 100:100 Section 7 (6).

4. The applicable risk-based remedial goals for surface soils are the residential and commercial/industrial soil numbers in the Appendix C Preliminary Remediation Goals table or those calculated based on approved receptor-specific values. Appendix E contains the risk-based concentrations for radionuclides, if applicable. The remedial goal for certain organic chemicals may be based on site-specific concentrations if it can be demonstrated to the cabinet that concentrations are the result of natural sources or are a by-product of combustion of fuels and not the result of activities on the property or site. For subsurface soils, a VERP applicant or party may select ten times the surface soil risk-based concentrations as an initial remedial goal with implementation of the institutional and physical controls and should not be a source of groundwater contamination. If contaminants are in the surface soil horizon, this can be attained through the use of cover (6 inches of pavement (e.g., asphalt or concrete), 12 inches of soil, or other approved method). For example, if the commercial/industrial soil number is 1.3 mg/kg on the risk-based PRGs table in Appendix C, and the contamination is more than a foot below the surface or is covered with a foot of clean soil, then the concentration that is left in place can be 13 mg/kg and the use of the site would need to be restricted to commercial or industrial use with the soil cover maintained in place.

#### Section 2.6. Human Health Risk Assessment Report Format.

The risk assessment results should be presented as part of the environmental remediation process wherever risk assessment is used for environmental decision-making. This may be included as part of the site characterization report, corrective action completion report, in an appendix to those reports, or as a separate document.

1. Screening. The screening report should consist of a brief description of the property, site characterization activities, a summary of the analytical data along with the statistical calculations of the 95% UCL, the summary table as described in Section 2.1 6., and results of the Screening Index.

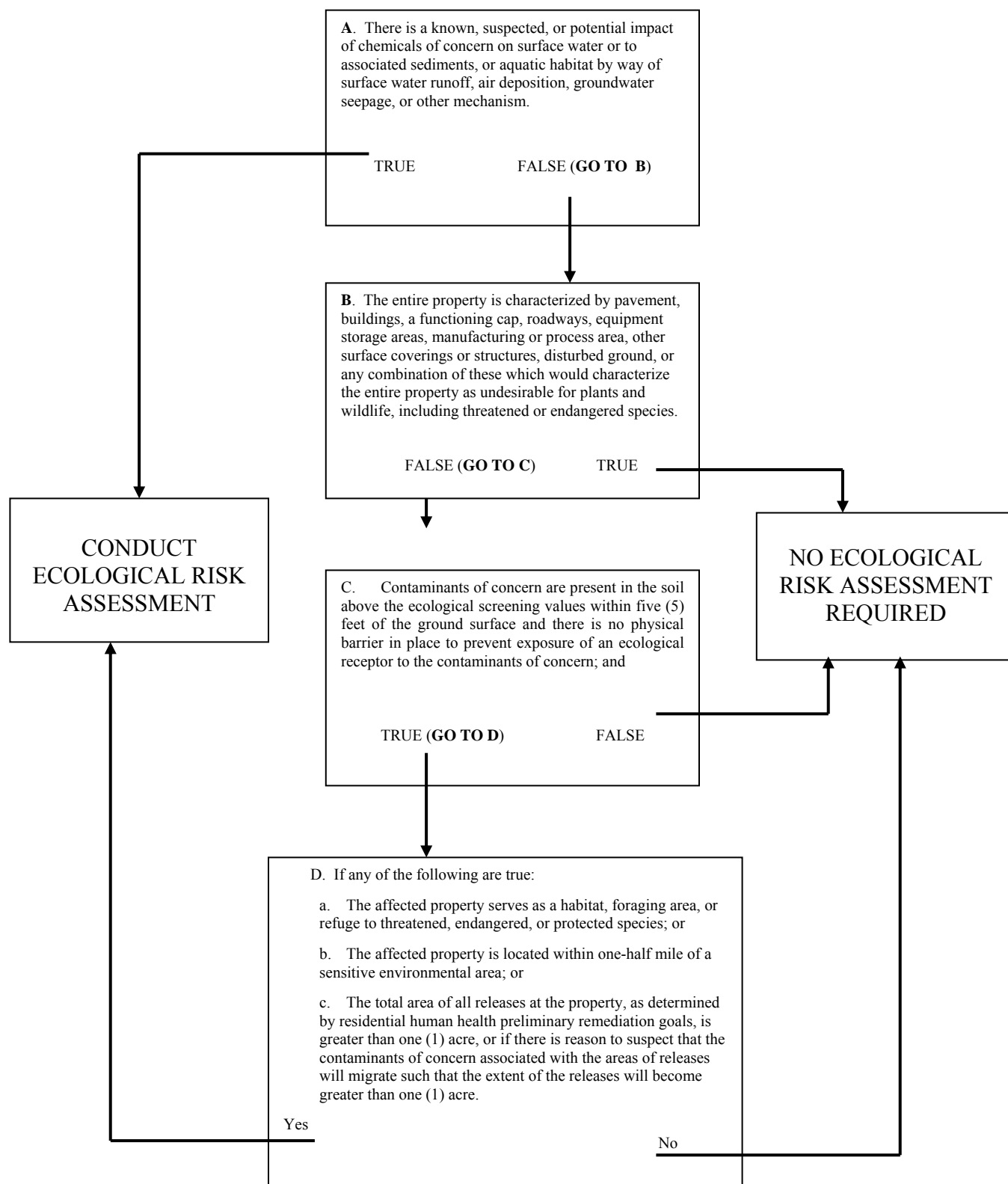
2. Baseline Risk Assessment. The baseline risk assessment report should follow the general outline shown in Appendix B. A copy of the screening risk assessment may be included with the baseline risk assessment to provide information that was used in the baseline risk assessment (selection of COCs, calculation of 95% UCL).

### Section 3.0 Ecological Risk Assessment

If it has been determined that an Ecological Risk Assessment (ERA) needs to be conducted (401 KAR 100:100 Section 5 (8)), this document provides the outline for that process. The flowchart in Figure 3 is the process for determining if an ERA needs to be conducted. The checklist in Appendix F can be used to identify features of the environmental setting that are related to ecological receptors.

The phrase “ecological risk assessment” refers to a qualitative and/or quantitative appraisal of the actual or potential impacts from a hazardous compound or physical stressor on plants and animals. Documents from various federal programs (Simini et. al., 2000; USEPA 1993; USEPA 1997a; USEPA 1998) were consulted in the process of developing this document and the procedures used in calculating risk-based concentrations. Figure 4 outlines the process of the ERA.

Figure 3. Flowchart For Determining An Ecological Risk Assessment



The ERA process is based on two major elements: characterization of effects and characterization of exposure. These provide the focus for conducting the phases of risk assessment: planning, problem formulation, analysis, risk characterization, and risk management.

- a) Planning – The Planning phase involves the determination of level-of-effort necessary for the ERA. ERA management goals and objectives are determined (i.e., what plant, animal, or ecosystem is at risk and might need protection), the focus of the ERA is laid out, and the time frame for the assessment is set.
- b) Problem Formulation – The overall strategy for estimating risk at a site is developed in Problem Formulation. During this phase, the Conceptual Site Model (CSM) is created, the receptors potentially at risk are defined, and a plan is written that describes the data to be analyzed and the process to be used to calculate risk.
- c) Analysis – This component of the ERA consists of data collection, the technical evaluation of the data, the calculation of the existing and potential exposures, and corresponding ecological effects.
- d) Risk Characterization – The likelihood and severity of the risk is evaluated for the assessment endpoints, and the ERA's uncertainty is described in the Risk Characterization. A good description of the risk, including the level of adverse effects, is important for interpreting the risk results.
- e) Risk Management – In this component, the results of the ERA are integrated with other considerations to make and justify remedial decisions. In a screening level ERA, the risk management decision is whether a baseline ERA is needed.

### Section 3.1. Tier 1. Screening-Level Ecological Risk Assessment.

The purpose of the screening-level risk assessment is to evaluate whether existing data justify a decision that site contaminants do not pose a risk to ecological receptors or whether additional evaluation is necessary. If no potential for risk is identified in a screening-level risk assessment, then risk managers can confidently conclude that no further action is required at the site. Tier 1 of ERA consists of two steps:

Step 1. Screening-Level Problem Formulation and Ecological Effects Evaluation.

Step 2. Screening-Level Preliminary Exposure Estimate and Risk Calculation.

Steps 1 and 2 of the ERA process contain the following elements:

- Site visit
  - Screening-level problem formulation (preliminary Conceptual Site Model)
  - Exposure pathways and endpoints
  - Screening-level effects evaluation (toxicity threshold benchmarks)
  - Screening-level exposure estimate (site concentration data)
  - Screening-level risk calculation (site concentration data screens)
  - Documentation
- a) Preliminary Conceptual Site Model (CSM). As part of Tier 1, Step 1 of the ERA, use available information to develop a preliminary CSM. Available information may include observations made during site visits, historical documents, existing data, and professional judgement of technical experts who are familiar with the site. The preliminary CSM should describe the environmental setting of the individual site, the site's immediate surroundings, and the contaminants known to exist at the site. The preliminary CSM should identify fate and transport mechanisms of contaminants potentially moving off-site, and briefly discuss the ways that site contaminants act on likely receptors.
- b) Exposure Pathways and Endpoints. Based on the preliminary CSM, the ecological risk assessor should identify the potentially complete exposure pathways and endpoints for the screening assessment. The exposure pathways and endpoints for the site specify which ecological effects data are required. The screening-level effects data are screening-level benchmarks and concentrations of substances in the abiotic media (e.g., soil, air or water). If groundwater potentially discharges to surface water, groundwater concentrations are compared to surface water screening benchmarks.
- c) Identify Chemicals of Potential Concern. As part of Tier 1, Step 2, determine (COPCs) by eliminating COPCs from further evaluation:
- Background Comparisons. Compare the mean concentration for inorganic constituents on-site against the 95% UCL of the mean concentrations of background for inorganic



constituents. At least ½ of the data points should be less than the 60<sup>th</sup> percentile, and no data point above the 95<sup>th</sup> percentile. Generic inorganic background values are listed in Appendix G or may be derived in accordance with 401 KAR 100:100 Section 7 (6).

- Screening Table Comparison. Compare the lesser of the maximum concentration or 95% UCL on site for substances in a given exposure medium to the screening-level benchmarks (Appendix D) for those substances. Compare site concentrations to screening-level benchmarks for surface soil, sediment, surface water, and groundwater (if site conditions will potentially result in exposure to ecological receptors).
- d) Retaining Chemicals of Concern. If any constituent in an abiotic medium to which organisms are potentially exposed is present at a concentration exceeding screening-level benchmark and ambient background or if there is not a screening-level benchmark, then further evaluation of the potential risk will be required. Chemicals with known synergistic effects or that bioaccumulate will be retained as COPCs. If existing data does not have adequate detection limits (i.e., detection limits above screening benchmarks) new data must be collected to replace it.
- e) Documentation. The documentation of Steps 1 and 2 should include the following:
- Brief habitat description, and map;
  - Preliminary CSM;
  - Tables of screening results;
  - List of wildlife species actually or potentially occurring at the site, including threatened and endangered plant and animal species;
  - Discussion of uncertainties. The discussion of the uncertainties should identify constituents for which there are no screening-level benchmarks or analytical chemistry data.

At the end of Tier 1, the decision whether to collect additional data for screening, to proceed with the ERA, or to take no further action can be documented in the report.

### Section 3.2. Tier 2 Baseline Ecological Risk Assessment

The baseline ecological risk assessment is a continuation of the screening ERA. It consists of 6 steps:

- Step 3. Baseline Risk Assessment Problem Formulation
- Step 4. Study Design and Data Quality Objectives
- Step 5. Field Verification of Sampling Design
- Step 6. Site Investigation and Analysis of Exposure and Effects
- Step 7. Risk Characterization
- Step 8. Risk Management

a) Step 3. Baseline Risk Assessment Problem Formulation. The Baseline Risk Assessment Problem Formulation should provide sufficient information to support a risk management decision concerning the need for additional evaluation of ecological risk. Further evaluation may mean site-specific ecological investigation at the site. This will require a work plan, documenting Step 4 of the process, and describing how the data will be used in Step 7 to make a remedial decision for the site. Important inputs to this decision are:

- Site concentration data;
- Conceptual Site Model;
- Habitat Description;
- Preliminary Hazard Quotients. The Hazard Quotient should be calculated for COPCs using toxicity values from current literature and intake factors from the Wildlife Exposure Factors Handbook (USEPA 1993) for the species listed below. A Hazard Quotient is calculated by dividing the site concentration (the lessor of the 95% UCL of the mean or maximum) by the No-Observed Adverse Effect Level (NOAEL). If the Hazard Quotient is above 1.0, that compound continues through the baseline ERA.

For terrestrial habitats, receptors must include (1) earthworm (Lumbricus terrestris), (2) short-tailed shrew (Blarina brevicauda), (3) long-tailed weasel (Mustela frenata), (4) meadow vole (Microtus pennsylvanicus) or prairie vole (Microtus ochrogaster), and (5) American woodcock (Scolopax minor). For aquatic habitats, receptors must include; mink (Mustela vison) little brown bat (Myotis lucifugus), and belted kingfisher (Ceryle alcyon). The above list of species should not be considered exclusive. If there are other species on site that exposure factors, intake rates, and

toxicity values are known, those species should be included in the ERA. Species that are on the Federal and/or State Threatened or Endangered Species List and either known to have been on or in the vicinity of the site or if the site contains habitat known to support those species, then they should also be included in the ERA.

- The identification of COPCs that warrant further evaluation.
- An understanding of the effects of COPCs on ecological receptors (including toxicity reference values).
- The identification of complete exposure pathways by which COPCs are brought into contact with ecological receptors (include bioaccumulation factors and ingestion rates for wildlife receptors).
- The identification of assessment endpoints (e.g., protection of fish eating birds from eggshell thinning due to DDT exposure) and measurement endpoints (e.g., natural population structure, feeding, resting, and reproductive cycles).
- Discussion of uncertainties should include the lack of site concentration or toxicity data for COPCs.

- b) In Step 4, the process identifies the study design and data quality objectives (DQOs) for the site investigation. The work plan (WP) and the sampling and analysis plan (SAP) are the primary products of Step 4. The WP and SAP must specify the study design in sufficient detail to evaluate its adequacy for collecting the data necessary to answer the risk questions.

The WP or SAP should include the following:

- The number and location of samples of each medium for each purpose
- The comparison of analytical detection limits and threshold concentrations
- The full description of toxicity tests and population/community study designs
- A description of how the results of site investigations will be used in the risk characterization (Step 7) to answer risk questions.

- c) In Step 5, the Verification of Field Sampling Design process evaluates the probability of successfully completing the study as designed. The WP or SAP should describe the methods for verifying the study design. The verification process and any remaining uncertainties

about the study design should be discussed when the results of the site investigation are reported.

- d) Step 6, the Site Investigation and Data Analysis, is the implementation of the site investigation designed in Step 4 and verified in Step 5. Approved alterations in the work plan should be documented in the report containing the risk characterization (i.e., the baseline risk report).

- e) Risk Characterization (Step 7) is conducted after data collected during the site investigation have been analyzed. The risk characterization evaluates the exposure and effects data to assess the risk to the assessment endpoints (risk estimation). The risk characterization also presents information necessary to interpret the risk assessment and to decide upon adverse effect thresholds for the assessment endpoints (risk description). This presentation should include a qualitative and quantitative summary of risk results and uncertainties.

In risk estimation, the lines of evidence, for which data were collected in the site investigation, are integrated in the risk characterization to support a conclusion about the significance of ecological risk. The different possible lines of evidence could be tissue concentration data, toxicity test results, and/or population/community data.

If site-specific tissue concentration data are available from the site investigation, HQs for wildlife receptors preying on those tissues are calculated. These HQs are calculated using appropriate exposure estimates and toxicity reference values.

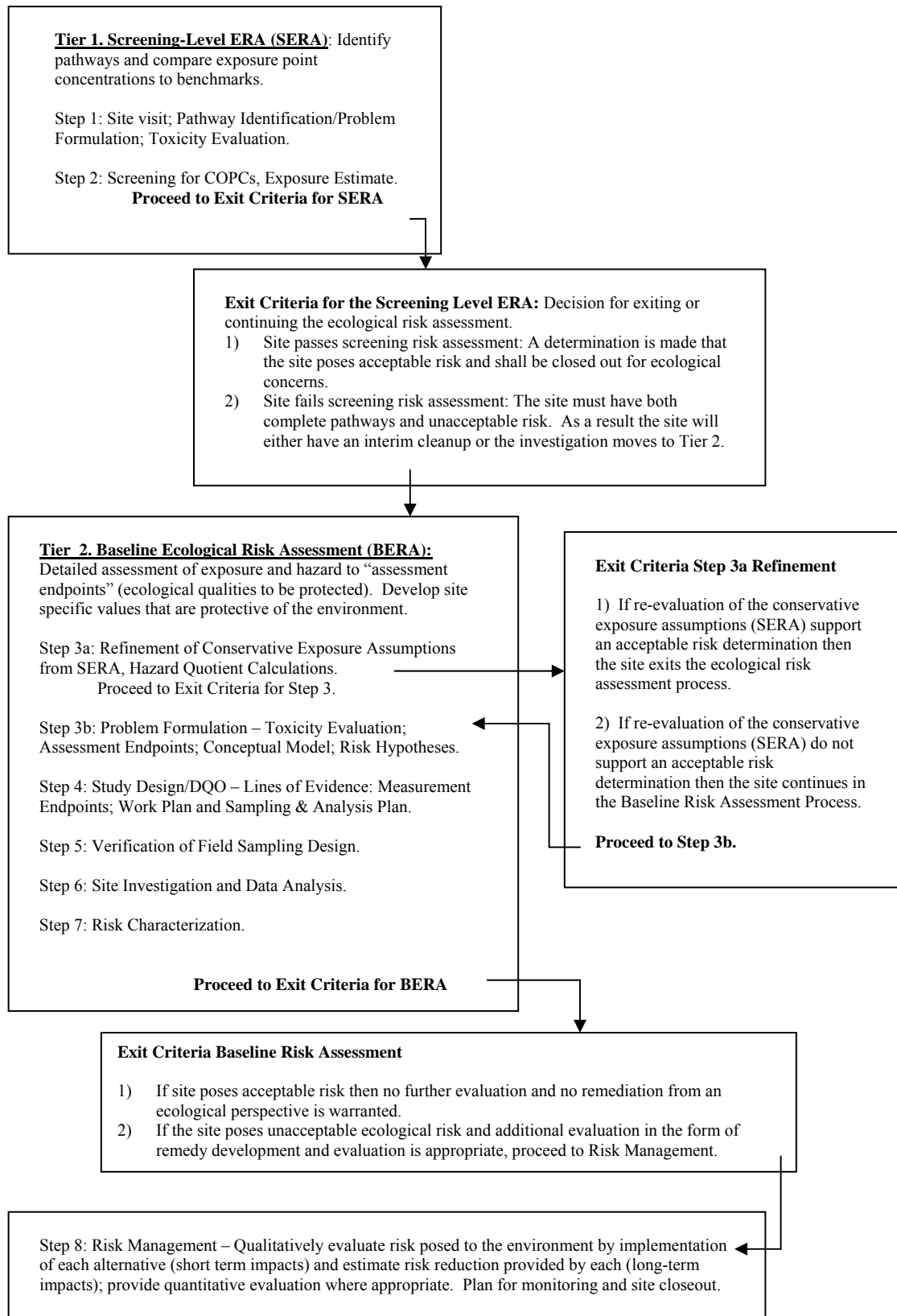
In the ERA, the risk characterization should put the level of risk at the site in context. The risk description should identify threshold concentrations in source or exposure media for effects on the assessment endpoint. All site-specific parameter values used to calculate HQs must be described and the source of the values identified.

At Step 7, the uncertainty about the risk posed by a substance should have been reduced to a level that allows risk managers to make a technically defensible remedial decision. The risk characterization provides information to judge the ecological significance of the estimated risk to assessment endpoints in the absence of any remedial action.

- f) Step 8 of the ERA is Risk Management. The role of ecological risk assessors is to advise the risk managers during the final actions. If the risk characterization concludes there is a risk to

ecological receptors, the risk management decision is whether to remediate the site or to leave the constituents of concern in place with controls on exposure and monitoring.

**Figure 4. Ecological Risk Assessment Flow Chart**



## References

- Simini, M., Checkai, R.T., and Maly, M.E. 2000. Tri-Service Remedial Project Manager's Handbook for Ecological Risk Assessment. Air Force Center for Environmental Excellence, Army Environmental Center, Navy Facilities Service Center. SFIM-AEC-ER-CR-200015.
- United States Environmental Protection Agency (U.S. EPA). 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A). EPA/540/1-89/002. Office of Emergency and Remedial Response. Washington, D.C. 276 p.
- United States Environmental Protection Agency (U.S. EPA). 1991. Risk Assessment Guidance for Superfund: Volume I-Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). Office of Emergency and Remedial Response. Washington, D.C. 54 p.
- United States Environmental Protection Agency (U.S. EPA). 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term. Publication 9285.7-081. Office of Solid Waste and Emergency Response. Washington, D.C. 8 p.
- United States Environmental Protection Agency (U.S. EPA). 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, Washington, DC. EPA/600/R-93/187a
- United States Environmental Protection Agency (U.S. EPA). 1996a. Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128. Office of Solid Waste and Emergency Response. Washington, D.C. 497 p.
- United States Environmental Protection Agency (U.S. EPA). 1996b. Soil Screening Guidance: Users Guide. Publication 9355.4-23. Office of Solid Waste and Emergency Response. Washington, D.C. 44 p.
- USEPA. 1997a. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. USEPA Environmental Response Team, Edison, NJ.
- United States Environmental Protection Agency (U.S. EPA). 1997b. Health Effects Assessment Summary Tables. Office of Emergency and Remedial Response. Washington, D.C.
- USEPA. 1998. Guidelines for Ecological Risk Assessment. Risk Assessment Forum, Washington, DC. EPA/630/R-95/002F.
- United States Environmental Protection Agency (U.S. EPA). 2000. Soil Screening Guidance for Radionuclides: Users Guide. Publication 9355.4-16A. Office of Radiation and Indoor Air. Office of Solid Waste and Emergency Response. Washington, D.C. 90 p.
- United States Environmental Protection Agency (U.S. EPA). 2001a. Integrated Risk Information System. Office of Research and Development. National Center for Environmental Assessment. Washington, D.C. Accessed November 2001. <http://www.epa.gov/iris/index.html>

United States Environmental Protection Agency (U.S. EPA). 2001b. Risk Assessment Guidance for Superfund: Volume I-Human Health Evaluation Manual (Part E) for Dermal Risk Assessment) Interim Guidance. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/R/99/005. OSWER 9285.7-02EP. PB99-963312. September 2001.

United States Environmental Protection Agency (U.S. EPA). 2001c. Supplemental Guidance to RAGS: Region 4 Bulletins. Office of Technical Services. Waste Management Division. U.S. EPA Region 4. Atlanta, GA. September 2001.  
<http://www.epa.gov/region4/waste/ots/otsguid.htm>.



## **Appendix A**

### **Exposure Factors**

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Table 1                      Incidental Soil Ingestion Pathway.	
Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Ingestion Rate: Child less than 7 years Child 7 through 18 years, and Adult Adult Worker (8 hour work day) Outdoor Adult (landscaping, construction, Rural outdoor activities, tilling and gardening)	200 mg/day 100 mg/day 50 mg/day 480 mg/day
Exposure Frequency: Resident General Workers Adult Outdoors (urban) Adult Outdoors (rural) Outdoor Worker Child Outdoors (recreational or trespasser)	350 days/year 250 days/year 52 days/year 104 days/year 185 days/year 140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adult Residential Rural Adult Adult Worker	6 years 12 years 12 years 22 years 25 years
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight: Child less than 7 years Child 7 through 18 years Adult	15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 2 Dermal Contact with Stressors in Soil Pathway.	
Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Skin Surface Area: Child less than 7 years Child 7 through 18 years Residential Adult Adult (Industrial) Outdoor Worker	2800 cm <sup>2</sup> /day (face, forearms, hands, lower legs, and feet) 7500 cm <sup>2</sup> /day (arms, hands, legs, and feet) 5700 cm <sup>2</sup> (face, hands, forearms, and lower legs) 3300 cm <sup>2</sup> /day (face, forearms, and hands) 4700 cm <sup>2</sup> /day (arms, hands, and head)
Exposure Frequency: Resident General Workers Adult Outdoors (urban) Adult Outdoors (rural) Outdoor Worker Child Outdoors (recreational or trespasser)	350 days/year 250 days/year 52 days/year 104 days/year 185 days/year 140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adult Residential Rural Adult Adult Worker	6 years 12 years 12 years 22 years 25 years
Dermal Absorption Factor	0.25 Volatile Organics (unitless) 0.1 Semivolatiles (unitless) 0.05 Inorganics (unitless)
Skin Contact Time (fraction of day soil remains on skin): Residential Worker Recreational or Trespasser	12 hours/24 hours (0.5 unitless) 8 hours/24 hours (0.33 unitless) 12 hours/24 hours (0.5 unitless)
Soil to Skin Adherence Factor	1.0 mg/cm <sup>2</sup>
Body Weight: Child less than 7 years Child 7 through 18 years Adult	15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 3 Inhalation of Particulate-phase Stressors from Soil Pathway.	
Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Inhalation Rate: Resident (Children and Adults) Trespasser Worker (Indoor and Outdoor)	20 m <sup>3</sup> /day (0.833m <sup>3</sup> /hour, 24 hr/day) 20 m <sup>3</sup> /day (2.5 m <sup>3</sup> /hour, 8 hr/day) 12.5 m <sup>3</sup> /day (2.5 m <sup>3</sup> /hour, 5 hr/day)
Exposure Frequency: Resident General Worker Adult Outdoors (urban) Adult Outdoors (rural) Outdoor Worker Child Outdoors (recreational or trespasser)	350 days/year 250 days/year 52 days/year 104 days/year 185 days/year 140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adults Residential Rural Adults Adult Worker	6 years 12 years 12 years 22 years 25 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Particulate Emission Factor: Residential Commercial/Industrial	9.3 x 10 <sup>8</sup> m <sup>3</sup> /kg or site-specific 6.2 x 10 <sup>8</sup> m <sup>3</sup> /kg or site-specific
Body Weight: Child less than 7 years Child 7 through 18 years Adults	15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 4 Inhalation of Airborne (Vapor Phase) Stressors from Soil Pathway.	
Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Inhalation Rate: Resident (Children and Adults) Trespasser Worker (Indoor and Outdoor)	20 m <sup>3</sup> /day (0.833 m <sup>3</sup> /hour, 24 hr/day) 20 m <sup>3</sup> /day (2.5 m <sup>3</sup> /hour, 8 hr/day) 12.5 m <sup>3</sup> /day (2.5 m <sup>3</sup> /hour, 5 hr/day)
Exposure Frequency: Resident General Worker Adult Outdoors (urban) Adult Outdoors (rural) Outdoor Worker Child Outdoors (recreational or trespasser)	350 days/year 250 days/year 52 days/year 104 days/year 185 days/year 140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adult Residential Rural Adult Adult Worker	6 years 12 years 12 years 22 years 25 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Volatilization Factor	Derived using Equation 8 of the Soil Screening Level Guidance User's Guide (U.S. EPA 1996b)
Body Weight: Child less than 7 years Child 7 through 18 years Adult	15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens



Table 5 Ingestion of Stressors from Water Pathway.	
Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Ingestion Rate: Child less than 3 years old Child 3 through 18 years and Adult Adult Worker (up to an 8 hour work day)	1.0 liter/day 2.0 liters/day 1.0 liter/day
Exposure Frequency: Resident General Worker	350 days/year 250 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adult Residential Rural Adult Adult Worker	6 years 12 years 12 years 22 years 25 years
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight: Child less than 7 years Child 7 through 18 years Adult	15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 6 Ingestion of Stressors in Surface Water While Swimming Pathway.	
Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Ingestion Rate:	50 milliliters/hour
Exposure Time:	2.6 hours/day
Exposure Frequency:	45 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adult Residential Rural Adult	6 years 12 years 12 years 22 years
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight: Child less than 7 years Child 7 through 18 years Adults	15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 7 Dermal Contact with Stressors in Water while Swimming or Wading Pathway.	
Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Skin Surface Area: Child swimmer 3 through 6 years Child swimmer 7 through 18 years Adult swimmer Child wader 1 through 6 years Child wader 7 through 18 years Adult wader	0.6500 m <sup>2</sup> /day 1.3100 m <sup>2</sup> /day 1.8150 m <sup>2</sup> /day 0.3300 m <sup>2</sup> /day (arms, hands, legs and feet) 0.7500 m <sup>2</sup> /day (arms, hands, legs and feet) 1.0600 m <sup>2</sup> /day (arms, hands, legs and feet)
Exposure Time	2.6 hours/day
Dermal Permeability factor (Kp)	Use RAGS Part E (U.S. EPA 2001b) Appendix B. If measured K <sub>p</sub> s are available, then those should be used instead of the modeled values for those chemicals.
Exposure Frequency: Swimming Child and Adolescent Wading Adult Wading	45 days/year 140 days/year 52 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adult Residential Rural Adult	6 years 12 years 12 years 22 years
Dermal Absorbed Dose per Event (DA <sub>event</sub> )	Calculated using RAGS Part E (U.S. EPA, 2001b)
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight: Child less than 7 years Child 7 through 18 years Adult	15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 8      Dermal Contact with Stressors in Water during Showering or Bathing Pathway.	
Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Skin Surface Area: Child 3 through 6 years Child 7 through 18 years Adult	0.6500 m <sup>2</sup> /day 1.3100 m <sup>2</sup> /day 1.8150 m <sup>2</sup> /day
Exposure Time	0.2 hours/day
Dermal Permeability factor (Kp)	Use RAGS Part E (U.S. EPA 2001b) Appendix B. If measured K <sub>p</sub> s are available, then those should be used instead of the modeled values for those chemicals.
Exposure Frequency: Residents Workers in the work place	350 days/year 250 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adult Residential Rural Adult Adult Worker	6 years 12 years 12 years 22 years 25 years
Dermal Absorbed Dose per Event (DA <sub>event</sub> )	Calculated using RAGS Part E (U.S. EPA, 2001b)
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight: Child less than 7 years Child 7 through 18 years Adult	15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 9 Inhalation of Airborne (Vapor Phase) Stressors in Water during Showering Pathway	
Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Concentration of Stressor in Air	Use Schaum, et al., 1994, Showering Exposure
Inhalation Rate	0.833 m <sup>3</sup> /day
Exposure Time	0.2 hours/day (12 minutes/day)
Exposure Frequency: Residents Workers in the work place	350 days/year 250 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adults Residential Rural Adults Adult Worker	6 years 12 years 12 years 22 years 25 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight: Child less than 7 years Child 7 through 18 years Adults	15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 10 Inhalation of Airborne (Vapor Phase) Stressors in Water during General Home Use Pathway.	
Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Concentration of Stressor in Air	Use Schaum et al., 1994, Whole House Model
Inhalation Rate	20 m <sup>3</sup> /day
Water Flow Rate	890 L/day
House Volume	450 m <sup>3</sup>
Air Exchange Rate	10 changes/day
Fraction Volatilized	0.5 (unitless)
Mixing Coefficient (how well mixed in the home)	0.5 (unitless)
Exposure Frequency: Resident	350 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adult Residential Rural Adult	6 years 12 years 12 years 22 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight: Child less than 7 years Child 7 through 18 years Adults	15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens



Other Pathways. Other pathways may be used at sites that have current or potential future pathways that are not listed in this Appendix. Examples include: consumption of contaminated fish, produce, and livestock. Exposure factors should be based on site-specific conditions and may be obtained from U.S. EPA documents including Exposure Factors Handbook, Risk Assessment Guidance for Superfund (Part A), and Risk Assessment Guidance for Superfund (Part B).

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## **Appendix B**

### **General Outline for Baseline Risk Assessment**

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## **Outline of Components of a Human Health Baseline Risk Assessment**

This is a general outline and not all components of the outline are applicable to all sites.

### **1.0 INTRODUCTION**

- 1.1 Overview
  - 1.1.a General Problem at site
  - 1.1.b Site-specific objectives of risk assessment
- 1.2 Scope of Risk Assessment
  - 1.2.a Complexity of risk assessment and rationale
  - 1.2.b Overview of study design

### **2.0 IDENTIFICATION OF STRESSORS OF POTENTIAL CONCERN**

- 2.1 General Site-Specific Data Collection Considerations
  - 2.1.a Preliminary identification of potential human exposure
  - 2.1.b Modeling parameter needs
- 2.2 General Site-Specific Data Evaluation Considerations
  - 2.2.a Steps used (including statistical methods used for evaluation and data selection)
  - 2.2.b Criteria employed in evaluating data
  - 2.2.c Discussion of data uncertainty
- 2.3 Stressor Analytical Data (Complete for All Media)
  - 2.3.a Listing of analytical methods used
  - 2.3.b Evaluation of chemical limits
  - 2.3.c Evaluation of qualified and coded data
  - 2.3.d Contaminants in field and laboratory blanks
  - 2.3.e Tentatively identified compounds
  - 2.3.f Further limitation of number of stressors
  - 2.3.g Uncertainties, limitations, gaps in quality of collection or analysis
- 2.4 Summary of Stressors of Potential Concern

### **3.0 EXPOSURE ASSESSMENT**

- 3.1 Characterization of Exposure Setting
  - 3.1.a Summary of Physical Setting
  - 3.1.b Potentially Exposed Individuals, Populations, and Communities (Human)
    - 3.1.b.1 Relative locations of individuals, populations, and communities with respect to site
    - 3.1.b.2 Current land use

- 3.1.b.3 Potential alternate future land uses
    - 3.1.b.4 Subpopulations of potential concern
  - 3.2 Identification of Exposure Pathways
    - 3.2.a Sources of the release and receiving media
    - 3.2.b Fate and transport in release media
    - 3.2.c Exposure points and exposure routes
    - 3.2.d Integration of sources, releases, fate and transport mechanisms, exposure points, and exposure routes into complete exposure pathways
    - 3.2.e Summary of exposure pathways to be quantified in this assessment
- 3.3 Quantification of Exposure
  - 3.3.a Exposure concentrations
  - 3.3.b Estimation of chemical intakes for individual pathways
- 3.4 Identification of Uncertainties
  - 3.4.a Current and future land-use
  - 3.4.b Environmental sampling and analysis
  - 3.4.c Exposure pathways evaluated
  - 3.4.d Fate and transport modeling
  - 3.4.e Parameter values
- 3.5 Summary of Exposure Assessment

#### **4.0 TOXICITY ASSESSMENT**

- 4.1 Toxicity Information for Noncarcinogenic Effects (Human Health)
  - 4.1.a Appropriate exposure periods for toxicity values
  - 4.1.b Up-to-date reference doses (RfDs) for all stressors
  - 4.1.c One-and ten-day health advisories for shorter-term oral exposures
  - 4.1.d Overall data base and the critical study on which the toxicity value is based (including the critical effect and the uncertainty and modifying factors used in the calculation)
  - 4.1.e Effects that may appear at doses higher than those required to elicit the critical effect
  - 4.1.f Absorption efficiency considered
- 4.2 Toxicity Information for Carcinogenic Effects
  - 4.2.a Exposure averaged over a lifetime
  - 4.2.b Up-to-date slope factors for all carcinogens
  - 4.2.c Weight-of-evidence classification for all carcinogens (Groups A, B, and C)
  - 4.2.d Type of cancer for Group A, B, and C carcinogens



- 4.2.e Concentration above which the dose-response curve is no longer linear, if applicable
- 4.3 Stressors for Which No EPA Toxicity Values are Available
  - 4.3.a Sources of values
  - 4.3.b Qualitative evaluation
  - 4.3.c Documentation or justification of any new toxicity values developed
- 4.4 Uncertainties Related to Toxicity Information
  - 4.4.a Quality of the individual studies
  - 4.4.b Completeness of the overall data base
- 4.5 Summary of Toxicity Information

## **5.0 RISK CHARACTERIZATION**

- 5.1 Current Land-use Conditions (Human Health)
  - 5.1.a Carcinogenic risk of individual stressors in individual pathways
  - 5.1.b Chronic hazard quotient calculation (individual stressors, individual pathways)
  - 5.1.c Subchronic hazard quotient calculation (individual stressors, individual pathways)
  - 5.1.d Shorter-term hazard quotient calculation (individual stressors, individual pathways)
  - 5.1.e Noncarcinogenic hazard index (individual stressors, all pathways)
  - 5.1.f Carcinogenic risk (individual stressors, all pathways)
- 5.2 Future Land-Use Conditions (Human Health)
  - 5.2.a Carcinogenic risk of individual stressors in individual pathways
  - 5.2.b Chronic hazard quotient calculation (individual stressors, individual pathways)
  - 5.2.c Subchronic hazard quotient calculation (individual stressors, individual pathways)
  - 5.2.d Noncarcinogenic hazard index (individual stressors, all pathways)
  - 5.2.e Carcinogenic risk (individual stressors, all pathways)
- 5.3 Uncertainties
  - 5.3.a Site-specific uncertainty factors
    - 5.3.a.1 Definition of physical setting
    - 5.3.a.2 Model applicability and assumptions
    - 5.3.a.3 Parameter values for fate or transport and exposure calculations
  - 5.3.b Summary of toxicity assessment uncertainty
    - 5.3.b.1 Uncertainty and identification of potential human health effects

- 5.3.b.2 Derivation of toxicity value including completeness of overall database
    - 5.3.b.3 Potential for synergistic or antagonistic interactions
    - 5.3.b.4 Uncertainty in evaluating less-than-lifetime exposures
  - 5.4 Comparison of Risk Characterization Results to Human Studies (if available)
    - 5.4.a Health assessment from the Agency for Toxic Substances and Disease Registry (ATSDR)
    - 5.4.b Site-specific health studies (pilot studies or epidemiological studies)
    - 5.4.c Incorporation of studies into the overall risk characterization
  - 5.5 Summary Discussion and Tabulation of the Risk Characterization
    - 5.5.a Key site-related stressors and key exposure pathways identified
    - 5.5.b Types of health risk of concern
    - 5.5.c Level of confidence in the quantitative information used to estimate risk
    - 5.5.d Presentation of qualitative information on toxicity
    - 5.5.e Confidence in the key exposure estimates for the key exposure pathways
    - 5.5.f Magnitude of the carcinogenic and noncarcinogenic risk estimates
    - 5.5.g Magnitude of chronic and subchronic risk estimates
    - 5.5.h Major factors contributing to risk
    - 5.5.i Major factors (COCs and Pathways) contributing to uncertainty
    - 5.5.j Exposed population and community characteristics
    - 5.5.k Comparison with site-specific health studies
    - 5.5.l Comparison of chemical concentrations with natural background

## **6.0 SUMMARY AND CONCLUSIONS**

- 6.1 Stressors of Potential Concern
- 6.2 Exposure Assessment
- 6.3 Toxicity Assessment
- 6.4 Risk Characterization
- 6.5 Uncertainties

## **Outline of Components of an Ecological Baseline Risk Assessment**

This is a general outline and not all components of the outline are applicable to all sites.

### **STEP 1: SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION**

#### **1.1 INTRODUCTION**

#### **1.2 SCREENING-LEVEL PROBLEM FORMULATION**

1.2.1 Environmental Setting and Contaminants at the Site

1.2.2 Contaminant Fate and Transport

1.2.3 Ecotoxicity and Potential Receptors

1.2.4 Complete Exposure Pathways

1.2.5 Assessment and Measurement Endpoints

#### **1.3 SCREENING-LEVEL ECOLOGICAL EFFECTS EVALUATION**

1.3.1 Preferred Toxicity Data

1.3.2 Dose Conversions

1.3.3 Uncertainty Assessment

#### **1.4 SUMMARY**

### **STEP 2: SCREENING-LEVEL EXPOSURE ESTIMATE AND RISK CALCULATION**

#### **2.1 INTRODUCTION**

#### **2.2 SCREENING-LEVEL EXPOSURE ESTIMATES**

2.2.1 Exposure Parameters

2.2.2 Uncertainty Assessment

#### **2.3 SCREENING-LEVEL RISK CALCULATION**

#### **2.4 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)**

#### **2.5 SUMMARY**

### **STEP 3: BASELINE RISK ASSESSMENT PROBLEM FORMULATION**

#### **3.1 THE PROBLEM-FORMULATION PROCESS**

#### **3.2 REFINEMENT OF PRELIMINARY CONTAMINANTS OF CONCERN**

#### **3.3 LITERATURE SEARCH ON KNOWN ECOLOGICAL EFFECTS**

### 3.4 CONTAMINANT FATE AND TRANSPORT, ECOSYSTEMS POTENTIALLY AT RISK, AND COMPLETE EXPOSURE PATHWAYS

#### 3.4.1 Contaminant Fate and Transport

#### 3.4.2 Ecosystems Potentially at Risk

#### 3.4.3 Complete Exposure Pathways

### 3.5 SELECTION OF ASSESSMENT ENDPOINTS

### 3.6 THE CONCEPTUAL MODEL AND RISK QUESTIONS

#### 3.6.1 Conceptual Model

#### 3.6.2 Risk Questions

### 3.7 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

### 3.8 SUMMARY

## STEP 4: STUDY DESIGN AND DATA QUALITY OBJECTIVE PROCESS

### 4.1 ESTABLISHING MEASUREMENT ENDPOINTS

#### 4.1.1 Species/Community/Habitat Considerations

#### 4.1.2 Relationship of the Measurement Endpoints to the Contaminant of Concern

#### 4.1.3 Mechanisms of Ecotoxicity

### 4.2 STUDY DESIGN

#### 4.2.1 Bioaccumulation and Field Tissue Residue Studies

#### 4.2.2 Population/Community Evaluations

#### 4.2.3 Toxicity Testing

### 4.3 DATA QUALITY OBJECTIVES AND STATISTICAL CONSIDERATIONS

#### 4.3.1 Data Quality Objectives

#### 4.3.2 Statistical Considerations

### 4.4 CONTENTS OF WORK PLAN AND SAMPLING AND ANALYSIS PLAN

#### 4.4.1 Work Plan

#### 4.4.2 Sampling and Analysis Plan

#### 4.4.3 Field Verification of Sampling Plan and Contingency Plans

### 4.5 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

### 4.6 SUMMARY

## STEP 5: FIELD VERIFICATION OF SAMPLING DESIGN

### 5.1 PURPOSE



## 5.2 DETERMINING SAMPLING FEASIBILITY

## 5.3 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

## 5.4 SUMMARY

# STEP 6: SITE INVESTIGATION AND ANALYSIS PHASE

## 6.1 INTRODUCTION

## 6.2 SITE INVESTIGATION

### 6.2.1 Changing Field Conditions

### 6.2.2 Unexpected Nature or Extent of Contamination

## 6.3 ANALYSIS OF ECOLOGICAL EXPOSURES AND EFFECTS

### 6.3.1 Characterizing Exposures

### 6.3.2 Characterizing Ecological Effects

## 6.4 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

## 6.5 SUMMARY

# STEP 7: RISK CHARACTERIZATION

## 7.1 INTRODUCTION

## 7.2 RISK ESTIMATION

## 7.3 RISK DESCRIPTION

### 7.3.1 Threshold for Effects on Assessment Endpoints

### 7.3.2 Likelihood of Risk

### 7.3.3 Additional Risk Information

## 7.4 UNCERTAINTY ANALYSIS

### 7.4.1 Categories of Uncertainty

### 7.4.2 Tracking Uncertainties

## 7.5 SUMMARY

# STEP 8: RISK MANAGEMENT

## 8.1 INTRODUCTION

## 8.2 ECOLOGICAL RISK MANAGEMENT

### 8.2.1 Other Risk Management Considerations

### 8.2.2 Ecological Impacts of Remedial Options

### 8.2.3 Monitoring

### 8.3 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

### 8.4 SUMMARY

## **Appendix C**

### Human Health Screening Values

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# **Development of Risk Based Concentrations for Environmental Remediation in Kentucky**

## **Introduction**

This appendix details the procedures used to develop risk-based concentrations that will be used for the Voluntary Environmental Remediation Program, KRS 224.01-400 and KRS 224.01-405 cleanups, and other programs where risk-based concentrations are needed. Documents from the United States Environmental Protection Agency were consulted in the process of developing this document and the procedures used in calculating risk-based concentrations.

## **Application**

It is intended for this table to have several applications to sites undergoing environmental remediation. Applications include: preliminary screening of site contaminants, closure of small spills, determination of potential toxic conditions, and reduction and refinement of the number of Chemicals of Concern (COCs) at a site during a baseline risk assessment. The values are also one of the factors that should be considered when selecting remedial goals. The values consider the more common exposure routes but if an individual site has other exposure routes that play a major role in the site-related exposures, these values may underestimate the risk.

## **Calculation of Risk-Based Values**

The formulae for calculating the risk-based concentrations are primarily from U.S. EPA guidance including Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A), commonly referred to as RAGS Part A (U.S. EPA, 1989), RAGS part B (U.S. EPA, 1991), Soil Screening Guidance: Users Guide (U.S. EPA, 1996c), and Soil Screening Guidance: Technical Background Document (U.S. EPA, 1996b). “Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water” (Schaum *et al.*, 1994) was used to represent the inhalation exposure to water based on the Whole House Dispersion Model. The assumptions that are used in estimating the risk-based concentrations are selected to be protective of sensitive subpopulations.

KYDEP incorporated applicable exposure routes into each medium of exposure. For residential and occupational exposure to soil; ingestion, dermal and inhalation exposure was considered. Dermal exposure to soil used default absorption values of 0.25 for volatiles, 0.1 for semivolatiles, and 0.05 for metals. Default dermal absorption factors were derived from literature reviews of dermal absorption. The Agency for Toxic Substances and Disease Registry



(ATSDR) Toxicological Profiles were a valuable source of absorption and chemical specific data. Ten compounds had chemical-specific dermal absorption rates as listed in RAGS Part E (U.S. EPA, 2000a). Inhalation of contaminants found in soil used two factors: a Volatilization Factor (VF), and a Particulate Emission Factor (PEF). Potential volatilization from soil to air was represented for volatiles by the volatilization factor that was calculated using the formula in the Soil Screening Guidance: User's Guide (U.S. EPA, 1996c). A compound was assumed to be volatile when the molecular weight was less than 200 mg/mol and the Henry's Law Constant (H) was greater than  $10^{-5}$  atm-m<sup>3</sup>/mol. The respective default dispersion factor for residential and commercial/industrial exposures were derived for Kentucky sites using exhibit 11 in U.S. EPA, 1996c. Climatic zone VII was used to calculate the dispersion factor term since that is the logical zone for Kentucky sites. For a residential dispersion factor, the 90% lower confidence limit was calculated for a 0.5-acre site size. A commercial/industrial value for dispersion factor was calculated based the 90% lower confidence limit of the values listed under a site size of 5 acres.

Inhalation was the route that was used for air exposures. Tap water exposure used ingestion and inhalation, the latter using the Schaum (1994) Whole House Exposure Model. The model describes the average indoor air concentration as a result of water use throughout the house. This model considers water use such as washing dishes, bathing, washing clothes, and cooking. The formula is:

$$C_a = \frac{WHF \times C_w \times f}{HV \times ER \times MC}$$

where:

Ca = concentration in air, mg/m<sup>3</sup>

Cw = concentration in water, mg/L

WHF = water flow rate in whole house, 890 L/day

HV = house volume, 450 m<sup>3</sup>

ER = exchange rate, 10 air changes/day

MC = mixing coefficient, 0.5 (unitless)

f = fraction of contaminant that volatilizes, 0.5 (unitless)

The default values for these parameters were selected from the text of the Schaum (1994) chapter and are listed following the description.

## **Formulae**

The formulae for calculation of the risk-based values are the result of taking the standard exposure equations used in risk assessments and solving for the concentration term. Toxicity values were used to represent the potential toxicity of each compound. These values are obtained from several sources. The source is listed next to each toxicity value. The abbreviations in order of preference are: “i” U.S. EPA’s Integrated Risk Information System (IRIS), “h” U.S. EPA’s Health Effects Assessment Summary Tables (HEAST), “n” U.S. EPA’s National Center for Environmental Assessment (NCEA), “w” withdrawn from IRIS or HEAST, “o” other EPA documents, “r” route extrapolation, and “s” when the toxicity value of a surrogate compound was used based on physicochemical characteristics. The Risk-Based Screening Values are based on a target risk of  $1 \times 10^{-6}$  for carcinogens and a Hazard Index of 1.0 for noncarcinogens in each media. The carcinogenic risk of  $1 \times 10^{-6}$ , or one excess cancer in one million is standard practice in risk assessment for *de minimis* risk. The target Hazard Index of 1.0 indicates that the noncarcinogenic risk is below a toxicity threshold represented by the reference dose. The basis for each screening value in the table is denoted by “ca” for a carcinogenic endpoint, and “nc” for a noncarcinogenic endpoint. A soil saturation limit was derived using the formula in U.S. EPA, 1996c. A ceiling limit was set at  $10^{+5}$  as a maximum soil concentration. If the risk-based screening value exceeded the saturation limit or the maximum, then the soil screening value was set at the saturation limit (denoted as “sat”) or the maximum ceiling limit (denoted as “max”) The following formulae were used to calculate the risk-based screening values for each media.

### **Noncarcinogenic Effects**

#### **Residential Soil**

$$\frac{(ED_c \times BW_c \times 365 \times THQ)}{(IRA_c \times (1/VF + 1/PEF_r) \times EF_r \times ED_c \times 1/RfD) + (SA_c \times AF \times ABS \times EF_r \times ED_c \times 0.000001 \times 1/RfD) + (IRS_c \times EF_r \times ED_c \times 0.000001 \times 1/RfD)}$$

#### **Commercial/Industrial Soil**

$$\frac{(ED_a \times BW_a \times 365 \times THQ)}{(IRA_a \times (1/VF + 1/PEF_o) \times EF_o \times ED_o \times 1/RfD) + (SA_i \times AF \times ABS \times EF_o \times ED_o \times 0.000001 \times 1/RfD) + (IRS_o \times EF_o \times ED_o \times 0.000001 \times 1/RfD)}$$

### **Ambient Air**

$$\frac{(ED_c \times BW_c \times 365 \times THQ \times RfDi \times 1000)}{(IRA_c \times EF_r \times ED_c)}$$

### **Tap Water**

$$\frac{(BW_c \times ED_c \times 365 \times THQ \times 1000)}{\left( \frac{(IRW_c < 3 \times 3) + (IRW_c > 3 \times 3)}{ED_c} \times EF_r \times ED_c \times 1 / RfDo \right) + \left( \frac{(890 \times 0.5)}{(450 \times 10 \times 0.5)} \times IRA_c \times EF_r \times ED_c \times 1 / RfDi \right)}$$

## **Carcinogenic Effects**

### **Residential Soil**

$$\frac{(AT \times 365 \times TR)}{(InhF_{adj} \times (1/VF + 1/PEF_r) \times EF_r \times SFi) + (SFS_{adj} \times AF \times ABS \times EF_r \times 0.000001 \times SFi) + (IRS_{adj} \times EF_r \times 0.000001 \times SFi)}$$

### **Commercial/Industrial Soil**

$$\frac{(AT \times BW_a \times 365 \times TR)}{(IRA_a \times (1/VF + 1/PEF_o) \times EF_o \times ED_o \times SFi) + (SA_i \times AF \times ABS \times EF_o \times ED_o \times 0.000001 \times SFi) + (IRS_o \times EF_o \times ED_o \times 0.000001 \times SFi)}$$

### **Ambient Air**

$$\frac{(AT \times 365 \times TR \times 1000)}{(InhF_{adj} \times EF_r \times SFi)}$$

### **Tap Water**

$$\frac{(AT \times 365 \times TR \times 1000)}{(IFW_{adj} \times EF_r \times SFi) + \left( \frac{(890 \times 0.5)}{(450 \times 10 \times 0.5)} \times InhF_{adj} \times EF_r \times SFi \right)}$$

Four age adjusted factors were calculated for carcinogenic exposure calculations. The formula for each factor is shown below.

### **Ingestion Factor for Soil**

$$\left( \frac{IRS_c \times ED_c}{BW_c} \right) + \left( \frac{IRS_{adol} \times ED_{adol}}{BW_{adol}} \right) + \left( \frac{IRS_a \times ED_a}{BW_a} \right)$$

### **Skin Contact Factor for Soil**

$$\left( \frac{SA_c \times ED_c}{BW_c} \right) + \left( \frac{SA_{adol} \times ED_{adol}}{BW_{adol}} \right) + \left( \frac{SA_a \times ED_a}{BW_a} \right)$$

**Inhalation Factor**

$$\left( \frac{IRA\_c \times ED\_c}{BW\_c} \right) + \left( \frac{IRA\_a \times ED\_adol}{BW\_adol} \right) + \left( \frac{IRA\_a \times ED\_a}{BW\_a} \right)$$

**Ingestion Factor for Water**

$$\left( \frac{IRW\_c < 3 \times 3}{BW\_c} \right) + \left( \frac{IRW\_a, c > 3 \times 3}{BW\_c} \right) + \left( \frac{IRW\_a, c > 3 \times ED\_adol}{BW\_adol} \right) + \left( \frac{IRW\_a, c > 3 \times ED\_a}{BW\_a} \right)$$

Table 1 summarizes the exposure factors that were used to calculate the risk-based screening values.

**Table 1. Exposure Factors**

<b>Parameter (units)</b>	<b>Value</b>	<b>Abbreviation</b>
Target Cancer Risk	$1 \times 10^{-6}$	TR
Target Hazard Quotient	1	THQ
Body weight, age 1-6 (kg)	15	BW_c
Body weight adolescent (kg)	43	BW_adol
Body weight, adult (kg)	70	BW_a
Surface area , child (cm <sup>2</sup> /day)	2800	SA_c
Surface area , adolescent (cm <sup>2</sup> /day)	7500	SA_adol
Surface area , adult resident (cm <sup>2</sup> /day)	5700	SA_a
Surface area , adult industrial (cm <sup>2</sup> /day)	3300	SA_i
Adherence factor (mg/cm <sup>2</sup> )	1	AF
Dermal absorption in soil (volatiles)	0.25	ABS_vol
Dermal absorption in soil (semivolatiles)	0.1	ABS_semi
Dermal absorption in soil (metals)	0.05	ABS_met
Averaging time (years)	70	AT
Inhalation rate (m <sup>3</sup> /d)	20	IRA_a
	20	IRA_c
Drinking water ingestion (L/d)	2	IRW_a, c>3
	1	IRW_c<3
	1	IRW_o
Volatilization factor - soil (m <sup>3</sup> /kg)	Chemical specific	VF_S
Particulate emission factor (m <sup>3</sup> /kg)	9.3E+08	PEF_r
	6.2E+08	PEF_o
Soil ingestion - adolescent & adult resident (mg/d)	100	IRS_a
Soil ingestion - age 1-6 (mg/d)	200	IRS_c
Soil ingestion – commercial/industrial (mg/d)	50	IRS_o
Exposure frequency (d/yr)	350	EF_r
Commercial/Industrial Exposure Frequency (d/yr)	250	EF_o
Exposure duration, age 1-6 (yr)	6	ED_c
Exposure duration, age 7-18 (yr)	12	ED_adol
Exposure duration, adult (yr)	12	ED_a
Commercial/Industrial Exposure Duration (yr)	25	ED_o
Total residential duration (yr)	30	ED_total
<b>Age-adjusted factors (for carcinogens only)</b>		
Ingestion factor for soils ([mg*yr]/[kg*d])	125.050	IFS_adj
Skin contact factor for soils ([cm <sup>2</sup> *yr]/[kg*d])	4190.166	SFS_adj
Inhalation factor ([m <sup>3</sup> *yr]/[kg-d])	17.010	InhF_adj
Ingestion factor for water ([L*yr]/[kg-d])	1.501	IFW_adj



The formulae for calculating the volatilization factor (VF), particulate emission factor (PEF), and soil screening levels (SSL) are contained in the Soil Screening Guidance: Users Guide (U.S. EPA, 1996c) and are listed below. The assumptions for those calculations are listed in the Soil Screening Guidance: Users Guide. The only factors in this document that were different were the dispersion factor (Q/C) values for residential (64.177) and commercial/industrial (43.07). The Kentucky-specific values for Q/C were estimated based on the 90% Lower Confidence Level of the mean dispersion factor of Climatic Zone VII of Table 3 of the SSL Technical Background Document (U.S. EPA, 1996b). Volatilization Factors are used in the soil exposure scenario to estimate partitioning between soil and vapor in the exposure zone, and the particulate emission factor represents the concentration of respirable particulates in air. The chemical specific values of  $D_i$  in the VF calculation were obtained from the U.S. EPA Region 9 Preliminary Remediation Goals Table dated November 1, 2000. Region 9 used several sources: Superfund Exposure Assessment Manual (U.S. EPA, 1988), Subsurface Contamination Reference Guide (U.S. EPA, 1990c), Fate and Exposure Data (Howard, 1991), and the Superfund Chemical Data Matrix (U.S. EPA 1994). Some chemicals required the use of a surrogate for physicochemical data based on chemical structure and characteristics.

The Soil Screening Level uses modeling to estimate soil concentrations that are protective of human health exposure to groundwater with a Dilution and Attenuation Factor of 1. The endpoint that was chosen for the SSL was the MCL from U.S. EPA (2001b) or the risk-based tap water concentration as calculated in the table if an MCL was not available.

### **Volatilization Factor**

$$VF(m^3 / kg) = \frac{Q / C \times (3.14 \times D_A \times T)^{1/2} \times 10^{-4}(m^2 / cm^2)}{2 \times \rho_b \times D_A}$$

where

$$D_A = \frac{(\theta_a^{10/3} \times D_i \times H' + \theta_w^{10/3} \times D_w) / n^2}{\rho_b \times K_d + \theta_w + \theta_a \times H'}$$

and:

$$\begin{aligned} Q/C &= 64.177 \text{ (residential)} \\ &43.07 \text{ (commercial/industrial)} \\ T &= 9.5E+8 \text{ seconds} \\ \rho_b &= 1.5 \text{ g/cm}^3 \\ \theta_a &= 0.28 \text{ } L_{air}/L_{soil} \\ D_i &= \text{chemical-specific} \\ H' &= H \times 41 \\ H &= \text{Henry's Law Constant (chemical-specific)} \\ \theta_w &= 0.15 \text{ } L_{water}/L_{soil} \\ D_w &= \text{chemical-specific} \\ n &= 0.43 \text{ } L_{pore}/L_{soil} \\ K_d &= \text{chemical-specific} \end{aligned}$$

## **Particulate Emission Factor**

$$PEF(m^3 / kg) = Q / C \times \frac{3600s / h}{0.036 \times (1 - V) \times (U_m / U_t)^3 \times F(x)}$$

where:

$$\begin{aligned} Q/C &= 64.177 \text{ (residential)} \\ &43.07 \text{ (commercial/industrial)} \\ V &= 0.5 \text{ (unitless)} \\ U_m &= 4.69 \text{ m/s} \\ U_t &= 11.32 \text{ m/s} \\ F(x) &= 0.194 \text{ (unitless)} \end{aligned}$$

## **Soil Screening Level**

$$SSL(mg / kg) = C_w \left[ K_d + \frac{\theta_w + \theta_a \times H'}{\rho_b} \right]$$

where the  $C_w$  is the MCL or risk-based tap water value in mg/L from the table.

and:

$$\begin{aligned} K_d &= \text{chemical-specific} \\ \theta_w &= 0.3 L_{\text{water}} / L_{\text{soil}} \\ \theta_a &= 0.13 L_{\text{air}} / L_{\text{soil}} \\ H' &= H \times 41 \\ H &= \text{Henry's Law Constant (chemical-specific)} \\ \rho_b &= 1.5 \text{ g/cm}^3 \end{aligned}$$

## **Exceptions**

There are a few exceptions to the standard procedures described in this document where modifications in the exposure assumptions or toxicity value were necessary to meet a certain class of chemicals.

**Metals.** Many of the metals only have oral toxicity values listed in IRIS or HEAST. In order to have complete information, it was necessary to extrapolate the oral toxicity values to inhalation exposures as well. The exposure routes were also modified based on the characteristics of metals. Soil exposure included ingestion, dermal exposure, and particulate inhalation. Exposure to tap water considered only ingestion. Elemental mercury, even though it is a metal, was assumed to be a volatile for exposure to soil and water. These conditions fit typical exposure conditions for tap water. If a site has potential exposure to mists containing metals in water, then exposure via inhalation should be considered in a site-specific tap water screening value calculated for the site using the formulae contained in this document.

**Gases.** Some of the constituents on the table are considered to be gases or vapors at standard temperature. In consideration of their physical state, both soil and water exposure consider only inhalation since their residence time in soil would not be expected to be long for ingestion or dermal exposure.

**Extrapolation.** Some chemicals had only oral or inhalation toxicity values listed on the Region IX PRGs Table. In those cases, extrapolation was necessary. Literature reviews were done to verify the potential for effects in other media of exposure.

**Lead.** U.S. EPA has implemented use of the IEUBK Model to estimate environmental levels that will result in a target blood lead level. KYDEP performed a review of lead issues (KYDEP, 1996) and determined that the most appropriate metric for lead risk assessment was the RfD<sub>o</sub> and RfD<sub>i</sub> derived based on the LOAEL in laboratory rats. For further discussion of lead see the Lead Issues document (KYDEP, 1996). KYDEP also has an action level of 50 ppm in residential or unrestricted use in soil, 400 ppm in commercial or industrial soils, and a tap water action level of 0.015 mg/L that are listed on the table. The soil value of 50 mg/kg was originally developed in the UST program.

**MTBE.** Methyl t-Butyl Ether had an oral RfD issued by NCEA, which was withdrawn. The RfD was retained and listed as withdrawn on the table. U.S. EPA has a Drinking Water Advisory: Consumer Acceptability Advisory level in water of 20 µg/L to 40 µg/L based on odor and taste, respectively. This is below the carcinogenic and noncarcinogenic risk-based numbers.

**PCBs.** PCBs also received special consideration. KYDEP has used the high risk value of 2.0 (mg/kg-day)<sup>-1</sup> based on the observation that as a mixture of PCBs weathers, the lower chlorinated biphenyls are more likely to degrade, leaving the higher chlorinated biphenyls in a higher proportion. Since the higher chlorinated biphenyl mixture (Arochlor 1260) exhibit more toxicity, the high-risk value was used for the screening values. For noncarcinogenic effects, the table has two mixtures listed. Arochlor 1254 is applied by KYDEP for the higher chlorinated mixtures (Arochlor 1260, 1254, and 1248) and the Arochlor 1016 value is applied to mixtures that are less chlorinated (1242, 1016).

### **How To Use the Table**

When evaluating an area using the screening values, it is useful to develop a Conceptual Site Model to verify that it fits into the assumptions that were used to derive the screening values. The first step is to identify the areas of potential contamination and analyze grab samples for a broad range of potential contaminants (typically the HSL, TAL/TCL, etc.) in several

samples to refine analytical parameters. The contaminants of potential concern are then identified. The potential ecological and human health receptors should be determined and also the potential pathways of exposure.

The screening values table is organized with the toxicity values in the left-hand columns, each one followed by the source of the RfD or Slope Factor. The VOC Column identifies (with “1” being volatile) which compounds use a volatilization factor in the soil exposure. The soil dermal absorption value is shown for each compound, and the Chemical Abstract Service (CAS) registry number and contaminant name are shown. The next four columns represent the risk-based concentration associated with each of the contaminants for soil, air, and water.

The Soil Screening Levels are determined for most volatiles and the compounds listed in the Soil Screening Guidance (U.S. EPA, 1996c). The Dilution and Attenuation Factor (DAF) of 1 is applicable for a screening value where there is the potential for shallow aquifers, karst terranes (a major factor in Kentucky), and areas of significant permeability. It is possible to develop Soil Screening Values for a higher DAF if site-specific information indicates that the depth to groundwater, soil type, and geological formations support that there is significant dilution between the contaminated zone and the groundwater. 401 KAR 100:100 Section 5(5) establishes procedures to modify the SSL based on site-specific conditions.

## References

Kentucky Department for Environmental Protection (KYDEP). 1995. Risk Assessment Guidance. Guidance document part of 401 KAR 100:050 regulation package. August 1995. 92 p.

Kentucky Department for Environmental Protection (KYDEP). 1996. Lead Issues. Prepared by Risk Assessment Review Group: Albert G. Westerman, Ph.D., Branch Manager, Michelle Nihei Shaw, Ph.D. and Sally L. Wiley, M.S., Analysts. August 5, 1996. 38 p.

Howard, P.H. 1990. Handbook of Environmental Fate and Exposure Data for Organic Chemicals. Lewis Publishers, Chelsea, MI. 546 p.

Schaum, J., K. Hoang, R. Kinerson, J. Moya, and R.G.M. Wang. 1994. Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water. In: Water Contamination and Health: Integration of Exposure Assessment, Toxicology, and Risk Assessment. Rhoda G.M. Wang, Editor. Marcel Dekker, Inc. New York, NY. P. 305-321.

United States Environmental Protection Agency (U.S. EPA). 1988. Superfund Exposure Assessment Manual. EPA/540/1-88/001. Office of Remedial Response. Washington, D.C. 157 p.

United States Environmental Protection Agency (U.S. EPA). 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A). EPA/540/1-89/002. Office of Emergency and Remedial Response. Washington, D.C. 276 p.

United States Environmental Protection Agency (U.S. EPA). 1990a. Exposure Factors Handbook. EPA/600/8-89/043. Office of Health and Environmental Assessment. Washington, D.C. 276 p.

United States Environmental Protection Agency (U.S. EPA). 1990b. National Oil and Hazardous Substances Pollution Contingency Plan. 40 CFR Part 300. Office of Solid Waste and Emergency Response. Washington, D.C. 572 p.

United States Environmental Protection Agency (U.S. EPA). 1990c. Subsurface Contamination Reference Guide. EPA/540/2-90/011. Office of Emergency and Remedial Response. Washington, D.C.

United States Environmental Protection Agency (U.S. EPA). 1991. Risk Assessment Guidance for Superfund: Volume I-Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). Office of Emergency and Remedial Response. Washington, D.C. 54 p.

United States Environmental Protection Agency (U.S. EPA). 1994. Superfund Chemical Data Matrix. EPA/540/R-94/009. Office of Solid Waste and Emergency Response. Washington, D.C.

United States Environmental Protection Agency (U.S. EPA). 1996a. Region 9 Preliminary Remediation Goals (PRGs). San Francisco, CA. August 1, 1996. 35 p.



United States Environmental Protection Agency (U.S. EPA). 1996b. Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128. Office of Solid Waste and Emergency Response. Washington, D.C. 497 p.

United States Environmental Protection Agency (U.S. EPA). 1996c. Soil Screening Guidance: Users Guide. Publication 9355.4-23. Office of Solid Waste and Emergency Response. Washington, D.C. 44 p.

United States Environmental Protection Agency (U.S. EPA). 1997. Health Effects Assessment Summary Tables. Office of Emergency and Remedial Response. Washington, D.C.

United States Environmental Protection Agency (U.S. EPA). 1998. Risk Based Concentration Table. U.S. EPA Region III. April 1, 1998. First Presented at EPA Superfund Risk Assessor's Conference, March, 1991. Philadelphia, PA.

United States Environmental Protection Agency (U.S. EPA). 2000a. Drinking Water Standards and Health Advisories. Office of Water. Washington, D.C. EPA 822-B-00-001 Summer 2000.

United States Environmental Protection Agency (U.S. EPA). 2000b. Region 9 Preliminary Remediation Goals (PRGs). San Francisco, CA. November 1, 2000. 35 p.

United States Environmental Protection Agency (U.S. EPA). 2001a. Integrated Risk Information System. Office of Research and Development. National Center for Environmental Assessment. Washington, D.C. Accessed November 2001. <http://www.epa.gov/iris/index.html>

United States Environmental Protection Agency (U.S. EPA). 2001b. National Primary Drinking Water Standards. EPA 816-F-01-007. Office of Water. Washington, D.C. March 2001. [www.epa.gov/safewater](http://www.epa.gov/safewater) 4 p.

United States Environmental Protection Agency (U.S. EPA). 2001c. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Interim Guidance. EPA/540/R-99/005. Office of Solid Waste and Emergency Response. Washington, D.C. PB99-963312.

**Appendix D**  
**Ecological Screening Values**  
**Available on [www.kentucky.gov](http://www.kentucky.gov)**

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**Appendix E**  
**Radionuclide Screening Values**  
**Available on [www.kentucky.gov](http://www.kentucky.gov)**

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## **Appendix F**

### **Checklist for Ecological Assessment/Sampling**



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## Checklist for Ecological Assessment/Sampling

### I. SITE DESCRIPTION

1. Site Name: \_\_\_\_\_  
Location: \_\_\_\_\_  
\_\_\_\_\_  
County: \_\_\_\_\_ City: \_\_\_\_\_ State: \_\_\_\_\_
2. Latitude: \_\_\_\_\_ Longitude: \_\_\_\_\_
3. What is the approximate area of the site? \_\_\_\_\_
4. Please attach to the checklist USGS topographic map(s) of the site, if available.
5. Are aerial or other site photographs available? ☐ yes ☐ no If yes, please attach any available photo(s).
6. What type of facility is located at the site?  
☐ Chemical    ☐ Manufacturing    ☐ Mixing    ☐ Waste disposal  
☐ Other (specify) \_\_\_\_\_
7. What are the suspected contaminants of concern at the site? If known, what are the maximum concentration levels?
8. Do any potentially sensitive environmental areas exist adjacent to or in proximity to the site, e.g., Federal and State parks, National and State monuments, wetlands, lakes, streams? *Remember, flood plains and wetlands are not always obvious; do not answer "no" without confirming information.*
9. Please provide the source(s) of information used to identify these sensitive areas, and indicate their general location on the site map.

10. The land use on the site is: The area surrounding the site is:
- \_\_\_\_\_ mile radius
- \_\_\_\_\_ % Urban \_\_\_\_\_ % Urban
- \_\_\_\_\_ % Rural \_\_\_\_\_ % Rural
- \_\_\_\_\_ % Residential \_\_\_\_\_ % Residential
- \_\_\_\_\_ % Industrial (☐ light ☐ heavy) \_\_\_\_\_ % Industrial (☐ light ☐ heavy)
- \_\_\_\_\_ % Agricultural \_\_\_\_\_ % Agricultural
- (Crops: \_\_\_\_\_) (Crops: \_\_\_\_\_)
- \_\_\_\_\_ % Recreational \_\_\_\_\_ % Recreational
- (Describe; note if it is a park, etc.) (Describe; note if it is a park, etc.)
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_ % Undisturbed \_\_\_\_\_ % Undisturbed
- \_\_\_\_\_ % Other \_\_\_\_\_ % Other
11. If known, what is the approximate depth to the water table? \_\_\_\_\_
12. Is the direction of surface runoff apparent from site observations? ☐ yes ☐ no If yes, to which of the following does the surface runoff discharge? Indicate all that apply.
- ☐ Surface water ☐ Groundwater ☐ Sewer ☐ Collection impoundment
13. Is there a navigable waterbody or tributary to a navigable waterbody? ☐ yes ☐ no
14. Is there a waterbody anywhere on or in the vicinity of the site?
- ☐ yes (approx. distance \_\_\_\_\_) ☐ no
15. Is there evidence of flooding? ☐ yes ☐ no *Wetlands and flood plains are not always obvious; do not answer "no" without confirming information.*
16. Are any threatened and/or endangered species (plant or animal) known to inhabit the area of the site?
- ☐ yes ☐ no
17. Are there any wooded areas at the site? ☐ yes ☐ no.

18. What percentage or area of the site is wooded? ( \_\_\_\_% \_\_\_\_ acres). Indicate the wooded area on the site map which is attached to a copy of this checklist.
19. Is shrub/scrub vegetation present at the site? ☐ yes ☐ no.
20. What percentage of the site is covered by scrub/shrub vegetation? ( \_\_\_\_% \_\_\_\_ acres). Indicate the areas of shrub/scrub on the site map.
21. Are there open (bare, barren) field areas present at the site? ☐ yes ☐ no
22. What percentage of the site is open field? ( \_\_\_\_% \_\_\_\_ acres). Indicate the open fields on the site map.
23. Based on observations and/or available information, are designated or known wetlands definitely present at the site? ☐ yes ☐ no
24. Please note the sources of observations and information used (e.g., USGS Topographic Maps, National Wetland Inventory, Federal or State Agency, etc.) to make this determination.
25. CONTINUE WITH ECOLOGICAL RISK ASSESSMENT. **YES**\_\_\_\_ **NO**\_\_\_\_

Record weather conditions at the time this checklist was prepared:

DATE: \_\_\_\_\_

\_\_\_\_\_ Temperature (EC/EF) \_\_\_\_\_ Normal daily high temperature

\_\_\_\_\_ Wind (direction/speed) \_\_\_\_\_ Precipitation (rain, snow)

\_\_\_\_\_ Cloud cover

Completed by \_\_\_\_\_ Affiliation \_\_\_\_\_

Additional Preparers \_\_\_\_\_

Site Manager \_\_\_\_\_

Date \_\_\_\_

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## **Appendix G**

### **Development of Generic Background Concentrations for Kentucky Soils**



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## **Development of Generic Background Concentrations for Kentucky Soils**

Background, as defined in 401 KAR 42:005 (definitions codified to support the Underground Storage Tank regulations), means the concentration of substances consistently present in the environment at, or regionally proximate to, a release but outside the influence of the release. There are two types of background:

- a) Natural background is the amount of naturally occurring substances in the environment, exclusive of that from anthropogenic sources.
- b) Ambient background means the concentrations of naturally-occurring inorganic substances and ubiquitous anthropogenic inorganic substances in the environment that are representative of the region surrounding the site and not attributable to activities on the property.

Since sites undergoing environmental assessment are often found in industrialized and potentially contaminated areas, the determination of site-specific background concentrations is difficult. Generic ambient background values applicable to all sites in Kentucky would be useful for comparison to site data for the purpose of identifying those constituents requiring remedial action (i.e., removal or exposure control). These generic ambient background values would provide a party or VERP applicant an alternative to attempting to identify site-specific background soils in areas that are likely contaminated.

To address this issue, the NREPC used background sample values provided by regulated facilities, as well as background sample values collected by cabinet employees. These samples were collected from areas generally considered to be outside of the influence of site activities, but were potentially impacted by regional or citywide activity. Therefore, these samples represent “ambient,” as opposed to “natural,” background. From 400 to over 800 samples for each constituent were used in the analysis. For each constituent, a 95% Upper Confidence Limit (UCL) of the arithmetic mean, 60<sup>th</sup> Percentile, and 95<sup>th</sup> percentile were calculated. The 95% UCL is the value that represents that the mean of the data set falls below that value with 95% confidence. The 60<sup>th</sup> and 95<sup>th</sup> percentiles indicate that 60 percent and 95 percent of the data falls below those values.

The following methodology was employed to calculate ambient background:

1. Values reported as “non-detected” were retained in the database at ½ the reporting limit (USEPA, 1998).
2. As the data sets came from areas having varied uses (e.g., industrial, commercial, residential, agricultural, woodlands, etc.), the probability that some of the samples were taken in contaminated areas is significant. Data sets were tested for outliers by the Grubb’s test, and individual samples that had a calculated Z-score above 3.8 were generally removed from the background data set. The Grubb’s test formula is as follows:

$$Z = \frac{|population\ mean - value\ of\ individual\ sample|}{standard\ deviation}$$

3. The descriptive statistics of mean and standard deviation were calculated by standard parametric methods assuming normality and are listed in Table G-1. Parametric methods were used to allow for comparisons between NREPC background values and other published values.

a. Standard deviation was calculated by the “nonbiased” method employing the formula:

$$S.D. = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n-1}}$$

b. Mean was calculated as the sum of all individual scores divided by the total number of observations.

4. The data sets were analyzed with Lillefor’s test for normality. Since the data sets are not normally or log normally distributed, the parameters that are to be used in determining if site samples are consistent with background (i.e. 95% UCL of mean, 60<sup>th</sup> percentile and 95<sup>th</sup> percentile) were calculated by nonparametric methods and are listed in Table G-2.

5. The 95% upper confidence limit of the arithmetic mean for each constituent was calculated on the trimmed data set using ProUCL. ProUCL is a statistical package developed by Lockheed Martin under contract with the U.S. EPA.
6. The 60<sup>th</sup> percentile value is used as the midpoint for each constituent. It was calculated as follows:
  - a. The constituent values were ranked in increasing order of magnitude.
  - b. The quantity  $60(n)/100$  was used to identify the measurement with the resulting rank.
7. The 95<sup>th</sup> percentile value is used as the upper bound value for each constituent and was calculated as follows:
  - a. The constituent values were ranked in increasing order of magnitude.
  - b. The quantity  $95(n)/100$  was used to identify the measurement with the resulting rank.

The thallium data were characterized by a large number of non-detects (633 non-detects verses 54 detects). Due to the large number of non-detects, non-detects were not entered as  $\frac{1}{2}$  the non-detect concentration. Each non-detect sample was assumed to have a concentration equal to the recorded non-detect concentration. Considering the number of non-detects and the likelihood that the recorded values skew thallium concentrations upward, only the 95<sup>th</sup> percentile of the total data is cited in table G-2.

### **Comparison to Background**

- The mean site concentration for inorganic constituents must be below the 95% UCL of the mean concentrations of background for inorganic constituents. At least  $\frac{1}{2}$  of the data points should be less than the midpoint (60<sup>th</sup> percentile), and no data point above the upper bound value (95<sup>th</sup> percentile). The site data should be segregated by surface and subsurface data. The surface and subsurface site data may be compared to the statewide numbers in Table G-2, or to site-specific background samples.

### **Horizontal and Vertical Extent**

401 KAR 100:100 Section 5(4) states that during site characterization, a minimum of two additional sampling locations is required for each sampling point at the edge of an area of concern that exceeds the method detection limit or ambient background and shall be located at a

minimum distance of ten (10) feet from the previous sampling point that had a confirmed exceedance of method detection limits, or ambient background. The following criteria may be used to determine if the sampling point exceeds generic or site-specific ambient background.

- If the value for the individual sample is less than the 95% UCL of the arithmetic mean of background, then no additional samples are required.
- If the sampling point is greater than the 95<sup>th</sup> percentile of background, then a minimum of two additional sampling points are required.
- If the sampling point is between the 95% UCL of background and the 95<sup>th</sup> percentile of background, then the complete dataset needs to be evaluated to determine if two additional sampling locations are required. If at least half of all data points at the edge of the AOC are at or below the 95% UCL of background and the remaining data points are between the 95% UCL of background and the 95<sup>th</sup> percentile of background, then no additional samples are required. If this criteria is not met, then two additional sampling points are required.

The cabinet may require additional sample locations if the data indicate that the extent of contamination has not been determined.

## **Literature Cited**

United States Environmental Protection Agency (USEPA), 1995. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites. Office of Research and Development. Office of Solid Waste and Emergency Response. EPA/540/S-96/500. December, 1995.

United States Environmental Protection Agency (USEPA), 1998. Statistical Tests for Background Comparison at Hazardous Waste Sites. Supplemental Guidance to RAGS: Region 4 Bulletins – Addition #1. Interim Draft. USEPA Region 4, Waste Management Division. Atlanta, Georgia. November, 1998.



Table G-1. Summary Statistics for Ambient Inorganic Chemicals

<b>Element</b>	<b>Number of Samples</b>	<b>Range (mg/kg)</b>	<b>Mean (mg/kg)</b>	<b>Standard Deviation (mg/kg)</b>
Aluminum	679	1290 - 38,100	10969	5462.9
Arsenic	539	0.059 - 55.5	8.9	7
Barium	756	6.14 – 1160	111.3	92.4
Beryllium	696	0.061 - 3.57	0.8	0.5
Cadmium	701	0.004 - 9.46	0.68	1.4
Chromium	771	2.83 - 168	20.5	13.9
Cobalt	649	0.29 - 67.6	11.9	8.1
Copper	729	0.49 - 636	18.9	39.7
Iron	697	222 - 86,900	22456	13269.7
Lead	808	0.03 - 284	30	31.3
Manganese	685	8.43 - 5100	1017	854.9
Mercury	459	0.007 - 0.721	0.06	0.1
Nickel	716	0.39 - 83.7	20.9	13.1
Selenium	714	0.001 - 3.93	0.94	0.7
Silver	697	0.006 - 5.2	0.42	0.6
Thallium	633	0.13 - 28		
Vanadium	679	4.82 - 92.1	26.9	11.8
Zinc	721	6 - 470	55	46.3

Table G-2. Generic Statewide Ambient Background for Kentucky

<b>Element</b>	<b>Mean (mg/kg)</b>	<b>95% UCL of Mean (mg/kg)</b>	<b>60<sup>th</sup> Percentile (mg/kg)</b>	<b>95<sup>th</sup> Percentile (mg/kg)</b>
Aluminum	10969	11314	10800	21000
Arsenic	8.9	9.4	8.3	21.2
Barium	111.3	116.9	100	241
Beryllium	0.8	0.83	0.75	1.8
Cadmium	0.68	0.78	0.27	3.9
Chromium	20.5	21.3	19.3	40
Cobalt	11.9	12.4	13.1	25.1
Copper	18.9	21.3	13.8	41.7
Iron	22456	23284	22000	47600
Lead	30	33	20.9	84.6
Manganese	1017	1071	948	2620
Mercury	0.06	0.07	0.059	0.14
Nickel	20.9	21.7	20.2	46.8
Selenium	0.94	0.99	1.38	2.1
Silver	0.42	0.45	0.257	1.2
Thallium				7.95
Vanadium	26.9	27.7	27.3	48.6
Zinc	55	57	48.6	115

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# **Kentucky Guidance for Ambient Background Assessment**

**January 8, 2004**



**Natural Resources and  
Environmental Protection Cabinet**

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## **Introduction**

This guidance document is intended to assist in comparing site data and background data for sites undergoing environmental assessment. These procedures provide a simplified statistical procedure for determining if the site data is part of the background population. It also provides generic statewide background values for inorganic chemicals that may be used in lieu of collecting site-specific background samples. The statistical procedures may be used for site-specific data or the generic statewide values in Tables 1 and 2. This guidance does not preclude other appropriate statistical comparisons from being made, but rather a simplified screening method that does not require a deep knowledge of statistics. If the site data set fails the statistical procedures in this guidance, it may be appropriate to perform a more complete statistical comparison.

Background, as defined in 401 KAR 42:005 (definitions codified to support the Underground Storage Tank regulations), means the concentration of substances consistently present in the environment at, or regionally proximate to, a release but outside the influence of the release. There are two types of background:

- a) Natural background is the amount of naturally occurring substances in the environment, exclusive of that from anthropogenic sources.
- b) Ambient background means the concentrations of naturally occurring inorganic substances and ubiquitous anthropogenic inorganic substances in the environment that are representative of the region surrounding the site and not attributable to an identifiable release.

Since sites undergoing environmental assessment are often found in industrialized and potentially contaminated areas, the determination of site-specific background concentrations is difficult. Generic ambient background values applicable to all sites in Kentucky would be useful for comparison to site data for the purpose of identifying those constituents requiring remedial action (i.e., removal or exposure control). These generic ambient background values would provide an alternative to attempting to identify site-specific background soils in areas that are likely contaminated.



## Methodology

To provide an alternative to site-specific background sampling, the NREPC used background sample values provided by regulated facilities, as well as background sample values collected by cabinet employees. These samples were collected from areas generally considered to be outside of the influence of site activities, but were potentially impacted by regional or urban activity. Therefore, these samples represent “ambient,” as opposed to “natural,” background. From 400 to over 800 samples for each constituent were used in the analysis. For each constituent, a 95% Upper Confidence Limit (UCL) of the arithmetic mean, 60<sup>th</sup> percentile, and 95<sup>th</sup> percentile were calculated. The 95% UCL is the value below which the true mean of the data set falls, with 95% confidence. The 60<sup>th</sup> and 95<sup>th</sup> percentiles indicate that 60 percent and 95 percent of the data falls below those values.

The following methodology was employed to calculate ambient background:

1. Values reported as “non-detected” were retained in the database at half the reporting limit (USEPA, 1998).
2. As the data sets came from areas having varied uses (e.g., industrial, commercial, residential, agricultural, woodlands, etc.), the probability that some of the samples were taken in contaminated areas is significant. Data sets were tested for outliers by the Grubb’s test, and individual samples that had a calculated Z-score above 3.8 were generally removed from the background data set. The Grubb’s test formula is as follows:

$$Z = \frac{|population\ mean - value\ of\ individual\ sample|}{standard\ deviation}$$

3. The descriptive statistics of mean and standard deviation were calculated by standard parametric methods assuming normality and are listed in Table 1. Parametric methods were used to allow for comparisons between these generic ambient background values and the results of other published studies of background.

a. Standard deviation was calculated by the “nonbiased” method employing the formula:

$$S.D. = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n-1}}$$

b. Mean was calculated as the sum of all individual scores divided by the total number of observations.

4. The data sets were analyzed with Lillefor’s test for normality. Since the data sets are not normally or lognormally distributed, the parameters that are to be used in determining if site samples are consistent with background (i.e. 95% UCL of mean, 60<sup>th</sup> percentile and 95<sup>th</sup> percentile) were calculated by nonparametric methods and are listed in Table 2.
5. The 95% UCL of the arithmetic mean for each constituent was calculated on the trimmed data set using ProUCL. ProUCL is a statistical package developed by Lockheed Martin under contract with the U.S. EPA.
6. The 60<sup>th</sup> percentile value is used as the midpoint for each constituent. It was calculated as follows:
  - a. The constituent values were ranked in increasing order of magnitude.
  - b. The quantity  $60(n)/100$  was used to identify the measurement with the resulting rank.
7. The 95<sup>th</sup> percentile value is used as the upper bound value for each constituent and was calculated as follows:
  - a. The constituent values were ranked in increasing order of magnitude.
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The thallium data were characterized by a large number of non-detects (633 non-detects verses 54 detects). Due to the large number of non-detects, non-detects were not entered as ½ the non-detect concentration. Each non-detect sample was assumed to have a concentration equal to the recorded non-detect concentration. Considering the number of non-detects and the likelihood that

the recorded values skew thallium concentrations upward, only the 95<sup>th</sup> percentile of the total data is cited in Table 2.

### **Procedure for Comparison to Background**

The site data should be segregated by surface and subsurface data. The surface and subsurface site data may be compared to the statewide numbers in Table 2, or to site-specific background samples. The following three criteria may be used to demonstrate that the site data is background:

1. The mean site concentration for inorganic constituents must be below the 95% UCL of the mean concentrations of background for inorganic constituents.
2. At least half of the data points should be less than the 60<sup>th</sup> percentile.
3. No data points should be above the upper bound value (95<sup>th</sup> percentile).

These procedures provide a tool for comparing site data with either generic statewide or site-specific background using the statistical characteristics of the two populations. Other statistical comparisons may be used, if appropriate.

### **Determining Site-specific Background**

Site-specific ambient background levels may be determined at the site. The site-specific ambient background data set shall consist of an appropriate number of samples for the statistical method employed. The number of samples necessary to characterize site-specific background will vary based on the variability of the data. Twenty data points may be used as a minimum number of samples per horizon (surface and subsurface) as a default number, unless other statistical methods can be used to develop a different number. A site-specific determination of the number of required samples may be calculated based on the statistical characteristics of the background population.

Upgradient groundwater samples are to be obtained from the same hydrogeological unit as the groundwater contamination at the site. The background monitoring wells shall be located hydrogeologically upgradient from the release(s) of concern, unless it can be demonstrated to the cabinet that the upgradient location is undefinable or infeasible.

Background soil samples should be collected from native soil in areas of similar soil type as found at the site. Background concentrations should be determined separately for surface and subsurface areas that are consistent with the on-site investigation.

The following areas are inappropriate to sample when determining soil background unless otherwise necessary to reach a corrective action decision or identify potential sources of contamination:

1. Fill areas;
2. Areas in which management, treatment, handling, storage or disposal activities of any of the following are known or suspected to have occurred: hazardous substances or petroleum, solid or hazardous wastes, or waste waters;
3. Areas within three feet of a roadway;
4. Parking lots and areas surrounding parking lots or other paved areas;
5. Railroad tracks or railway areas or other areas affected by their runoff;
6. Areas of concentrated air pollutant depositions or areas affected by their runoff;
7. Storm drains or ditches presently or historically receiving industrial or urban runoff;  
or
8. Areas within three feet of any current structure, or the former location of any structure, which is likely to have been painted with lead-based paint.

## Literature Cited

United States Environmental Protection Agency (USEPA), 1995. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites. Office of Research and Development. Office of Solid Waste and Emergency Response. EPA/540/S-96/500. December, 1995.

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Silver	697	0.006 - 5.2	0.42	0.6
Thallium	633	0.13 - 28		
Vanadium	679	4.82 - 92.1	26.9	11.8
Zinc	721	6 - 470	55	46.3

Table 2. Generic Statewide Ambient Background for Kentucky

<b>Element</b>	<b>Mean (mg/kg)</b>	<b>95% UCL of Mean (mg/kg)</b>	<b>60<sup>th</sup> Percentile (mg/kg)</b>	<b>95<sup>th</sup> Percentile (mg/kg)</b>
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Silver	0.42	0.45	0.257	1.2
Thallium				7.95
Vanadium	26.9	27.7	27.3	48.6
Zinc	55	57	48.6	115



# **Kentucky Guidance for Groundwater Assessment Screening**

**January 15, 2004**



**Environmental and  
Public Protection Cabinet**

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## **Introduction**

This document provides guidance for evaluating contaminated sites to determine whether superficial and shallow contamination in soils indicates an existing or potential groundwater contamination problem, and whether a direct assessment of groundwater conditions is necessary. This method is intended to provide the party or applicant a cost-effective approach using soils data collected as part of the site characterization for determining the need to assess groundwater quality.

## **Methodology**

An assessment of the effect of a release of a hazardous substance or petroleum on groundwater quality may not be necessary at all sites. This process is intended for sites that lack adequate groundwater monitoring data and where the party or applicant anticipates to leave in place contaminants of concern (COCs).

This approach to evaluating impacts and potential impacts of a release on groundwater is based on the attenuation of contaminants moving through the soil profile by means of biodegradation, hydrolysis, volatilization, adsorption, and dilution. Contaminants may not attenuate similarly in all situations, and therefore conservative Dilution Attenuation Factor (DAF) values are applied. However, conditions at some sites may result in contaminant migration through the soil profile in a manner that bypasses physical, chemical, and biological processes in the soils. Caution should be applied to use of this methodology at sites where normal physical, chemical, and biological processes in the soils are bypassed, including sites underlain by soils with large, interconnected pores (macropores) that provide for the rapid transport of water and contaminants through the soil profile, sites underlain by well-developed karst terrane,

sites underlain by highly fractured media, or where contamination extends to the soil-bedrock interface. These types of sites may not provide for the soil processes assumed to be in effect in this method. In addition, this process is primarily intended for COCs that are relatively insoluble and are expected, under normal conditions, to remain in the soil profile and not to migrate to groundwater. Therefore, caution should be used in applying this methodology at sites where soluble or mobile COCs such as volatile organic compounds, nitrates, or dense non-aqueous phase liquids (DNAPL) are present; the presence of such COCs in the soils may indicate that a groundwater assessment may be necessary. The cabinet reserves the authority to require a direct assessment of groundwater at sites where it deems such investigation is prudent to understanding the extent of contamination and the risks associated with the release.

To determine whether a direct assessment of groundwater conditions is necessary, analytical data from the soil profile may be evaluated by the methods outlined in this document in combination with an evaluation of other soil conditions, and the geology and hydrology of the site. These data can be used to determine whether groundwater was likely to have been impacted, and whether these soils will serve as a future source of groundwater contamination.

In order to use this method, the horizontal and vertical extent of soil contamination must be known. An adequate number of soil borings with multiple, discrete sampling intervals of sufficient length and spacing to characterize vertical distribution of contamination are also necessary.

If it can be demonstrated using one of the following options that a release has not had and will not have an adverse effect on groundwater quality, a direct assessment of groundwater impacts may not be necessary.

1. An assessment of groundwater for a release may not be necessary if the applicable Soil Screening Levels, or SSL (DAF 1), in the U.S. EPA Region 9 Preliminary Remediation Goals (October 1, 2002) are not exceeded in the bottom two (2) sampling intervals of each soil boring.

2. Rather than using the default SSLs (DAF 1), a modified SSL may be used. This modified SSL takes into account the surface area of the site, the vertical separation between the contamination in the soil profile and groundwater, and the underlying bedrock conditions. The appropriate modified SSL is equivalent to the SSL (DAF 1) referenced in the U.S. EPA Region 9 Preliminary Remediation Goals, (October 1, 2002) multiplied by the applicable value in Table 1, below. An assessment of groundwater for a release may not be necessary if the applicable modified SSLs are not exceeded in samples from the bottom two (2) sampling intervals.

**Table 1.**

Vertical Separation Between Contamination in the Soil Profile and the Zone of Saturation	Surface Area of Site and other considerations		
	< 0.5 acres	0.5-10 acres	> 10 acres, or site underlain by karst or highly fractured media
0-5 ft	1	1	1
5-10 ft	5	2.5	1
10-15 ft	10	5	1
15-20 ft	15	7.5	2.5
Greater than 20 ft	20	10	5

3. A site-specific SSL may be developed and applied based on site-specific conditions, including soil types, characteristics of COCs, total organic carbon in the soil, soil porosity, infiltration rate, and the vertical separation between the contamination in the soil profile and groundwater. If the analytical results in the bottom two (2) sampling intervals do not exceed the site-specific SSLs, a groundwater assessment may not be necessary for that site.

4. A fate and transport evaluation may be developed to demonstrate that levels of COCs in the soils will not result in groundwater contamination beyond the property boundary. If a fate and transport evaluation adequately demonstrates that levels of COCs in the soils will not result in groundwater contamination beyond the property boundary, a groundwater assessment may not be necessary. However, a direct groundwater assessment will be required to make such a determination in most situations.

5. An analysis of the results of current and historical groundwater monitoring may be used to determine whether groundwater has been adequately characterized. Such an analysis shall contain sufficient information to determine whether groundwater has been affected by any releases at the site. The report of this analysis shall include:

a. The location of monitoring wells relative to the location of the soil contamination at the site, and to groundwater flow direction at the property;

b. Monitoring well construction details, including diameter of the annulus, diameter of the well casing, the depth and length of the screened interval, construction of the sand pack, and the type and manner of sealing materials used;

c. The proximity of wells to one another and to the property boundary; and

d. The results of all groundwater analyses conducted to date on samples collected at the property, including sample dates, the parameters analyzed, and the methods of collection and analysis.

A groundwater assessment is necessary and prudent in some circumstances. Any direct evidence of groundwater contamination, including seeps, contaminated wells and springs, or other similar information is compelling evidence to conduct a thorough groundwater investigation. The cabinet may direct a person or applicant to conduct a groundwater assessment in regards to a known or suspected release, regardless of the results of the methods employed above.



## References

1. U.S. EPA 1996. Soils Screening Guidance: Technical Background Document, May 1996. United States Environmental Protection Agency 9355.-17a, EPA/540/R-95/128, PB96-963502.
2. U.S. EPA 2002. Region 9 Preliminary Remediation Goals and the Region 9 PRGs Table User's Guide/Technical Background Document (October 1, 2002).

## Trichloroethylene Environmental Levels of Concern

Kentucky Department for Environmental Protection  
Division of Environmental Services  
Risk Assessment Branch  
Jeri W. Higginbotham, Ph.D.

April 21, 2004

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**Kentucky Risk Based Screening Values for Trichloroethylene**

**Based on a Slope Factor of 3.22E-01 per mg/kg-d**

**Ambient Air – 0.013 ug/m<sup>3</sup>**

**Tap Water – 0.046 ug/l**

**Residential Soil – 0.031 mg/kg**

**Industrial Soil – 0.077 mg/kg**

**Rural Residential Soil – 0.027 mg/kg**

**Recreational Soil – 0.5 mg/kg**

**Farmer Exposure Soil – 0.089 mg/kg**

**Outdoor Worker Soil – 0.1 mg/kg**

**Short-Term Outdoor Worker Soil – 2.5 mg/kg**

**Ambient Air (Child age 1 to 18) – 0.00084 ug/m<sup>3</sup>**

**Tap Water (Child age 1 to 18) – 0.0018 ug/l**

Trichloroethylene (TCE) is a colorless liquid with a somewhat sweet odor (ATSDR 1997a) similar to that of chloroform (Plunkett 1987). Synonyms are 1,1,2-trichloroethylene, trichloroethene, acetylene trichloride, and ethylene trichloride (Proctor, Hughes, and Fischman 1989). Registered trade names include Algylen, Blacosolv, Dow-Tri, Perma-A-Chlor, Trilene, and Vestrol (ATSDR 1997a). It has been produced commercially since the 1920's (IARC 1997) and is commonly used as a cleaning and degreasing agent in the manufacture of furniture and fixtures, fabricated metal products, electric and electronic equipment, transport equipment, and, to a lesser extent, textiles, paper, and glass (HSDB 2004). It is an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers (ATSDR 2003). Between the 1930's and 1950's, it was used in the dry cleaning industry (IARC 1997). In 1977, the United States Food and Drug Administration (FDA) banned the use of TCE as a grain fumigant, disinfectant, anesthetic, and as an extraction solvent to extract caffeine from coffee, oleoresins from spices, and oil from palm, coconut, and soybean seed (ATSDR 1997a).

Due to its long history of use, TCE is a widespread environmental contaminant. Between 1988 and 2001, total on-site and off-site releases of TCE in the United States decreased from 57,445,582 pounds to 8,484,115 pounds (Table 1). In every year, at least 97% was in the form of air emissions (TRI 2003) but there were also releases to land, surface water discharge, and underground injection. It has been found at 861 Superfund National Priorities List (NPL) sites (ATSDR 1997a). And not surprisingly, by leaching through soil, the rate of which is dependent on organic matter and soil moisture content, it has contaminated underground water sources (ATSDR 1997a).

**Table 1. Releases of trichloroethylene by year from 1988 to 2001 in the United States. All values are reported in pounds. Data from TRI, 2003.**

total air emissions	surface water discharge	under- ground injection	releases to land	total on-site releases	total off- site releases	total on- and off-site releases	year	air/total
8,249,587	406	98,220	12,609	8,360,822	123,296	8,484,118	2001	0.972356
9,759,536	593	47,877	9,713	9,817,719	159,396	9,977,115	2000	0.978192
10,605,822	1,034	0	148,867	10,755,723	168,374	10,924,097	1999	0.970865
13,265,539	882	593	800	13,267,814	126,053	13,393,867	1998	0.990419
18,224,059	568	986	3,975	18,229,588	182,423	18,412,011	1997	0.989792
21,886,451	541	1,291	9,740	21,898,023	89,527	21,987,550	1996	0.995402
26,282,939	1,477	550	3,577	26,288,543	74,145	26,362,688	1995	0.996975
30,948,761	1,671	288	4,070	30,954,790	96,312	31,051,102	1994	0.996704
31,007,030	5,220	460	8,212	31,020,922	233,561	31,254,483	1993	0.992083
30,838,983	8,606	466	20,726	30,868,781	248,714	31,117,495	1992	0.99105
36,356,277	12,784	800	62,991	36,432,852	115,973	36,548,825	1991	0.994732
40,028,932	14,285	805	12,554	40,056,576	753,864	40,810,440	1990	0.98085
49,798,528	15,849	390	8,686	49,823,453	1,250,933	51,074,386	1989	0.97502
55,943,736	13,801	390	21,186	55,979,113	1,466,469	57,445,582	1988	0.973856

TCE is degraded most rapidly in the air and least rapidly in groundwater.

Degradation products depend on the medium and have adverse health effects of their own. In air, TCE persists for 11 to 14 days before decomposing to hydrochloric acid, dichloroacetyl chloride, phosgene, and carbon monoxide (Cal/EPA 1999). It rapidly evaporates from surface water but may persist in groundwater and soil for prolonged periods (ATSDR 2003). There is some evidence for microbiological degradation to cis and trans 1,2-dichloroethylene in soil and groundwater. In one study, a half-life of 1.0 to 1.5 years in groundwater was calculated (Cal/EPA 1999). Other studies have calculated half-lives in groundwater of 10.7 months and 4.5 years (Howard 1991). Rate of degradation depends on the presence of organisms capable of degrading the chemical, the availability of other metabolic requirements, and the amount of chemical present. In the absence of appropriate microflora or appropriate microfloral habitat, TCE may persist for centuries as a dense nonaqueous phase liquid (DNAPL) in subsurface pools and lenses. With a solubility of 1.1 grams per

liter (Verschueren 1983), DNAPL TCE slowly dissolves into groundwater over prolonged periods, creating contaminant plumes (Newell and Ross 1992).

In mammals, the liver is the primary site of TCE metabolism with trichloroacetic acid (TCA) being the major end product. Other metabolic products are trichloroethanol, trichloroethanol-glucuronide, dichloroacetic acid, and dichlorovinyl cysteine. In addition to the liver, TCE metabolism occurs in the lungs and kidneys (EPA 2001). Blood and urine tests can detect TCE and many of its metabolic products for up to a week after exposure (ATSDR 2003).

Exposure to TCE has been linked to adverse health effects including liver and neurological dysfunction (ATSDR 1997a) and, accordingly, occupational and drinking water standards have been set. Based on adverse central nervous system effects, the Occupational Safety and Health Administration has established a time-weighted average permissible exposure limit (TWA PEL) of 50 ppm and a short term exposure limit (STEL) of 200 ppm (NIOSH 2001). The maximum contaminant level (MCL) for trichloroethylene in drinking water is 0.005 mg/L and the maximum contaminant level goal (MCLG) is zero. The basis for the MCL and MCLG was its potential to cause liver damage and certain cancers from a lifetime exposure above 0.005 mg/L (EPA 2002a).

However, carcinogenicity data for TCE was withdrawn from the United States Environmental Protection Agency (EPA) Integrated Risk Information System in 1989. The most recent EPA document concerning TCE is a preliminary draft entitled, “Trichloroethylene Health Risk Assessment: Synthesis and Characterization,” from the National Center for Environmental Assessment (EPA 2001). It draws on 16 state-of-the-science papers published as a supplemental issue of Environmental Health Perspectives



(volume 108, supplement 2, May 2000) as well as many other papers and was reviewed by a panel of the EPA Science Advisory Board's Environmental Health Committee (EPA 2002b).

In this draft, EPA concludes that TCE is "highly likely to produce cancer in humans" and can be classified as a "probable human carcinogen" (group B1). The International Agency for Research on Cancer (IARC), also, classifies TCE as "probably carcinogenic to humans" (Group 2A). Their evaluation was based on limited evidence in humans and sufficient evidence in experimental animals for the carcinogenicity of trichloroethylene (IARC 1997).

Many epidemiological studies are reported for the effects of TCE, but their quality and informational content vary considerably. One of the less informative studies concerned a cohort of workers at one manufacturing plant in Roscoe, Illinois (Shindell et al. 1985). As compared to the entire U.S. population, fewer individuals than expected died, and this was true for every cause of death (cardiovascular, respiratory cancer, nonrespiratory cancer, stroke, trauma, and other). Statistically significant deficits were in overall mortality, nonrespiratory cancer, and trauma. That there were deficits for every cause of death suggests that other parameters besides TCE exposure were varying between the cohort and the comparison group (healthy worker effect). The authors end by postulating the presence of "some other factor contributing to the favorable experience." Furthermore, cancers were only categorized as respiratory or nonrespiratory and exposure data were not provided. This study is simply not informative and provides no evidence for TCE health effects of any kind. Wartenberg (2000) placed it in his Tier II group of cohort studies, Tier I being composed of the most informative studies. The Science Advisory Board review panel endorsed

Wartenberg's classification system and went on to recommend that EPA weight the Tier I studies more strongly than other studies (EPA 2002b).

Of the four epidemiological studies discussed by EPA (2001), three were Tier I cohort studies and one was community based (Wartenberg 2000). A New Jersey study tracked individuals in a 75-town area affected by drinking water contamination (Cohn et al. 1994). Occupational exposure of Finnish workers to three halogenated hydrocarbons, tetrachloroethylene (PCE), 1,1,1-trichloroethane, and TCE was reported by Anttila et al. (1995). Blair et al. (1998) followed a cohort of workers who were employed at Hill Air Force Base for at least one year and who were exposed by vapour inhalation. A fourth and final study reported on the incidence of kidney cancer in German cardboard workers (EPA 2001).

In the New Jersey study, female residents had statistically significant excesses of leukemia and non-Hodgkin lymphoma where relative risks (RR), 95% confidence intervals (CI), and the number of cases (N) were RR=1.43, 95% CI=1.07-1.90, N=56 and RR=1.36, 95% CI=1.08-1.70, N=87 respectively (Cohn et al. 1994). Epidemiological studies often report data as relative risk where the probability of disease in the study group is divided by the probability of disease in the control group. A RR value above 1.0 indicates an excess of disease in the study group while a RR value below 1.0 indicates a deficit of disease in the study group. If the confidence interval does not contain 1.0, then the relative risk is statistically significant at the stated level of confidence which is usually 95%.

Based on this study, a unit risk estimate and slope factor for non-Hodgkin lymphoma was calculated by EPA (2001) using the following rationale. A relative risk factor of 1.36 is interpreted as a 36% increased risk of getting this disease. (EPA actually rounded up the

relative risk to 1.40.) By multiplying the background risk of getting non-Hodgkin lymphoma by 0.36 and dividing by the average concentration of TCE in those homes where the concentration exceeded the MCL of 5 ppb a unit risk estimate was calculated. The background risk was given as  $6\text{E-}04$  (prevalence of the disease in the United States), and the average concentration was 23.4 ug/L. The unit risk is  $9.2\text{E-}06$  per ug/L. The resulting slope factor based on a 70 kg adult drinking 2 L/d is  $3.22\text{E-}01$  per mg/kg-d average lifetime exposure to TCE for non-Hodgkin lymphoma. (EPA, using 1.4 as the relative risk and rounding up, listed  $4.00\text{E-}01$  per mg/kg-d in Table 4-9.) Dividing this slope factor into  $10^{-6}$  yields a risk-specific dose of  $3.1\text{E-}06$  mg/kg-d. For a 70 kg individual, the maximum daily dose is  $2.2\text{E-}04$  mg/d (0.22 ppb) which is well below the routine detection limit of  $1.0\text{E-}03$  mg/l (1.0 ppb) in water (King County 2002).

One weakness of this study was that it was impossible to control for other impurities in the water, some of which might contribute to the risk of developing these two cancers. Though TCE was present in the greatest concentration, PCE was also a common contaminant. Both are thought to exert carcinogenic effects through common metabolites. To that end, it is estimated that only from 1-3% of the absorbed PCE is metabolized (ATSDR 1997b), whereas from 40-75% of the absorbed TCE is metabolized (ATSDR 1997a). Furthermore, very little research has been done to confirm or refute the hypothesis that combinations of compounds act in an additive or greater-than-additive (synergistic) manner. Certain combinations might act in a less-than-additive (antagonistic) manner. And there is one report indicating that PCE inhibits the metabolism of TCE in humans (ATSDR 2002). As for other contaminants, no association was detected between leukemia or non-Hodgkin lymphoma incidence and trihalomethanes, benzene, 1,1,1-trichloroethane, carbon

tetrachloride, and trans-1,2-dichloroethylene. The apparent risk seems largely attributable to TCE.

A strength of the study was the socio-economic similarity of the municipalities compared. And, as with any epidemiological study, uncertainties in extrapolating from animal to human effects and from high to low doses are avoided (EPA 2001).

In the Finnish study, the following statistically significant standardized incidence ratios (SIRs) and 95% CI were reported for the entire cohort of 3974 workers: 2.35 for cervical cancer (95% CI-1.08-4.46), 2.13 for non-Hodgkin's lymphoma (95% CI-1.06-3.8), and 1.63 for lymphohematopoietic cancers (95% CI-1.06-2.41). Standardized incidence ratios are the ratio of observed cancer incidence in the cohort to the expected cancer incidence based on the population of Finland adjusted for age and sex. The cohort was subdivided according to exposure and duration of exposure. One subgroup was monitored for urinary TCA, a major metabolite of TCE, and had been followed for at least 19 years since the first measurement. This subgroup had statistically significant SIRs of 1.57 for all cancers (95% CI-1.2-2.02), 2.98 for stomach cancer (95% CI-1.2-6.13), 6.07 for liver cancer (95% CI-1.25-17.7), 3.57 for prostate cancer (95% CI-1.54-7.02), and 2.98 for lymphohematopoietic cancers (95% CI-1.2-6.14). Among a subgroup who were monitored for blood PCE levels, no statistically significant SIRs were reported. By the author's calculations though, exposure was greatest for TCE accounting for 80% of the person-years at risk (Anttila et al. 1995).

Using urinary TCA to quantify exposure, slope factors were calculated for liver cancer (7.0E-02), kidney cancer (2.0E+00), and non-Hodgkin lymphoma (7.0E+00) (EPA 2001). However, only liver cancer was statistically significantly elevated among those

workers with known exposure to trichloroethylene. Of the 11 cases of non-Hodgkin lymphoma, 3 were attributed to exposure to PCE resulting in a statistically non-significant excess in those exposed to TCE (SIR=1.81, 95% CI=0.78-3.56). In addition to the small number of cancer cases, exposure duration was uncertain (Anttila et al. 1995). Even though the comparison group was generated from the Finnish population, Anttila (1995) argues that, “It is not probable that chemicals other than solvents, or life-style patterns (such as alcohol consumption, smoking, sexual habits) explain the excesses in the present cohort, because excesses of the same primary sites were not seen in a parallel, in many respects comparable, cohort of workers monitored for lead exposure.”

In the Hill Air Force Base study, statistically non-significant excesses of non-Hodgkin lymphoma (RR=2.0, 95% CI=0.9-4.6), multiple myeloma (RR=1.3, 95% CI=0.5-3.4), breast cancer (RR=1.8, 95% CI=0.9-3.3), kidney cancer (RR=1.6, 95% CI=0.5-5.1), and cancer of the liver (RR=1.7, 95% CI=0.2-16.2) and biliary passages (RR=1.3, 95% CI=0.5-3.4) were reported. It is, perhaps, timely to note here that a trend may be biologically significant but not statistically significant. Strengths of this study include its size (n=14,457), the extended follow up that enables inclusion of effects with long latent periods, and the use of an internal control group to “minimise the potential for selection and socioeconomic problems associated with the use of the general population for comparison.” Limitations of the study include the fact that other solvents were used on base, though TCE was the main solvent used historically, and exposure estimates were qualitative rather than quantitative (Blair et al. 1998). Without quantitative exposure estimates, risk estimates cannot be derived.

The fourth study discussed by EPA (2001) tracked German cardboard workers exposed to TCE. This study noted an increased incidence of kidney cancer but may have been initiated after the observation of a cluster (IARC 1997). Problems associated with this study include a lack of exposure data, the use of other solvents in addition to TCE, an unadjusted incidence (EPA 2001), and differing diagnostic methodology between the cohort and comparison group (EPA 2002b).

More recently, Raaschou-Nielsen et al. (2003) reported on a Danish cohort of 40,049 blue-collar workers in 347 Danish companies with documented TCE use. The SIR for all cancers was 1.08 (95% CI-1.04-1.12). Other statistically significant SIRs were:

- 1.8 for esophageal adenocarcinoma (95% CI-1.15-2.73) among men,
- 2.8 for primary liver cancer (95% CI-1.13-5.80) among women,
- 2.8 for gallbladder and biliary passage cancer (95% CI-1.28-5.34) among women,
- 1.4 for lung cancer (95% CI-1.28-1.51) among men and
- 1.9 (95% CI-1.48-2.35) among women,
- 1.9 for cervical cancer (95% CI-1.42-2.37),
- 1.2 for non-Hodgkin's lymphoma (95% CI-1.0-1.5) among the entire cohort, and
- 1.8 for esophageal adenocarcinoma (95% CI-1.2-2.7) among the entire cohort.

A non-significant SIR of 1.7 was noted for leukemia (95% CI-0.89-2.86) in women. An obvious strength of this study is its large cohort size. Unfortunately, it suffers from a poorly chosen control group, the Danish population. The authors admit that their experimental and control groups probably differed in the proportion of individuals in each socio-economic group. Cigarette smoking is known to be higher in the least educated groups in Denmark and may be a confounding factor in this study weakening the association between TCE and lung

cancer. The authors note that social class is probably a confounding factor for cervical cancer as well. And because exposure was not quantified, risk estimates cannot be calculated.

Raaschou-Nielsen et al. (2003) as well as the three studies used by EPA (2001) report increased incidence of lymphohematopoietic cancers (non-Hodgkin's lymphoma, multiple myeloma, and leukemia). Three studies noted excesses of liver cancer. Leukemia and myeloma originate in the bone marrow while lymphoma originates in lymphatic tissues. These cancers are considered to be related because they involve the uncontrolled growth of cells with similar functions and origins. The diseases are not thought to be heritable, although a few cases of familial lymphoma have been reported, but rather to result from acquired injury to the cell, which becomes abnormal (malignant) and multiplies continuously (Bock 2004). Lymphohematopoietic cancers are basically environmentally caused diseases. Known environmental risk factors for liver cancer include aflatoxin, anabolic steroids, arsenic, cirrhosis, hepatitis, thorium dioxide, tobacco use, and vinyl chloride (ACS 2003).

Furthermore, three of these cancers have increased in incidence over the last 30 years as reported by the Surveillance, Epidemiology, and End Results (SEER) database. The incidence of non-Hodgkin's lymphoma across all races in the US increased from 11.1 per 100,000 in 1975 to 19.9 per 100,000 in 1994 with a subsequent decline to 19.0 per 100,000 in 2000. Incidence of myeloma followed a similar pattern increasing from 4.65 per 100,000 in 1973 to 6.0 per 100,000 in 1997 with a subsequent decline to 5.47 per 100,000 in 2000. Leukemia incidence actually declined from 12.5 per 100,000 in 1973 to 11.9 per 100,000 in 2000, but not by much (SEER 2003). Liver cancer has increased from 2.7 per 100,000 in

1973 to 5.3 per 100,000 in 2000 (SEER 2003). All of the above-mentioned rates are age adjusted with all age groups, 0 to 85+, used.

Genetic toxicity studies using cultured cells from exposed and unexposed individuals lend support to the epidemiological connection between TCE and lymphohematopoietic cancers in humans. As reviewed by the California Environmental Protection Agency (Cal/EPA), in some, but not all, studies using peripheral lymphocyte cultures, genetic effects were noted. These included hyperdiploidy, hypodiploidy, sister chromatid exchanges, and chromosome structural anomalies including breaks, deletions, gaps, inversions, and translocations (Cal/EPA1999).

The epidemiological evidence is, also, supported by studies in rats and mice. Cal/EPA noted, “The principal findings are: 1) liver carcinomas in male mice by inhalation and in both sexes by gavage administration; 2) lung carcinomas in female mice by inhalation; and 3) kidney tubular carcinoma in male rats by inhalation and gavage dosing.” In one study, an increased incidence of malignant lymphoma was observed in TCE-exposed female Han:NMR1 mice and, in another, TCE was associated with the development of testicular interstitial cell tumors in Marshall rats (Cal/EPA 1999).

Cal/EPA (1999) used data from two liver tumor studies in mice to generate slope factors. Using total amount of TCE metabolized by the liver, the lower 95% confidence limit on the dose associated with a 10% tumor incidence ( $LED_{10}$ ) was calculated (EPA 1996). The following four slope factors were calculated as  $0.1/LED_{10}$ :

- $2.1E-02$  in females by gavage,
- $7.7E-02$  in males by gavage,
- $4.7E-03$  in females by inhalation, and



- $3.4\text{E-}03$  in males by inhalation.

The geometric mean of these slope factors is  $1.3\text{E-}02$  per mg/kg-d which is what Cal/EPA used to calculate their public health goal for the concentration of TCE in drinking water. The author admits ignorance as to how an average value can be protective of sensitive populations. On the other hand, their public health goal of 0.8 ppb is below the routine detection limit of 1.0 ppb. Moreover, this is the slope factor which was endorsed by EPA Region 4 last year (email from Ted Simon 2003).

Risk estimates associated with the rat and mice studies were reported by EPA (2001) as well. The slope factor and risk-specific dose for kidney cancer in rats was  $3.0\text{E-}04$  and  $3.3\text{E-}03$  respectively. Slope factors and risk-specific doses for liver cancer in mice using internal TCA as the dose metric ranged from  $3.0\text{E-}02$  to  $2.0\text{E-}01$  per mg/kg-d and from  $0.5\text{E-}05$  to  $3.1\text{E-}05$  mg/kg-d respectively.

Considering both the epidemiological studies and the rat and mice studies, slope factors range from 7.0 to  $3.0\text{E-}04$  per mg/kg-day which is a 23,000 fold difference. EPA proposed ignoring the lowest and highest estimates. The remaining slope factors range from  $4.0\text{E-}01$  ( $3.22\text{E-}01$  as calculated here) to  $2.0\text{E-}02$  per mg/kg-d which is a 20 fold difference. This is slightly higher than EPA's previous slope factor of  $1.1\text{E-}02$  and Cal/EPA's,  $1.3\text{E-}02$ .

EPA (2001), following National Research Council recommendations, did not consolidate these slope factors into a single estimate. They advise selecting an appropriate slope factor from the range. For example, "Risk assessments involving the presence of risk factors such as diabetes or alcohol consumption, or high background exposure to TCE or its metabolites, would more appropriately choose a higher slope factor." An estimated 6.3% of the population in this country have diabetes (NIDDK 2003) and in Kentucky, 6.8% have

been diagnosed with it (CDC 2003). Given that diabetes is so prevalent, the higher slope factor should be chosen all the time.

Historically, EPA (1989) has been protective of sensitive populations and, in calculating reference doses, has recommended an uncertainty factor of 10 to account “for variation in the general population....intended to protect sensitive subpopulations.” Moreover, the Science Advisory Board review panel (EPA 2002b) expressed concern “for diseased individuals (diabetes, hepatitis, HIV positive, etc.), who may be especially susceptible to TCE exposure.” We are only just beginning to understand the range of human metabolic variation, the frequency of metabolic variants within the population, and what amount and kind of variation would cause susceptibility to the effects of chronic exposure to TCE (see Lipscomb et al. 2003 for an example). Until we know the frequency of metabolic variants susceptible to low level exposure to TCE we must assume that the frequency is greater than  $1.0\text{E-}06$ .

The Science Advisory Board review panel (EPA 2002b) recognized the importance of epidemiological studies, stating that they “merit special attention because they may be potentially important in terms of population-attributable risk.” Furthermore, the panel recommended that where such studies are the basis of risk estimates, they should be the ones, “among the studies that are well designed, that would generate the most health-protective number.”

EPA Region 9 (2002) lists  $4.00\text{E-}01$  per mg/kg-d as both the oral and inhalation slope factor for TCE citing NCEA as the source. In an effort to find the origin of that slope factor, I contacted EPA Environmental Health Scientist, Dr. Weihsueh Chiu, who thought it came from the 2001 draft assessment (EPA 2001 and email from Weihsueh Chiu 2004). EPA

(2001) provides two slope factors using data from Cohn et al. (1994), 4.00E-01 per mg/kg-d in Table 4-9 and 3.5E-01 per mg/kg-d in Section 4.5.1.3. A slope factor of 4.00E-01 per mg/kg-d is not associated with any other study in EPA (2001). Using the original paper (Cohn et al. 1994), it is calculated as 3.22E-01 per mg/kg-d here.

**The choice of a higher slope factor (3.22E-01 per mg/kg-d) seems easily justified.**

It is being used in EPA Region 9 and EPA Region 10 (2004) who uses Region 9's values.

The higher risk estimates are protective of sensitive populations. This specific risk estimate is based on an epidemiological study. The epidemiological studies are supported by evidence from rat, mice, and cell culture studies.

Literature Cited:

ACS. 2003. American Cancer Society, Inc.  
[http://www.cancer.org/docroot/CRI/content/CRI\\_2\\_2\\_2X\\_What\\_causes\\_liver\\_cancer\\_25.asp?nav=crl](http://www.cancer.org/docroot/CRI/content/CRI_2_2_2X_What_causes_liver_cancer_25.asp?nav=crl).  
Accessed March 1, 2004.

Anttila, A., E. Pukkala, M. Sallmen, S. Hernberg, K. Hemminki. 1995. Cancer incidence among Finnish workers exposed to halogenated hydrocarbons. J. Occup. Environ. Med. 37: 797-806.

ATSDR (1997a). Toxicological Profile for Trichloroethylene. Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health & Human Services, Atlanta, GA.

ATSDR (1997b). Toxicological Profile for Tetrachloroethylene. Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health & Human Services, Atlanta, GA.

ATSDR (2002). Draft Interaction Profile for: 1,1,1-Trichloroethane, 1,1-Dichloroethane, Trichloroethylene, and Tetrachloroethylene. Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health & Human Services, Atlanta, GA.

ATSDR (2003). ToxFAQs™ for Trichloroethylene (TCE). Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health & Human Services, Atlanta, GA. <http://www.atsdr.cdc.gov/tfacts19.html>

Blair, A., P. Hartge, P. Stewart, M. McAdams, J. Lubin. 1998. Mortality and cancer incidence of aircraft maintenance workers exposed of trichloroethylene and other organic solvents and chemicals: extended follow up. *Occup Environ Med* **55**: 161-171.

Bock, F., T. Platt, M. Siederer, P. West. 2004. The Leukemia and Lymphoma Society web site. [http://www.leukemia.org/all\\_page?item\\_id=4689](http://www.leukemia.org/all_page?item_id=4689). Accessed Feb. 13, 2004

Cal/EPA. 1999. Public Health Goal for Trichloroethylene in Drinking Water. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

CDC. 2003. Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, United States Department of Health and Human Services, Atlanta, GA.  
<http://www.cdc.gov/diabetes/statistics/prev/state/table16.htm>. Accessed March 2, 2004.

Cohn, P., J. Klotz, F. Bove, M. Berkowitz, and J. Fagliano. 1994. Drinking water contamination and the incidence of leukemia and non-Hodgkin's lymphoma. *Environ Health Perspect* **102**: 556-561.

EPA. 1989. Risk Assessment Guidance for Superfund Volume 1 Human Health Evaluation Manual (Part A) Interim Final. Office of Emergency and Remedial Response, United States Environmental Protection Agency, Washington, D. C. Pg. 7-7.  
EPA/540/1-89/002

EPA. 1996. Proposed Guidelines for Carcinogen Risk Assessment. United States Environmental Protection Agency, Washington, D. C. EPA/600/P-92/003C

EPA. 2001. Trichloroethylene Health Risk Assessment: Synthesis and Characterization. United States Environmental Protection Agency, Washington, D. C. EPA/600/P-01/002A

EPA. 2002a. National Primary Drinking Water Regulations. United States Environmental Protection Agency, Washington, D. C. <http://www.epa.gov/safewater/dwh/t-voc/trichlor.html>. Accessed Feb. 12, 2004.

EPA. 2002b. Review of Draft Trichloroethylene Health Risk Assessment: Synthesis and Characterization: An EPA Science Advisory Board Report. United States Environmental Protection Agency, Washington, D. C. EPA-SAB-EHC-03-002.

EPA Region 9. 2002. EPA Region 9 PRGs Table. United States Environmental Protection Agency Region IX, San Francisco, CA. <http://www.epa.gov/region09/waste/sfund/prg/files/02table.pdf>. Accessed March 11, 2004.

EPA Region 10. 2004.  
<http://yosemite.epa.gov/r10/cleanup.nsf/9f3c21896330b4898825687b007a0f33/98d7cd70f79714be882568f90079f6e3?OpenDocument>. Accessed March 29, 2004.

HSDB. 2004. Hazardous Substances Data Bank. National Library of Medicine, National Toxicology Information Program, Bethesda, MD. <http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~YvnQ5E:1>. Accessed Feb. 10, 2004.

Howard, P., R. Boethling, W. Jarvis, W. Meylan, E. Michalenko. 1991. Handbook of Environmental Degradation Rates. Lewis Publishers, Chelsea, Michigan. Pg. 190.

IARC. 1997. International Agency for Research on Cancer, World Health Organization, Lyon, France. <http://www-cie.iarc.fr/htdocs/monographs/vol63/trichloroethylene.htm>. Accessed Feb. 12, 2004.

King County. 2002. Detection Limits for Organic Parameters. Water and Land Resources Division, Department of Natural Resources. Seattle, WA. [http://dnr.metrokc.gov/wlr/envlab/labguide/dtcn\\_org.htm](http://dnr.metrokc.gov/wlr/envlab/labguide/dtcn_org.htm). Accessed Feb. 19, 2004.

Lipscomb, J., L. Teuschler, J. Swartout, D. Popken, T. Cox, and G. Kedderis. 2003. The impact of cytochrome P450 2E1-dependent metabolic variance on a risk-relevant pharmacokinetic outcome in humans. Risk Analysis 23(6): 1221-1238.

Newell, C. and R. Ross. 1992. Estimating Potential for Occurrence of DNAPL at Superfund Sites. United States Environmental Protection Agency, Washington, D. C. <http://www.hanford.gov/dqo/project/level5/edn.pdf>. Accessed March 2, 2004.

NIDDK. 2003. National Institute of Diabetes and Digestive and Kidney Diseases. National Diabetes Statistics fact sheet: general information and national estimates on diabetes in the United States, 2003. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health. <http://diabetes.niddk.nih.gov/dm/pubs/statistics/index.htm#7>

NIOSH. 2001. National Institute for Occupational Safety and Health, Centers for Disease Control. <http://www.cdc.gov/niosh/pel88/79-01.html>. Accessed Feb. 12, 2004.

Plunkett, E.R. 1987. Handbook of Industrial Toxicology 3<sup>rd</sup> Ed. Chemical Publishing Co. New, York, NY, Pg 544-545.

Proctor, N.H., J.P. Hughes, and M.L. Fischman. 1989. Chemical Hazards of the Workplace 2<sup>nd</sup> Ed. Van Nostrand Reinhold Co., New York. Pg 487-489.

Raaschou-Nielsen, O., J. Hansen, J. McLaughlin, H. Kolstad, J. Christensen, R. Tarone, and J. Olsen. 2003. Cancer risk among workers at Danish companies using trichloroethylene: A cohort study. American Journal of Epidemiology 158: 1182-1192.

SEER. 2003. Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER\*Stat Database: Incidence - SEER 9 Regs Public-Use, Nov 2002 Sub (1973-2000), National Cancer Institute, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 2003, based on the November 2002 submission. Accessed Feb. 13, 2004.

Shindell, S. and S. Ulrich. 1985. A cohort study of employees of a manufacturing plant using trichloroethylene. *Journal of Occupational Medicine* 27: 577-579.

TRI. 2003. Toxics Release Inventory. United States Environmental Protection Agency. <http://www.epa.gov/triexplorer>. Accessed Feb. 10, 2004.

Verschueren, K. 1983. *Handbook of Environmental Data on Organic Compounds*. Van Nostrand Reinhold Co., New York. Pg. 1132.

Wartenberg, D., D. Reyner, C. Scott. 2000. Trichloroethylene and cancer: epidemiologic evidence. *Environ Health Perspect* 108(suppl 2) 161-176.

#### **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.

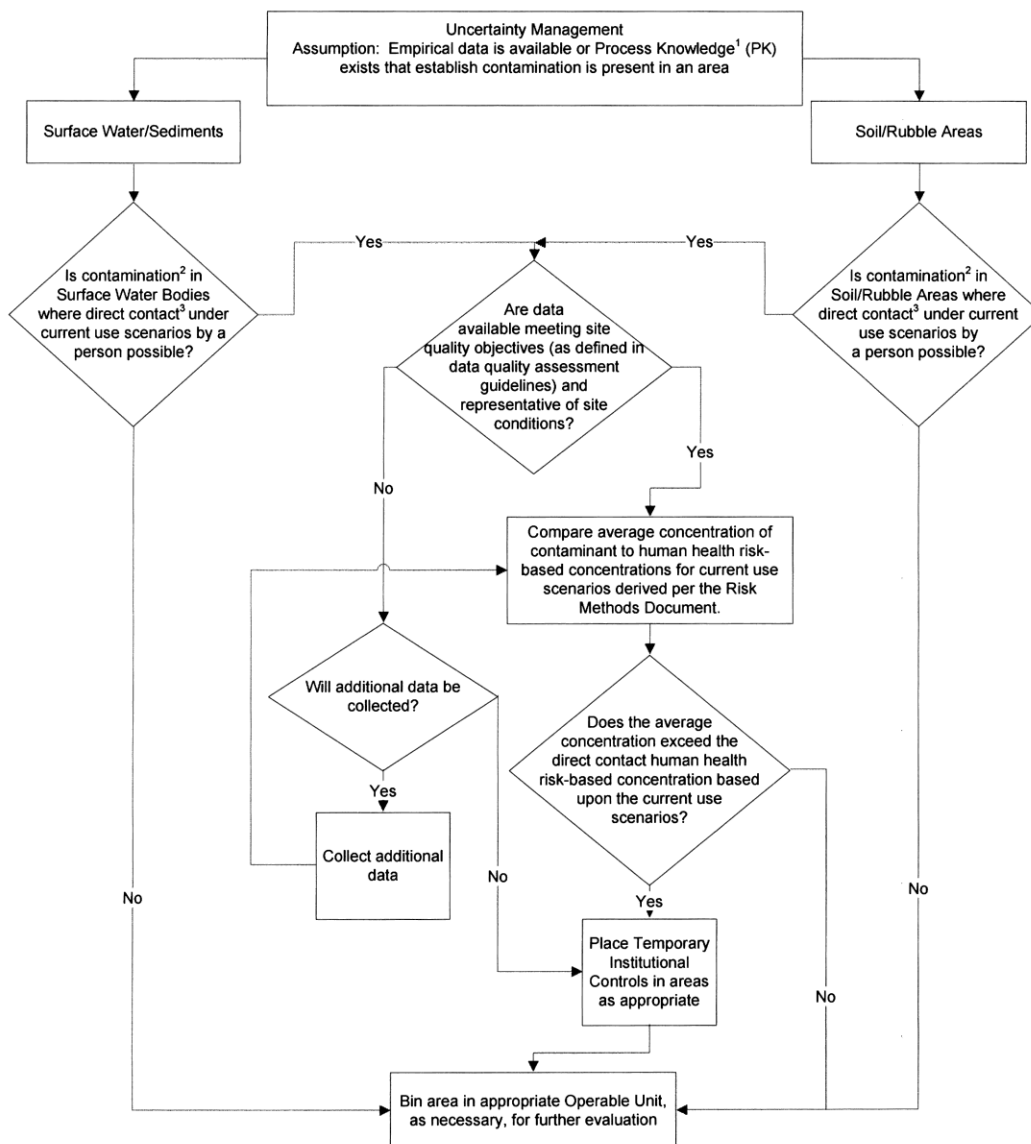
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## Enclosure

### 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.

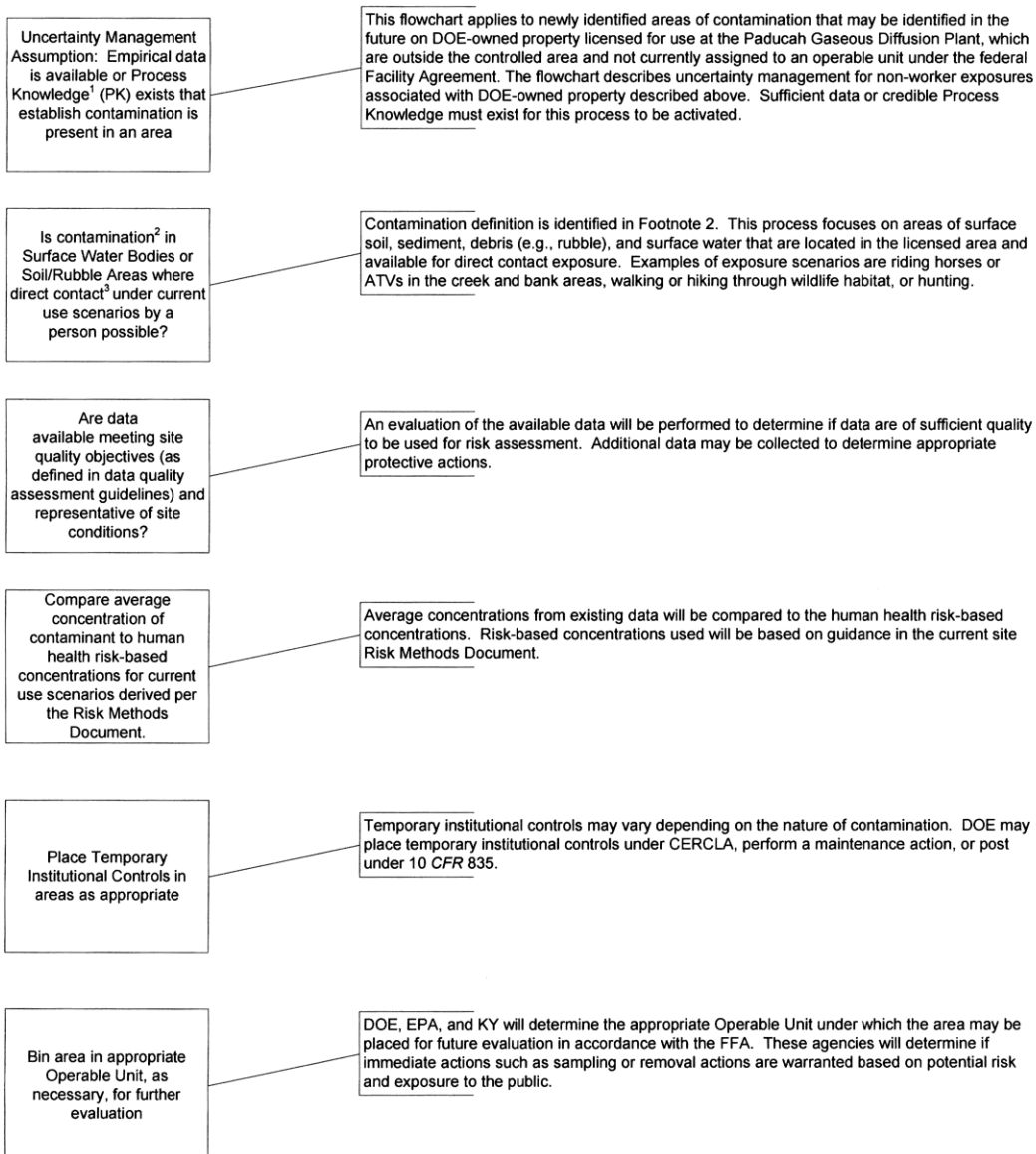


1 "Process Knowledge" is defined as information identifying releases from past or current processes at the PGDP.

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**



## **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 (issued May 2006). 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.

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## 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.

- The most likely value of the variable falls between the minimum and maximum values forming a triangular-shaped distribution and showing that values near the minimum and maximum are less likely to occur than those near the most likely values.
2. **Normal Distribution:** This is the most important distribution in the probability theory because it describes many natural phenomena (Decisioneering, Inc. 2000). Three conditions underlying this distribution are as follows:
- Some value of the variable is the most likely (the mean of the distribution).
  - The value of the variable could as likely be below the mean as it could be above the mean (symmetrical about the mean).
  - The value of the variable is more likely to be near the mean than far away.

Generally, if the coefficient of variability is less than 30%, a normal distribution is recommended. A skewness value between -0.5 and +0.5 indicates a fairly symmetrical distribution (Decisioneering, Inc. 2000).

3. **Log-Normal Distribution:** This distribution is widely used to describe a variable with values that are positively skewed (Decisioneering, Inc. 2000). The three conditions underlying this distribution are as follows:
- The variable can increase without limits but cannot fall below zero.
  - The variable is positively skewed with most of the values near the lower limit.
  - The natural logarithm of the variable yields a normal distribution

Generally, if the coefficient of variability is greater than 30%, a log-normal distribution is recommended. A skewness value less than -1 or greater than +1 indicates a highly skewed distribution (Decisioneering, Inc. 2000).

4. **Uniform Distribution:** This distribution is used to describe a variable when each value of the variable has the same probability of occurrence within a selected range. This distribution is often used when no information about variable's distribution is available. The three conditions underlying this distribution are as follows:
- The minimum value of the variable is fixed.
  - The maximum value of the variable is fixed.
  - The probability of any value being selected within the range between the minimum and maximum values is equal.

## 4. SESOIL PARAMETERS

The SESOIL software was used to simulate contaminant transport through the Upper Continental Recharge System (UCRS) to the Regional Gravel Aquifer (RGA). The parameters used for SESOIL are listed in Tables F.2.1 and F.2.2. As mentioned earlier, there are two groups of parameters. Remarks for each parameter are provided in these tables to clarify the source of the value and the justification for its selected value. Additional remarks for each variable parameter, including the values input into Crystal Ball, are provided in Table F.2.3. Finally, summary statistics for each variable parameter output by

Crystal Ball are provided in Table F.2.4. Histograms of the values output by Crystal Ball for the variable parameters are in Figs. F.2.1 through F.2.18.

1. **Fixed Parameters:** These parameters are summarized in Tables F.2.1 and F.2.2.

- **Soil Type:** The upper portion of the UCRS is loam, while the bottom portion of it is silty clay (DOE 1999). The soil type was considered to be silty loam for each area.
- **Bulk Density:** The bulk density of the UCRS is  $1.46 \text{ g/cm}^3$  (DOE 1999). The bulk density was set to this value for each area.
- **Disconnectedness Index:** The disconnected index was set to a site-specific approximate value of 10 used in earlier work. The value was estimated by calibrating the deterministic model to an average recharge of 11.38 cm/yr.
- **Porosity:** The porosity of the UCRS is 0.45 (DOE 1999). The porosity was set to this value for each area.
- **Depth to Water Table:** The depth to the water table was estimated for each area considering site-specific data. The depths were estimated as 16.76 m (55 ft), and 18.29 m (60 ft) for SWMU 1 and C-720 areas, respectively.
- **Freundlich Equation Exponent:** The Freundlich equation exponent typically ranges from 0.9 to 1.4; the default value of 1.0 is recommended if the actual value is not known (GSC 1996). The exponent was set to 1 for each area.
- **Contaminant of Concern (COC):** The COC of interest was TCE.
- **Source Area:** The source area was developed analyzing site-specific data for each area. Soil concentration for the area was analyzed layer-by-layer using SADA. A limitation of SESOIL required that all layers have the same area. Source areas and the average soil concentration in each layer were estimated, and the source area with the maximum contaminant mass was identified and set as the “uniform area.” Concentrations within each layer were then normalized against the “uniform area” (discussed later). The “uniform areas” used for SWMU 1 and the C-720 area were  $324 \text{ m}^2$  and  $1394 \text{ m}^2$ , respectively.
- **Molecular Weight:** The molecular weight was set to 131 g/gm-mol (EPA 1994).
- **Solubility in Water:** The solubility in water was set to 1100 mg/L (EPA 1996).
- **Diffusion in Air:** The diffusion in air was set to  $0.08 \text{ cm}^2/\text{sec}$  (EPA 1996).
- **Henry’s Constant:** The Henry’s constant was set to  $0.0103 \text{ atm}\cdot\text{m}^3/\text{mol}$  (EPA 1996).
- **Soil Organic Carbon/Water Partition coefficient ( $K_{oc}$ ):** The  $K_{oc}$  was set to 94 L/kg (EPA 1996).

2. **Variable Parameters:** These parameters are summarized in Tables F.2.1 through F.2.4.

- **Intrinsic Permeability:** Site-specific data were available for the vertical hydraulic conductivity of the UCRS. Therefore, the intrinsic permeability was estimated from vertical hydraulic conductivity using the following equation.

$$K = k \frac{g}{\nu} \quad (1)$$

where  $K$  = vertical hydraulic conductivity of soil,  $k$  = intrinsic permeability of soil,  $\nu$  = kinematic viscosity of water, and  $g$  = gravitational acceleration (Bear 1979). Taking  $\nu = 0.01 \text{ cm}^2/\text{sec}$  and  $g = 981 \text{ cm}/\text{sec}^2$  (Mills et al. 1985), and substituting in Equation 1 leads to

$$k (\text{cm}^2) = \frac{K (\text{cm}/\text{sec})}{9.81 \times 10^4 (1/\text{cm} - \text{sec})} \quad (2)$$

The intrinsic permeability was estimated from the saturated vertical hydraulic conductivity using Equation 2.

The site-specific vertical hydraulic conductivities measured earlier were assumed to be representative of that expected in the UCRS at each area. Summary statistics for the site-specific data are in Table F.2.3. A set of 13 results was available (DOE 1997a, DOE 1997b). These results ranged from 1.00E-08 cm/sec to 2.00E-04 cm/sec with a likeliest (mean) value of 1.64E-05 cm/sec. The coefficient of variation was estimated as 336%, and the skewness was estimated as 3.6. Next, the statistics were studied. The maximum value, when used in SESOIL produced an unreasonable recharge; therefore, a second estimate of maximum was sought through calibration. The maximum was re-estimated as 3.20E-05 through calibration to a recharge of 22 cm/yr (DOE 2000). Given that a range and a most likely value could be determined from the site-specific data, a triangular distribution was assumed. The vertical hydraulic conductivity was assumed not correlated to any other parameter. The summary statistics for the values output by Crystal Ball are in Table F.2.4. Histograms for the output values for the resulting intrinsic permeabilities for each of the two source areas are in Figs. F.2.1 and F.2.2.

- **Organic Carbon Content:** Site-specific data were available for the organic carbon content of the UCRS. The site-specific organic carbon contents measured earlier were assumed to be representative of that expected in the UCRS at each source area. Summary statistics for the site-specific data are in Table F.2.3. A set of 138 results was available. The coefficient of variation was estimated as 66%, and the skewness was estimated as 4.3. Given the coefficient of variation and skewness, a log-normal distribution was assumed. The organic carbon content was assumed not correlated to any other parameter. The summary statistics for the values output by Crystal Ball are in Table F.2.4. Histograms for the output values for organic carbon content for each of the two source areas are in Figs. F.2.3 and F.2.4.
- **Soil Concentration:** Site-specific data were available for the TCE soil concentrations in each source area. Summary statistics for each layer are in Table F.2.3. For SWMU 1, a set of 135 results was available. The coefficient of variation for these results was



estimated as 523%, and the skewness was estimated as 6.42. Given the coefficient of variation and skewness, a log-normal distribution was assumed. Using site-specific data, the correlation between Layers 1 and 2 soil concentrations was determined to be 0.92. (Please see Section 4.3 for additional discussion of correlations between layers.) Similar analyses led to choosing the log-normal distribution for Layer 1 at the C-720 area. The correlation coefficients between Layers 1 and 2 for the C-720 area were determined to be 0 and -0.50, respectively. Site-specific data were also available for the soil concentrations in Layer 2 through Layer 6. Summary statistics for each of these layers at each location are in Table F.2.3. For each layer at each location, a log-normal distribution was chosen, and correlations between layers were derived.

As mentioned earlier, a limitation of the SESOIL model required normalization of soil concentrations in each layer at each location to a “uniform area.” To accomplish this, the layer with the maximum contaminant mass at each source was used as that source’s “uniform area,” and a simple ratio was used to normalize each layer’s concentration to that of the “uniform area.” The summary statistics for the value output by Crystal Ball are in Table F.2.4. Histograms for each layer at each location are in Figs. F.2.5 through F.2.16.

- Degradation Half-Life/Degradation Rate:** Site-specific data were limited for the degradation half-life of TCE in the UCRS; therefore, a range of half-lives estimated for the RGA (3.2 to 11.3 years) were selected with uniform distribution for the UCRS. (Please see Attachment F.3 of Appendix F for additional information on the estimation of degradation half-life of TCE in the RGA at PGDP.) The degradation half-life was assumed not correlated to any other parameter. Summary statistics for the values output by Crystal Ball are in Table F.2.4. Histograms of the output values for degradation rate for each of the two source areas are in Figs. F.2.17 and F.2.18. Note that only histograms of degradation rate are presented because the rate, and not the half-life, was the value input into SESOIL. Where, the degradation rate is derived from the degradation half-life using the following expression:

$$\lambda = \frac{\ln 2}{t_{1/2}} \quad (3)$$

where  $\lambda$  = degradation rate ( $\text{day}^{-1}$ ), and  $t_{1/2}$  = degradation half-life (days).

An additional scenario termed the “fixed degradation scenario” was also assessed in the probabilistic analysis. The degradation half-life was set equal to 26.6 years for these runs, while the remaining parameters listed above were allowed to vary.

## 5. AT123D PARAMETERS AND SOURCE TERM MODELING PARAMETERS

The AT123D software was used to simulate contaminant transport from the source areas through the RGA to the POEs. The parameters used for AT123D modeling are listed in Tables F.2.5, F.2.6, and F.2.7. Remarks for each parameter are provided in the table to clarify the source and justification of selected values. Additional remarks for each variable parameter are provided in Table F.2.8. Finally, the summary

statistics for each variable parameter sampled output by Crystal Ball and used in the runs for AT123D and source term modeling are provided in Table F.2.9. Histograms of the values output by Crystal Ball for the variable parameters are in Figs. F.2.19 through F.2.24.

1. **Fixed Parameters:** These parameters are summarized in Tables F.2.5, F.2.6, and F.2.7.

- **Dispersivity:** The longitudinal dispersivity was set to 1.5 m for each area (DOE 1999). Similarly, the transverse (lateral) dispersivity and the vertical dispersivity were set to 1.5 m and 0.03 m, respectively, for the area.
- **Bulk Density:** The bulk density of the RGA is 1670 kg/m<sup>3</sup> (DOE 1999). The bulk density was set to this value for each area.
- **Density of Water:** The density of water was set to 1000 kg/m<sup>3</sup> (Mills et al. 1985).
- **COC:** As mentioned earlier, the COC was TCE.
- **Source Area:** The area used in AT123D modeling for each source was the “uniform area” developed for the source in SESOIL modeling.
- **Diffusion in Water:** The diffusion in water was set to 3.28E-6 m<sup>2</sup>/hr (EPA 1996).
- **K<sub>oc</sub>:** As mentioned earlier, the K<sub>oc</sub> was set to 94 L/kg (EPA 1996).
- **Distance to POEs:** The distance from the center of each source area to the POEs was estimated from plant maps. Each of the POEs was placed at the centerline of the estimated path of contaminant migration.

2. **Variable Parameter:** These parameters are summarized in Tables F.2.5 through F.2.9.

- **Aquifer Depth (Thickness):** The aquifer depth was allowed to vary in order to account for changes in the thickness of RGA as a contaminant migrates from a source area to the Ohio River. Site-specific data were available from field measurements, and these data were assumed to be applicable to the RGA at each source area and along the estimated contaminant flow paths. A set of 24 results was available. The coefficient of variation was estimated as 31%, and the skewness was estimated as -0.61. Given the coefficient of variation and skewness, the distribution was assumed to be normal. The aquifer depth was assumed not correlated to any other parameter. Summary statistics for the values output by Crystal Ball<sup>®</sup> and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for aquifer depth is in Fig. F.2.19. (Note that each source area used the same set of parameters in AT123D modeling; therefore, only one histogram is presented for each of the AT123D variable parameters.)
- **Hydraulic Conductivity:** Site specific data were available for the hydraulic conductivity of the RGA, and these data were assumed to be applicable to the RGA at each source area and along the contaminant flow paths. A set of 62 results was available. The data ranged from 1.00E-04 ft/day to 8.50E+05 ft/day with a likeliest value of 1.93E+04 ft/day. The coefficient of variation was estimated as 563%, and the skewness was estimated as 7.53. A value of 1500 ft/day was used in DOE 1999. During model set-up, the range was judged to be too variable given the site-specific soil condition, and a second estimate was

sought from the PGDP groundwater flow model. This estimate was developed using an analysis based upon a plan area from the PGDP site-wide groundwater model and the path of contaminant migration from the source areas to the Ohio River (please see Fig.5.1 of the main report). Based upon this analysis, the minimum, maximum, and most likely values chosen were 75, 1500, and 967 ft/day, respectively. The coefficient of variation was estimated as 65%, and the skewness was estimated as -0.35. Subsequently, the selected most likely value was determined to be inconsistent with probable site conditions, and after consultation with site experts this value was changed to 350 ft/day (i.e., the geometric mean of the minimum and maximum in the plan area). The standard deviation was assumed equal to the likeliest value yielding a coefficient of variation of 100%. Given this coefficient of variation and the skewness from the earlier analyses (i.e., that related to site-specific data and plan area), a log-normal distribution was assumed. In addition, the hydraulic conductivity was assumed correlated to the hydraulic gradient and the porosity. The correlation coefficients selected by site experts were -0.50 and 0.20 for correlating the hydraulic conductivity to the hydraulic gradient and to the porosity, respectively. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for hydraulic conductivity is in Fig. F.2.20.

**Hydraulic Gradient:** Site-specific data were available for the hydraulic gradient of the RGA, and these data were assumed applicable to the RGA at each source area and along the contaminant flow paths. A set of 12 results was available. The coefficient of variation was estimated as 111%, and the skewness was estimated as 1.95. Given the coefficient of variation and skewness, a log-normal distribution was assumed with minimum, maximum, and most likely values of 1.00E-04, 4.00E-03, and 1.01E-03 m/m, respectively. The standard deviation was set at 1.12E-03 m/m. Additionally, the hydraulic gradient was assumed correlated to the hydraulic conductivity and the porosity. The correlation coefficients were assumed as -0.50 and -0.20 for correlating the hydraulic gradient to the hydraulic conductivity and to the porosity, respectively. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for hydraulic gradient is in Fig. F.2.21.

**Effective Porosity:** Site-specific data were available for the porosity of the RGA; therefore, the effective porosity was estimated from the porosity using a conversion value of 81% taken from DOE 1999. [In that report, an effective porosity of 0.30 and a porosity of 0.37 were reported (i.e.,  $0.30/0.37 = 0.81$  or 81%).] The data were assumed applicable to the RGA at each source area and along the contaminant flow paths. A set of 28 results was available. The minimum, maximum, and most likely values selected for porosity were 27, 54, and 39%. The coefficient of variation was estimated as 15%, and the skewness was estimated as 0.43. Given the coefficient of variation and skewness, a normal distribution was assumed. Additionally, the porosity was assumed correlated to the hydraulic conductivity and the hydraulic gradient. The correlation coefficients were assumed as 0.20 and -0.20 for correlating the porosity to the hydraulic conductivity and to the hydraulic gradient, respectively. Summary statistics for the values output by Crystal Ball® and the resulting effective porosity values used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the effective porosity values is in Fig. F.2.22<sup>1</sup>. Note that only a histogram of effective porosity is presented because effective porosity and not porosity was the value input into AT123D.

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<sup>1</sup> Future groundwater modeling efforts at PGDP will utilize 35% as a practical upper-bound for effective porosity values.

- Organic Carbon Content:** Site-specific data were available for the organic carbon content of the RGA, and these data were assumed applicable to the RGA at each source area and along the contaminant flow paths. A set of 38 results was available. The minimum, maximum, and most likely values selected were 3.0E-03, 2.53E-01, and 3.5E-02%, respectively. The coefficient of variation was estimated as 1.05%, and the skewness was estimated as 4.0. Given the coefficient of variation and skewness, a log-normal distribution was assumed. The organic carbon content was assumed not correlated to any other parameter. Summary statistics for the values output by Crystal Ball<sup>®</sup> and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for organic carbon content is in Fig. F.2.23.
- Degradation Half-Life:** Recently, as part of response actions, the U.S. Department of Energy (DOE) has developed revised biodegradation rates that were incorporated into the SI modeling. Attachment F.3 to this appendix presents a detailed discussion of the derivation of the degradation rates. Additionally, the degradation half-life was observed to be correlated with groundwater flow which is a direct function of hydraulic conductivity and hydraulic gradient. However, for this analysis the degradation half-life was assumed 100% correlated to the hydraulic gradient. Summary statistics for the values output by Crystal Ball<sup>®</sup> and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for degradation rate is in Fig. F.2.24. Note that only histograms of degradation rate are presented because the rate, and not the half-life, was the value input into AT123D. It should be noted here that although hydraulic gradient assumed a normal distribution, Crystal Ball output for degradation rate presented in Fig. F.2.24 does not appear to be normally distributed. An additional scenario termed the “fixed degradation scenario” was also assessed in the probabilistic analysis. No degradation was assumed for these runs, while the remaining parameters listed above were allowed to vary.

## 6. CORRELATION MATRIX

As mentioned earlier, the soil concentration in each layer was assumed correlated to the adjacent layers for a given area. To estimate the correlation coefficient between two adjacent layers, sets of ordered pairs of concentrations were analyzed. Because data were sparse, ordered pairs were difficult to establish using the sampling date; therefore, the source developed using SADA was used for the estimation. For SADA data, the size and shape of the source areas in the adjacent layers differed; therefore, an ordered pair was formed only in the parts of the source where two layers overlapped.

The correlation values are presented in Table F.2.3.

## 7. SENSITIVITY ANALYSIS

Although there was not any sensitivity analysis performed under this task to select the parameters that were allowed to vary, previous groundwater modeling efforts at the PGDP have included sensitivity analyses of several of the parameters input into SESOIL and AT123D in order to understand some of the modeling uncertainties. The analyses are included in these documents:

- U-Landfill Design and Analysis (DOE 2002)
- $K_d$ -Sensitivity Analysis (SAIC 2002)
- Northeast and Northwest Plume Groundwater Modeling (BJC 2003)
- Recharge- and Ohio River Stage-Sensitivity Analysis (DOE 2002)

Based on these analyses, the following parameters were determined to be the most sensitive parameters for fate and transport modeling using SESOIL and AT123D:

- Contaminant's concentration in the soil/source term,
- Contaminant's degradation half-life,
- Contaminant's distribution coefficient ( $K_d$ ) (i.e., directly related to the organic carbon content of source soils for organic compounds)
- Percolation rate (controlled by source vertical permeability)
- Saturated hydraulic conductivity,
- Hydraulic gradient,
- Effective porosity, and
- Aquifer thickness

The contaminant concentration in the source term is one of the most sensitive parameters; increasing the source term concentration increases the predicted groundwater concentration at the POE by increasing contaminant flux and lengthening the time required for depletion of contaminant in the source. The percolation rate is also a very sensitive parameter; increasing the percolation rate results in increased contaminant flux to the RGA and, potentially, a greater peak concentration at the POE. An increased percolation rate, however, is related to faster depletion of contaminant in the source. The contaminant's distribution coefficient,  $K_d$ , is a very sensitive parameter for the SESOIL and AT123D models and may rank only behind contaminant concentration in terms of importance. Sensitivity analyses have shown that increasing the  $K_d$  of any layer included in the SESOIL model or of the RGA included in the AT123D model decreases contaminant concentrations at the POE because of retardation and attenuation due to sorption. Therefore, with higher  $K_d$ 's the rate of source depletion is slowed, and the time required for source depletion is increased. Degradation half-life is also important if the time taken for source depletion or required for contaminant migration from the source to the POE is long relative to the contaminant's degradation half-life (i.e., 3 or more times half-life). This is the case because, under this condition, the rate of contaminant degradation in the source or as the contaminant migrates from the source to the POE results in markedly lower contaminant concentrations at the POE.

For AT123D modeling, the earlier sensitivity analyses have identified three additional input parameters. These parameters are hydraulic conductivity, hydraulic gradient, and effective porosity. In the AT123D model, hydraulic conductivity, hydraulic gradient, and effective porosity work together to control seepage velocity (i.e., seepage velocity equals hydraulic conductivity times hydraulic gradient divided by effective porosity), and an increase in seepage velocity increases the rate of contaminant migration to the POE. The values chosen for the Southwest Plume model indicates that the hydraulic gradient varies over a relatively narrow range in the RGA. Therefore, the impact of hydraulic gradient on seepage velocity is expected to be relatively smaller than that of hydraulic conductivity. Table 2.10

presents an overall summary of qualitative sensitivity of modeling results to input parameters for this analysis.

## 8. REFERENCES

- BJC (BechtelJacobs Company, LLC) 2003. *Quarterly Modeling Report for the Second Quarter Calendar Year 2003 for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-559.
- BJC 2001a. C-746-U Solid Waste Landfill Groundwater Monitoring Plan Paducah Gaseous Diffusion Plant Paducah, Kentucky, BJC/PAD-205/R1, December.
- BJC 2001b. Groundwater Monitoring Plan for the C-746-S Residential Landfill, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, BJC/PAD-268/R1, December.
- Bonazountas, M., and J. Wagner 1984. *SESOIL: A Seasonal Soil Compartment Model*, prepared for the U.S. Environmental Protection Agency, Office of Toxic Substances. Arthur D. Little, Inc., Cambridge, MA.
- Decisioneering, Inc. 2000. Crystal Ball® 2000: A user friendly graphically oriented forecasting and risk analysis program. 1515 Arapahoe Street, Denver, CO.
- DOE (U.S. Department of Energy) 1995. *Northeast Plume Preliminary Characterization Summary Report*, DOE/OR/07-1339/V2&D2, July.
- DOE, 1997a. *Ground-Water Conceptual Model for the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/06-1628&D0, August.
- DOE, 1997b. *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the PGDP Paducah, Kentucky*, DOE/OR/07-1549&D1, February.
- DOE 1999. *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1777/V4&D2, U.S. Department of Energy, June.
- DOE 1999a. *Remedial Investigation Report for Waste Area Grouping 6 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1727V1&D2, May.
- DOE 1999b. *Remedial Investigation Report for Waste Area Grouping 27 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1777V1&D2, June.
- DOE 1999c. *Remedial Investigation Report for Waste Area Grouping 6 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1727V2&D2, May.
- DOE 2000. *Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1857&D1, July.

- DOE 2000a. *Data Report for the Sitewide Remedial Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1845/D1, January.
- DOE 2000b. *Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1895/V2&D1, September.
- DOE 2002. *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2041&D2.
- DOE 2003. *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*. DOE/OR/07-2041&D2R1.
- DOE 2004. *Site Investigation Report for the Southwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2180&D0, October.
- EPA (Environmental Protection Agency) 1994. Risk Reduction Engineering Laboratory (RREL) Treatability Database, ver. 5.0, Office of Research and Development, Cincinnati, OH.
- EPA 1996. *Soil Screening Guidance: Technical Background Document*, Office of Solid Waste and Emergency Response, Washington, DC.
- GSC (General Sciences Corporation) 1996. RISKPRO®'s SESOIL for Windows, General Sciences Corporation, Laurel, MD.
- GSC 1998. RISKPRO®'s AT123D for Windows, Version 3.2. General Sciences Corporation, Laurel, MD.
- Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko, 1991. *Environmental Degradation Rates*, Lewis Publishers, Inc., Chelsea, MI.
- KY 1992a. *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III*, KY/E-150, November 25.
- KY 1992b. *Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant*, KY/SUB/13B-97777C P-03/1991/1, April.
- KY 1997. *Analysis and Interpretation of Water Levels in Observation Wells at the Paducah Gaseous Diffusion Plant 1990-1997*, KY/EM-210, June 30.
- LMES (Lockheed Martin Energy Systems) 1997. *Evaluation of Natural Attenuation Processes for Trichloroethylene and Technetium-99 in the Northeast and Northwest Plumes at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-113, Lockheed Martin Energy Systems.
- Mills, W. B., D. B. Porcella, M. J. Unga, S.A. Gherini, K. V. Summers, Lingfung Mok, G. L. Rupp, G. L. Bowie, and D. A. Hadith 1985. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants*, Parts II, EPA-600/6-85/002b, September, U. S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development, Athens, GA.

- SAIC (Science Applications International Corporation) 2002. Final White Paper on *Sensitivity Analysis on Distribution Coefficient ( $K_d$ ) Values for TCE and Tc-99 with the Regional Flow and Transport Model at the Paducah Gaseous Diffusion Plant*, submitted to BJC on June 2002.
- UT (University of Tennessee) 2002. Spatial Analysis and Decision Assistance (SADA), Version 2.3, User Guide, January. Accessible at <http://www.tiem.utk.edu/~sada/>.
- Yeh, G. T. 1981. *AT123D: Analytical Transient One-, Two-, and Three-Dimensional Simulation of Waste Transport in the Aquifer System*, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN, Publication No. 1439.



Table F.2.1. Sil-specific parameters for SESOIL modeling (see Table F.46a)

Input Parameter	Unit	SWMU 1	C-720 Building	Remark
Soil Type	-	Silty Loam	Silty Loam	DOE 1999
Bulk Density	g/cm <sup>3</sup>	1.46	1.46	DOE 1999
Intrinsic Permeability	cm <sup>2</sup>	Variable	Variable	Probabilistic method
Disconnectedness Index	-	10	10	Site-specific (to PGDP) approximate value used in earlier work
Porosity	-	0.45	0.45	DOE 1999
Depth to Water Table	m	16.76	18.29	Site-specific (to RGA) field data
Organic Carbon Content	%	Variable	Variable	Probabilistic method
Freundlich Equation Exponent	-	1	1	Default

DOE 1999. Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky, DOE/OR/07-1777/N4&D2, June.  
DOE 2000. Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Paducah, Kentucky, DOE/OR/07-1857&D1, July.

Table F.2.2. Chemical-specific parameters for SESOIL modeling (see Table F.46b)

Input Parameter	Unit	SWMU 1	C-720 Building	Remark
Contaminant of Concern	-	Trichloroethene	Trichloroethene	
Source Area	m <sup>2</sup>	324	1394	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 1	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 2	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 3	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 4	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 5	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 6	mg/kg	Variable	Variable	Probabilistic method
Molecular Weight	g/gmol	131	131	EPA 1994
Solubility in Water	mg/L	1100	1100	EPA 1996
Diffusion in Air	cm <sup>2</sup> /s	0.08	0.08	EPA 1996
Henry's Constant	atm.m <sup>3</sup> /mol	0.0103	0.0103	EPA 1996
K <sub>oc</sub>	L/kg	94	94	EPA 1996
Degradation Rate	day <sup>-1</sup>	Variable	Variable	Probabilistic method

DOE 1999, *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1777/V4&D2, June.  
EPA 1994, Risk Reduction Engineering Laboratory (RREL) Treatability Database, ver. 5.0, Office of Research and Development, Cincinnati, OH.  
EPA 1996, *Soil Screening Guidance: Technical Background Document*, Office of Solid Waste and Emergency Response, Washington, DC.

Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building	Remark
Vertical Hydraulic Conductivity <sup>a</sup>	Minimum	cm/sec	1.00E-08	1.00E-08	DOE 1997a, DOE 1997b
	Likeliest	cm/sec	1.64E-05	1.64E-05	DOE 1997a, DOE 1997b
	Maximum	cm/sec	2.00E-04	2.00E-04	<sup>b</sup> DOE 1997a, DOE 1997b
	Standard Deviation	cm/sec	5.52E-05	5.52E-05	DOE 1997a, DOE 1997b
	Count	#	13	13	DOE 1997a, DOE 1997b
	Coefficient of Variation	%	336.49	336.49	DOE 1997a, DOE 1997b
	Skew	-	3.60	3.60	DOE 1997a, DOE 1997b
	Maximum	cm/sec	3.20E-05	3.20E-05	DOE 1997a, DOE 1997b
	Distribution	-	Triangular	Triangular	<sup>c,d</sup> Recharge-specific (to RGA) calibration
	Correlation Pair	-	None	None	See Section 4.0, Intrinsic Permeability
Organic Carbon Content	Correlation Coefficient	-	NA	NA	None
	Minimum	%	2.48E-02	2.48E-02	NA
	Likeliest	%	8.01E-02	8.01E-02	Site-specific (to PGDP) field data
	Maximum	%	4.55E-01	4.55E-01	Site-specific (to PGDP) field data
	Standard Deviation	%	5.27E-02	5.27E-02	Site-specific (to PGDP) field data
	Count	#	138	138	Site-specific (to PGDP) field data
	Coefficient of Variation	%	65.82	65.82	Site-specific (to PGDP) field data
	Skew	-	4.30	4.30	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	None	None	See Section 4.0, Organic Carbon Content
Soil Concentration - Layer 1	Correlation Coefficient	-	NA	NA	NA
	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	2.14E+00	1.56E+00	Site-specific (to PGDP) field data
	Maximum	mg/kg	8.70E+01	1.70E+01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.12E+01	5.12E+00	Site-specific (to PGDP) field data
	Count	#	135	11	Site-specific (to PGDP) field data
	Coefficient of Variation	%	522.90	328.48	Site-specific (to PGDP) field data
	Skew	-	6.42	3.32	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	see Layer 2	see Layer 2	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 2	Correlation Coefficient	-	see Layer 2	see Layer 2	Site-specific (to TCE) SADA analysis

Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45) (continued)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building	Remark
Soil Concentration - Layer 2	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	1.59E+01	1.22E+00	Site-specific (to PGDP) field data
	Maximum	mg/kg	4.39E+02	1.90E+01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	7.87E+01	4.23E+00	Site-specific (to PGDP) field data
	Count	#	31	36	Site-specific (to PGDP) field data
	Coefficient of Variation	%	494.84	347.17	Site-specific (to PGDP) field data
	Skew	-	5.53	3.81	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 1 and Layer 2	Layer 1 with Layer 2	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	9.20E-01	-5.00E-01	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 3	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	7.60E+00	5.94E+00	Site-specific (to PGDP) field data
	Maximum	mg/kg	8.50E+01	6.80E+01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.82E+01	1.54E+01	Site-specific (to PGDP) field data
	Count	#	32	23	Site-specific (to PGDP) field data
	Coefficient of Variation	%	238.82	258.66	Site-specific (to PGDP) field data
	Skew	-	3.15	3.49	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 2 and Layer 3	Layer 2 with Layer 3	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	3.50E-01	5.90E-01	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 4	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	5.12E+00	3.87E-01	Site-specific (to PGDP) field data
	Maximum	mg/kg	7.40E+01	1.80E+00	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.46E+01	6.50E-01	Site-specific (to PGDP) field data
	Count	#	27	33	Site-specific (to PGDP) field data
	Coefficient of Variation	%	285.55	168.18	Site-specific (to PGDP) field data
	Skew	-	4.37	1.44	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 3 and Layer 4	Layer 3 with Layer 4	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	2.10E-01	1.60E-01	Site-specific (to TCE) SADA analysis

Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45) (continued)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building	Remark
Soil Concentration - Layer 5	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	5.95E+00	2.00E-01	Site-specific (to PGDP) field data
	Maximum	mg/kg	6.60E+01	1.30E+00	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.42E+01	3.69E-01	Site-specific (to PGDP) field data
	Count	#	33	30	Site-specific (to PGDP) field data
	Coefficient of Variation	%	238.99	184.61	Site-specific (to PGDP) field data
	Skew	-	3.24	2.04	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 4 with Layer 5	Layer 4 with Layer 5	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 6	Correlation Coefficient	-	4.00E-01	9.90E-01	Site-specific (to TCE) SADA analysis
	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	7.20E-01	1.17E-01	Site-specific (to PGDP) field data
	Maximum	mg/kg	3.40E+00	6.30E-01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.07E+00	2.04E-01	Site-specific (to PGDP) field data
	Count	#	12	16	Site-specific (to PGDP) field data
	Coefficient of Variation	%	148.61	174.34	Site-specific (to PGDP) field data
	Skew	-	1.71	1.61	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
Degradation Half-life	Correlation Pair	-	Layer 5 with Layer 6	Layer 5 with Layer 6	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	9.20E-01	5.00E-01	Site-specific (to TCE) SADA analysis
	Minimum	yr	3.20E+00	3.20E+00	See Attachment F.3
	Likeliest	yr	NA	NA	NA
	Maximum	yr	1.13E+01	1.13E+01	See Attachment F.3
	Standard Deviation	yr	NA	NA	NA
	Distribution	-	Uniform	Uniform	See Section 4.0, Degradation Half-Life
	Correlation Pair	-	None	None	See Section 4.0, Degradation Half-Life
	Correlation Coefficient	-	NA	NA	NA

**Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45) (continued)**

- <sup>a</sup> Field observation was available for vertical hydraulic conductivity. Therefore, intrinsic permeability was estimated from vertical hydraulic conductivity.
- <sup>b</sup> The maximum from DOE 1997a and DOE 1997b was judged to be high and was re-estimated through calibration.
- <sup>c</sup> The maximum was estimated through calibration to a recharge of 22 cm/yr (DOE 2000).
- <sup>d</sup> The value selected for probabilistic method.
- Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko, *Environmental Degradation Rates*, Lewis Publishers, Inc. Chelsea, MI, 1991.
- LMES (Lockheed Martin Energy Systems) 1997. *Evaluation of Natural Attenuation Processes for Trichloroethylene and Technetium-99 in the Northeast and Northwest Plumes at the Paducah Gaseous Diffusion Plant*, Paducah, Kentucky, KY/EM-113.
- DOE, 1997a. *Ground-Water Conceptual Model for the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/06-1628&D0, August.
- DOE, 1997b. *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the PGDP Paducah, Kentucky*, DOE/OR/07-1549&D1, February.
- DOE 2000. *Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1857&D1, July.

**Table F.2.4. Statistics of variable inputs used in Monte Carlo runs for SESOIL modeling (see Table F.47)**

<b>Input Parameter</b>	<b>Statistics</b>	<b>Unit</b>	<b>SWMU 1</b>	<b>C-720 Building</b>
Vertical Hydraulic Conductivity <sup>a</sup>	Minimum	cm/sec	2.75E-06	2.75E-06
	Median	cm/sec	1.64E-05	1.64E-05
	Maximum	cm/sec	2.82E-05	2.83E-05
	Arithmetic Mean	cm/sec	1.60E-05	1.58E-05
	Standard Deviation	cm/sec	6.57E-06	6.73E-06
Intrinsic Permeability <sup>a</sup>	Minimum	cm <sup>2</sup>	2.80E-11	2.80E-11
	Median	cm <sup>2</sup>	1.67E-10	1.67E-10
	Maximum	cm <sup>2</sup>	2.87E-10	2.89E-10
	Arithmetic Mean	cm <sup>2</sup>	1.63E-10	1.61E-10
	Standard Deviation	cm <sup>2</sup>	6.70E-11	6.86E-11
Organic Carbon Content <sup>b</sup>	Minimum	mg/kg	2.53E+02	2.67E+02
	Median	mg/kg	6.76E+02	6.86E+02
	Maximum	mg/kg	2.78E+03	3.47E+03
	Arithmetic Mean	mg/kg	7.90E+02	8.37E+02
	Standard Deviation	mg/kg	4.71E+02	5.14E+02
Organic Carbon Content (%) <sup>b</sup>	Minimum	%	2.53E-02	2.67E-02
	Median	%	6.76E-02	6.86E-02
	Maximum	%	2.78E-01	3.47E-01
	Arithmetic Mean	%	7.90E-02	8.37E-02
	Standard Deviation	%	4.71E-02	5.14E-02
Soil Concentration - Layer 1 <sup>c</sup>	Minimum	mg/kg	2.86E-03	2.33E-03
	Median	mg/kg	5.73E-01	2.37E-01
	Maximum	mg/kg	3.58E+01	4.63E+00
	Arithmetic Mean	mg/kg	2.37E+00	6.46E-01
	Standard Deviation	mg/kg	5.15E+00	1.03E+00
Soil Concentration - Layer 2 <sup>c</sup>	Minimum	mg/kg	6.03E-02	5.20E-03
	Median	mg/kg	3.64E+00	2.14E-01
	Maximum	mg/kg	1.88E+02	5.80E+00
	Arithmetic Mean	mg/kg	1.41E+01	5.95E-01
	Standard Deviation	mg/kg	3.09E+01	1.12E+00
Soil Concentration - Layer 3 <sup>c</sup>	Minimum	mg/kg	1.28E-01	2.34E-02
	Median	mg/kg	5.80E+00	1.67E+00
	Maximum	mg/kg	1.02E+02	4.82E+01
	Arithmetic Mean	mg/kg	1.14E+01	5.08E+00
	Standard Deviation	mg/kg	1.63E+01	8.66E+00
Soil Concentration - Layer 4 <sup>c</sup>	Minimum	mg/kg	1.28E-01	5.11E-03
	Median	mg/kg	2.78E+00	7.76E-02
	Maximum	mg/kg	1.15E+02	5.91E-01
	Arithmetic Mean	mg/kg	8.93E+00	1.24E-01
	Standard Deviation	mg/kg	1.62E+01	1.23E-01
Soil Concentration - Layer 5 <sup>c</sup>	Minimum	mg/kg	1.26E-01	1.01E-03
	Median	mg/kg	4.39E+00	3.56E-02
	Maximum	mg/kg	7.50E+01	4.01E-01
	Arithmetic Mean	mg/kg	1.04E+01	6.09E-02
	Standard Deviation	mg/kg	1.44E+01	6.68E-02

**Table F.2.4. Statistics of variable inputs used in Monte Carlo runs for SESOIL modeling  
(see Table F.47) (continued)**

<b>Input Parameter</b>	<b>Statistics</b>	<b>Unit</b>	<b>SWMU 1</b>	<b>C-720 Building</b>
Soil Concentration - Layer 6 <sup>c</sup>	Minimum	mg/kg	5.30E-02	7.50E-04
	Median	mg/kg	1.04E+00	1.95E-02
	Maximum	mg/kg	6.65E+00	1.92E-01
	Arithmetic Mean	mg/kg	1.55E+00	3.31E-02
	Standard Deviation	mg/kg	1.53E+00	3.63E-02
Degradation Half-Life <sup>d</sup>	Minimum	yr	3.2	3.2
	Median	yr	4.9	4.9
	Maximum	yr	11.3	11.3
	Arithmetic Mean	yr	4.9	4.9
	Standard Deviation	yr	NA	NA
Degradation Rate <sup>d</sup>	Minimum	/hr	7.13E-06	7.21e-06
	Median	/hr	1.22E-05	1.13E-05
	Maximum	/hr	2.43E-05	2.43E-05
	Arithmetic Mean	/hr	1.32E-05	1.30E-05
	Standard Deviation	/hr	NA	NA

<sup>a</sup> Intrinsic permeability (cm<sup>2</sup>) was estimated from the vertical hydraulic conductivity (cm/sec) using a conversion factor of 1.019E-5.

<sup>b</sup> Organic carbon content (%) was estimated from organic carbon content (mg/kg) using a conversion factor of 1E-4.

<sup>c</sup> Soil concentrations are normalized using the volume of the layer with the largest mass.

<sup>d</sup> Degradation rate was estimated from degradation half-life in units of days using the formula: rate = [(ln 2)/degradation half-life].



**Table F.2.5. Hydrogeology-specific parameters for AT123D modeling (see Table F.49)**

<b>Input Parameter</b>	<b>Unit</b>	<b>SWMU 1</b>	<b>C-720 Building</b>	<b>Remark</b>
Aquifer Thickness	m	Variable	Variable	Probabilistic method
Hydraulic Conductivity	m/hr	Variable	Variable	Probabilistic method
Hydraulic Gradient	m/m	Variable	Variable	Probabilistic method
Effective Porosity	-	Variable	Variable	Probabilistic method
Organic Carbon Content	%	Variable	Variable	Probabilistic method
Dispersivity - Longitudinal	m	15	15	DOE 1999
Dispersivity - Transverse	m	1.5	5	DOE 1999
Dispersivity - Vertical	m	0.03	5	DOE 1999
Bulk Density	kg/m <sup>3</sup>	1670	1670	DOE 1999
Density of Water	kg/m <sup>3</sup>	1000	1000	Mills et al. 1985

DOE 1999. *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1777/N4&D2, June.

Mills, W. B., D. B. Porcella, M. J. Unga, S. A. Gherini, K. V. Summers, Lingfung Mok, G. L. Rupp, G. L. Bowie, and D. A. Hadith, 1985.

*Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants, Parts II*, EPA-600/6-85/002b, September.

U.S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development, Athens, GA.

**Table F.2.6. Chemical-specific parameters for AT123D modeling (see Table F.49)**

<b>Input Parameter</b>	<b>Unit</b>	<b>SWMU 1</b>	<b>C-720 Building</b>	<b>Remark</b>
Contaminant of Concern	-	Trichloroethene	Trichloroethene	Selected for analysis
Source Area	m <sup>2</sup>	324	1394	Site-specific (to TCE) SADA analysis
Diffusion in Water	m <sup>2</sup> /hr	3.28E-06	3.28E-06	EPA 1996
Koc	L/kg	94	94	EPA 1996
Degradation Rate (half-life) <sup>a</sup>	hr <sup>-1</sup> (year)	Variable	Variable	Attachment F.3

<sup>a</sup> Degradation rate was estimated from degradation half-life (see text).

EPA 1996. *Soil Screening Guidance: Technical Background Document*, Office of Solid Waste and Emergency Response, Washington, D.C.

**Table F.2.7. POE-specific parameters for AT123D modeling (see Table F.51)**

<b>Input Parameter</b>	<b>Unit</b>	<b>SWMU 1</b>	<b>C-720 Area</b>	<b>Remark</b>
Distance to Plant Boundary	m (ft)	170 (558)	762 (2500)	See Fig. F.20
Distance to Property Boundary	m (ft)	915 (3000)	1460 (4789)	See Fig. F.20
Distance to Ohio River	m (ft)	7317 (24000)	7927 (26000)	See Fig. F.20

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48)

Input Parameter	Statistics	SWMU 1 and C-720 Building			Remark
		Crystal Ball	Unit	AT123D	
Aquifer Thickness	Minimum Value	10.00	ft	3.05	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Likeliest Value	38.71	ft	11.80	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Maximum Value	63.50	ft	19.36	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Standard deviation	11.84	ft	3.61	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Count	24	#	24	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Coefficient of Variation	30.59	%	30.59	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Skew	-0.61	-	-0.61	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Distribution	Normal	-	Normal	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Correlation pair	None	-	None	Assumed none
	Correlation coefficient	NA	-	NA	NA
Hydraulic Conductivity	Minimum Value	1.00E-04	ft/day	1.27E+06	"BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Likeliest Value	1.93E+04	ft/day	2.46E+02	"BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Maximum Value	8.50E+05	ft/day	1.08E+04	"BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Standard deviation	1.09E+05	ft/day	1.38E+03	"BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Count	62	#	62	"BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Coefficient of Variation	563.17	%	563.17	"BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Skew	7.53	-	7.53	"BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

Input Parameter	Statistics	SWMU 1 and C-720 Building				Remark
		Crystal Ball	Unit	AT123D	Unit	
Hydraulic Conductivity	Minimum Value	75.00	ft/day	0.95	m/hr	<sup>a</sup> PGDP Groundwater flow model
	Likeliest Value	966.85	ft/day	12.28	m/hr	<sup>a</sup> PGDP Groundwater flow model
	Maximum Value	1500.00	ft/day	19.05	m/hr	<sup>a</sup> PGDP Groundwater flow model
	Standard deviation	628.74	ft/day	7.99	m/hr	<sup>a</sup> PGDP Groundwater flow model
	Count	12166	#	12166	#	<sup>a</sup> PGDP Groundwater flow model
	Coefficient of Variation	65.03	%	65.03	%	<sup>a</sup> PGDP Groundwater flow model
	Skew	-0.35	-	-0.35	-	<sup>a</sup> PGDP Groundwater flow model
	Minimum Value	75.00	ft/day	0.95	m/hr	<sup>a,b</sup> Minimum of the site-specific (to PGDP) groundwater flow model
Hydraulic Conductivity	Likeliest Value	350.00	ft/day	4.45	m/hr	<sup>a,b</sup> Assumed approximate geomean of the minimum and maximum of the site-specific (to PGDP) groundwater flow model
	Maximum Value	1500.00	ft/day	19.05	m/hr	<sup>a,b</sup> Maximum of the site-specific (to PGDP) groundwater flow model
	Standard deviation	350.00	ft/day	4.45	m/hr	<sup>a,b</sup> Assumed equal to likeliest value
	Coefficient of Variation	100.00	%	100.00	%	<sup>a,b</sup> Assumed equal to likeliest value
	Distribution	Log normal	-	Log normal	-	BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Correlation pair	Hydraulic Conductivity and Porosity	-	Hydraulic Conductivity and Porosity	-	Assumed
	Correlation coefficient	NA	-	NA	-	NA
	Minimum Value	1.00E-04	ft/ft	1.00E-04	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
Hydraulic Gradient	Likeliest Value	1.01E-03	ft/ft	1.01E-03	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Maximum Value	4.00E-03	ft/ft	4.00E-03	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Standard deviation	1.12E-03	ft/ft	1.12E-03	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Count	12	#	12	#	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Coefficient of Variation	110.89	%	110.89	%	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Skew	1.95	-	1.95	-	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Distribution	Normal	-	Normal	-	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Correlation pair	Hydraulic Conductivity and Hydraulic Gradient	-	Hydraulic Conductivity and Hydraulic Gradient	-	Assumed

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

Input Parameter	Statistics	SWMU 1 and C-720 Building				Remark
		Crystal Ball	Unit	AT123D	Unit	
Porosity <sup>c</sup>	Correlation coefficient	-0.50	-	-0.50	-	Assumed
	Minimum Value	27.00	%	27.00	%	DOE 1997a, DOE 1999a, DOE 1999c
	Likeliest Value	39.11	%	39.11	%	DOE 1997a, DOE 1999a, DOE 1999c
	Maximum Value	54.00	%	54.00	%	DOE 1997a, DOE 1999a, DOE 1999c
	Standard deviation	5.98	%	5.98	%	DOE 1997a, DOE 1999a, DOE 1999c
	Count	28	#	28	#	DOE 1997a, DOE 1999a, DOE 1999c
	Coefficient of Variation	15.29	%	15.29	%	DOE 1997a, DOE 1999a, DOE 1999c
	Skew	0.43	-	0.43	-	DOE 1997a, DOE 1999a, DOE 1999c
	Distribution	Normal	-	Normal	-	DOE 1997a, DOE 1999a, DOE 1999c
	Correlation pair	Hydraulic Gradient and Porosity	-	Hydraulic Gradient and Porosity	-	Assumed
Organic Carbon Content	Correlation coefficient	-0.20	-	-0.20	-	Assumed
	Minimum Value	0.003	%	0.003	%	KY 1992a, DOE 1997a, BJC 2006
	Likeliest Value	0.035	%	0.035	%	KY 1992a, DOE 1997a, BJC 2006
	Maximum Value	0.253	%	0.253	%	KY 1992a, DOE 1997a, BJC 2006
	Standard deviation	0.037	%	0.037	%	KY 1992a, DOE 1997a, BJC 2006
	Count	38	#	38	#	KY 1992a, DOE 1997a, BJC 2006
	Coefficient of Variation	1.05	%	1.05	%	KY 1992a, DOE 1997a, BJC 2006
	Skew	4.00	-	4.00	-	KY 1992a, DOE 1997a, BJC 2006
	Distribution	Log normal	-	Log normal	-	KY 1992a, DOE 1997a, BJC 2006
	Correlation pair	None	-	None	-	Assumed
	Correlation coefficient	NA	-	NA	-	NA

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

Input Parameter	Statistics	SWMU 1 and C-720 Building			Remark
		Crystal Ball	Unit	AT123D	Unit
Degradation Half-Life	Minimum Value	3.2	yr	NA	- <sup>d</sup> See Attachment F.3
	Likeliest Value	NA	-	NA	NA
	Maximum Value	11.3	yr	NA	- <sup>d</sup> See Attachment F.3
	Standard deviation	NA	-	NA	NA
	Count	NA	-	NA	NA
	Coefficient of Variation	NA	-	NA	NA
	Skew	NA	-	NA	NA
	Distribution	Uniform	-	NA	- <sup>d</sup> See Attachment F.3
	Correlation pair	Hydraulic Gradient and Degradation Rate	-	NA	Assumed
	Correlation coefficient	-1.00	-	NA	- <sup>d</sup> See Attachment F.3
Degradation Rate	Minimum Value	NA	-	7.01E-06	/hr <sup>d</sup> See Attachment F.3
	Likeliest Value	NA	-	NA	NA
	Maximum Value	NA	-	2.45E-05	/hr <sup>d</sup> See Attachment F.3
	Standard deviation	NA	-	NA	NA
	Count	NA	-	NA	NA
	Coefficient of Variation	NA	-	NA	NA
	Skew	NA	-	NA	NA
	Distribution	NA	-	Uniform	- <sup>d</sup> See Attachment F.3
	Correlation pair	NA	-	Hydraulic Gradient and Degradation Rate	Assumed
	Correlation coefficient	NA	-	-1.00	- <sup>d</sup> See Attachment F.3

<sup>a</sup> Multiple values were noted.

<sup>b</sup> The value selected for probabilistic method.

<sup>c</sup> Field observation was available for porosity. Therefore, effective porosity was estimated from porosity.

<sup>d</sup> Degradation rate was estimated from degradation half-life in units of hours using the formula: rate =  $[(\ln 2)/\text{degradation half-life}]$ .

BJC 2001a. C-746-U Solid Waste Landfill Groundwater Monitoring Plan Paducah Gaseous Diffusion Plant Paducah, Kentucky. BJC/PAD-205/R1, December.

BJC 2001b. Groundwater Monitoring Plan for the C-746-S Residential Landfill Paducah Gaseous Diffusion Plant Paducah, Kentucky. BJC/PAD-268/R1, December.

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

Input Parameter	Statistics	SWMU 1 and C-720 Building			Remark
		Crystal Ball	Unit	AT123D	
B/C 2006.					
DOE 1995.	Northeast Plume Preliminary Characterization Summary Report, DOE/OR/07-1339/V2 & D2, July.				
DOE 1997a.	Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the PGDP Paducah, Kentucky, DOE/OR/07-1549&D1, February.				
DOE 1997b.	Ground-Water Conceptual Model for the Paducah Gaseous Diffusion Plant Paducah, Kentucky, DOE/OR/06-1628&D0, August.				
DOE 1999a.	Remedial Investigation Report for Waste Area Grouping 6 at Paducah Gaseous Diffusion Plant Paducah, Kentucky, DOE/OR/07-1727V1&D2, May.				
DOE 1999b.	Remedial Investigation Report for Waste Area Grouping 27 at Paducah Gaseous Diffusion Plant Paducah, Kentucky, DOE/OR/07-1777V1&D2, June.				
DOE 1999c.	Remedial Investigation Report for Waste Area Grouping 6 at Paducah Gaseous Diffusion Plant Paducah, Kentucky, DOE/OR/07-1727V2&D2, May.				
DOE 2000a.	Data Report for the Sitewide Remedial Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1845/D1, January.				
DOE 2000b.	Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1895/V2&D1, September.				
DOE 2004.	Site Investigation Report for the Southwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-2180&D0, October.				
KY 1992a.	Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III, KY/E-150, November 25.				
KY 1992b.	Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant, KY/SUB/13B-97777C P-03/1991/1, April.				
KY 1997.	Analysis and Interpretation of Water Levels in Observations Wells at the Paducah Gaseous Diffusion Plant 1990-1997, KY/EM-210, June 30.				

**Table F.2.9. Statistics of variable inputs used in Monte Carlo runs for  
Source Term development and AT123D modeling (see Table F.50)**

<b>Input Parameter</b>	<sup>c</sup> <b>Statistics</b>	<b>Unit</b>	<b>SWMU 1 and C-720 Building</b>
Aquifer Depth	Minimum	m	3.38
	Median	m	11.30
	Maximum	m	18.50
	Arithmetic Mean	m	10.90
	<sup>c</sup> Standard Deviation	m	3.44
Hydraulic Conductivity	Minimum	m/hr	0.97
	Median	m/hr	3.54
	Maximum	m/hr	17.60
	Arithmetic Mean	m/hr	4.77
	<sup>c</sup> Standard Deviation	m/hr	3.70
Hydraulic Gradient	Minimum	m/m	1.63E-04
	Median	m/m	1.37E-03
	Maximum	m/m	3.98E-03
	Arithmetic Mean	m/m	1.49E-03
	<sup>c</sup> Standard Deviation	m/m	9.20E-04
Porosity	<sup>a</sup> Minimum	%	27.16
	Median	%	38.27
	Maximum	%	53.09
	Arithmetic Mean	%	39.51
	<sup>c</sup> Standard Deviation	%	6.17
Effective Porosity	<sup>a</sup> Minimum	-	0.22
	Median	-	0.31
	Maximum	-	0.43
	Arithmetic Mean	-	0.32
	<sup>c</sup> Standard Deviation	-	0.05
Organic Carbon Content	Minimum	%	0.003
	Median	%	0.024
	Maximum	%	0.228
	Arithmetic Mean	%	0.034
	<sup>c</sup> Standard Deviation	%	0.034
Degradation Half-Life	<sup>b</sup> Minimum	yr	3.2
	Median	yr	4.9
	Maximum	yr	11.3
	Arithmetic Mean	yr	4.9
	<sup>c</sup> Standard Deviation	yr	NA
Degradation Rate	<sup>b</sup> Minimum	/hr	7.20E-06
	Median	/hr	1.62E-05
	Maximum	/hr	2.45E-05
	Arithmetic Mean	/hr	1.61E-05
	<sup>c</sup> Standard Deviation	/hr	NA

**Table F.2.9. Statistics of variable inputs used in Monte Carlo runs for AT123D modeling (see Table F.50) (continued)**

<b>Input Parameter</b>	<sup>c</sup> <b>Statistics</b>	<b>Unit</b>	<b>SWMU 1 and C-720 Building</b>
Groundwater Concentration in the RGA <sup>c</sup>	Minimum	µg/L	2.92
	Median	µg/L	362.7
	Maximum	µg/L	25311
	Arithmetic Mean	µg/L	2138.6
	<sup>c</sup> Standard Deviation	µg/L	4534.8
Total Soil Concentration Derived from Groundwater Concentrations <sup>c</sup>	Minimum	mg/kg	7.25E-04
	Median	mg/kg	9.73E-02
	Maximum	mg/kg	5.68E+00
	Arithmetic Mean	mg/kg	5.72E-01
	<sup>c</sup> Standard Deviation	mg/kg	1.18E+00

<sup>a</sup> Effective porosity was estimated from porosity (see text).

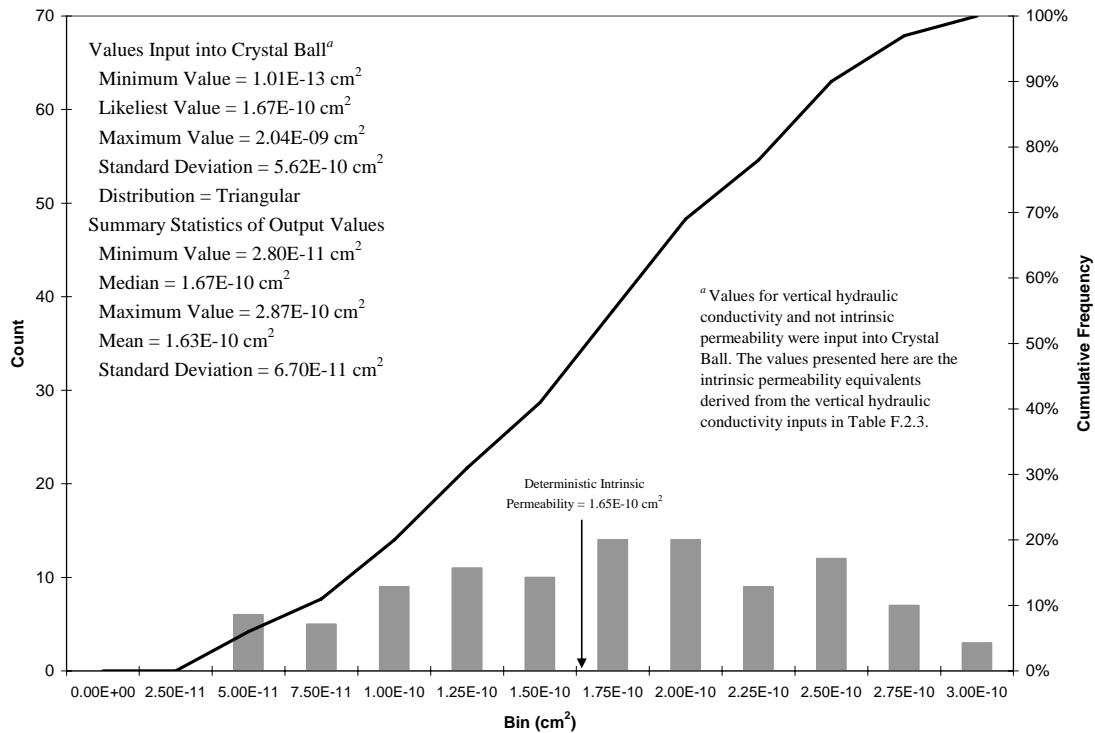
<sup>b</sup> Degradation rate was estimated from degradation half-life in units of hours using the formula: rate = [(ln 2)/degradation half-life].

<sup>c</sup> This parameter was only used for secondary source term modeling.

**Table F.2.10. Qualitative sensitivity of modeling results to input parameters for the Southwest Plume SI Report**

<b>Input Parameter</b>	<b>Degree of sensitivity</b>		
	<b>Low</b>	<b>Medium</b>	<b>High</b>
Bulk density	√		
Effective porosity		√	
Horizontal hydraulic conductivity in the RGA		√	
Vertical hydraulic conductivity in the UCRS	√		
Percolation rate		√	
Horizontal hydraulic gradient in the RGA		√	
Aquifer thickness	√		
Longitudinal dispersivity	√		
Soil-water partition coefficient (K <sub>d</sub> )			√
Fraction of organic carbon (%)			√
Biodegradation half-life			√
Molecular diffusion	√		
Source Area		√	
Source term in the UCRS			√





**Fig. F.2.1. Histogram of Intrinsic Permeability SESOIL inputs for SWMU 1.**

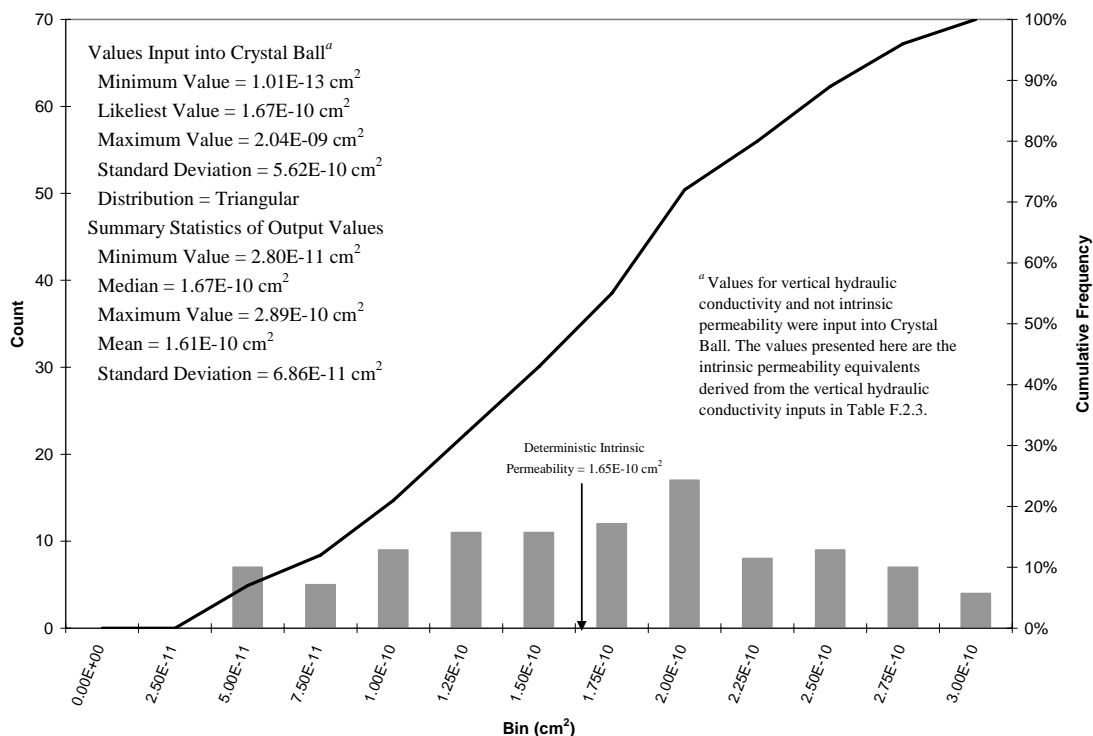


Fig. F.2.2. Histogram of Intrinsic Permeability SESOIL inputs for the C-720 Area.

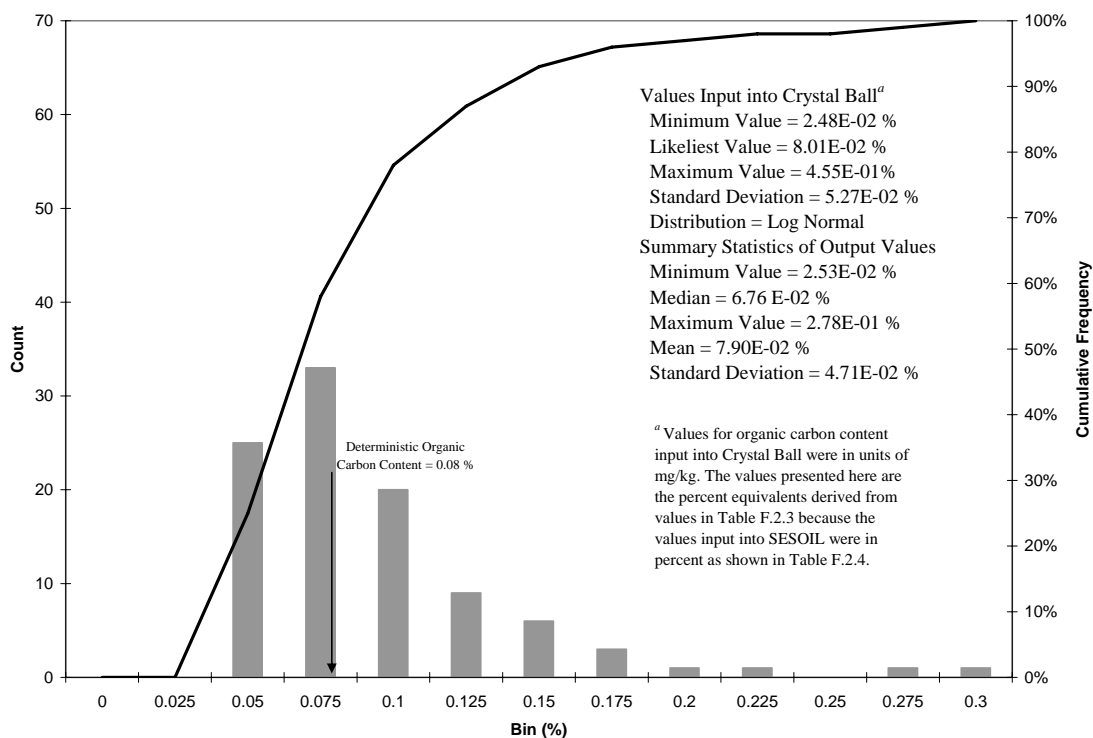


Fig. F.2.3. Histogram of Organic Carbon Content SESOIL inputs for SWMU 1.

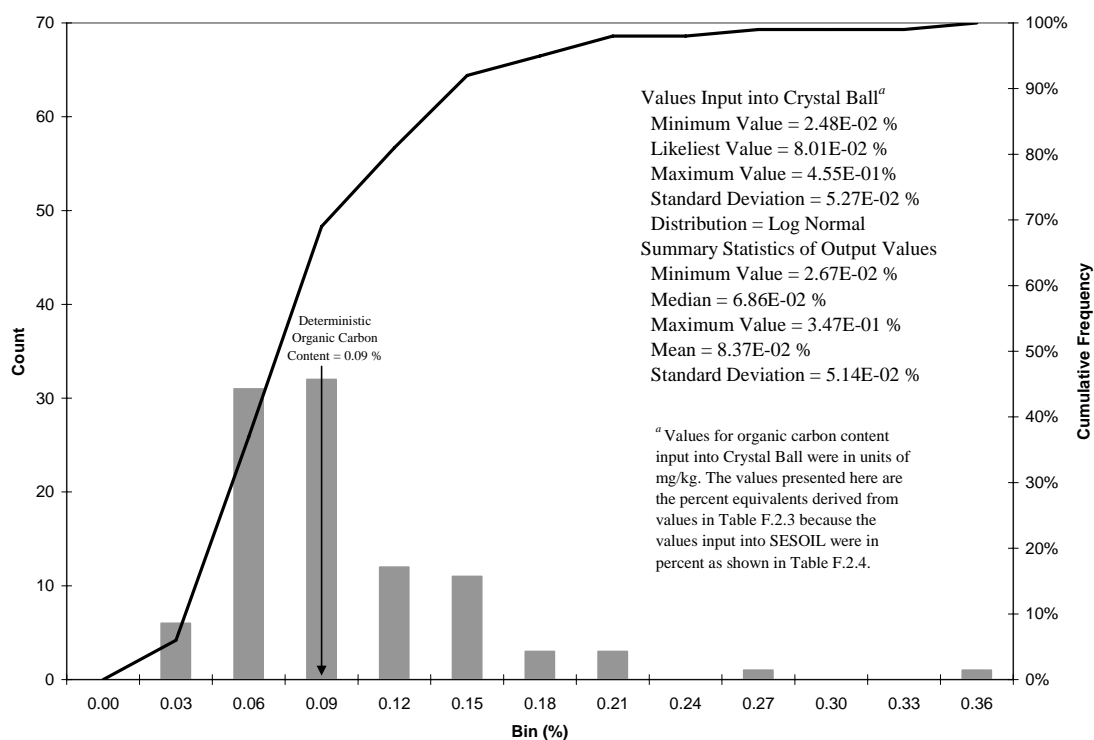


Fig. F.2.4. Histogram of Organic Carbon Content SESOIL inputs for the C-720 Area.

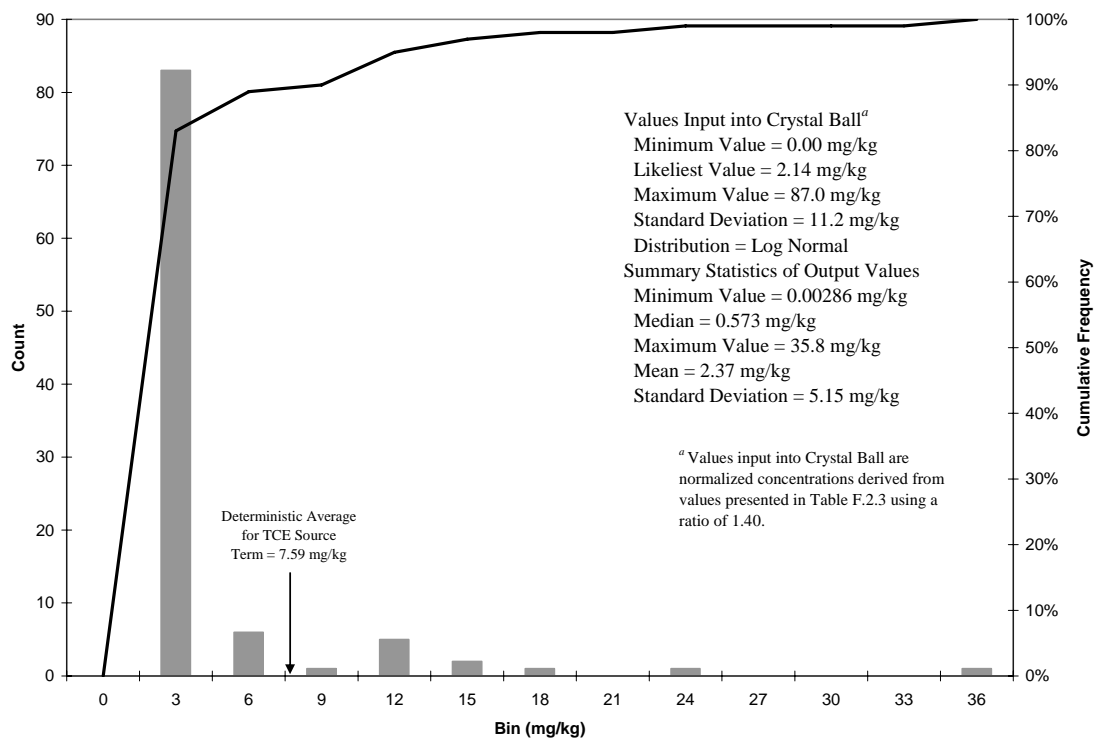
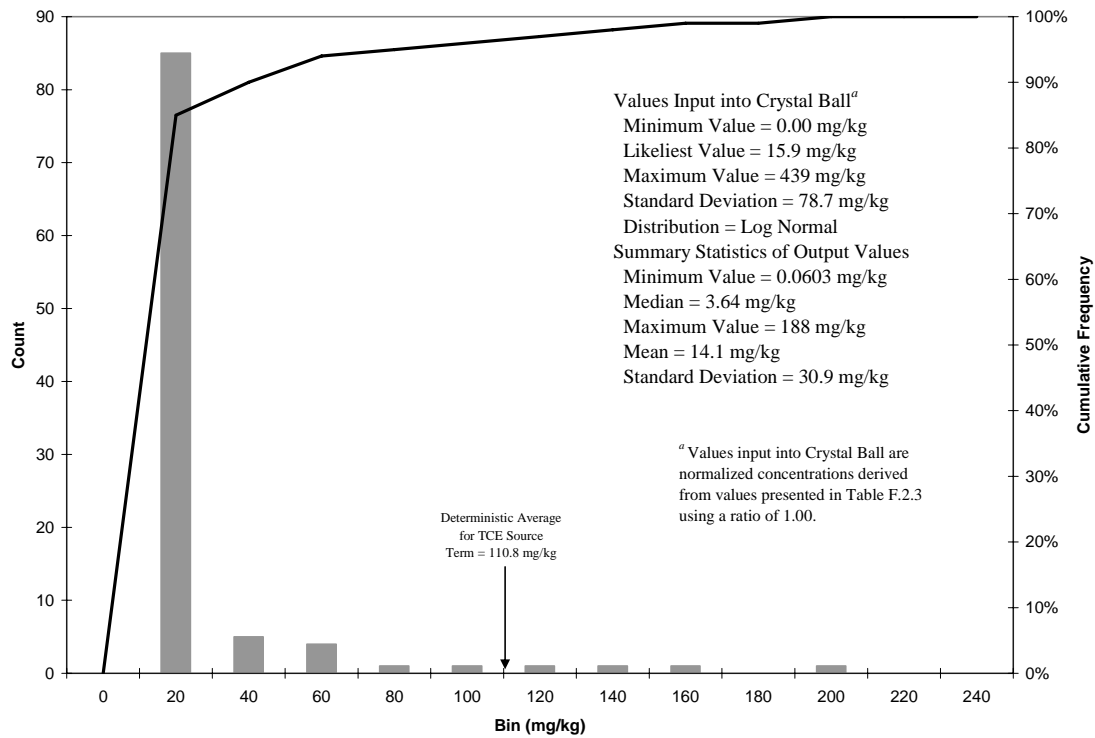
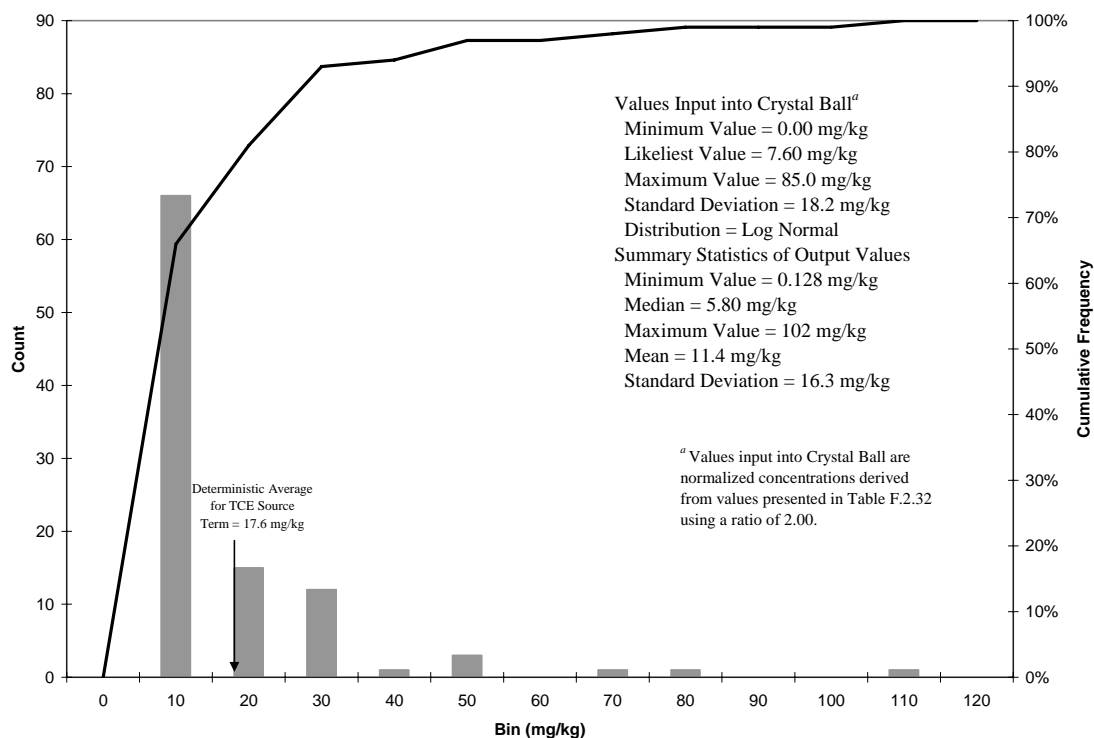


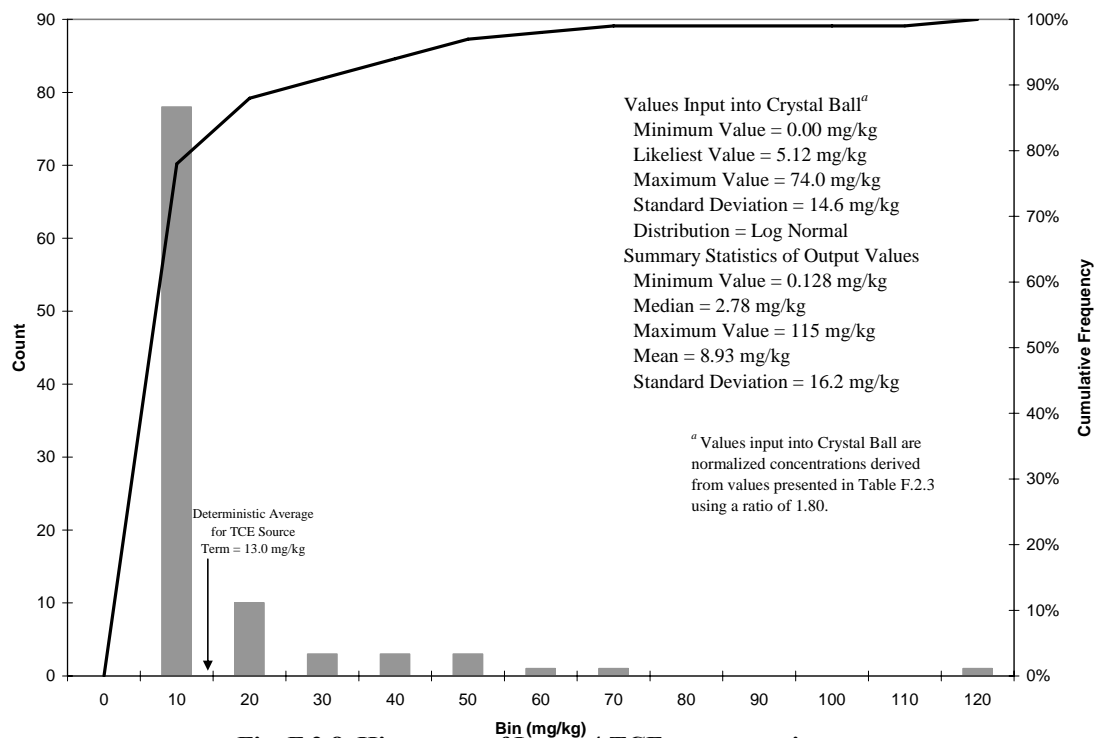
Fig. F.2.5. Histogram of Layer 1 TCE concentrations at SWMU 1 used as SESOIL inputs.



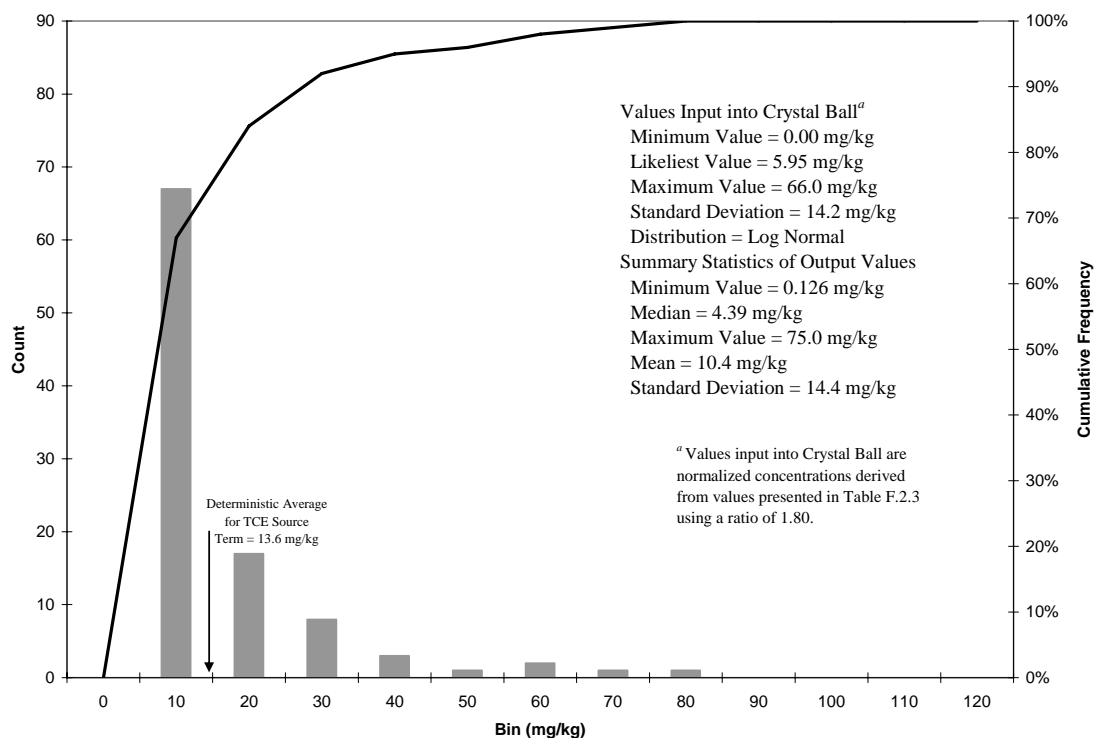
**Fig. F.2.6. Histogram of Layer 2 TCE concentrations at SWMU 1 used as SESOIL inputs.**



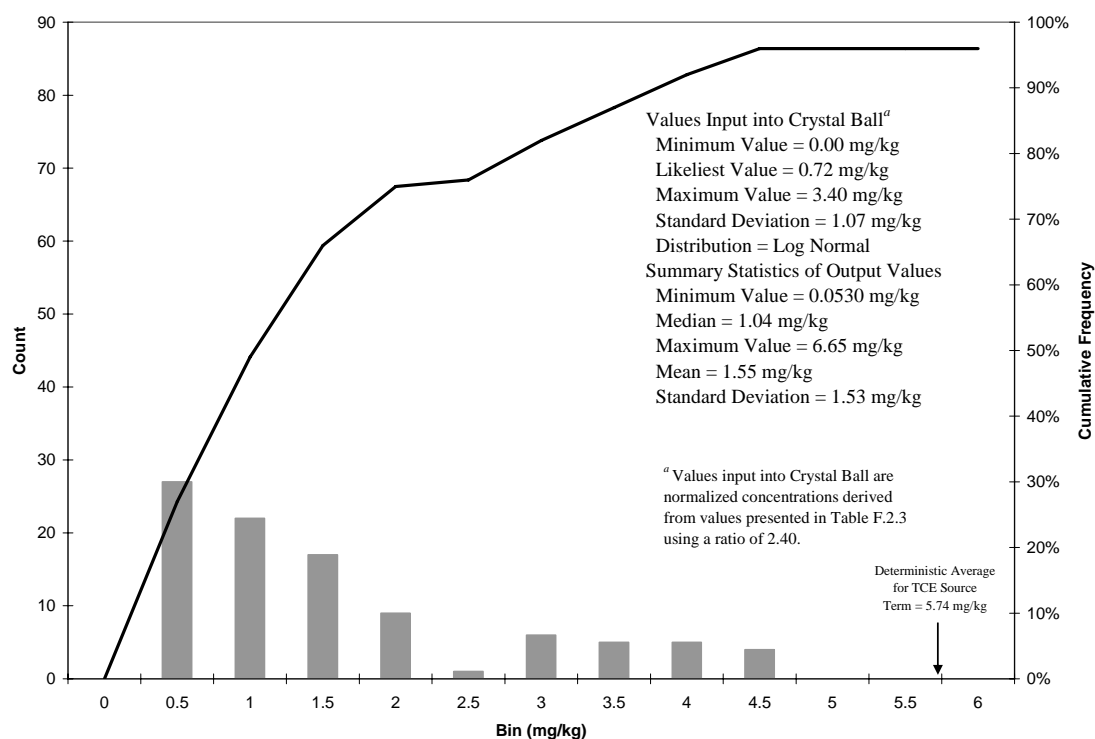
**Fig. F.2.7. Histogram of Layer 3 TCE concentrations at SWMU 1 used as SESOIL inputs.**



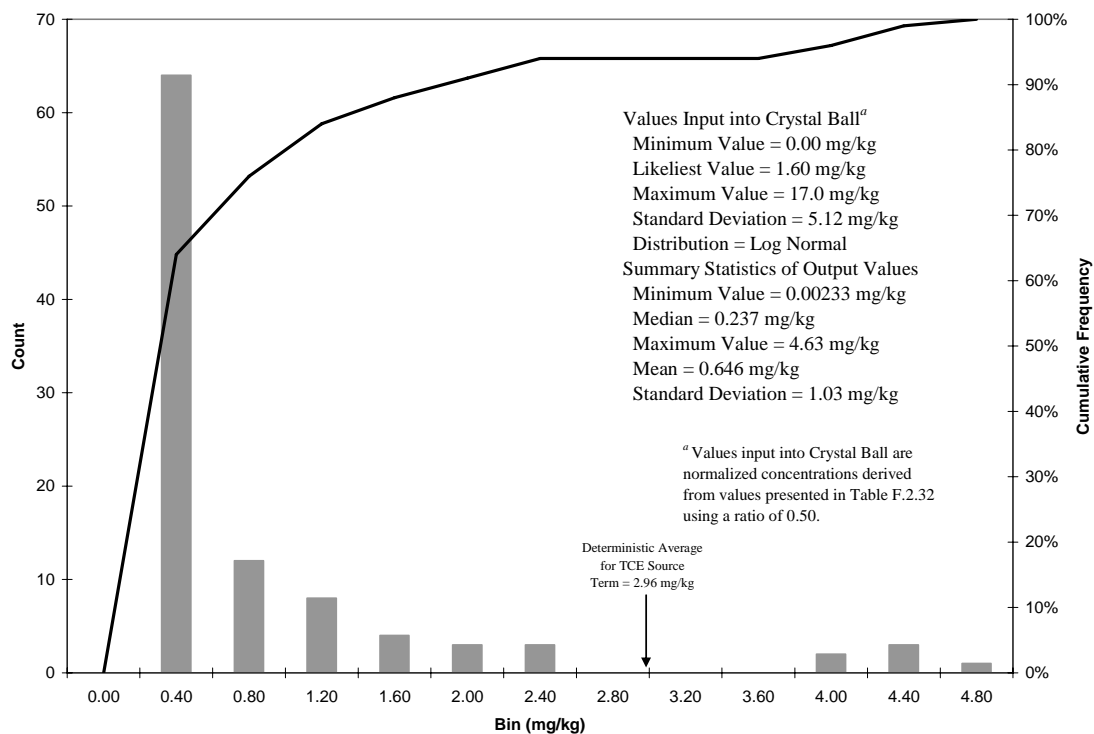
**Fig. F.2.8. Histogram of Layer 4 TCE concentrations at SWMU 1 used as SESOIL inputs.**



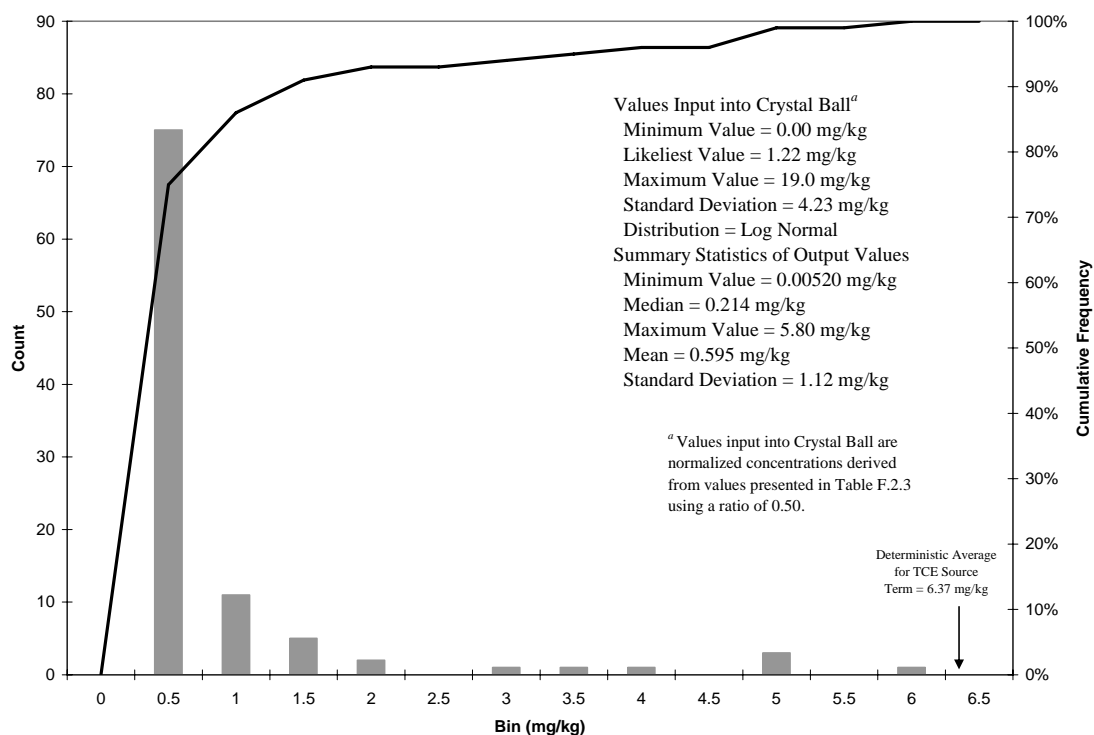
**Fig. F.2.9. Histogram of Layer 5 TCE concentrations at SWMU 1 used as SESOIL inputs.**



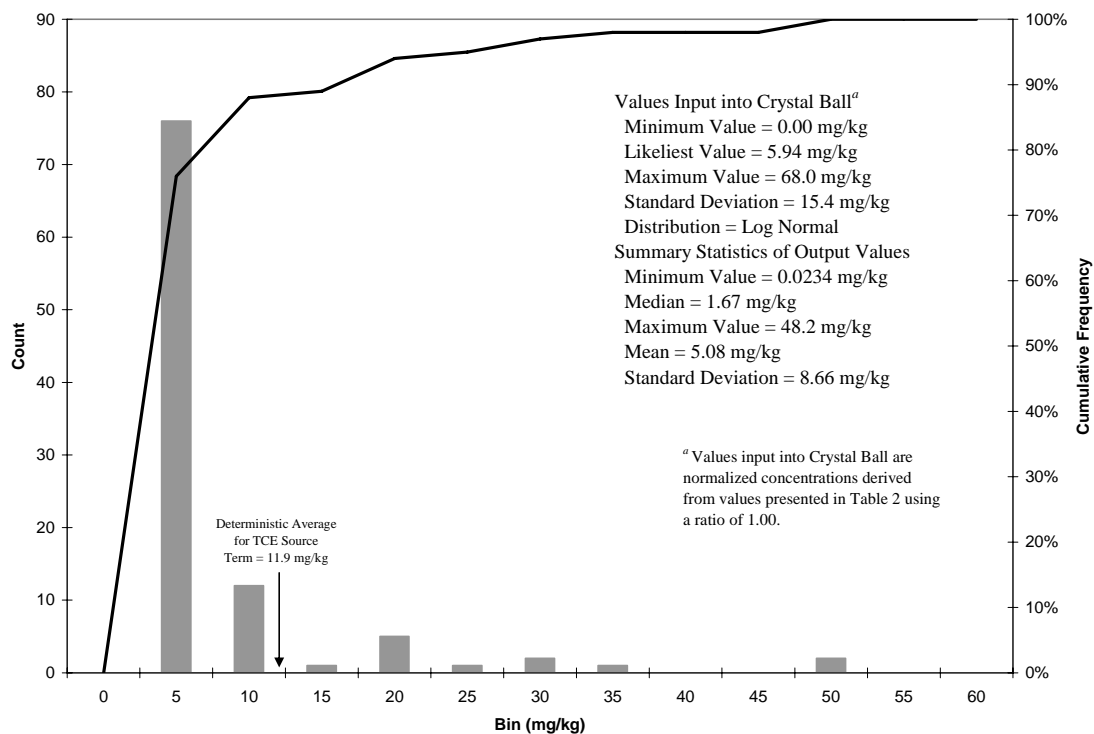
**Fig. F.2.10. Histogram of Layer 6 TCE concentrations at SWMU 1 used as SESOIL inputs.**



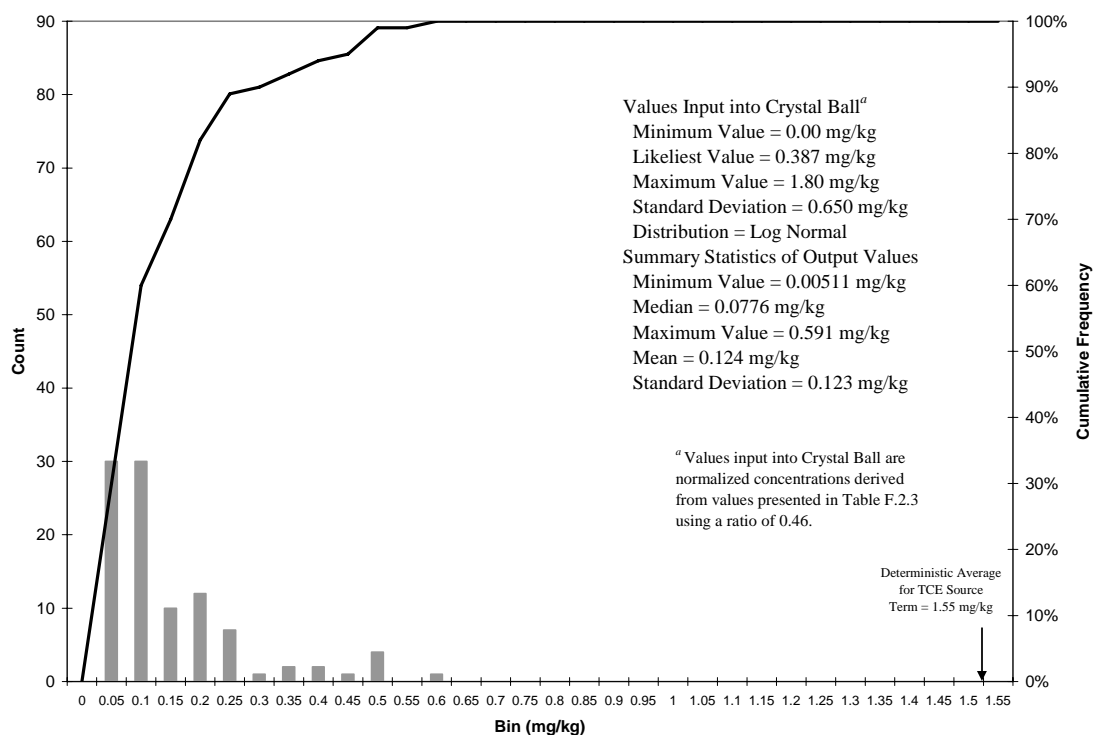
**Fig. F.2.11. Histogram of Layer 1 TCE concentrations at C-720 Area used as SESOIL inputs.**



**Fig. F.2.12. Histogram of Layer 2 TCE concentrations at C-720 Area used as SESOIL inputs.**

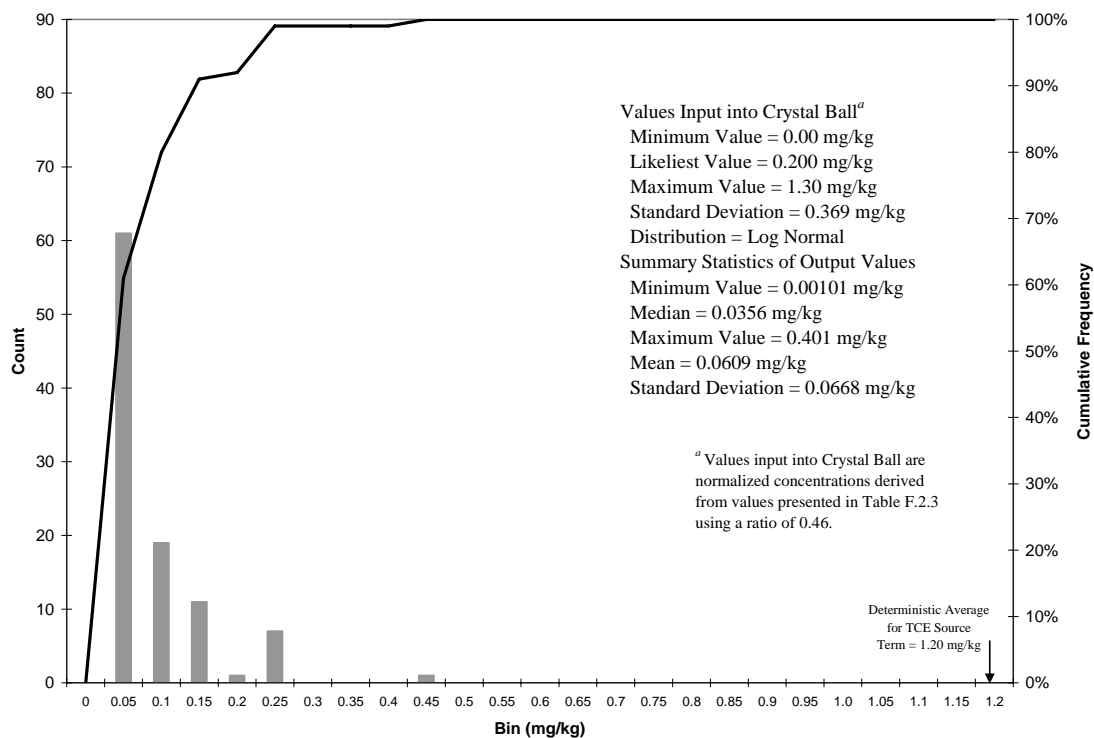


**Fig. F.2.13. Histogram of Layer 3 TCE concentrations at C-720 Area used as SESOIL inputs.**

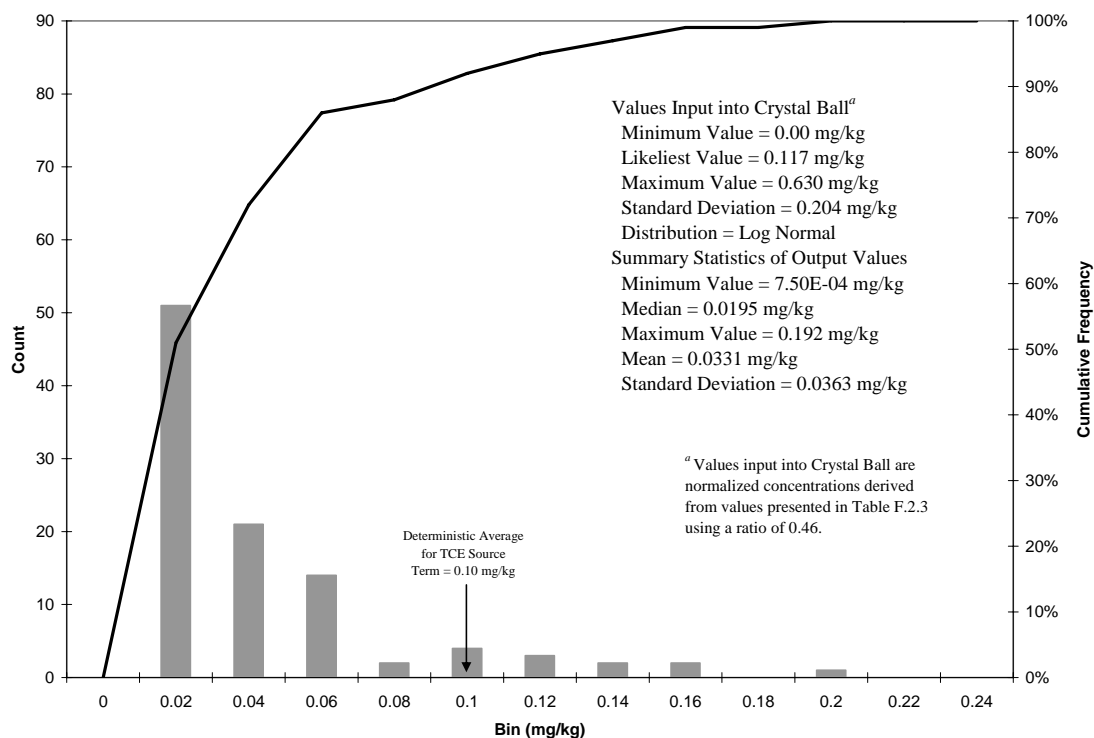


**Fig. F.2.14. Histogram of Layer 4 TCE concentrations at C-720 Area used as SESOIL inputs.**

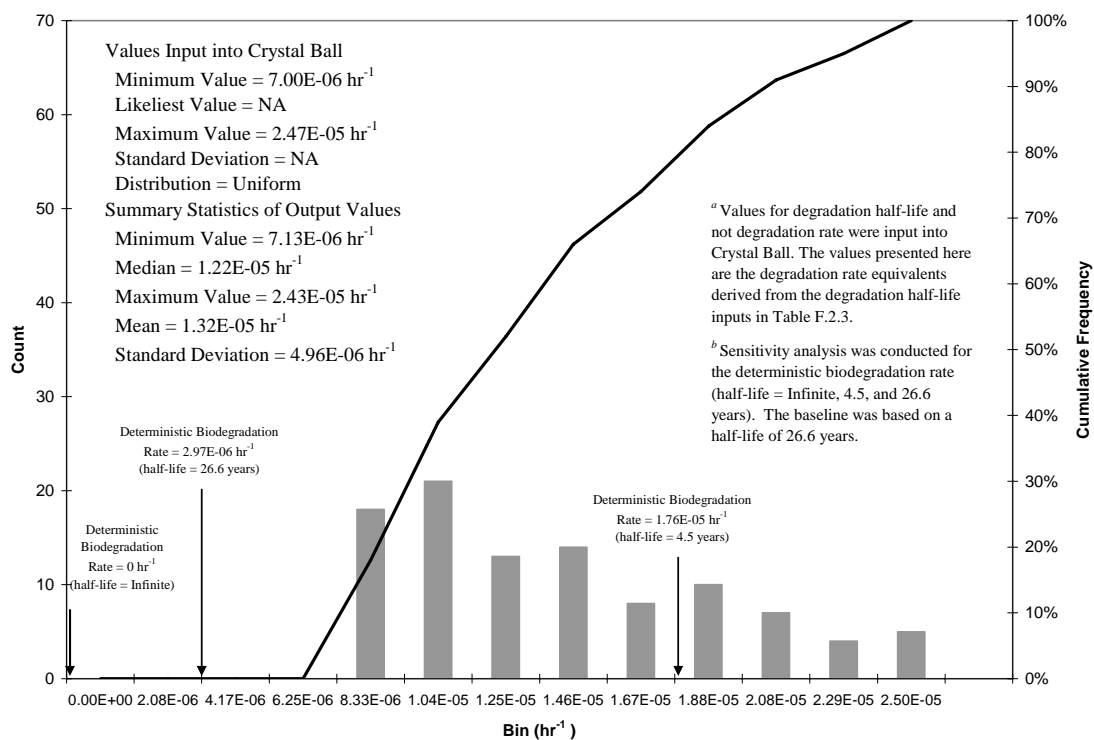




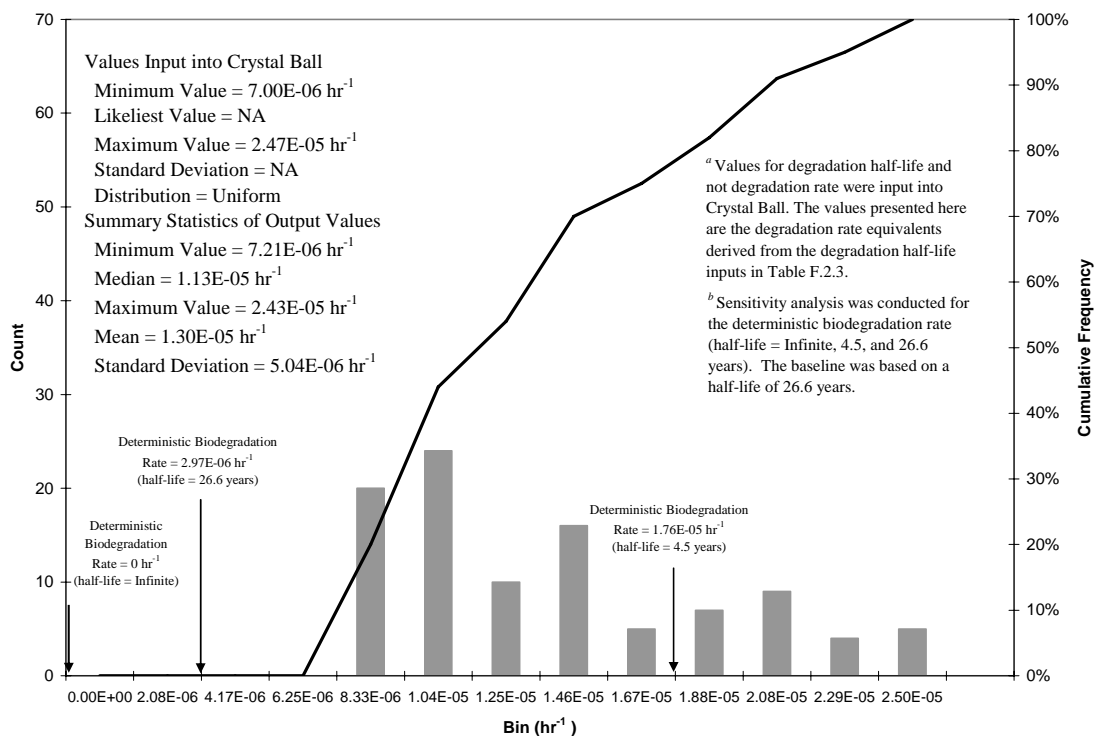
**Fig. F.2.15. Histogram of Layer 5 TCE concentrations at C-720 Area used as SESOIL inputs.**



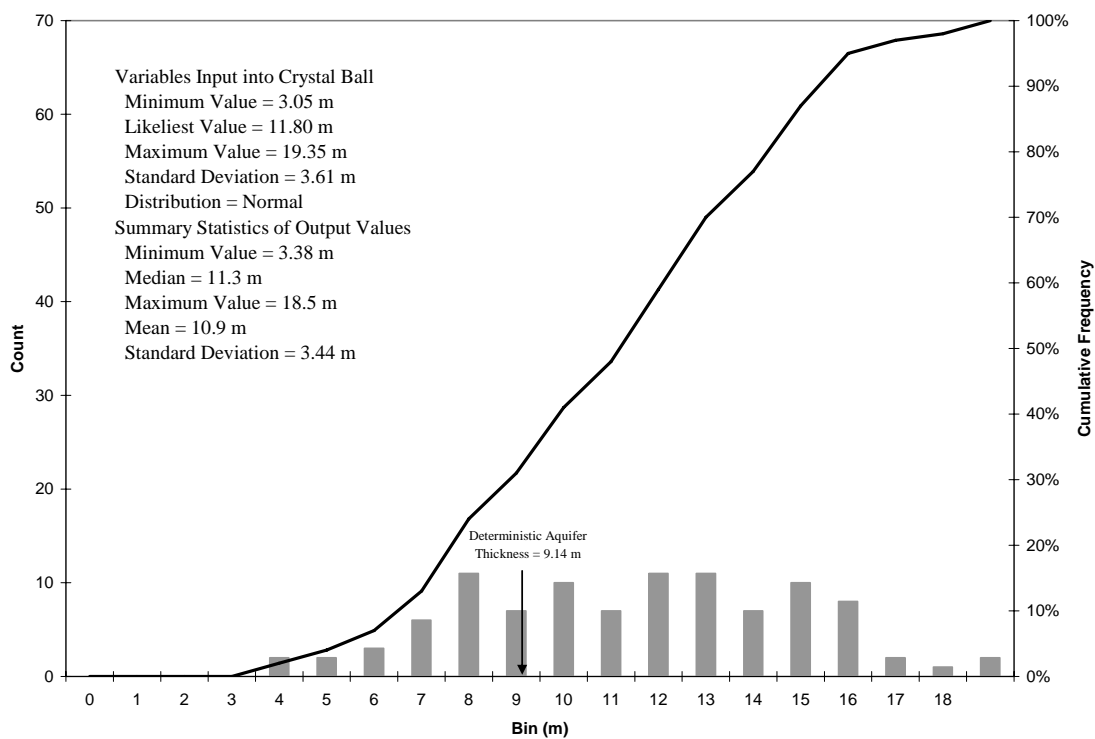
**Fig. F.2.16. Histogram of Layer 6 TCE concentrations at C-720 Area used as SESOIL inputs.**



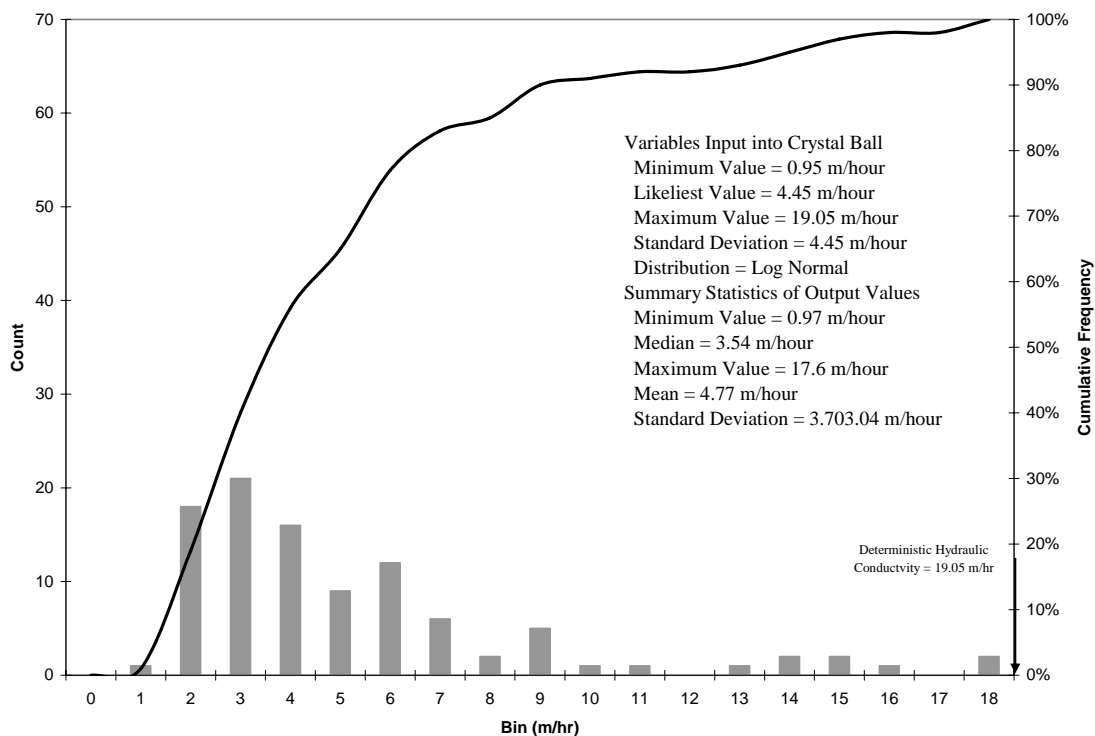
**Fig. F.2.17. Histogram of Degradation Rate SESOIL inputs for SWMU 1.**



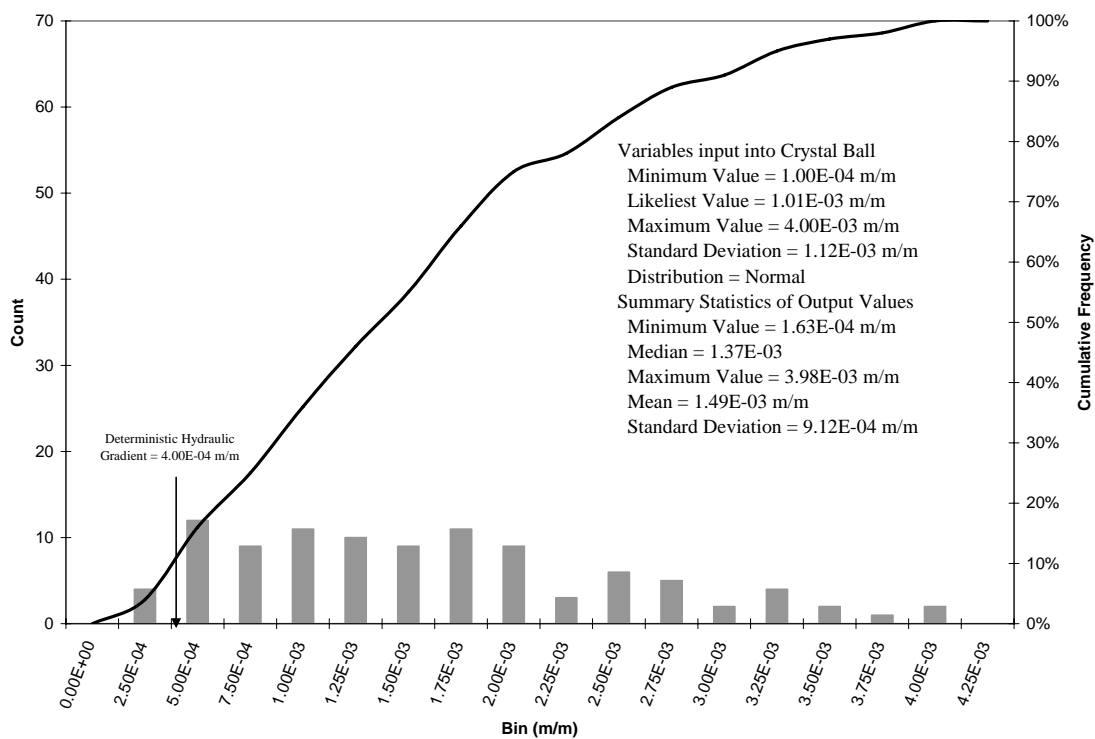
**Fig. F.2.18. Histogram of Degradation Rate SESOIL inputs for C-720 Area.**



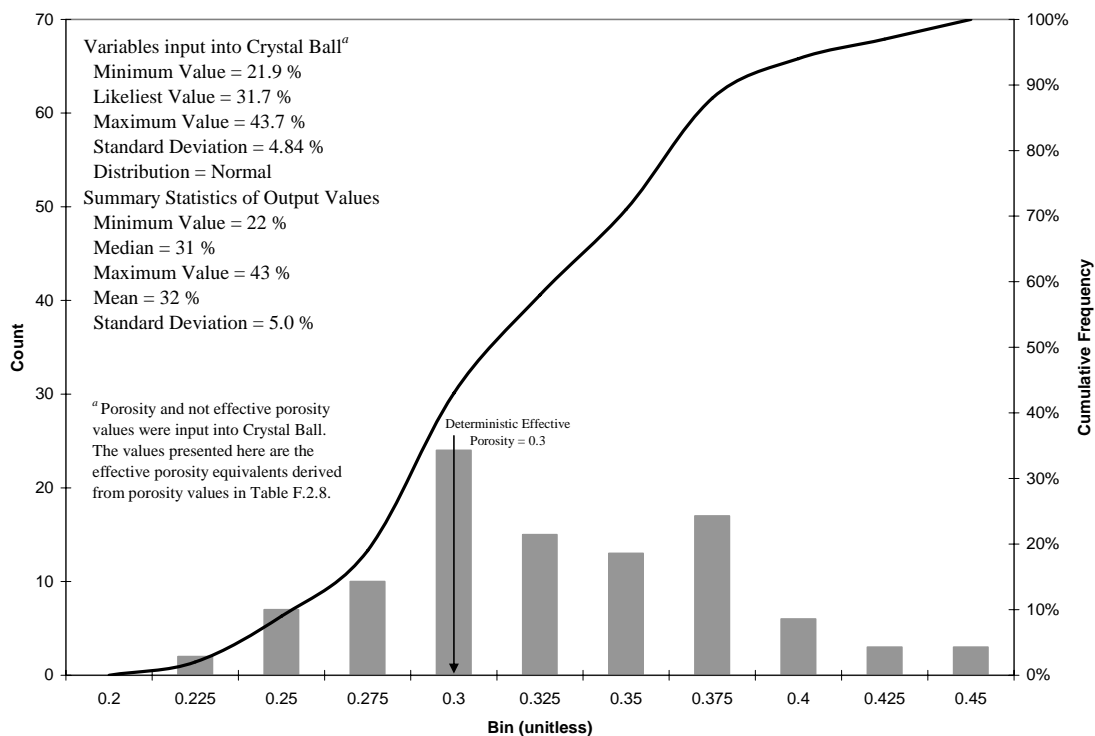
**Fig. F.2.19. Histogram of Aquifer Thickness AT123D inputs for SWMU 1 and the C-720 Area.**



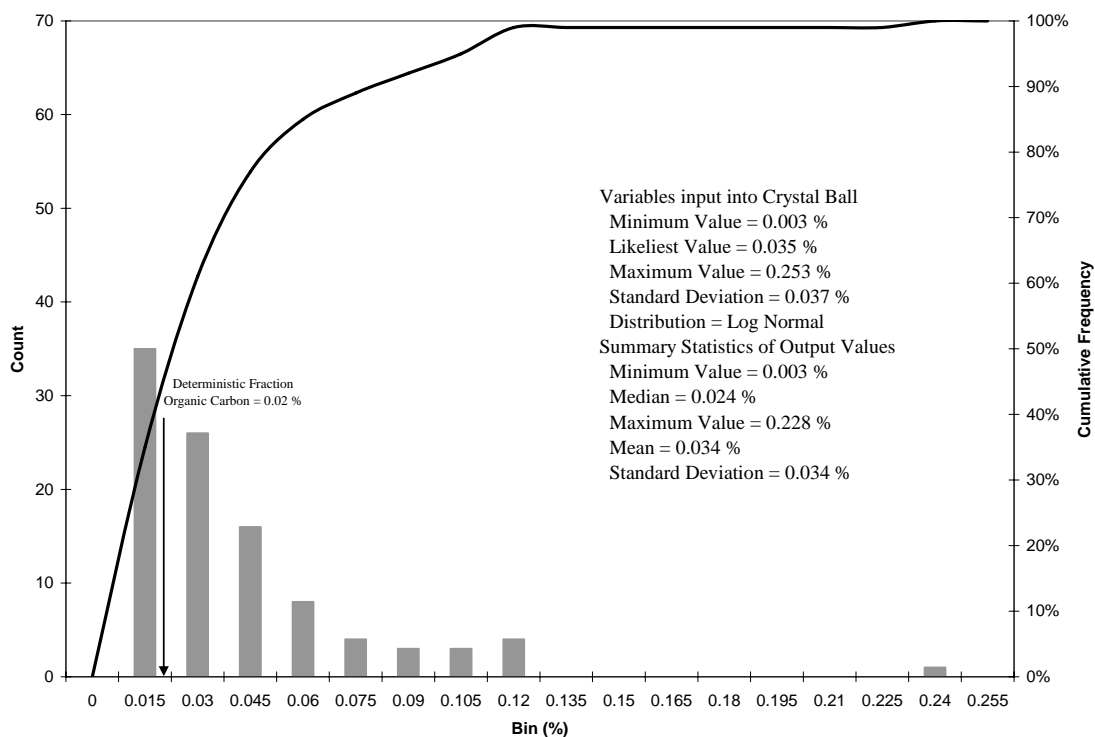
**Fig. F.2.20. Histogram of Hydraulic Conductivity AT123D inputs for SWMU 1 and the C-720 Area.**



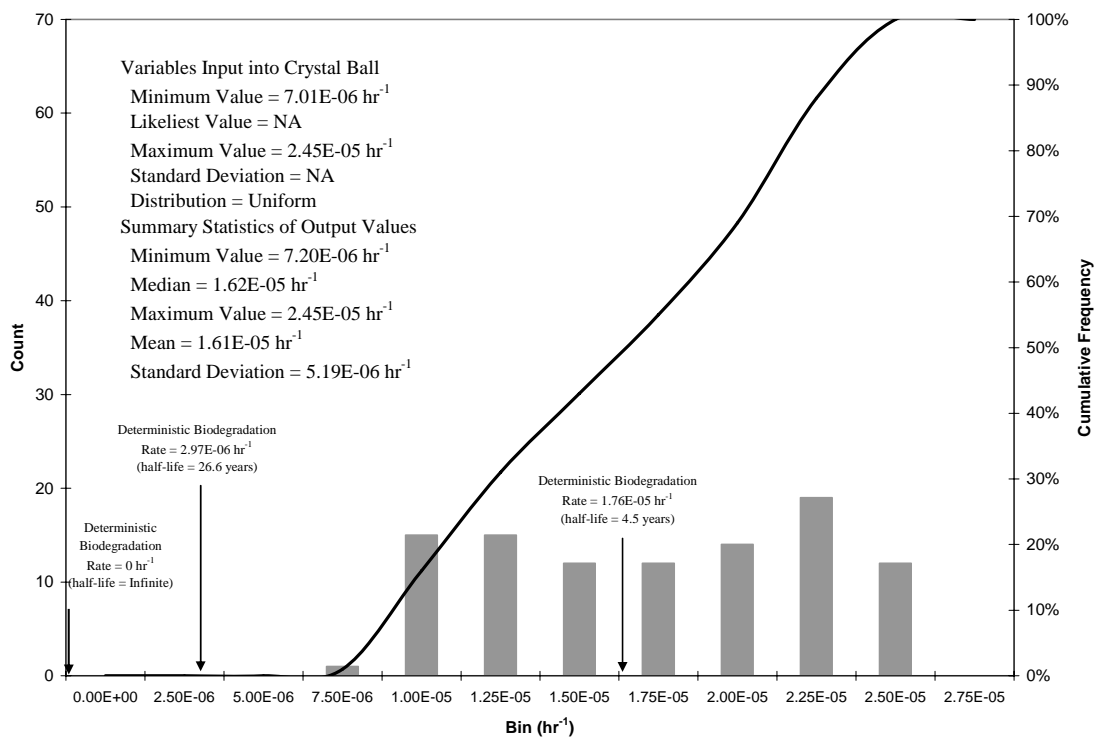
**Fig. F.2.21. Histogram of Hydraulic Gradient AT123D inputs for SWMU 1 and the C-720 Area.**



**Fig. F.2.22. Histogram of Effective Porosity AT123D inputs for SWMU 1 and the C-720 Area.**



**Fig. F.2.23. Histogram of Organic Carbon Content AT123D inputs for SWMU 1 and the C-720 Area.**



**Fig. F.2.24. Histogram of Degradation Rate inputs for SWMU 1, and the C-720 Area.**

## 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.6). 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).<sup>1</sup>

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.

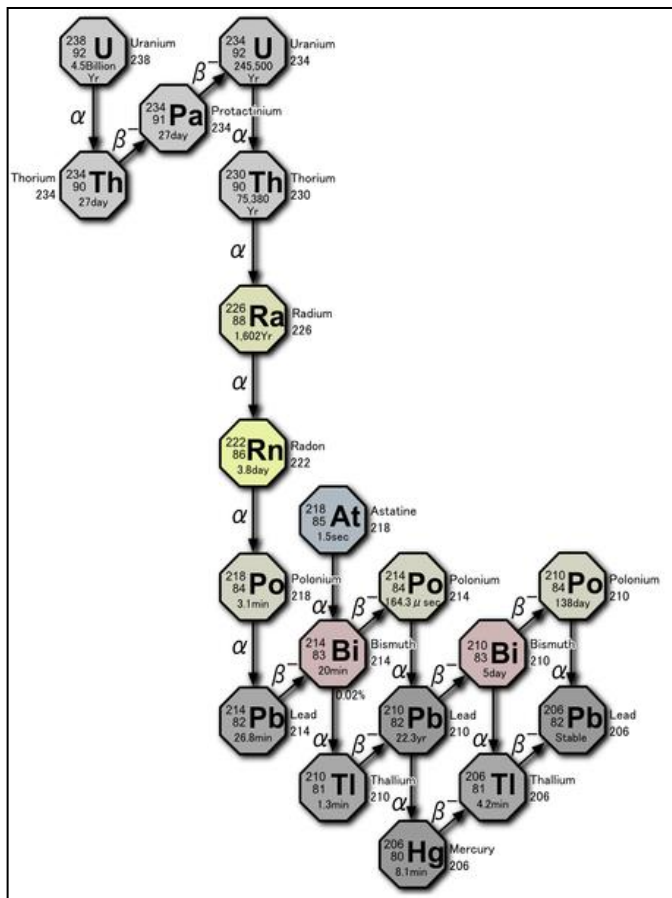


Figure E.6. Lead-210 Decay Chain

Available PGDP lead-210 data was plotted to estimate an approximate background value. This map is shown in Figure E.7. 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.

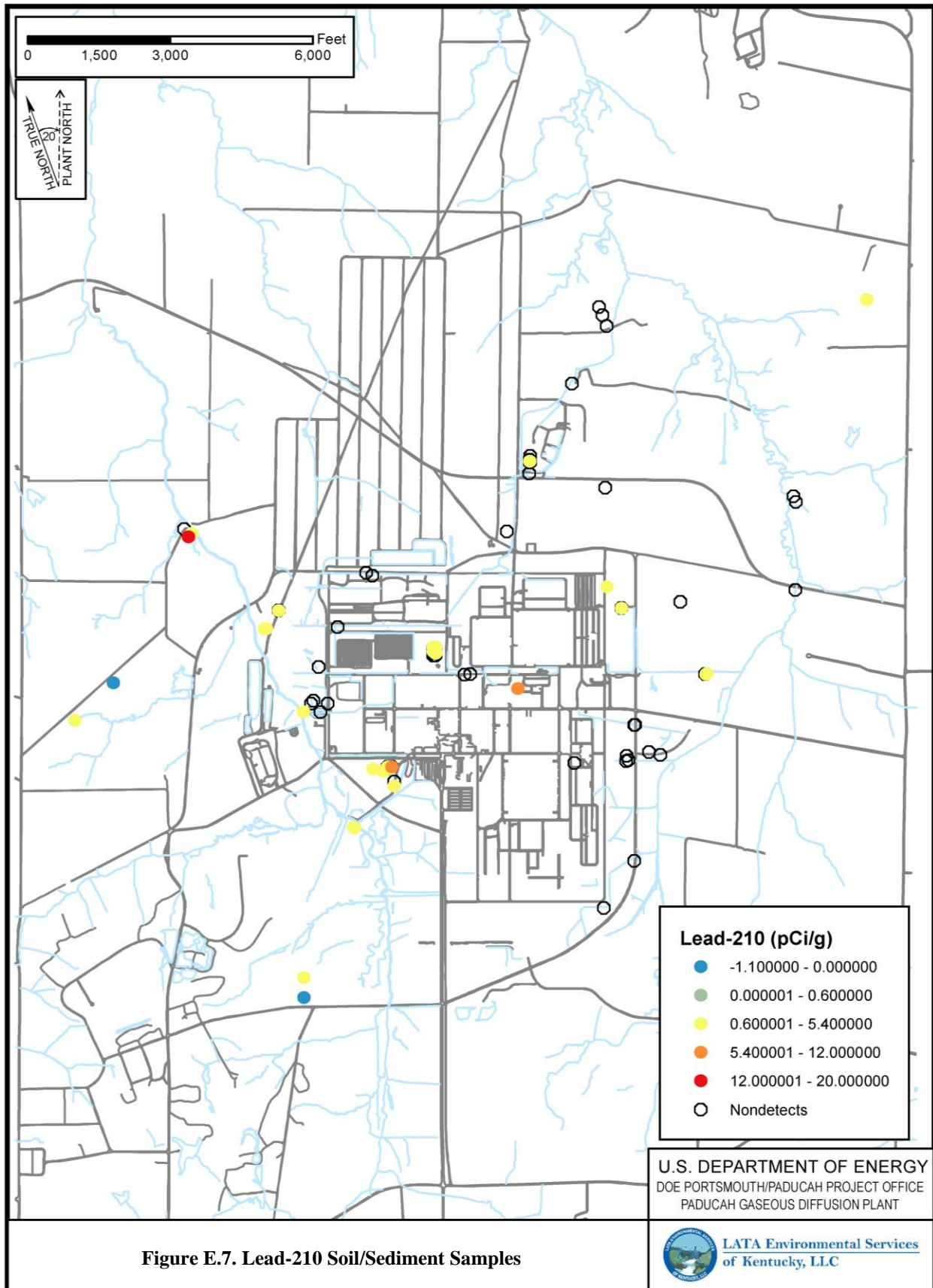


Figure No. Lead-210\_Soil.mxd  
DATE 11-01-2012



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

Station	Sample ID	Depth (ft bgs)	Lab Code	Lead-210 (pCi/g)			Radium-226 (pCi/g)			Uranium-238 (pCi/g)		
				Results	MDA	Rad Error	Results	MDA	Rad Error	Results	MDA	Rad Error
I94-01.02	301043	9	LOCK	20.00	0.02	29.10	Yes	No	0.77	0.31	1.53	1.53
JP-0092	DOI1-99-0092		PGDP	14.55	18.18	29.10	No	No	0.77	0.31	1.53	1.53
I94-01.02	301048	20	LOCK	12.00	0.05		Yes	No				
SWMU222-4	2010-53093 <sup>a</sup>		KYRAD	10.60	2.05	1.03	Yes	No				
SWMU222-4	2010-53093		KYRAD	10.60	2.05	1.03	Yes	No				
SWMU222-5	2010-53094 <sup>b</sup>		KYRAD	8.60	1.47	0.76	Yes	No				
SWMU222-1	2010-53090 <sup>b</sup>		KYRAD	8.44	1.71	0.87	Yes	No				
I94-01.02	301044	11.33	LOCK	8.00	0.03		Yes	No				
SWMU222-2	2010-53091 <sup>b</sup>		KYRAD	6.98	1.41	0.71	Yes	No				
SWMU222-3	2010-53092 <sup>b</sup>		KYRAD	6.81	1.14	0.61	Yes	No				
SOU195-120A	2010-51253 <sup>a</sup>	1	KYRAD	6.57	9.25	3.83	No	Yes	2.53	2.08	0.94	0.94
SOU195-014C	2010-51264 <sup>a</sup>	10	KYRAD	6.01	5.28	2.16	Yes	Yes	1.44	1.27	0.57	0.57
I94-01.02	301047	18.6	LOCK	5.40	0.00		Yes	No				
SWMU222-1	2010-52457 <sup>b</sup>		KYRAD	4.92	0.82	0.41	Yes	No				
JP-0160	DOI1-99-0160		PGDP	4.31	1.79	2.11	Yes	Yes	0.71	1.64	1.42	1.42
BCBOKYRAD01	2010-50535 <sup>a</sup>		KYRAD	4.27	0.46	0.25	Yes	Yes	2.35	0.87	0.39	0.39
LBC2L020	LBCSOSU2S1-04	1	STLMO	4.20	2.00		Yes	Yes	0.80	0.21		
RSO3	110013 <sup>c</sup>		STLMO	3.90	1.90		Yes	No				
JP-0152	DOI1-99-0152		PGDP	3.76	5.96	7.52	No	No	0.84	0.12	1.69	1.69
H01.05.15	301025	0.7	LOCK	3.70	0.00		Yes	No				
SOU195-014A	2010-51258 <sup>a</sup>	10	KYRAD	3.56	5.07	2.13	No	Yes	1.40	1.10	0.50	0.50
RSO3	110012 <sup>c</sup>		STLMO	3.50	1.40		Yes	No				
BC5KYRAD01	2010-50537 <sup>a</sup>		KYRAD	3.43	0.36	0.21	Yes	Yes	2.06	0.71	0.32	0.32
C12.18.19	301012 <sup>d</sup>	2	LOCK	3.20	0.00		Yes	No				
A10	PLDJNSA10-01SO	2.5	PGDP	3.10	5.90	6.20	No	No	0.16	0.07	0.01	0.01
LBC2L015	LBCSOSU2S1-03	1	STLMO	3.00	2.90		Yes	Yes	1.21	0.26	0.30	0.30
JP-0161	DOI1-99-0161		PGDP	2.92	1.93	2.07	Yes	Yes	0.83	0.17	1.66	1.66
SOU200-004	2010-51270 <sup>a</sup>	4	KYRAD	2.81	5.18	2.19	No	Yes	2.51	1.31	0.61	0.61
F04.02.29	301005	0.8	LOCK	2.80	0.00		Yes	No				
SOU195-120C	2010-51252 <sup>a</sup>	1	KYRAD	2.70	0.62	0.32	Yes	Yes	1.67	0.90	0.41	0.41
K008-AIP-RP	030301	0	STLMO	2.70	1.20	1.10	Yes	No				
C07.08.09	301013 <sup>d</sup>	0.9	LOCK	2.70	0.00		Yes	No				
NST2S04	BIC2041SS	8	PGDP	2.65	2.40	2.50	Yes	Yes	2.43	0.33	4.85	4.85
SOU222-001	2010-51277 <sup>a</sup>	0.5	KYRAD	2.57	0.59	0.76	Yes	Yes	11.10	1.30	0.71	0.71
BCBOKYRAD02	2010-50536 <sup>a</sup>		KYRAD	2.51	0.71	0.33	Yes	Yes	7.18	1.17	0.56	0.56
F12.20.22	301004	1.5	LOCK	2.46	0.00		Yes	No				
H04.06.09	301023	0.8	LOCK	2.45	0.00		Yes	No				
JP-0019	DOI1-99-0017		PGDP	2.44	16.16	4.87	No	No	1.06	0.29	2.11	2.11
C12.18.19	301011 <sup>d</sup>	0.8	LOCK	2.40	0.00		Yes	No				
I96-03.04	301038	6.67	LOCK	2.40	0.00		Yes	No				
C01.10.24	301017 <sup>d</sup>	0.7	LOCK	2.30	0.00		Yes	No				
F05.07.17	301008	1.6	LOCK	2.20	0.00		Yes	No				
C07.08.09	301015 <sup>d</sup>	0.9	LOCK	2.09	0.00		Yes	No				

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

Station	Sample ID	Depth (ft bgs)	Lab Code	Lead-210 (pCi/g)			Detect?	Radium-226 (pCi/g)			Detect?	Uranium-238 (pCi/g)			Detect?
				Results	MDA	Rad Error		Results	MDA	Rad Error		Results	MDA	Rad Error	
JP-0046	DOI1-99-0046		PGDP	2.07	1.91	2.03	Yes	0.70	0.13	1.40	No	13.90	1.00	1.43	Yes
A2	PLDJNSA2D-01SO	8.5	PGDP	2.00	6.00	4.10	No	0.59	0.13	1.10	No	0.77	0.24	0.39	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 <sup>a</sup>	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	DOI1-99-0177		PGDP	1.84	2.62	3.68	No	0.65	0.12	1.30	No	2.01	0.91	1.08	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 <sup>d</sup>	0.7	LOCK	1.80	0.00		Yes				No	1.03		0.10	Yes
BC5KYRAD02	2010-50538 <sup>a</sup>		KYRAD	1.74	0.90	0.42	Yes	2.01	1.56	0.70	Yes	0.69	0.93	0.55	Yes
I94-05,06	301039	9	LOCK	1.72	0.00		Yes				No	0.79		0.12	Yes
I94-03,04	301045 <sup>e</sup>	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	No	1.10	0.18	2.20	No	1.69	0.86	1.03	No
F01,21,23	301009	0.8	LOCK	1.60	0.00		Yes				No	0.92		0.08	Yes
C02,03,20	301020 <sup>d</sup>	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 <sup>d</sup>	2.1	LOCK	1.56	0.00		Yes				No	0.94		0.08	Yes
JP-0157	DOI1-99-0157		PGDP	1.56	4.07	3.11	No	0.90	0.16	1.80	No	108.00	1.80	2.95	Yes
JP-0113	DOI1-99-0115		PGDP	1.54	1.60	1.68	No	0.49	0.12	0.97	No	6.02	0.88	1.33	Yes
C07,08,09	301016 <sup>d</sup>	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 <sup>a</sup>		KYRAD	1.49	0.68	0.32	Yes	1.94	1.52	0.67	Yes	1.64	0.70	0.40	Yes
JP-0075	DOI1-99-0075		PGDP	1.48	4.62	2.97	No	1.24	0.16	2.48	No	14.80	1.54	2.05	Yes
I94-03,04	301036 <sup>e</sup>	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 <sup>a</sup>	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	DOI1-99-0090		PGDP	1.37	2.21	2.74	No	0.77	0.14	1.55	No	22.00	0.02	0.75	Yes
OUTFALL10-1	WC02-242	4	PORTS	1.36	0.67	0.68	No	0.94	0.32	0.22	No	0.67	0.05	0.12	Yes
SOU195-014C	2010-51262 <sup>a</sup>	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	DOI1-99-0062		PGDP	1.31	2.95	2.61	No	0.71	0.13	1.41	No	4.01	1.17	1.62	Yes
F01,21,23	301010	1.6	LOCK	1.26	0.00		Yes				No	0.82		0.08	Yes
SWMU222-4	2010-52458 <sup>a</sup>		KYRAD	1.25	0.48	0.22	Yes				No	1.52	0.44	0.29	Yes
JP-0163	DOI1-99-0163		PGDP	1.22	2.94	2.45	No	0.97	0.23	1.93	No	3.23	1.36	0.78	Yes
NST2S02	BJC2021SS	3	PGDP	1.20	2.87	2.41	No	0.64	0.18	1.28	No	104.00	0.31	3.50	Yes
I94-01,02	301040	6.75	LOCK	1.20	0.00		Yes				No	0.79		0.12	Yes
I94-05,06	301050	17.5	LOCK	1.20	0.00		Yes				No	0.71		0.11	Yes
SOU195-014	2010-51255 <sup>a</sup>	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 <sup>a</sup>	7	KYRAD	1.17	0.64	0.30	Yes	2.25	0.91	0.43	Yes	0.79	0.56	0.35	Yes
I94-05,06	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)

Station	Sample ID	Depth (ft bgs)	Lab Code	Lead-210 (pCi/g)			Radium-226 (pCi/g)			Uranium-238 (pCi/g)		
				Results	MDA	Detect?	Results	MDA	Detect?	Results	MDA	Detect?
H03.07.13	301029	0.7	LOCK	1.10	0.00	Yes	2.13	1.16	Yes	1.10	0.86	Yes
SOU195-006	2010-51265 <sup>a</sup>	7	KYRAD	1.09	0.73	Yes	2.13	1.16	Yes	0.53	0.57	Yes
SOU195-025	2010-51250 <sup>a</sup>	7	KYRAD	1.09	0.84	Yes	2.41	1.65	Yes	0.73	0.72	Yes
SOU195-014B	2010-51261 <sup>a</sup>	10	KYRAD	1.08	0.96	Yes	1.46	1.45	Yes	0.64	0.69	Yes
SOU200-009	2010-51275 <sup>a</sup>	4	KYRAD	1.08	5.15	No	1.87	1.32	Yes	0.60	0.93	Yes
H02.10.18	301028	3	LOCK	1.07	0.00	Yes	0.84	0.16	No	0.92	0.08	Yes
JP-0162	DOJ1-99-0162		PGDP	1.05	1.94	No	2.10	2.10	No	1.67	0.91	No
194-03.04	301041 <sup>e</sup>	12	LOCK	1.04	0.00	Yes			No	0.81	0.12	Yes
SOU200-005	2010-51271 <sup>a</sup>	4	KYRAD	1.04	0.89	Yes	2.15	1.57	Yes	0.70	0.99	Yes
SOU195-014C	2010-51263 <sup>a</sup>	7	KYRAD	1.03	1.04	No	1.73	1.32	Yes	0.59	0.75	Yes
SOU195-025	2010-51251 <sup>a</sup>	10	KYRAD	1.02	0.77	Yes	1.91	1.46	Yes	0.66	1.07	Yes
JP-0091	DOJ1-99-0091		PGDP	1.01	2.08	No	0.82	0.14	No	1.24	1.72	Yes
NST1S01	B3C1011SS	2.5	PGDP	1.01	3.31	No	0.65	0.19	No	1.29	1.87	Yes
SOU200-008	2010-51274 <sup>a</sup>	4	KYRAD	1.01	0.70	Yes	1.88	1.18	Yes	0.53	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	No	0.87	0.29	No	0.25	0.13	Yes
SOU195-014B	2010-51259 <sup>a</sup>	4	KYRAD	0.99	0.92	Yes	1.62	1.32	Yes	0.59	0.99	Yes
JP-0018	DOJ1-99-0016		PGDP	0.96	4.68	No	0.64	0.14	No	1.28	2.30	Yes
OUTFALL10-2	WC02-243	4	PORTS	0.96	0.68	No	0.82	0.31	No	0.28	0.13	Yes
SOU200-006	2010-51272 <sup>a</sup>	4	KYRAD	0.95	0.66	Yes	2.67	1.09	Yes	0.51	0.38	Yes
SOU200-001	2010-51267 <sup>a</sup>	4	KYRAD	0.94	0.83	Yes	2.73	1.33	Yes	0.61	0.39	Yes
SOU200-010	2010-51276 <sup>a</sup>	4	KYRAD	0.89	0.94	No	1.75	1.47	Yes	0.65	0.36	Yes
SOU195-006	2010-51266 <sup>a</sup>	10	KYRAD	0.88	0.78	Yes	1.98	1.52	Yes	0.68	0.63	Yes
JP-0081	DOJ1-99-0081		PGDP	0.87	1.43	No	0.61	0.11	No	1.22	0.17	Yes
SOU200-003	2010-51269 <sup>a</sup>	4	KYRAD	0.86	0.92	No	2.22	1.27	Yes	0.57	0.50	Yes
JP-0015	DOJ1-99-0013		PGDP	0.81	1.66	No	0.62	0.13	No	1.23	1.25	Yes
H03.07.13	301030	3	LOCK	0.80	0.00	Yes			No	0.83	0.08	Yes
NST1S03	B3C1031SS	12	PGDP	0.79	1.55	No	0.80	0.18	No	1.60	0.11	Yes
JP-0080	DOJ1-99-0080		PGDP	0.73	1.91	No	0.82	0.15	No	1.64	0.47	No
SOU195-014	2010-51254 <sup>a</sup>	7	KYRAD	0.71	0.74	No	1.72	1.50	Yes	0.66	0.44	Yes
LBC21L005	LBCSOSU2S1-01	1	STLMO	0.70	2.20	No	1.40	0.15	Yes	0.30	16.80	No
SOU200-007	2010-51273 <sup>a</sup>	4	KYRAD	0.69	0.78	No	2.12	1.68	Yes	0.75	0.41	Yes
JP-0110	DOJ1-99-0110		PGDP	0.67	8.67	No	0.81	0.19	No	1.61	168.00	Yes
SOU200-002	2010-51268 <sup>a</sup>	4	KYRAD	0.65	0.62	Yes	2.10	0.94	Yes	0.44	0.33	Yes
JP-0057	DOJ1-99-0057		PGDP	0.65	1.60	No	0.28	0.09	No	0.56	1.14	Yes
JP-0097	DOJ1-99-0097		PGDP	0.62	1.70	No	0.76	0.13	No	1.52	1.04	No
JP-0066	DOJ1-99-0066		PGDP	0.60	2.87	No	0.85	0.14	No	1.70	1.63	Yes
JP-0082	DOJ1-99-0082		PGDP	0.60	2.74	No	1.29	0.18	No	2.58	0.75	Yes
194-03.04	301046 <sup>e</sup>	21	LOCK	0.60	0.00	Yes			No	1.18	0.16	Yes
JP-0061	DOJ1-99-0061		PGDP	0.60	2.19	No	0.33	0.08	No	0.66	1.00	Yes
JP-0013	DOJ1-99-0011		PGDP	0.55	2.26	No	0.83	0.15	No	1.66	1.38	Yes
JP-0063	DOJ1-99-0063		PGDP	0.54	2.50	No	0.65	0.12	No	1.29	0.10	Yes
JP-0087	DOJ1-99-0088		PGDP	0.47	5.67	No	0.77	0.13	No	1.54	4.19	Yes

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

Station	Sample ID	Depth (ft bgs)	Lab Code	Lead-210 (pCi/g)			Radium-226 (pCi/g)			Uranium-238 (pCi/g)							
				Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU	Detect?	Results	MDA	Rad Error	TPU
A10	PLDJNSA10-02SO	8.5	PGDP	0.34	5.70	0.69	3.60	No	0.49	0.12	0.98	No	1.91	0.79	0.42	3.26	No
S0C	ISOCBKR08-01	0	PGDP	0.34	1.04	0.68	0.68	No				No	1.58	0.47	0.25	0.33	Yes
	BJC2031SS	15	PGDP	0.31	2.30	0.61	1.39	No	0.99	0.19	1.98	No	19.80	0.08	0.79	3.00	Yes
P-0112	DOJ1-99-0114		PGDP	0.27	1.38	0.54	0.85	No	0.67	0.11	1.34	No	7.50	0.01	0.37	1.10	Yes
P-0060	DOJ1-99-0060		PGDP	0.22	2.13	0.44	1.40	No	0.13	0.04	0.16	No	8.24	0.85	1.26	3.40	Yes
C01.10.24	301018 <sup>d</sup>	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	No	1.21	0.20	0.32	1.70	No
P-0100	DOJ1-99-0100		PGDP	0.09	1.44	0.18	0.89	No	0.72	0.12	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	No	29.70	1.38	2.18	8.27	Yes
P-0016	DOJ1-99-0014		PGDP	0.00	1.81	0.01	1.10	No	0.57	0.12	1.13	No	8.80	0.04	0.35	1.20	Yes
96-01.02	301037	7	LOCK	0.00 <sup>f</sup>	0.00			No				No	0.82	0.12			Yes
P-0164	DOJ1-99-0164		PGDP	-0.01	1.86	0.01	1.15	No	0.69	0.15	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	No	8.11	0.91	1.35	2.56	Yes
P-0045	DOJ1-99-0045		PGDP	-0.29	2.68	0.58	1.76	No	0.58	0.12	1.15	No	6.00	0.01	0.23	0.77	Yes
P-0016	DOJ1-99-0014DUP		PGDP	-0.29	1.76	0.59	1.08	No	0.52	0.12	1.05	No	11.00	0.02	0.37	1.40	Yes
P-0087	DOJ1-99-0087		PGDP	-0.43	5.27	0.86	3.23	No	0.65	0.12	1.30	No	126.00	2.33	3.83	48.30	Yes
P-0071	DOJ1-99-0071		PGDP	-0.75	5.45	1.50	3.40	No	2.78	0.26	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
P-0085	DOJ1-99-0085		PGDP	-0.86 <sup>f</sup>	6.72	1.72	4.14	No	0.80	0.15	1.60	No	160.00	3.01	5.07	61.80	Yes
F05.07.17	301007	1	LOCK	-1.10 <sup>f</sup>	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	No	326.00	4.61	7.56	125.00	Yes
P-0072	DOJ1-99-0072		PGDP	-1.31	9.10	2.62	5.58	No	6.88	0.41	13.75	No	87.00	0.24	2.80	21.00	Yes
P-0111	DOJ1-99-0112		PGDP	-1.99	6.10	3.99	3.99	No	0.84	0.17	1.69	No	317.00	0.67	11.00	68.00	Yes
P-0076	DOJ1-99-0076		PGDP	-2.04	6.16	4.07	4.07	No	2.19	0.23	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	No	11.10	1.90	3.14	4.33	Yes
P-0077	DOJ1-99-0077		PGDP	-2.71	5.02	5.42	5.42	No	1.47	0.17	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	No	1.24	0.26	0.44	2.14	No
P-0152	DOJ1-99-DUP1		PGDP	-2.91	6.47	5.83	5.83	No	0.87	0.13	1.73	No	393.00	0.69	12.00	120.00	Yes
P-0111	DOJ1-99-0111		PGDP	-2.99	6.03	5.98	5.98	No	0.91	0.17	1.81	No	365.00	0.13	4.50	63.00	Yes
P-0151	DOJ1-99-0151		PGDP	-4.78	8.89	9.57	9.57	No	0.54	0.13	1.07	No	365.00	3.25	5.42	140.00	Yes
P-0150	DOJ1-99-0150		PGDP	-10.07	12.75	20.14	20.14	No	0.79	0.18	1.58	No	599.00	4.88	8.14	230.00	Yes
P-0153	DOJ1-99-0153		PGDP	-19.47	14.31	38.93	38.93	No	0.32	0.17	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 = Lockhead 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

<sup>a</sup> The uranium-238 results were reported by the lab as thorium-234/uranium-238.

<sup>b</sup> The maximum uranium-238 result was used for comparison.

<sup>c</sup> This sample is not plotted in Figure 2, the coordinates place the sample in Illinois. The available coordinates are likely incorrect.

<sup>d</sup> This sample is not plotted in Figure 2, no coordinates are available.

<sup>e</sup> This sample is not plotted in Figure 2, the coordinates place the sample in Ballard County, which is outside the scale of the map.

<sup>f</sup> This result 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	161	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 3<sup>rd</sup> party validation was performed

U = not detected above the MDA

R = result rejected

"=" = result accepted by 3<sup>rd</sup> 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.,  $1\text{E-}6$  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  $1\text{E-}5$ .

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.

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

USGS 2012. *<sup>210</sup>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 Polycyclic Aromatic Hydrocarbons (PAHs),<sup>1</sup> the presence of PAHs in Paducah Gaseous Diffusion Plant (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.<sup>2</sup> Thus, in evaluating risk/hazard at PGDP SWMUs/areas of concern (AOCs) 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.<sup>3</sup>

### **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;<sup>4</sup> 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,<sup>2</sup> 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 (TSD) activities; and (2) concentrations are sufficiently high that the acceptable risk range of  $1\text{E-}4$  to  $1\text{E-}6$  is exceeded.<sup>5</sup> Additionally, 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.<sup>3,6</sup> Kentucky Revised Statutes exclude emissions from the engine exhaust of a motor vehicle from the definition of a release;<sup>7</sup> 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 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.
- Because of the many potential sources, 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. Alternatively, 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. At PGDP, there were 334 detected benzo(a)pyrene results, out of 4,544 analyzed 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 are used to calculate Total PAHs.<sup>8</sup> Factors utilize results from the carcinogen PAHs of 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 Total PAHs as they are found in surface (0–1 ft), subsurface (1–10 ft), and deep subsurface soils (> 10 ft) (as defined by the Paducah Risk Methods Document).<sup>8</sup>

**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

Figures E.8 through E.10 illustrate the location of these total PAHs by depth. Ranges of values are shown with respect to the no action level for the industrial worker (i.e., 1E-6) and action level for the industrial worker (i.e., 1E-4), 0.784 mg/kg and 78.4 mg/kg, respectively.

In conclusion, the Observations section of the BHHRA should address the uncertainties associated with the presence of PAHs, and the feasibility study (FS) should include discussions ensuring that remedial actions appropriately address the uncertainties associated with the presence of residual concentrations of PAHs.

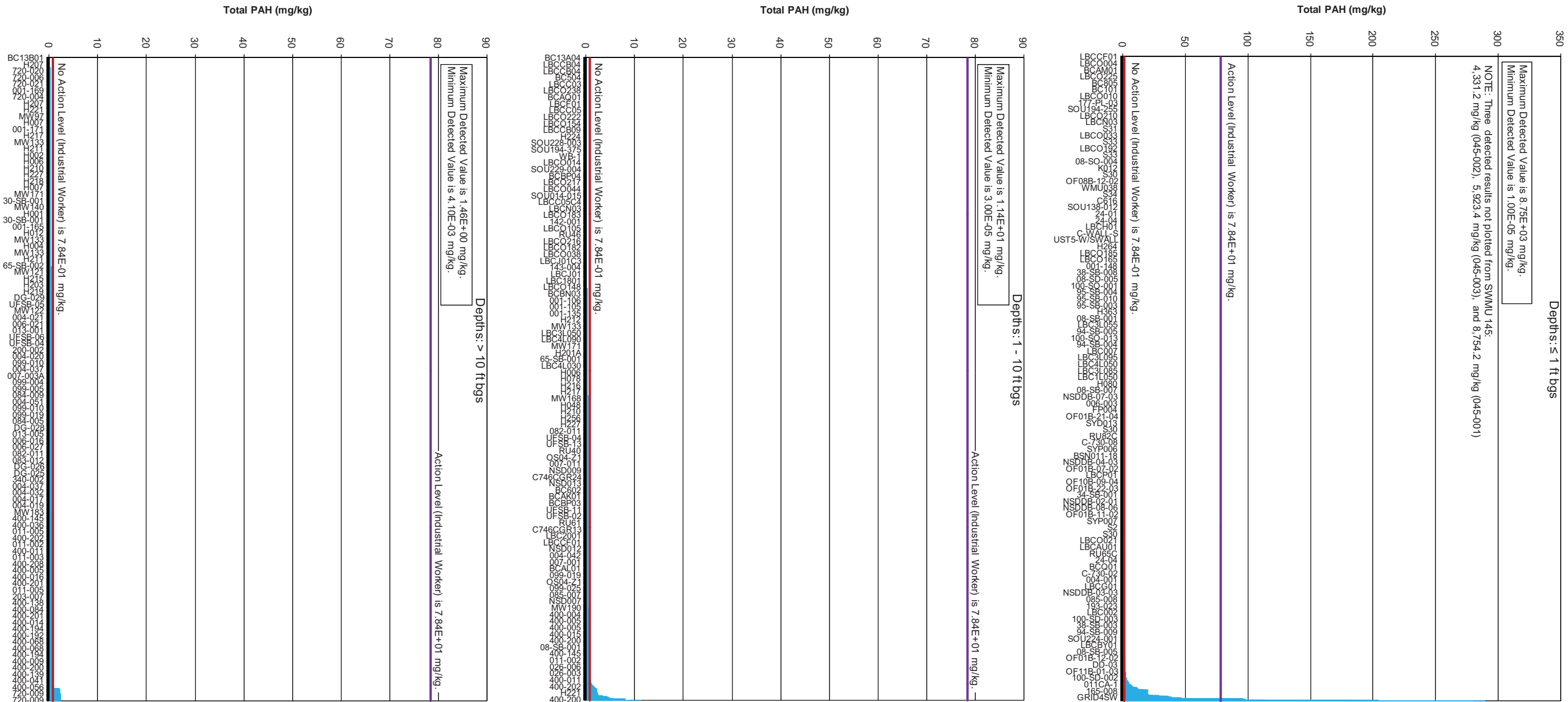


Figure E.8. Total PAH Concentrations by Depth

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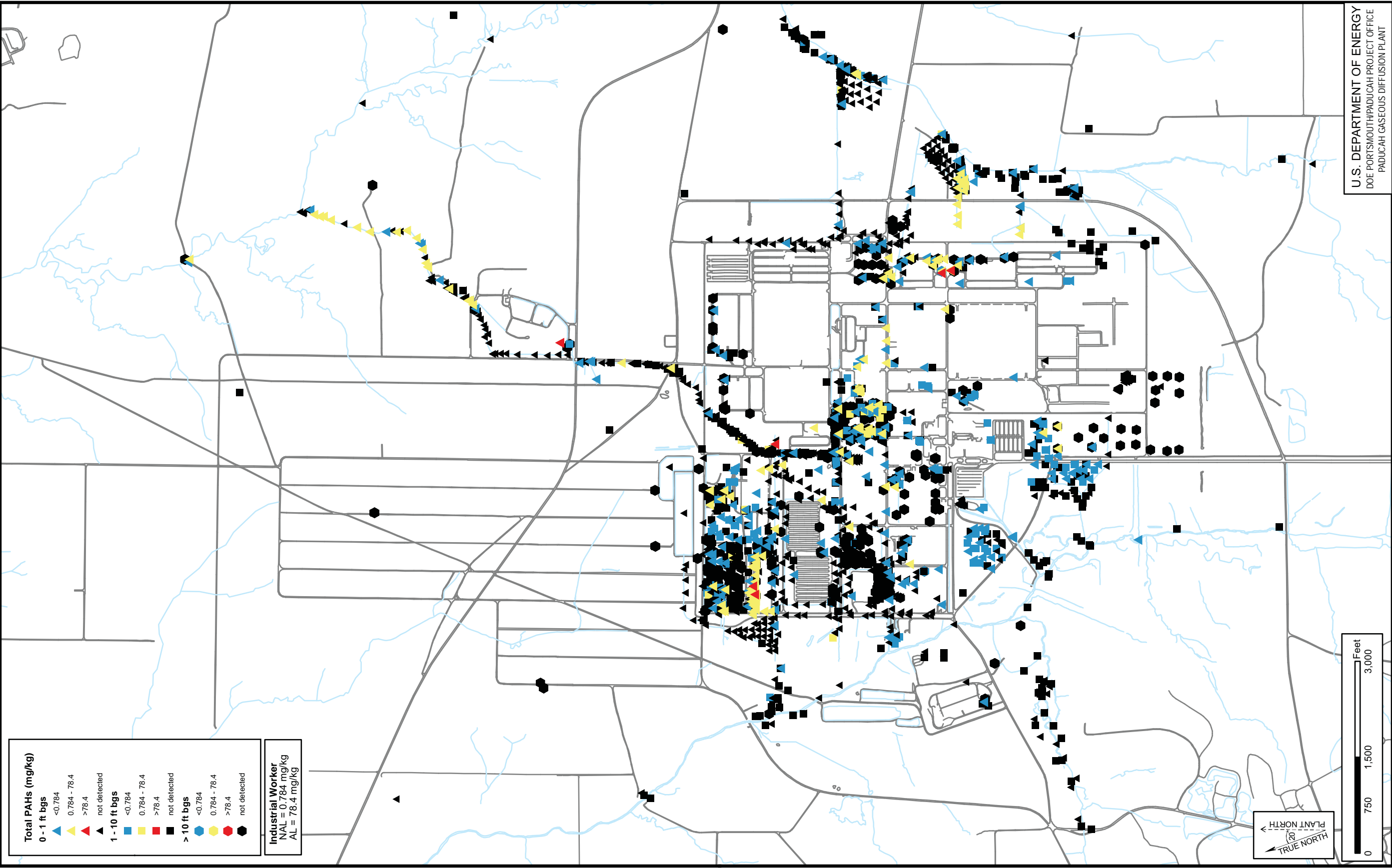


Figure E.9. Total PAH Soil/Sediment Samples

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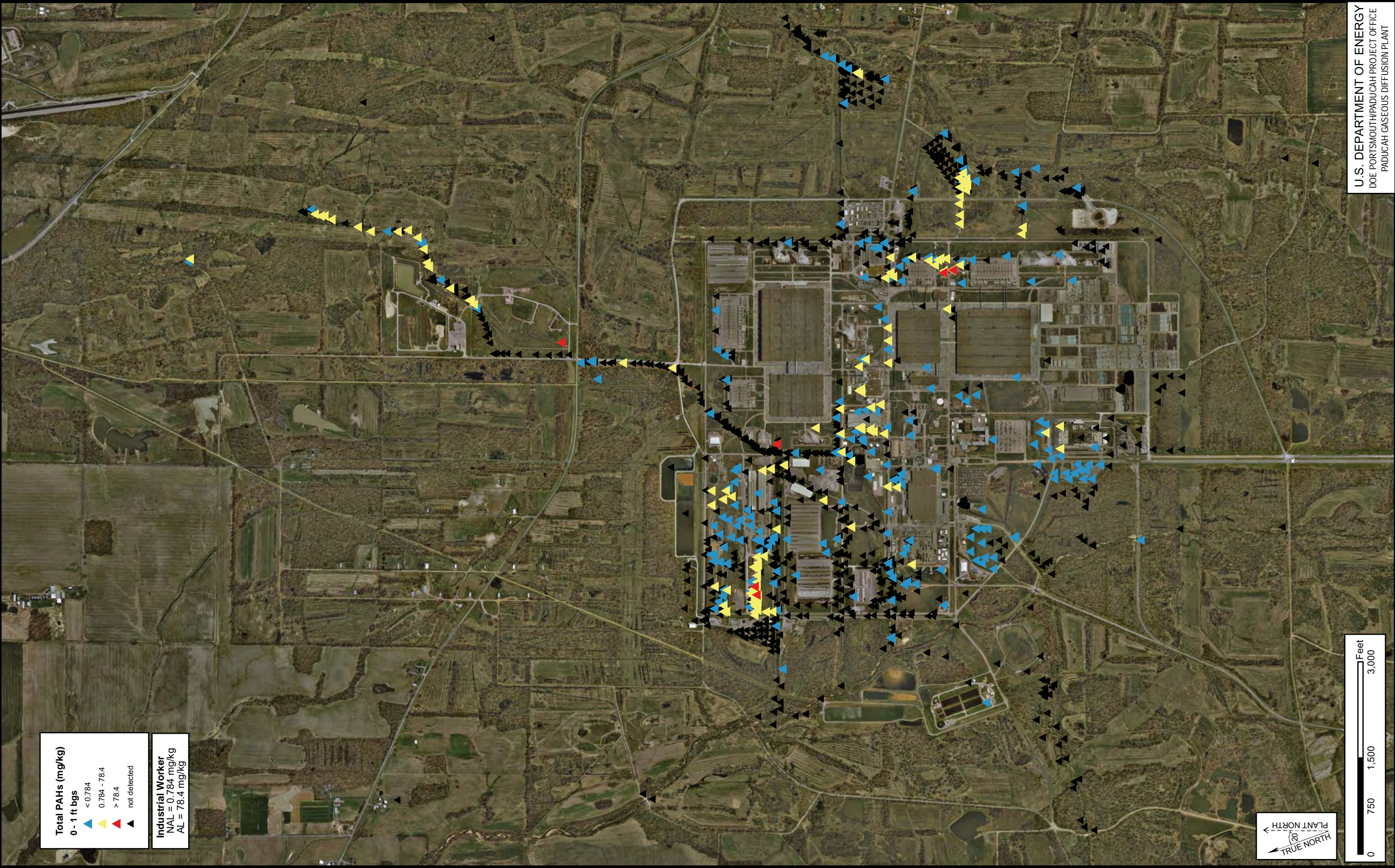


Figure E.10. Total PAH Surface (0-1 ft bgs) Soil/Sediment Samples

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DOE PORTSMOUTH/PADUCAH PROJECT OFFICE  
PADUCAH GASEOUS DIFFUSION PLANT



Figure No. 2012\_Total PAHs in Soil-Sediment\_SurfaceR1.mxd  
DATE 12-19-2012



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### E.7.3 SUMMARY

In evaluating risk/hazard at PGDP, PAHs will be evaluated 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, consistent with the Paducah Risk Methods Document.<sup>8</sup> 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.

Because PAHs generally are not related to identifiable sources, sampling for PAHs at many SWMUs should be deferred to post-gaseous diffusion plant (GDP) activities; however, the need for sampling for PAHs would be appropriate during pre-GDP activities at SWMUs where PAHs release are potentially expected (e.g., SWMU 30, which contained an incinerator). The need for sampling for PAHs should be addressed during project scoping on a SWMU-specific basis.

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

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

<sup>3</sup> E-mail correspondence among FFA parties.

<sup>4</sup> *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.

<sup>5</sup> “Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions” (OSWER Directive 9355.0-30) April 22, 1991.

<sup>6</sup> Kentucky Guidance for Ambient Background Assessment, January 8, 2004, Natural Resources and Environmental Protection Cabinet.

<sup>7</sup> Kentucky Revised Statute 224.01-400 (1) (b).

<sup>8</sup> *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.

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## **E.8. DILUTION ATTENUATION FACTOR EVALUATION**

An evaluation of the dilution attenuation factor (DAF), including a sensitivity analysis of how the screening results would vary in response to a change in the target DAF used in screening was conducted in the *Soils Operable Unit Remedial Investigation Report at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0358&D2/R1 (issued February 2013).

The attachment from DOE/LX/07-0358 containing this evaluation is reprinted in this section.

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## C2. DILUTION ATTENUATION FACTOR EVALUATION

The maximum Upper Continental Recharge System (UCRS) soil concentrations that are protective of Regional Gravel Aquifer (RGA) groundwater quality are determined by combining the dilution attenuation factor (DAF) (unitless) calculations with contaminant-specific distribution coefficients ( $K_d$ ) (units of volume/mass). The DAF is a measure of how much the UCRS concentration of a soil constituent is diluted or attenuated by the migration through the UCRS, coupled with the migration through the RGA.

The DAF was calculated by comparing the volume of contaminated groundwater passing vertically through a UCRS solid waste management unit (SWMU)/area of concern (AOC) with the volume of “clean” RGA groundwater flowing beneath the SWMU/AOC and mixing with the UCRS water. 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 “clean” 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 the horizontal rate of migration of “clean” RGA groundwater to yield a concentration of the blended diluted/attenuated 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 relative to that dissolved in groundwater.

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

Once calculated, the maximum UCRS soil contaminant concentrations were used as site-specific remedial guide soil screening levels to screen the site-specific soil contamination data to identify those constituents that may pose a threat to groundwater. Soil contaminants found at concentrations below the levels identified as protective were screened from further evaluation of impacts to groundwater. Sites having soil contamination above the identified protective levels then were subjected to additional evaluation to estimate the potential for impacts to groundwater. This evaluation is summarized elsewhere in Appendix C and included the following:

- Comparing the nature of the constituent against the constituents found to have had an impact on the RGA groundwater at Paducah Gaseous Diffusion Plant (PGDP) (see Attachment C1) to identify whether there is evidence of these soil concentrations having had an impact on the RGA groundwater;
- Evaluating the horizontal and vertical spatial distribution of soil constituent concentrations to identify hot spots that may need to be addressed;
- Evaluating the locations of the constituents and comparing them to the RGA groundwater impacts; and
- Performing numerical modeling using the spatial distribution of soil contamination as an input into the Seasonal Soil Compartment Model (SESOL) and Analytical Transient 1-,2-,3- Dimensional (AT123D) modeling to predict downgradient RGA temporal groundwater concentrations.

This attachment discusses the derivation of the DAF and the finding that the deterministic DAF for these soils is calculated at 58. This attachment also provides a sensitivity analysis of the screening of Soils Operable Unit (OU) concentrations against values calculated using a DAF of 58 and a DAF of 20. The effects on the decision to model groundwater impacts from individual SWMU/AOC soil constituent combinations are also discussed.

## C2.1. METHODOLOGY

The DAF calculation recognizes that vertical mixing of UCRS and RGA groundwater does not immediately occur throughout the entire RGA thickness and mixing primarily occurs in the upper portions of the RGA immediately below the source area, deemed the mixing depth. The DAF (unitless) for the Soils OU is calculated using the following equation:

$$DAF = 1 + \frac{Kid}{IL} \quad (\text{EPA 1996})$$

Where:

i = horizontal hydraulic gradient (m/m)

d = mixing zone depth (m)

I = infiltration rate (m/yr)

L = length of source area parallel to groundwater flow (m)

K = aquifer hydraulic conductivity (m/yr)

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

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

Where:

d<sub>a</sub> = aquifer thickness (m)

The first term in the equation predicts the depth of the mixing due to vertical dispersivity along the length of the groundwater flow path:

$$(0.0112 L^2)^{0.5}$$



The second term in the equation estimates the depth of mixing due to the downward velocity of infiltrating water:

$$d_a \left\{ 1 - e^{\left[ \frac{(-L I)}{(K i d_a)} \right]} \right\}$$

Most important is the presence of L (length of source area parallel to groundwater flow) in d (mixing zone depth) in the DAF equation. Incorporation of L in d, results in L being in both the numerator and denominator of the DAF equation. NOTE: These equations indicate that as long as hydraulic conductivity (K), hydraulic gradient (i) and the infiltration rate (I) remain constant, the DAF will be constant regardless of the size of the source area undergoing evaluation. While mathematically true, the DAF is ultimately based on plume center-line concentrations which remain the same regardless of source area size. What does differ is the plume footprint, smaller source areas will generate smaller plume widths and lengths relative to larger source areas; however, the plume center-line concentrations will be the calculated to be the same regardless of source area size.

## C2.2. DAF CALCULATIONS

Assuming an L of 1 m and using the input parameters provided in Table C2.1, the DAF result is 58 for all Soils OU SWMUs/AOCs. With the exception of aquifer thickness, Table C2.1 values are exactly the same as those used for the Southwest Plume Site Investigation (DOE 2007) DAF evaluation. The aquifer thickness differs (9.14 m versus 10.54 m) slightly because the previous efforts did not include the Hydrogeologic Unit (HU) 4 stratigraphic thickness in the total RGA aquifer thickness despite the HU4 being considered part of the RGA flow system as evidenced by the unit being included in determining a representative RGA/HU4 hydraulic conductivity value.

**Table C2.1. DAF Input Parameter Values**

Parameter	Description	Value	Source
K	Horizontal Hydraulic Conductivity	<p>0.45 cm/s; 1,286 ft/d</p> <p>This value represents the arithmetic averaged hydraulic conductivity for the RGA/HU4 stratigraphic sequence</p> <p><u>RGA</u> K, 0.53 cm/s; thickness, 9.14 m K, 1,502 ft/d; thickness, 30 ft</p> <p><u>HU4</u> K, 0.001 cm/s; thickness, 1.5 m K, 2.8 ft/d; thickness, 5 ft</p>	Southwest Plume Site-Investigation Report (DOE 2007)
I	Horizontal Hydraulic Gradient	4.00E-04 m/m, 4.00E-04 ft/ft	Southwest Plume Site-Investigation Report (DOE 2007)

**Table C2.1. DAF Input Parameter Values (Continued)**

Parameter	Description	Value	Source
I	Infiltration Rate	0.1054 m/yr, 4.1 inches/yr	SESOIL predicted net recharge rate to groundwater, Southwest Plume Remedial Investigation Report (DOE 2007)
d <sub>a</sub>	Aquifer Thickness (HU4 +RGA)	10.54 m, 35 ft	Southwest Plume Site-Investigation Report (DOE 2007)

As noted previously, the DAF is independent of waste area size, but is dependent on K, i, and I. Given that the 50 Soils OU SWMUs/AOCs are widely distributed within the PGDP and the vicinity, it is expected that site-specific K, i, and I will vary somewhat.

An evaluation of RGA horizontal hydraulic gradients shows i is expected to range between  $1.84 \times 10^{-4}$  and  $2.98 \times 10^{-3}$  ft/ft and have average and median values of  $7.81 \times 10^{-4}$  and  $4.4 \times 10^{-4}$  ft/ft, respectively (DOE 2010). Because of the inclusion in the data set of some localized, relatively high horizontal hydraulic gradients associated with PGDP anthropogenic influences, the median horizontal hydraulic gradient is more representative than the average horizontal hydraulic gradient.

With respect to K variability, six RGA pumping tests have been conducted and have produced hydraulic conductivity estimates ranging between approximately 100 and 3,600 ft/day (CH2M HILL 1992; LMES 1996a; LMES 1996b; LMES 1997; Terran 1990; Terran 1992). The lowest measured RGA hydraulic conductivity is beneath PGDP. The highest measured value is between PGDP and the Ohio River. A previous evaluation assumed that RGA hydraulic conductivity ranged between 75 ft/d and 1,500 ft/d, with a likeliest value of 350 ft/d (DOE 2007). The evaluation was based on the 1997 PGDP groundwater flow model (DOE 1997), which has since undergone recalibration. The current calibrated PGDP RGA groundwater flow model (DOE 2010) contains K values that range over the values characterized by the RGA pumping tests.

Minimal HU4 K measurements have been collected so the value presented in Table C2.1 is assumed to be representative. In addition, the thicker (and thus higher weighted) and higher RGA K values dominate the arithmetic averaged calculations, thus fixing the HU4 K in the analysis will have minimal impact on the evaluation.

Thornthwaite analysis (Thornthwaite and Mather 1957), which is based on monthly precipitation and potential evaporation rates, was used to estimate I at PGDP (DOE 2010). The calculations estimate that I ranges from 2.64 to 7.64 inches/yr. In addition to I from precipitation, anthropogenic I from man-made sources could be as high as 48 inches/yr (DOE 2010). Note that the higher anthropogenic I values are believed to be associated with features such as the cooling towers, the C-616 Lagoons, and building drainage systems; thus, the anthropogenic I values are expected to have only limited impacts on the migration of constituents from the Soils OU SWMUs/AOCs. It is assumed that the calculated range associated with precipitation I is most appropriate for an evaluation of the Soils OU SWMUs/AOCs.

For this analysis, it was assumed that the HU4 and RGA thickness reported in Table C2.1 are “typical.”

**Table C2.2. Minimum and Maximum DAF Input Parameter Values**

Parameter	Description	Minimum Value	Maximum Value
K	Horizontal Hydraulic Conductivity	0.03 cm/s; 85 ft/d  This value represents the arithmetic averaged hydraulic conductivity for the RGA/HU4 stratigraphic sequence  <u>RGA</u> K, 0.035 cm/s; thickness, 9.14 m K, 100 ft/d; thickness, 30 ft  <u>HU4</u> K, 0.001 cm/s; thickness, 1.5 m K, 2.8 ft/d; thickness, 5 ft	1.09 cm/s; 3,087 ft/d  This value represents the arithmetic averaged hydraulic conductivity for the RGA/HU4 stratigraphic sequence  <u>RGA</u> K, 1.27 cm/s; thickness, 9.14 m K, 3,600 ft/d; thickness, 30 ft  <u>HU4</u> K, 0.001 cm/s; thickness, 1.5 m K, 2.8 ft/d; thickness, 5 ft
i	Horizontal Hydraulic Gradient	1.84E-04 m/m, 1.84E-04 ft/ft	2.98E-03 m/m, 2.98E-04 ft/ft
I	Infiltration Rate	0.0679 m/yr, 2.64 inches/yr	0.1964 m/yr, 7.64 inches/yr
d <sub>a</sub>	Aquifer Thickness (HU4 +RGA)	10.54 m, 35 ft	10.54 m, 35 ft

Based on expected minimum and maximum K, i, and I values (Table C2.2), DAF values for the Soils OU are expected to range between 5 and 139. If the maximum hydraulic conductivity value is limited to 1,500 ft/d, to reflect the lower hydraulic conductivity values found beneath the PGDP, then the maximum DAF is 68.

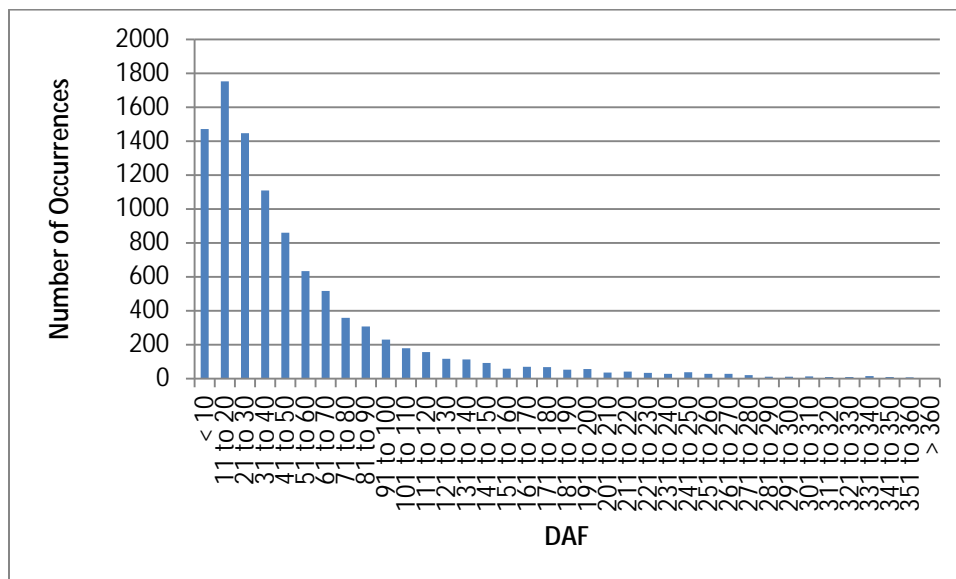
The previous calculations provide an indication of the potential DAF range based on sitewide input parameter variability; however, the evaluation does not characterize the DAF distribution between the potential minimum and maximum DAF values. To develop a better understanding of the potential DAF distribution, probabilistic evaluation was performed using the parameter value distributions listed in Table C2.3.

**Table C2.3. Parameter Distributions**

Parameter	Most Likely Value	Minimum Value	Maximum Value	Standard Deviation	Coefficient of Variation	Distribution Type
Hydraulic Conductivity, ft/d	350	75	1,500	350	100	Log Normal
Horizontal Hydraulic Gradient, ft/ft	1.01E-03	1.00E-04	4.00E-03	1.12E-03	1.11E+02	Normal
Infiltration, inches/yr	4.1	2.64	7.64	--	--	Uniform
Aquifer Thickness, ft	38.71	10	63.5	11.84	30.59	Normal

The parameter distributions, with the exception of I, were developed for probabilistic evaluation of soil cleanup RGs for SWMU 1 and the C-720 Building (DOE 2007; DOE 2011). For the soil RG probabilistic evaluation, I was held constant. For this probabilistic evaluation, I, as discussed previously, was assumed to range linearly between 2.64 inches/yr and 7.64 inches/yr.

Crystal Ball® (Decisioneering, Inc. 2000) was used to generate 10,000 individual K, horizontal i, I, and  $d_a$  values which were used as input to the DAF calculation. The evaluation predicted mean, median, minimum, and maximum DAF values of 52, 33, 3, and 366, respectively. Note that the probabilistic mean (52) DAF value is similar to the deterministic mean DAF value of 58. Additionally, the probabilistic minimum DAF (3) is similar to the minimum DAF (5) calculated using minimum parameter inputs (Table C2.2). The maximum probabilistic DAF (366), while larger than the deterministic maximum DAF (139), is within the same order of magnitude. Evaluation of the probabilistic DAF distribution (Figure C2.1) shows that lower DAF values occur more frequently than higher DAF values with the most frequently occurring DAF being between 11 and 20.



**Figure C2.1. Probabilistic DAF Distribution**

## C2.3. SUMMARY

Deterministic evaluation of PGDP site conditions predicts a DAF of 58 for the Soils OU. Minimum and maximum deterministic predicted DAF values are 5 and 139, respectively. Probabilistic evaluation predicts average, median, minimum, and maximum DAF values of 52, 33, 3, and 366, respectively. Frequency evaluation shows that lower value DAF values are more common than higher DAF values, with the most frequently occurring DAF being between 11 and 20.

The DAF of 58 determined in this calculation was used to support screening of the Soils OU results to identify those SWMUs/AOCs where constituents might present an impact to groundwater. The results of this screening are summarized in Attachment C1 to Appendix C.

Section C2.4 presents a sensitivity analysis of this same screening using a DAF of 20. The DAF of 20 was used because it is a value that EPA uses as a default value for screening in their derivation of soil screening values and also because it is a lower value than the median value calculated for PGDP of 33. A value of 20 is recognized as a reasonable value for general soil conditions (including sandy soils); however, the UCRS at PGDP has much more silt and clay than the typical sandy soil condition; thus, a DAF greater than 20 (33 or 58) is expected to better estimate the actual potential for migration to

groundwater at the PGDP. The DAF of 58 is similar to that calculated for the Southwest Plume and is considered typical of that found at PGDP where most locations have a majority of the URCS composed of silt and clay.

## **C2.4. SENSITIVITY ANALYSIS**

The screening identified in Attachment C1 of Appendix C was carried out using a DAF of 58 to yield the results summarized in Tables C1.3 and C1.4. This screening identified 109 SWMU/AOC soil constituent combinations that exceeded the screening values based on the overall average concentration, as follows:

- Thirty exceeded for silver (9 exceeded average without maximum value exceedance);
- Twenty-three exceeded for Total polycyclic aromatic hydrocarbons (PAHs) or benz(a)anthracene [3 exceeded the average (calculated using half the detection limit) but the maximum detected value did not exceed the screening level];
- Twenty-three exceeded for molybdenum (18 exceeded average without maximum value exceedance);
- Two exceeded for nickel;
- Four exceeded for neptunium-237;
- Two exceeded for technetium-99;
- Eight exceeded for naphthalene;
- One exceeded for thorium-230;
- Two exceeded for cobalt;
- One exceeded for uranium-238;
- One exceeded for uranium;
- Two exceeded for vanadium;
- Three exceeded for Total polychlorinated biphenyl (PCBs);
- Two exceeded for pentachlorophenol (1 exceeded average without maximum value exceedance);
- Two exceeded for arsenic; and
- Three exceeded for volatile organic compounds (VOCs) (1 VOC each; all at SWMU 1).

Based upon the additional evaluation presented in Attachment C1 to Appendix C, 8 SWMU/AOC soil constituent combinations were subjected to fate and transport modeling as summarized in Appendix C.

This same screening approach was performed using values derived from a DAF of 20 in order to evaluate the sensitivity of this screening to the DAF. Screening against DAF 20 values identified 280

SWMU/AOC soil constituent combinations that exceeded the screening values based on the average concentrations, as follows, and shown in Table C2.4, sorted by analyte.

- Two exceeded soil screening levels/background for antimony
- Seven exceeded for arsenic
- Fifty-four exceeded for Total PAHs or benz(a)anthracene
- Two exceeded for cobalt
- Twenty-nine exceeded for mercury
- Thirty-three exceeded for molybdenum
- Eight exceeded for naphthalene
- Nine exceeded for neptunium-237
- Twenty-nine exceeded for nickel
- Two exceeded for pentachlorophenol
- Three exceeded for plutonium 239/240
- Thirty exceeded for selenium
- Thirty exceeded for silver
- Five exceeded for Tc-99
- Five exceeded for thallium
- Two exceeded for thorium-230
- Sixteen exceeded for Total PCBs
- Three exceeded for uranium
- Three exceeded for uranium-238
- Two exceeded for vanadium
- One exceeded for zinc
- Six exceeded for VOCs

**Table C2.4. SWMU/AOC Soil Constituent Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20**

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
1	99	Antimony	mg/kg	5.47E+00	5.30E-01	<b>2.10E-01</b>	<b>5.42E+00</b>
2	196	Antimony	mg/kg	7.81E+00	1.21E+02	<b>2.10E-01</b>	<b>5.42E+00</b>
1	76	Arsenic	mg/kg	8.10E+00	1.31E+01	<b>7.90E+00</b>	<b>5.84E+00</b>
2	81	Arsenic	mg/kg	8.18E+00	1.37E+01	<b>7.90E+00</b>	<b>5.84E+00</b>
3	165	Arsenic	mg/kg	2.72E+01	1.30E+02	<b>7.90E+00</b>	<b>5.84E+00</b>
4	180	Arsenic	mg/kg	8.23E+00	1.38E+02	<b>7.90E+00</b>	<b>5.84E+00</b>
5	531	Arsenic	mg/kg	9.97E+00	4.68E+01	<b>7.90E+00</b>	<b>5.84E+00</b>
6	561	Arsenic	mg/kg	9.00E+00	3.96E+01	<b>7.90E+00</b>	<b>5.84E+00</b>
7	564	Arsenic	mg/kg	2.54E+01	4.30E+01	<b>7.90E+00</b>	<b>5.84E+00</b>
1	1	Benz(a)anthracene	mg/kg	3.02E-01	6.40E-02	<b>0.00E+00</b>	<b>8.64E-02</b>
2	19	Benz(a)anthracene	mg/kg	4.45E-01	3.70E+00	<b>0.00E+00</b>	<b>8.64E-02</b>
3	76	Benz(a)anthracene	mg/kg	9.40E-01	1.70E+00	<b>0.00E+00</b>	<b>8.64E-02</b>
4	81	Benz(a)anthracene	mg/kg	2.43E-01	6.50E-01	<b>0.00E+00</b>	<b>8.64E-02</b>
5	138	Benz(a)anthracene	mg/kg	5.24E-01	4.80E-02	<b>0.00E+00</b>	<b>8.64E-02</b>
6	153	Benz(a)anthracene	mg/kg	1.32E-01	5.80E-02	<b>0.00E+00</b>	<b>8.64E-02</b>

**Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)**

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
7	156	Benz(a)anthracene	mg/kg	1.55E-01	6.60E-02	0.00E+00	8.64E-02
8	158	Benz(a)anthracene	mg/kg	3.67E-01	4.30E-01	0.00E+00	8.64E-02
9	163	Benz(a)anthracene	mg/kg	1.97E-01	1.60E-01	0.00E+00	8.64E-02
10	165	Benz(a)anthracene	mg/kg	3.36E-01	1.50E+00	0.00E+00	8.64E-02
11	169	Benz(a)anthracene	mg/kg	7.50E-01	1.30E+00	0.00E+00	8.64E-02
12	180	Benz(a)anthracene	mg/kg	1.84E-01	4.80E-02	0.00E+00	8.64E-02
13	194	Benz(a)anthracene	mg/kg	2.13E-01	8.90E-01	0.00E+00	8.64E-02
14	195	Benz(a)anthracene	mg/kg	2.05E-01	1.90E-01	0.00E+00	8.64E-02
15	196	Benz(a)anthracene	mg/kg	1.24E+00	6.90E+00	0.00E+00	8.64E-02
16	213	Benz(a)anthracene	mg/kg	1.10E-01	1.10E-01	0.00E+00	8.64E-02
17	215	Benz(a)anthracene	mg/kg	2.25E-01	8.00E-02	0.00E+00	8.64E-02
18	217	Benz(a)anthracene	mg/kg	2.08E-01	3.80E-01	0.00E+00	8.64E-02
19	221	Benz(a)anthracene	mg/kg	6.10E-01	6.10E-01	0.00E+00	8.64E-02
20	222	Benz(a)anthracene	mg/kg	1.20E-01	1.20E-01	0.00E+00	8.64E-02
21	227	Benz(a)anthracene	mg/kg	2.11E-01	1.18E-01	0.00E+00	8.64E-02
22	228	Benz(a)anthracene	mg/kg	1.18E-01	4.00E-02	0.00E+00	8.64E-02
23	488	Benz(a)anthracene	mg/kg	1.93E-01	1.90E-01	0.00E+00	8.64E-02
24	489	Benz(a)anthracene	mg/kg	1.36E-01	7.60E-02	0.00E+00	8.64E-02
25	518	Benz(a)anthracene	mg/kg	7.92E+00	1.10E+02	0.00E+00	8.64E-02
26	520	Benz(a)anthracene	mg/kg	2.25E-01	3.80E-01	0.00E+00	8.64E-02
27	531	Benz(a)anthracene	mg/kg	1.17E-01	3.90E-02	0.00E+00	8.64E-02
28	541	Benz(a)anthracene	mg/kg	6.29E-01	6.40E+00	0.00E+00	8.64E-02
29	561	Benz(a)anthracene	mg/kg	2.17E-01	1.90E+00	0.00E+00	8.64E-02
30	562	Benz(a)anthracene	mg/kg	2.55E-01	5.20E-01	0.00E+00	8.64E-02
1	1	<i>cis</i> -1,2-Dichloroethene	mg/kg	1.79E+01	2.40E+03	0.00E+00	4.12E-01
1	217	Cobalt	mg/kg	1.38E+01	1.90E+02	1.30E+01	2.82E-01
2	221	Cobalt	mg/kg	4.05E+01	1.44E+02	1.30E+01	2.82E-01
1	14	Mercury	mg/kg	4.87E+00	4.37E+01	1.30E-01	2.08E+00
2	76	Mercury	mg/kg	3.50E+00	7.45E+00	1.30E-01	2.08E+00
3	81	Mercury	mg/kg	4.27E+00	8.33E+00	1.30E-01	2.08E+00
4	99	Mercury	mg/kg	4.20E+00	9.53E+00	1.30E-01	2.08E+00
5	138	Mercury	mg/kg	4.89E+00	2.13E+01	1.30E-01	2.08E+00
6	153	Mercury	mg/kg	4.34E+00	1.99E-02	1.30E-01	2.08E+00
7	156	Mercury	mg/kg	4.70E+00	9.87E+00	1.30E-01	2.08E+00
8	158	Mercury	mg/kg	4.49E+00	1.05E+01	1.30E-01	2.08E+00
9	163	Mercury	mg/kg	4.33E+00	7.53E+00	1.30E-01	2.08E+00
10	169	Mercury	mg/kg	3.02E+00	7.87E+00	1.30E-01	2.08E+00
11	180	Mercury	mg/kg	4.69E+00	8.28E+00	1.30E-01	2.08E+00
12	194	Mercury	mg/kg	4.58E+00	8.94E+00	1.30E-01	2.08E+00

**Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)**

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
13	195	Mercury	mg/kg	4.64E+00	8.43E+00	<b>1.30E-01</b>	<b>2.08E+00</b>
14	200	Mercury	mg/kg	4.62E+00	6.93E+00	<b>1.30E-01</b>	<b>2.08E+00</b>
15	212	Mercury	mg/kg	3.20E+00	6.94E+00	<b>1.30E-01</b>	<b>2.08E+00</b>
16	213	Mercury	mg/kg	4.75E+00	3.75E-02	<b>1.30E-01</b>	<b>2.08E+00</b>
17	214	Mercury	mg/kg	3.35E+00	4.16E-02	<b>1.30E-01</b>	<b>2.08E+00</b>
18	215	Mercury	mg/kg	4.35E+00	2.83E-02	<b>1.30E-01</b>	<b>2.08E+00</b>
19	216	Mercury	mg/kg	2.52E+00	3.49E-02	<b>1.30E-01</b>	<b>2.08E+00</b>
20	217	Mercury	mg/kg	3.60E+00	9.20E+00	<b>1.30E-01</b>	<b>2.08E+00</b>
21	219	Mercury	mg/kg	3.01E+00	2.59E-02	<b>1.30E-01</b>	<b>2.08E+00</b>
22	221	Mercury	mg/kg	4.80E+00	1.23E+01	<b>1.30E-01</b>	<b>2.08E+00</b>
23	222	Mercury	mg/kg	3.81E+00	2.77E-02	<b>1.30E-01</b>	<b>2.08E+00</b>
24	227	Mercury	mg/kg	3.83E+00	8.41E+00	<b>1.30E-01</b>	<b>2.08E+00</b>
25	228	Mercury	mg/kg	4.18E+00	9.37E+00	<b>1.30E-01</b>	<b>2.08E+00</b>
26	488	Mercury	mg/kg	3.90E+00	5.03E-02	<b>1.30E-01</b>	<b>2.08E+00</b>
27	489	Mercury	mg/kg	3.01E+00	3.39E-02	<b>1.30E-01</b>	<b>2.08E+00</b>
28	520	Mercury	mg/kg	4.25E+00	1.19E+01	<b>1.30E-01</b>	<b>2.08E+00</b>
29	531	Mercury	mg/kg	4.38E+00	3.65E-02	<b>1.30E-01</b>	<b>2.08E+00</b>
1	165	Methylene chloride	mg/kg	4.67E-02	6.80E-02	<b>0.00E+00</b>	<b>2.54E-02</b>
1	1	Molybdenum	mg/kg	4.31E+00	1.42E+01	<b>0.00E+00</b>	<b>2.10E+00</b>
2	14	Molybdenum	mg/kg	7.16E+00	2.87E+01	<b>0.00E+00</b>	<b>2.10E+00</b>
3	81	Molybdenum	mg/kg	6.70E+00	2.20E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
4	99	Molybdenum	mg/kg	7.09E+00	1.60E+01	<b>0.00E+00</b>	<b>2.10E+00</b>
5	138	Molybdenum	mg/kg	6.90E+00	1.10E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
6	153	Molybdenum	mg/kg	6.65E+00	1.20E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
7	156	Molybdenum	mg/kg	6.73E+00	7.40E-01	<b>0.00E+00</b>	<b>2.10E+00</b>
8	158	Molybdenum	mg/kg	6.77E+00	1.20E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
9	160	Molybdenum	mg/kg	5.54E+00	7.70E-01	<b>0.00E+00</b>	<b>2.10E+00</b>
10	163	Molybdenum	mg/kg	6.90E+00	1.60E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
11	169	Molybdenum	mg/kg	6.59E+00	6.27E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
12	180	Molybdenum	mg/kg	6.98E+00	1.40E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
13	194	Molybdenum	mg/kg	6.94E+00	1.96E+01	<b>0.00E+00</b>	<b>2.10E+00</b>
14	195	Molybdenum	mg/kg	6.97E+00	5.60E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
15	196	Molybdenum	mg/kg	4.14E+00	1.30E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
16	200	Molybdenum	mg/kg	6.90E+00	7.30E-01	<b>0.00E+00</b>	<b>2.10E+00</b>
17	212	Molybdenum	mg/kg	6.06E+00	1.30E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
18	213	Molybdenum	mg/kg	7.16E+00	6.10E-01	<b>0.00E+00</b>	<b>2.10E+00</b>
19	214	Molybdenum	mg/kg	5.15E+00	4.50E-01	<b>0.00E+00</b>	<b>2.10E+00</b>
20	215	Molybdenum	mg/kg	6.63E+00	1.00E+00	<b>0.00E+00</b>	<b>2.10E+00</b>
21	216	Molybdenum	mg/kg	4.11E+00	7.10E-01	<b>0.00E+00</b>	<b>2.10E+00</b>



**Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)**

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
22	217	Molybdenum	mg/kg	6.88E+00	5.89E+00	0.00E+00	2.10E+00
23	219	Molybdenum	mg/kg	4.63E+00	3.40E-01	0.00E+00	2.10E+00
24	221	Molybdenum	mg/kg	6.83E+00	4.00E+00	0.00E+00	2.10E+00
25	222	Molybdenum	mg/kg	6.62E+00	1.20E+00	0.00E+00	2.10E+00
26	227	Molybdenum	mg/kg	6.51E+00	5.21E+00	0.00E+00	2.10E+00
27	228	Molybdenum	mg/kg	6.23E+00	1.20E+00	0.00E+00	2.10E+00
28	488	Molybdenum	mg/kg	5.92E+00	5.50E-01	0.00E+00	2.10E+00
29	489	Molybdenum	mg/kg	4.75E+00	7.40E-01	0.00E+00	2.10E+00
30	520	Molybdenum	mg/kg	6.99E+00	1.30E+00	0.00E+00	2.10E+00
31	531	Molybdenum	mg/kg	6.66E+00	1.10E+00	0.00E+00	2.10E+00
32	541	Molybdenum	mg/kg	2.42E+00	5.62E+00	0.00E+00	2.10E+00
33	564	Molybdenum	mg/kg	6.88E+00	7.84E+00	0.00E+00	2.10E+00
1	1	Naphthalene	mg/kg	1.25E+00	5.78E-04	0.00E+00	1.16E-02
2	19	Naphthalene	mg/kg	1.89E-01	1.10E+00	0.00E+00	1.16E-02
3	81	Naphthalene	mg/kg	2.21E-01	3.90E-01	0.00E+00	1.16E-02
4	165	Naphthalene	mg/kg	5.84E-01	4.70E+00	0.00E+00	1.16E-02
5	194	Naphthalene	mg/kg	1.98E-01	4.80E-02	0.00E+00	1.16E-02
6	196	Naphthalene	mg/kg	1.78E-01	1.10E+00	0.00E+00	1.16E-02
7	541	Naphthalene	mg/kg	2.71E-01	1.80E+00	0.00E+00	1.16E-02
8	561	Naphthalene	mg/kg	2.05E-01	5.50E-01	0.00E+00	1.16E-02
1	1	Neptunium-237	pCi/g	1.14E-01	6.63E-01	0.00E+00	9.00E-02
2	14	Neptunium-237	pCi/g	1.47E+00	1.60E+01	0.00E+00	9.00E-02
3	165	Neptunium-237	pCi/g	3.66E-01	5.60E-01	0.00E+00	9.00E-02
4	196	Neptunium-237	pCi/g	1.33E-01	3.11E-01	0.00E+00	9.00E-02
5	212	Neptunium-237	pCi/g	1.73E+00	4.00E+00	0.00E+00	9.00E-02
6	227	Neptunium-237	pCi/g	2.15E-01	2.53E+00	0.00E+00	9.00E-02
7	228	Neptunium-237	pCi/g	1.47E-01	8.00E-01	0.00E+00	9.00E-02
8	517	Neptunium-237	pCi/g	3.04E-01	1.07E+00	0.00E+00	9.00E-02
9	520	Neptunium-237	pCi/g	1.20E-01	1.10E+00	0.00E+00	9.00E-02
1	14	Nickel	mg/kg	2.44E+02	2.67E+03	2.20E+01	2.72E+01
2	19	Nickel	mg/kg	4.26E+01	4.38E+02	2.20E+01	2.72E+01
3	81	Nickel	mg/kg	3.31E+01	1.14E+02	2.20E+01	2.72E+01
4	99	Nickel	mg/kg	3.45E+01	9.05E+01	2.20E+01	2.72E+01
5	138	Nickel	mg/kg	3.56E+01	1.13E+02	2.20E+01	2.72E+01
6	153	Nickel	mg/kg	4.18E+01	9.92E+01	2.20E+01	2.72E+01
7	156	Nickel	mg/kg	3.13E+01	6.16E+01	2.20E+01	2.72E+01
8	158	Nickel	mg/kg	3.58E+01	1.32E+02	2.20E+01	2.72E+01
9	163	Nickel	mg/kg	3.70E+01	7.81E+01	2.20E+01	2.72E+01
10	169	Nickel	mg/kg	6.61E+01	8.04E+02	2.20E+01	2.72E+01

**Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)**

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
11	180	Nickel	mg/kg	3.97E+01	1.08E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
12	194	Nickel	mg/kg	3.55E+01	1.08E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
13	195	Nickel	mg/kg	3.58E+01	1.02E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
14	196	Nickel	mg/kg	3.91E+01	5.87E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
15	200	Nickel	mg/kg	5.00E+01	2.60E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
16	212	Nickel	mg/kg	2.91E+01	8.69E+01	<b>2.20E+01</b>	<b>2.72E+01</b>
17	213	Nickel	mg/kg	3.98E+01	9.10E+01	<b>2.20E+01</b>	<b>2.72E+01</b>
18	215	Nickel	mg/kg	3.26E+01	7.32E+01	<b>2.20E+01</b>	<b>2.72E+01</b>
19	217	Nickel	mg/kg	3.53E+01	1.31E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
20	219	Nickel	mg/kg	3.08E+01	6.71E+01	<b>2.20E+01</b>	<b>2.72E+01</b>
21	221	Nickel	mg/kg	3.84E+01	1.39E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
22	222	Nickel	mg/kg	3.66E+01	9.19E+01	<b>2.20E+01</b>	<b>2.72E+01</b>
23	227	Nickel	mg/kg	6.37E+01	6.53E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
24	228	Nickel	mg/kg	3.58E+01	7.92E+01	<b>2.20E+01</b>	<b>2.72E+01</b>
25	489	Nickel	mg/kg	3.77E+01	7.88E+01	<b>2.20E+01</b>	<b>2.72E+01</b>
26	517	Nickel	mg/kg	5.65E+01	1.72E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
27	520	Nickel	mg/kg	7.91E+01	8.10E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
28	531	Nickel	mg/kg	5.37E+01	1.62E+02	<b>2.20E+01</b>	<b>2.72E+01</b>
1	14	PCB, Total	mg/kg	2.71E+00	1.00E+01	<b>0.00E+00</b>	<b>1.56E+00</b>
2	76	PCB, Total	mg/kg	1.57E+00	2.60E-01	<b>0.00E+00</b>	<b>1.56E+00</b>
3	81	PCB, Total	mg/kg	6.31E+00	3.70E+02	<b>0.00E+00</b>	<b>1.56E+00</b>
4	138	PCB, Total	mg/kg	1.93E+00	5.00E-01	<b>0.00E+00</b>	<b>1.56E+00</b>
5	153	PCB, Total	mg/kg	2.09E+00	6.00E-01	<b>0.00E+00</b>	<b>1.56E+00</b>
6	156	PCB, Total	mg/kg	2.33E+00	3.00E-01	<b>0.00E+00</b>	<b>1.56E+00</b>
7	169	PCB, Total	mg/kg	1.68E+00	1.00E+01	<b>0.00E+00</b>	<b>1.56E+00</b>
8	194	PCB, Total	mg/kg	2.29E+00	1.80E+01	<b>0.00E+00</b>	<b>1.56E+00</b>
9	195	PCB, Total	mg/kg	2.32E+00	7.40E-01	<b>0.00E+00</b>	<b>1.56E+00</b>
10	200	PCB, Total	mg/kg	2.35E+00	2.60E+00	<b>0.00E+00</b>	<b>1.56E+00</b>
11	213	PCB, Total	mg/kg	2.38E+00	7.30E-02	<b>0.00E+00</b>	<b>1.56E+00</b>
12	221	PCB, Total	mg/kg	2.23E+00	5.00E-01	<b>0.00E+00</b>	<b>1.56E+00</b>
13	227	PCB, Total	mg/kg	1.93E+00	1.26E+01	<b>0.00E+00</b>	<b>1.56E+00</b>
14	488	PCB, Total	mg/kg	2.81E+00	1.03E+01	<b>0.00E+00</b>	<b>1.56E+00</b>
15	492	PCB, Total	mg/kg	4.77E+00	4.41E+01	<b>0.00E+00</b>	<b>1.56E+00</b>
16	541	PCB, Total	mg/kg	1.39E+01	9.40E+01	<b>0.00E+00</b>	<b>1.56E+00</b>
1	1	Pentachlorophenol	mg/kg	9.33E-01	1.10E-01	<b>0.00E+00</b>	<b>2.02E-01</b>
2	165	Pentachlorophenol	mg/kg	1.10E+00	2.10E+00	<b>0.00E+00</b>	<b>2.02E-01</b>
1	1	Plutonium-239/240	pCi/g	2.20E+00	9.05E+00	<b>0.00E+00</b>	<b>1.56E+00</b>
2	165	Plutonium-239/240	pCi/g	2.93E+00	7.78E+00	<b>0.00E+00</b>	<b>1.56E+00</b>
3	212	Plutonium-239/240	pCi/g	3.32E+00	6.71E+00	<b>0.00E+00</b>	<b>1.56E+00</b>

**Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)**

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
1	14	Selenium	mg/kg	9.30E+00	3.07E+01	7.00E-01	5.20E+00
2	76	Selenium	mg/kg	6.49E+00	1.50E+00	7.00E-01	5.20E+00
3	81	Selenium	mg/kg	8.48E+00	1.40E+00	7.00E-01	5.20E+00
4	99	Selenium	mg/kg	9.06E+00	1.30E+00	7.00E-01	5.20E+00
5	138	Selenium	mg/kg	8.54E+00	4.72E+00	7.00E-01	5.20E+00
6	153	Selenium	mg/kg	8.85E+00	1.70E+00	7.00E-01	5.20E+00
7	156	Selenium	mg/kg	9.04E+00	1.50E+00	7.00E-01	5.20E+00
8	158	Selenium	mg/kg	8.69E+00	4.15E+00	7.00E-01	5.20E+00
9	160	Selenium	mg/kg	7.44E+00	1.30E+00	7.00E-01	5.20E+00
10	163	Selenium	mg/kg	8.79E+00	2.00E+00	7.00E-01	5.20E+00
11	169	Selenium	mg/kg	6.14E+00	1.70E+00	7.00E-01	5.20E+00
12	180	Selenium	mg/kg	9.29E+00	3.82E+00	7.00E-01	5.20E+00
13	194	Selenium	mg/kg	9.15E+00	4.03E+00	7.00E-01	5.20E+00
14	195	Selenium	mg/kg	9.29E+00	3.06E+00	7.00E-01	5.20E+00
15	200	Selenium	mg/kg	8.99E+00	5.84E+00	7.00E-01	5.20E+00
16	212	Selenium	mg/kg	6.80E+00	1.60E+00	7.00E-01	5.20E+00
17	213	Selenium	mg/kg	9.54E+00	7.70E-01	7.00E-01	5.20E+00
18	214	Selenium	mg/kg	6.89E+00	6.70E-01	7.00E-01	5.20E+00
19	215	Selenium	mg/kg	8.81E+00	1.10E+00	7.00E-01	5.20E+00
20	216	Selenium	mg/kg	5.65E+00	1.30E+00	7.00E-01	5.20E+00
21	217	Selenium	mg/kg	7.63E+00	1.67E+00	7.00E-01	5.20E+00
22	219	Selenium	mg/kg	6.46E+00	1.20E+00	7.00E-01	5.20E+00
23	221	Selenium	mg/kg	9.26E+00	9.80E+00	7.00E-01	5.20E+00
24	222	Selenium	mg/kg	7.75E+00	1.40E+00	7.00E-01	5.20E+00
25	227	Selenium	mg/kg	8.27E+00	2.20E+00	7.00E-01	5.20E+00
26	228	Selenium	mg/kg	7.99E+00	3.97E+00	7.00E-01	5.20E+00
27	488	Selenium	mg/kg	8.09E+00	1.60E+00	7.00E-01	5.20E+00
28	489	Selenium	mg/kg	6.52E+00	1.40E+00	7.00E-01	5.20E+00
29	520	Selenium	mg/kg	8.24E+00	4.55E+00	7.00E-01	5.20E+00
30	531	Selenium	mg/kg	8.85E+00	1.10E+00	7.00E-01	5.20E+00
1	14	Silver	mg/kg	5.13E+00	2.22E+01	2.70E+00	8.76E-01
2	76	Silver	mg/kg	3.02E+00	6.30E-02	2.70E+00	8.76E-01
3	81	Silver	mg/kg	4.29E+00	2.70E+00	2.70E+00	8.76E-01
4	99	Silver	mg/kg	4.44E+00	1.03E+01	2.70E+00	8.76E-01
5	138	Silver	mg/kg	4.84E+00	1.65E+01	2.70E+00	8.76E-01
6	153	Silver	mg/kg	5.37E+00	1.32E+01	2.70E+00	8.76E-01
7	156	Silver	mg/kg	4.71E+00	1.19E+01	2.70E+00	8.76E-01
8	158	Silver	mg/kg	4.47E+00	1.47E+01	2.70E+00	8.76E-01
9	160	Silver	mg/kg	4.48E+00	1.13E+01	2.70E+00	8.76E-01

**Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)**

#	SWMU/ AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
10	163	Silver	mg/kg	4.53E+00	1.05E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
11	165	Silver	mg/kg	1.14E+01	8.33E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
12	169	Silver	mg/kg	3.09E+00	7.90E-02	<b>2.70E+00</b>	<b>8.76E-01</b>
13	180	Silver	mg/kg	4.90E+00	1.17E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
14	194	Silver	mg/kg	4.97E+00	1.70E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
15	195	Silver	mg/kg	4.77E+00	1.31E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
16	200	Silver	mg/kg	4.63E+00	9.47E+00	<b>2.70E+00</b>	<b>8.76E-01</b>
17	212	Silver	mg/kg	4.24E+00	1.55E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
18	213	Silver	mg/kg	6.12E+00	1.32E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
19	214	Silver	mg/kg	3.34E+00	2.10E-02	<b>2.70E+00</b>	<b>8.76E-01</b>
20	215	Silver	mg/kg	4.55E+00	9.51E+00	<b>2.70E+00</b>	<b>8.76E-01</b>
21	217	Silver	mg/kg	4.14E+00	1.61E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
22	219	Silver	mg/kg	3.02E+00	5.60E-02	<b>2.70E+00</b>	<b>8.76E-01</b>
23	221	Silver	mg/kg	4.58E+00	9.74E+00	<b>2.70E+00</b>	<b>8.76E-01</b>
24	222	Silver	mg/kg	3.84E+00	5.00E-02	<b>2.70E+00</b>	<b>8.76E-01</b>
25	227	Silver	mg/kg	4.09E+00	1.01E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
26	228	Silver	mg/kg	4.58E+00	1.16E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
27	488	Silver	mg/kg	3.91E+00	8.50E-02	<b>2.70E+00</b>	<b>8.76E-01</b>
28	489	Silver	mg/kg	3.01E+00	4.10E-02	<b>2.70E+00</b>	<b>8.76E-01</b>
29	520	Silver	mg/kg	4.54E+00	1.40E+01	<b>2.70E+00</b>	<b>8.76E-01</b>
30	531	Silver	mg/kg	4.38E+00	1.00E-01	<b>2.70E+00</b>	<b>8.76E-01</b>
1	14	Technetium-99	pCi/g	5.44E+01	4.06E+02	<b>2.80E+00</b>	<b>7.32E+00</b>
2	19	Technetium-99	pCi/g	1.01E+01	3.70E+01	<b>2.80E+00</b>	<b>7.32E+00</b>
3	165	Technetium-99	pCi/g	1.67E+01	6.00E+01	<b>2.80E+00</b>	<b>7.32E+00</b>
4	227	Technetium-99	pCi/g	1.65E+01	1.52E+02	<b>2.80E+00</b>	<b>7.32E+00</b>
5	517	Technetium-99	pCi/g	2.43E+01	8.32E+01	<b>2.80E+00</b>	<b>7.32E+00</b>
1	99	Thallium	mg/kg	5.03E+00	2.50E-01	<b>3.40E-01</b>	<b>2.84E+00</b>
2	163	Thallium	mg/kg	3.13E+00	3.50E-01	<b>3.40E-01</b>	<b>2.84E+00</b>
3	181	Thallium	mg/kg	3.06E+00	3.50E+00	<b>3.40E-01</b>	<b>2.84E+00</b>
4	227	Thallium	mg/kg	5.69E+00	5.10E-01	<b>3.40E-01</b>	<b>2.84E+00</b>
5	520	Thallium	mg/kg	4.66E+00	3.40E-01	<b>3.40E-01</b>	<b>2.84E+00</b>
1	1	Thorium-230	pCi/g	1.56E+01	6.50E+01	<b>1.40E+00</b>	<b>6.06E+00</b>
2	212	Thorium-230	pCi/g	6.64E+01	2.60E+02	<b>1.40E+00</b>	<b>6.06E+00</b>
1	14	Total PAH	mg/kg	1.04E-01	4.87E-01	<b>0.00E+00</b>	<b>8.64E-02</b>
2	19	Total PAH	mg/kg	5.94E-01	5.23E+00	<b>0.00E+00</b>	<b>8.64E-02</b>
3	76	Total PAH	mg/kg	1.01E+00	1.76E+00	<b>0.00E+00</b>	<b>8.64E-02</b>
4	81	Total PAH	mg/kg	2.39E-01	7.79E-01	<b>0.00E+00</b>	<b>8.64E-02</b>
5	138	Total PAH	mg/kg	4.45E-01	9.74E-02	<b>0.00E+00</b>	<b>8.64E-02</b>
6	158	Total PAH	mg/kg	3.31E-01	4.78E-01	<b>0.00E+00</b>	<b>8.64E-02</b>

**Table C2.4. SWMU/COPC Combinations That Survive Screening and Are Considered for Modeling Based on Overall Average Concentration Using a DAF of 20 (Continued)**

#	SWMU/AOC	Analysis	Units	Average Conc.	Maximum Conc.	Subsurface Background Conc.	RG SSL Conc. (DAF 20)
7	163	Total PAH	mg/kg	1.08E-01	2.85E-01	0.00E+00	8.64E-02
8	165	Total PAH	mg/kg	3.00E+00	1.87E+00	0.00E+00	8.64E-02
9	169	Total PAH	mg/kg	2.30E+00	4.59E+00	0.00E+00	8.64E-02
10	196	Total PAH	mg/kg	1.08E+00	9.04E+00	0.00E+00	8.64E-02
11	212	Total PAH	mg/kg	1.14E-01	0.00E+00	0.00E+00	8.64E-02
12	213	Total PAH	mg/kg	1.72E-01	1.72E-01	0.00E+00	8.64E-02
13	215	Total PAH	mg/kg	4.04E-01	5.00E-01	0.00E+00	8.64E-02
14	216	Total PAH	mg/kg	1.49E-01	1.49E-01	0.00E+00	8.64E-02
15	217	Total PAH	mg/kg	1.76E-01	7.37E-01	0.00E+00	8.64E-02
16	221	Total PAH	mg/kg	1.02E+00	1.02E+00	0.00E+00	8.64E-02
17	222	Total PAH	mg/kg	1.77E-01	1.77E-01	0.00E+00	8.64E-02
18	227	Total PAH	mg/kg	1.80E-01	3.38E-01	0.00E+00	8.64E-02
19	488	Total PAH	mg/kg	1.27E-01	2.50E-01	0.00E+00	8.64E-02
20	493	Total PAH	mg/kg	4.86E-01	5.00E-01	0.00E+00	8.64E-02
21	518	Total PAH	mg/kg	1.88E+00	1.27E+01	0.00E+00	8.64E-02
22	520	Total PAH	mg/kg	2.13E-01	5.52E-01	0.00E+00	8.64E-02
23	541	Total PAH	mg/kg	1.67E-01	7.63E+00	0.00E+00	8.64E-02
24	561	Total PAH	mg/kg	2.18E-01	2.63E+00	0.00E+00	8.64E-02
1	1	<i>trans</i> -1,2-Dichloroethene	mg/kg	8.69E-01	1.60E+01	0.00E+00	5.88E-01
1	1	Trichloroethene	mg/kg	1.79E+00	8.70E+01	0.00E+00	3.56E-02
2	165	Trichloroethene	mg/kg	3.56E-02	6.00E-03	0.00E+00	3.56E-02
1	81	Uranium	mg/kg	9.14E+02	6.50E+03	4.60E+00	2.70E+02
2	518	Uranium	mg/kg	3.05E+02	2.17E+02	4.60E+00	2.70E+02
3	541	Uranium	mg/kg	7.22E+02	2.02E+04	4.60E+00	2.70E+02
1	14	Uranium-238	pCi/g	9.74E+01	1.54E+03	1.20E+00	9.09E+01
2	492	Uranium-238	pCi/g	1.39E+02	3.83E+02	1.20E+00	9.09E+01
3	541	Uranium-238	pCi/g	2.83E+02	4.54E+03	1.20E+00	9.09E+01
1	221	Vanadium	mg/kg	4.57E+01	1.08E+02	3.70E+01	1.41E+00
2	564	Vanadium	mg/kg	6.87E+01	8.06E+01	3.70E+01	1.41E+00
1	1	Vinyl chloride	mg/kg	4.48E-01	4.80E+00	0.00E+00	1.37E-02
1	531	Zinc	mg/kg	7.78E+02	2.45E+03	6.00E+01	3.90E+02

A review of this table indicates that the principal impact of using a DAF of 20 is to increase the number of SWMU/AOC soil constituent combinations that fail the screening; however, there is no impact on the SWMU/AOC soil constituent combinations subjected to modeling because of the following:

- Where a SWMU/AOC soil constituent was going to be modeled because of screening against a DAF of 58, that same SWMU/AOC soil constituent will be modeled if screened against a DAF of 20 because it is the SWMU/AOC with the highest average concentration of that soil constituent. Thus,

the additional SWMU/AOC soil constituent combinations will have impacts that are lower than those already subjected to modeling;

- Where a SWMU/AOC soil constituent was not going to be modeled because it is not found in groundwater, is not a groundwater COC, or where its concentration is controlled by other factors, it will not be modeled based on screening against either a DAF of 20 or DAF of 58; and
- All of those additional soil constituents that are not screened out using a DAF of 20, but are screened out using a DAF of 58, are also constituents that are not groundwater COCs, or the concentration is controlled by other factors, or the constituent is not found in groundwater.

This rationale is summarized in Table C2.5.

Based on this sensitivity analysis, no additional SWMU/AOC soil constituent combinations were subjected to modeling.

**Table C2.5. Comparison of Soil Constituents Exceeding RG SSLs and Background Derived From DAF of 58 Versus Values Derived from DAF of 20**

<b>Soil Constituent (Modeled?)</b>	<b>DAF 58: # of SWMUs/AOCs with Soil Constituent Exceedance</b>	<b>DAF 20: # SWMUs/AOCs with Soil Constituent Exceedance</b>	<b>Comments on Impact of Screening Using DAF of 20 Values</b>
Silver (No)	30	30	No impact on modeling. Silver not detected in RGA groundwater.
Total PAHs or benz(a)anthracene (No)	23	54	No impact on modeling. Not a groundwater COC.
Molybdenum (No)	23	33	No impact on modeling. Not major RGA issue; concentrations controlled by redox chemistry.
Nickel (Yes)	2	28	No impact on modeling. SWMU/AOC with highest average nickel concentration will be modeled.
Np-237 (No)	4	9	No impact on modeling. No above-MCL detections of Np-237 in RGA groundwater.
Tc-99 (Yes)	2	5	No impact on modeling. SWMU/AOC with highest average Tc-99 concentration will be modeled.
Naphthalene (No)	8	8	No impact on modeling. Not RGA COC.
Thorium-230 (No)	1	2	No impact on modeling. Not RGA COC.
Cobalt (No)	2	2	No impact on modeling. Not RGA COC.
U-238 (No)	1	3	No impact on modeling. No RGA impacts from Soils OU.
Uranium (Yes)	1	3	No impact on modeling. SWMU/AOC with highest avg. uranium concentration will be modeled.
Vanadium (No)	2	2	No impact on modeling. Not major RGA issue.
Arsenic (Yes)	2	7	No impact. SWMU/AOC with highest average arsenic concentration will be modeled.
VOCs (Yes/No)	3	6	No impact on modeling. Mostly in SWMU 1—modeled separately.
Antimony (No)	0	2	No impact. No RGA detects in 2,063 samples.
Chromium (Yes)	0	0	No impact. SWMU/AOC with highest concentration subjected to modeling.

**Table C2.5. Comparison of Soil Constituents Exceeding RG SSLs and Background Derived From DAF of 58 Versus Values Derived from DAF of 20 (Continued)**

<b>Soil Constituent (Modeled?)</b>	<b>DAF 58: # of SWMUs/AOCs with Soil Constituent Exceedance</b>	<b>DAF 20: # SWMUs/AOCs with Soil Constituent Exceedance</b>	<b>Comments on Impact of Screening Using DAF of 20 Values</b>
Manganese (No)	0	0	No impact on modeling. Concentrations controlled by redox chemistry.
Mercury (No)	0	29	No impact. Not a groundwater COC. RGA concentrations < MCL for all 2,265 samples.
PCB, Total (Yes)	3	16	No impact on modeling. SWMU/AOC with highest total PCB concentration will be modeled.
Pentachlorophenol (No)	2	2	No impact on modeling. Not RGA COC. No detects out of 436 RGA samples.
Plutonium-239/240 (No)	0	3	No impact. Not RGA COC. 1 detect out of 256 samples. Detect not near Soils OU SWMU/AOC.
Selenium (No)	0	30	No impact on modeling. Not RGA COC. No RGA results > MCL out of 2,426 samples.
Thallium (No)	0	5	No impact on modeling. Not RGA COC. 1 split detect (not near Soils OU SWMU/AOC) of 1,283 samples.
Zinc (No)	0	1	No impact on modeling. Not RGA COC. 2 exceed NAL (not near Soils OU SWMU/AOC) of 1,763.

VOCs = volatile organic compounds

## C2.5. REFERENCES

- CH2M HILL 1992. Technical Memorandum No. 7, Aquifer Pumping Test, in *Results of the Site Investigation, Phase II, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/Sub/13B-97777C P03/1991/1.
- Decisioneering, Inc. 2000. Crystal Ball® 2000: A user friendly graphically oriented forecasting and risk analysis program. 1515 Arapahoe Street, Denver, CO.
- DOE (U.S. Department of Energy) 1997. *Numerical Ground-Water Model Recalibration and Evaluation of the Northwest Plume Remedial Action Report for the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, JE/PAD/97-0185, Paducah, KY, July.
- DOE 2007. *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2180&D2/R1, U.S. Department of Energy, Paducah, KY, June.
- DOE 2010. *2008 Update of the Paducah Gaseous Diffusion Plant Site-wide Groundwater Flow Model*, PRS-ENR-0028, Paducah, KY, February.

- DOE 2011. *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/R1, February.
- EPA (U.S. Environmental Protection Agency) 1996. Soil Screening Guidance: Technical Background Document. EPA/540/R95/128. U.S. Environmental Protection Agency.
- LMES (Lockheed Martin Energy Systems, Inc.) 1996a. *Preliminary Site Characterization/Baseline Risk Assessment/LASAGNA™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128, Lockheed Martin Energy Systems, Inc., Paducah, KY, May.
- LMES 1996b. *Aquifer Test Analysis of the Northwest Plume, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-145, Lockheed Martin Energy Systems, Inc., Kevil, KY, June.
- LMES 1997. *Analysis of Aquifer Pumping Tests of the Northeast Plume Containment System at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-250, for Lockheed Martin Energy Systems, Inc., Kevil, KY, December.
- Terran 1990. *Groundwater Monitoring Phase II, C-404 Aquifer Testing Program, ESO 16749, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, Terran Corporation, Fairborn, OH, February 26.
- Terran 1992. *Groundwater Monitoring, Phase III, Aquifer Test Program West of Building C-333, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, Terran Corporation, Kettering, OH, June 22.
- Thornthwaite, C.W., and J.R. Mather 1957. "Instructions and tables for computing potential evaporation and the water balance." *Climatology*, 10 (3).



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

Information provided in Table E.8 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 December 2014), “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.”

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Table E.8. Human Health Information for the Paducah Vapor Intrusion Evaluation

VOC	CAS Number	OSHA PEL* (ppm)	OSHA PEL* (µg/m³)	ACGIH TLV* (ppm)	ACGIH TLV* (µg/m³)	OSWER Vapor Intrusion Calculator (EPA 2013)		Using RAIS' Calculator (10/15/2014)					
						Residential ELCR = 1E-06 in µg/m³	Residential HI = 1 in µg/m³	Resident PRG: ELCR= 1E-06 in µg/m³	Resident PRG: ELCR= 1E-04 in µg/m³	Resident PRG: HI=1 in µg/m³	Indoor Worker PRG: ELCR=1E-06 in µg/m³	Indoor Worker PRG: ELCR=1E-04 in µg/m³	Indoor Worker PRG: HI=1 in µg/m³
1,2-Dichloroethene	540-59-0	200	7.93E+05	200	7.93E+05	NA	NA	NA	NA	NA	NA	NA	NA
<i>cis</i> -1,2-Dichloroethene	156-59-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
<i>trans</i> -1,2-Dichloroethene	156-60-5	NA	NA	NA	NA	NA	NA	NA	NA	62.6	NA	NA	263
Trichloroethene	79-01-6	100	5.37E+05	10	5.37E+04	0.48	2.1	0.478	47.8	2.09	2.99	299	8.76
Vinyl Chloride	75-01-4	1	2.56E+03	1	2.56E+03	0.17	100	0.168	16.8	104	2.79	279	438

Notes:

\* 8-hour time-weighted average (TWA)  
VOC = Volatile Organic Compound  
CAS Number = Chemical Abstract Services Registry Number  
OSHA PEL = Occupational Safety and Health Administration Permissible Exposure Limit  
PPM = parts per million by volume  
ACGIH TLV = American Council of Governmental Industrial Hygienists Threshold Limit Value  
RAIS = Risk Assessment Information System (<http://rais.ornl.gov/>)  
ELCR = Excess Lifetime Cancer Risk  
HI = Hazard Index  
OSWER = Office of Solid Waste and Emergency Response  
EPA = U.S. Environmental Protection Agency  
PRG = Preliminary Remedial Goal  
For *cis*- and *trans*-1,2-dichloroethene, toxicity information (slope factors and reference doses/concentrations) are not available; therefore risk-based values are not available (NA) at this time.

NIOSH calculator (National Institute for Occupational Safety and Health) 10/15/2014 at <http://www.cdc.gov/niosh/docs/2004-101/calc.html> EPA's Draft 2013 OSWER guidance calculator at <http://www.epa.gov/oswer/vaporintrusion/documents/VISL-Calculator.xlsm> (Version 3.3.1)

EPA's Draft 2013 OSWER guidance calculator uses: ET= 24 hr/d; EF=350 d/yr; ED=26 yrs; AT(nc)=26 yrs; and AT(c)=70 yrs. Populations considered are the elderly, women of child bearing years, people suffering from a chronic illness, and disadvantaged populations. RAIS' Calculator uses: ET= 24 hr/d; EF=350 d/yr; ED=26 yrs; AT(nc)=26 yrs x 365 d/yr; and AT(c)=70 yrs x 365 d/yr for the residential scenario. RAIS' Calculator uses: ET= 8 hr/d; EF=250 d/yr; ED=25 yrs; AT(nc)=25 yrs x 365 d/yr; and AT(c)=70 yrs x 365 d/yr for the indoor worker scenario.

From on-line source: <https://www.osha.gov/dsg/annotated-pels/> it states: "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."

From [https://www.osha.gov/dts/chemicalsampling/toc/toc\\_chemsamp.html](https://www.osha.gov/dts/chemicalsampling/toc/toc_chemsamp.html), American Council of Governmental and Industrial Hygienists (ACGIH) list of threshold limit values (as 8 hour time-weighted averages) of concentrations

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## **E.10. MEETING MINUTES FROM PADUCAH RISK ASSESSMENT WORKING GROUP**

This chapter presents meeting minutes from the Paducah Risk Assessment Working Group, beginning in June 2012. Future revisions of this document will present meeting minutes held to date.

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## **Risk Assessment Working Group Quarterly Meeting Minutes—June 13, 2012—Revised August 2012**

**1. No Action Level (NAL)/Action Level (AL) tables:**

**a. Discuss use of PORTS calculator for Paducah instead of NAL/AL tables in the Risk Methods Document (RMD) or use of EPA's Regional Screening Levels (RSLs).**

After discussion, it was agreed to revise NALs and ALs and post them by September 30, 2012, and to include an "as of" date. These values will use updated toxicity values.

Targets for hazard: NAL is 0.1; AL is 3.

Targets for ELCR: AL is  $10E-4$ ; NAL is  $10E-6$  with statement regarding cumulative risk.

Issues arising during NAL calculations will be brought up and addressed by email.

**NOTE: These revised NALs/ALs will NOT affect current projects (specifically the Soils OU RI, with a few noted exceptions to be written up in the risk assessment sections of the Soils OU RI Report).**

An e-mail was sent July 24, 2012, proposing use of RAIS for calculating NALs using site-specific exposure parameters to the extent possible. RAIS is consistent with RSL values.

No responses to the e-mail were received.

In a comment to the minutes, KY expressed a reluctance to use the PORTS calculator in determining NALs for Paducah.

For dose, ranges are 1 mrem/yr, 4 mrem/yr (for water only), 15 mrem/yr, and 25 mrem/yr. 100 mrem/yr will be added to relate to the DOE order and KY public dose limits. It should be noted that 1 mrem/yr and 15 mrem/yr are not DOE or KY standards, and none of these radiation dose rates are EPA's standards, including the 15 mrem/yr.

**b. Revise lead action levels**

Currently, 400 mg/kg is listed as the action level for the resident. The industrial worker action level also is listed as 400 mg/kg—this number will be changed to 800 mg/kg. A reference will be provided prior to change. The MCL is 15 ug/L, this will remain unchanged in the RMD.

**c. Tox factors and dermal; but also MCLs for Rad, SSLs**

An "as of" date will be used and sent by email for review and concurrence. The RSL table will be used for toxicity values and original references (although the original references may be revisited if it proves problematic). The actual hierarchy of the source of the toxicity values will remain as in the current RMD (consistent with EPA guidance.) This hierarchy is on page 3-33 of the 2011 RMD.

Use GI ABS value for calculating dermal absorption from oral values.

Add section to RMD/Risk Assessments that recognizes the uncertainty of using RAGS Part E for metals and volatiles for dermal. This text will be sent for review by the RAWG prior to the next meeting and approval of the revised NALs/ALs

RESRAD to be used to determine risk or dose-based values and SSLs based on dosimetry—presenting the results based on the current dosimetry, and also consistent with the factors designated in the standards.

For example, the current EPA MCLs for Tc-99, etc. will continue to be recognized even though we agree that the dosimetry is outdated (i.e., 1959 vs current dosimetry calculations). (That is, we will present both the 900 pCi/L and the 4 mrem/yr-based value.)

**d. SSLs for noncancer are usually based on an HI of 1, not 0.1 for the groundwater pathway.**

The SSL table in the RMD (Table A.7a) will now only include those from EPA-based values (remove values calculated for NALs). The first preference for calculation will be the MCL value, if an MCL is not available, the risk-based value will be used, as shown in the EPA RSL table (note: values in the RSL table are for a DAF of 1). RMD will include values for DAFs of 1, 20, and 58.

**2. Setting cleanup goals for the various soil horizons**

Background: the FS for BGOU SWMUs, IW RGO based on 0-1 ft bgs; OW RGO (for subsurface) based on 1-16 ft bgs.

For BGOU SWMUs IW cleanup set at  $10^{-5}$  and OW set at  $10^{-4}$  (for subsurface) (though KY may not agree with this value).

Cleanup scenarios need to be explained over all horizons, not just the surface layer.

The key is that the scenarios need to be explained. Additional information will be provided in the BGOU FS.

**3. Risk result presentation**

Discussion of possible formats that may help the agency review. It was decided that the presentation was okay, as is.

**4. Gamma walkovers**

A discussion was held as to the process that should be used on how to incorporate/consider gamma walkover survey results in the assessment. It was decided that gamma walkover survey results can be used in determining boundaries for determining exposure point concentrations (EPCs), but not in calculating EPCs.

Further, discussion was held regarding how we handle gamma walkover survey results that cast doubt on analytical values and what upfront QC can be done. Results of gamma walkover surveys should be included in the data representativeness evaluation prior to calculating risk. A specific evaluation for inconsistencies between gamma survey results and analytical results will be added to the uncertainty section (list of uncertainties) in RMD.

Nature and extent determinations need to be connected to the risk evaluation. "Is data sufficient to determine what you have..."

A sample text write-up will be sent to the group for comment.

**5. Principal Threat Waste Determination: Establish Additional Criteria**

**a. The RMD needs further direction with respect to PTW on the outcome for currently required calculations resulting in an ELCR, HI, or dose greater than the benchmarks.**

Additional comments regarding Meeting Notes with respect to PTW were made and will be addressed with the revised PTW text box for the RMD.



- b. **Current dose benchmark of 25 mrem/yr is not the same scale of magnitude above the acceptable level, as is the ELCR benchmark. Propose setting the benchmark for PTW. Radiation dosimetry should be based on ICRP 60 and ICRP 72. All dosimetry should be consistent with DOE Order 458.1. DCFs should be the consistent with 458.1.**

See #1 for additional dose benchmarks added.

A revised textbox (from RMD) will be circulated to the Risk Assessment Working Group (RAWG) for review and concurrence in July, prior to presenting to managers. The entire textbox may be dropped instead of revising.

## **6. Background Values**

Currently used values may need to be revisited to develop recommendation on future activities. All background values, but especially groundwater are listed as provisional. Many background values are set at detection limits values. There are no plans for changes here. Background values should be finalized and will be placed on the next quarter's agenda.

Background values over all media are considered to be a range. The basic background screen is against Paducah-specific values; for COPC identification Paducah-specific values are used.

Additional criteria for comparison, such as the KY state background values (listed in Appendix E of the RMD) and fallout values, can be used to refine COC selection. These chemicals do remain as COPCs. As discussed, caution should be used when comparing sample results at PGDP with nationwide fallout averages that are an order of magnitude in range. It may not be very defensible to make that comparison (especially concerning results that indicate a very heterogeneous distribution of the contaminant) and there are likely better ways of evaluating the importance of elevated (but still low) activity concentrations of radionuclides attributable to fallout.

## **7. Lessons Learned from Recent Projects**

- a. **Begin development of lessons learned for the Modeling Matrix from the recent CERCLA Cell and SW Plume modeling efforts.**
- b. **Begin development of lessons learned for Remedial Goal (RG) calculations from the internal ditches and SW Plume projects.**  
No specific issues were discussed.

## **8. PAHs: Establish Direction for Handling PAH Contamination in Establishing Remedial Goals (RGs).**

Background: for the SWOU Onsite RA, PAHs were not used in cleanup determination based on their sporadic nature.

It was proposed to include criteria in the next RMD revision to exclude PAH contamination from RG calculations, though KY has commented on meeting notes that they are not in favor of this. This text, if adopted, could be included in the SMP regarding ubiquitous PAH contamination in the CSOU. One KAR states that PAHs near roadways are not subject to cleanup (find citation)  
Draft text for presentation to risk managers will be sent for review/concurrence to RAWG.

## **9. Recreational User Equations**

The proposed new equation is below on the following page. A replacement page will be sent for the RMD.

## **10. Dermal Risk for Metals**

See Minutes Item #1.

RMD Appendix D footnotes will be revised to “Chemical-specific absorption factors available are listed in Table B.5 [38].”

Table B.5 of the RMD will be updated from the RSL table; KY ABS values will remain in the table in order to compare as an uncertainty. It was noted that the uncertainty discussion needs to be as transparent as possible.

**11. Revisit SSLs**

See Minutes Item #1d.

**12. Difference(in calculations for exposure to Rads) between what is currently used in the (1) PORTS Risk Calculator and is used by the (2) Oak Ridge Risk Analysis Information System (RAIS); *lambda* and *t* are used.**

Example equations from RAIS documentation are shown on pages 5 and 6.

PORTS and RAIS equations correct for decay and time of release. Equations in the RMD are simpler. Paducah radionuclides of interest (specifically uranium and technetium) do not decay very fast; therefore, while the preliminary remediation goal (PRG) would be lower than if the decay rate were used, the simpler equation will be used for Paducah. If the PORTS calculator is used for Paducah in the future, their equation will need to be changed.

NOTE: These equations were not changed for the NALs to be reviewed for the September 2012 meeting. [RAIS equations were used as is with no changes, unless otherwise noted.](#)

This calculation needs further discussion with respect to decay correction.

**13. Example RGO Discussion (provided through Soils OU team)**

The example text will be discussed/commented upon by e-mail. Additional information (like from Appendix D) needs to be sent.

**Table D.15. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Incidental Ingestion of Sediment by a Recreational User<sup>a</sup>**

Equations:

$$\text{Chemical Intake [mg/(kg} \times \text{day)]} = \frac{C_{sed} \times CF \times EF \times ED \times IR \times FI}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{sed} \times CF_{rad} \times EF \times ED \times IR \times FI$$

Parameter	Units	Value used	References <sup>b</sup>
Concentration in sediment = <b>C<sub>sed</sub></b>	mg/kg	Chemical-specific	----
Conversion factor = <b>CF</b>	kg/mg	10 <sup>-6</sup>	----
Activity in soil = <b>A<sub>sed</sub></b>	pCi/g	Chemical-specific	----
Conversion factor = <b>CF<sub>rad</sub></b>	g/mg	10 <sup>-3</sup>	----
Exposure frequency = <b>EF</b>	day/yr	104 (adult) 140 (child and teen)	[14]
Exposure duration = <b>ED</b>	year	12 (adult) 12 (teen) 6 (child)	[14]
Ingestion rate = <b>IR</b>	mg/day	100 (adult) 100 (teen) 200 (child)	[14]
Fraction ingested = <b>FI</b>	unitless	1	[14]
Body weight = <b>BW</b>	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = <b>AT</b>	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

<sup>a</sup> Equation after [1].

<sup>b</sup> References follow Table D.50.

## Residential Soil from RAIS

The residential soil land use equations, presented here, contain the following exposure routes:

incidental ingestion of soil,

$$PRG_{res-soil-rad-ing} (pCi/g) = \frac{TR \times t_{res} \times \lambda}{\left(1 - e^{-\lambda t_{res}}\right) \times SF_{\alpha} \left(\frac{risk}{pCi}\right) \times IFS_{adj} \left(\frac{120 \text{ mg}}{\text{day}}\right) \times EF_r \left(\frac{360 \text{ days}}{\text{year}}\right) \times ED_r (30 \text{ years}) \times \left(\frac{g}{1000 \text{ mg}}\right)}$$

where

$$IFS_{adj} \left(\frac{120 \text{ mg}}{\text{day}}\right) = \frac{\left(IRS_c \left(\frac{200 \text{ mg}}{\text{day}}\right) \times ED_c (8 \text{ years}) + IRS_a \left(\frac{100 \text{ mg}}{\text{day}}\right) \times ED_r - ED_c (24 \text{ years})\right)}{ED_r (30 \text{ years})}$$

inhalation of particulates emitted from soil,

$$PRG_{res-soil-rad-inh} (pCi/g) = \frac{TR \times t_{res} \times \lambda}{\left(1 - e^{-\lambda t_{res}}\right) \times SF_I \left(\frac{risk}{pCi}\right) \times IFA_{adj} \left(\frac{18 \text{ m}^3}{\text{day}}\right) \times EF_r \left(\frac{360 \text{ days}}{\text{year}}\right) \times ED_r (30 \text{ years}) \times \frac{1}{PEF \left(\frac{\text{m}^3}{\text{kg}}\right)} \times \left[ET_{ro} \left(\frac{0.073 \text{ hour}}{\text{hour}}\right) + \left(ET_{rl} \left(\frac{0.883 \text{ hour}}{\text{hour}}\right) \times DF_I (0.4)\right)\right] \times \left(\frac{1000 \text{ g}}{\text{kg}}\right)}$$

where

$$IFA_{adj} \left(\frac{18 \text{ m}^3}{\text{day}}\right) = \frac{IRA_c \left(\frac{10 \text{ m}^3}{\text{day}}\right) \times ED_c (6 \text{ years}) + IRA_a \left(\frac{20 \text{ m}^3}{\text{day}}\right) \times ED_r - ED_c (24 \text{ years})}{ED_r (30 \text{ years})}$$

external exposure to ionizing radiation and

$$PRG_{res-soil-rad-ext} (pCi/g) = \frac{TR \times t_{res} \times \lambda}{\left(1 - e^{-\lambda t_{res}}\right) \times SF_x \left(\frac{risk/year}{pCi/g}\right) \times ACF (0.9) \times \left[ET_{ro} + \left(ET_{rl} \times GSF (0.4)\right)\right] \times EF_r \left(\frac{360 \text{ days}}{\text{year}}\right) \times \left(\frac{1 \text{ year}}{365 \text{ days}}\right) \times ED_r (30 \text{ years})}$$

Total.

$$PRG_{res-soil-rad-tot} (pCi/g) = \frac{1}{\frac{1}{PRG_{res-soil-rad-ing}} + \frac{1}{PRG_{res-soil-rad-inh}} + \frac{1}{PRG_{res-soil-rad-ext}}}$$

# RADIONUCLIDE SOIL SCREENING LEVELS FOR RESIDENTS from PORTS calculator

Soil Ingestion

$$SL_{r-ing} \left( \frac{pCi}{g} \right) = \frac{TR \times t_r \times \lambda}{(1 - e^{-\lambda t_r}) \times SF_s \times IFS_{r-adj} \times EF_r \times ED_r \times \frac{g}{1000mg}}$$

$$IFS_{r-adj} \left( \frac{mg}{day} \right) = \frac{ED_{r-c} \times IRS_{r-c} + ED_{r-a} \times IRS_{r-a}}{ED_{r-a}}$$

Inhalation

$$SL_{r-inh} \left( \frac{pCi}{g} \right) = \frac{TR \times t_r \times \lambda}{(1 - e^{-\lambda t_r}) \times SF_i \times IFA_{r-adj} \times EF_r \times ED_r \times \frac{1}{PEF} \times \frac{1000g}{kg} \times ET_r \times \frac{1day}{24hours}}$$

$$IFA_{r-adj} \left( \frac{m^3}{day} \right) = \frac{ED_{r-c} \times IRA_{r-c} + ED_{r-a} \times IRA_{r-a}}{ED_{r-a}}$$

External

$$SL_{r-ext} \left( \frac{pCi}{g} \right) = \frac{TR \times t_r \times \lambda}{(1 - e^{-\lambda t_r}) \times SF_{ext-sv_i} \times ACF \times EF_r \times \frac{1year}{365days} \times ED_r \times [ET_{r-o} + (ET_{r-i} \times GSF_i)]}$$

## Risk Assessment Working Group Proposed Agenda—September 2012

1. **Additional changes to June 2012 Meeting Minutes.**  
Changes made and finalized.
2. **Discuss FY 13 RAWG Work Plan and Quarterly Meeting Schedule.**  
December 5, 2012—8:30-11:00 central (9:30-12:00 eastern)  
March 6, 2013—8:30-11:00 central (9:30-12:00 eastern)  
June 5, 2013—8:30-11:00 central (9:30-12:00 eastern)  
September 11, 2013—8:30-11:00 central (9:30-12:00 eastern)  
RMD is site-specific guidance for risk assessment. LATA to provide page changes for review/approval. (Include in plan for proceeding – see Item 7)
3. **Revisions to the Risk Methods Document text:**
  - a. Suggest deletion of the following text from page 3-21: “The total dioxin concentration will be compared to the EPA residential cleanup level of 1 ppb toxicity equivalents (TEQs) for residential and 5 to 20 ppb TEQs for industrial scenarios (EPA 1998c), in addition to comparison to the PRGs in Appendix A.”  
These levels are no longer recommended.  
EPA recommends the use of the RSL values. These are screening levels, not necessarily cleanup levels.
  - b. Remove Cobalt-60 from PGDP COPC List.  
No indication Co-60 is site contaminant. Still including Co-60 in risk assessments? Would still be included in dataset, but dropped from COPC list because the Co-60 results would not be representative. This explanation would need to be included in the risk assessment write-up. IF cobalt-60 shows up in new sample data, values would be included in risk assessment [Follow up: how is gross gamma screen performed? How do we ensure we don’t miss other rads (e.g., Sr-90)? Double-check with Sample Management to ensure Co-60 is in gamma library for labs—this would need to remain in the lab SOW].  
-Won’t be in PRG tables.  
-Won’t be in Site QAPP (footnote that Co-60 remain in lab’s gamma library).
4. **Discussion to incorporate RAGS Part F.**  
RAGS Part F is the inhalation unit risk guidance.  
RMD text would be updated to refer to RAGS Part F.  
The equations in Appendix D would be updated, with reference to RAGS Part F.  
Changes to other tables?
5. **Discussion regarding PAHs text. See attached file.**  
Coal-fire facility at PGDP is likely a source for PAHs that need to be remediated.  
Comments on PAH paper expected by Wednesday, October 31. Look at doing a sitewide PAH study (using data already available, noting data within 2(?) ft of roadway and outside influence of coal plant). The purpose is to understand the concentration distribution at the site.  
Risk from PAHs could also be addressed as an uncertainty.

Follow-up: map of existing PAH samples (separated surface and subsurface), is it possible to use these samples for a sitewide study?

6. **Discussion regarding revised PTW language. Revised text box language for the Risk Methods Document is not available at this time. Discussion will be in general.**  
RMD will reference EPA guidance (1991, fact sheets) and text box will be removed. “High risks lead to early actions.” Principal threats discussed in RMD (esp. ROD section) will refer to EPA guidance. Also should be discussed in FS section. Figure 1.1 will reference guidance (1991).
7. **Discussion regarding revised NALs/ALs and Table B.5.**  
Jerri’s e-mail (text is below)— Corrections will be sent.

In addition to our previous discussions via e-mail, here are some errors/clarifications that need to be discussed tomorrow.			
Chromium (total)	KY ABS	5E-02	Change to 2.5E-02 (CrVI) or 1.3E-02 (CrIII)
Manganese (diet)	KY ABS	4E-02	Change to 5E-02 (default); current value is
GI ABS non-dietary exposure			
Vanadium	KY ABS	2.6E-02	Change to 5E-02 (default)
1,1-Dichloroethylene	VF Res	1.02E+03	Change to 1.2E+03
1,1-Dichloroethylene	VF Ind	6.84E+02	Change to 1.2E+03
Naphthalene	KY ABS	2.5E-02	Change to 1.3E-1 (EPA ABS)
Acenaphthylene	What is surrogate source of ABS and Permeability Constant?		
Phenanthrene	What is surrogate source of ABS and Permeability Constant?		
PCB (high risk)	What is surrogate source of Permeability Constant?		
PCB (low risk)	What is surrogate source of Permeability Constant?		
PCB (lowest risk)	What is surrogate source of Permeability Constant?		

Add columns for reference to ABS and permeability constant.  
Ensure parameters input into RAIS calculator are transparent.  
Use RSL/RAIS calculator, working through issues.  
Each media to be sent separately with documentation of any issues and parameters input so that values can be reproduced.

Recommendation for any tables to be removed from RMD Appendices—(Table B.4?) TableB.5 would likely stay for documentation purposes.

First week of October: plan for proceeding, including review cycle (30 day review—keeping holidays in mind).

# **Risk Assessment Working Group Agenda—December 5, 2012 and Draft Meeting Minutes**

## **Present:**

**Jerri Martin  
Nathan Garner  
Gaye Brewer  
Todd Mullins**

**Tim Fredrick  
Turpin Ballard  
Jon Richards**

**Rich Bonczek  
Bobette Nourse  
John Volpe  
Joe Towarnicky  
LeAnne Garner**

### **1. Review of the September 2012 Meeting Minutes.**

Meeting minutes are acceptable, but need to add PAH discussion to this agenda.

### **2. Discussion of Revisions sent to date.**

#### **a. Soil/Sediment NALs and associated write-ups**

Action level for HI = 3. Range of values for HI, based on RGO tables were 0.1, 1, and 3.

\*A footnote explaining why the action level for HI is 3 needs to be added (Might refer to Figure 1.1).

Also add to introduction notes in Appendix A.

RAIS screens were helpful.

\*Check with RAIS why the adherence factor and surface area are not input parameters available for adjustment in the calculator for the industrial worker scenario.

#### **b. Groundwater NALs and associated write-ups**

Action level for HI = 3. Range of values for HI, based on RGO tables were 0.1, 1, and 3. A footnote explaining why the action level for HI is 3 needs to be added (Might refer to Figure 1.1).

#### **c. Gamma Screens (removing Co-60 as a Paducah COPC and discussion of Pb-210)**

Current recommendation, after comments received: "Currently, contracted laboratories only report what is requested in the laboratory SOW, which typically is the PGDP COPC list.

For future SOWs that are applicable (i.e., have gamma analyses), it will be requested that if cobalt-60 appears in the gamma screen above the MDA, it will be noted.

This also will be documented in the appropriate QAPP.

For the USEC lab, the presence of cobalt-60 will appear as a laboratory comment. For offsite labs, the presence of cobalt-60 will be reported in their case narratives; this information will then be manually input into the database systems (most likely in lab comments).

While lead-210 is another radionuclide that has been detected in some samples onsite (notably SWMU 222), it is not expected to be a sitewide contaminant. Lead-210 may be requested as a special analysis on specific projects. On these projects, the MDC should be set at 1 pCi/g or less for lead-210 (46 KeV peak) using a thin window HPGe detector. Additionally, the counting uncertainty should be less than 50% for lead-210."

Additional information regarding lead-210 is included in Attachment 1.

**\*What is the risk for MDC of lead-210 with no special detector?**



Residential default at  $10^{-6}$  is 0.7 pCi/g. Industrial worker at  $10^{-6}$  is 4 pCi/g.

**\*Check to see if labs would need to recalibrate equipment to see lead-210.**

d. Revisions to Risk Methods Document

— Main text

1. Discussion regarding RGO text in Section 4.1. Excerpts from guidance documents are included for reference on Pages 6 and 7.

Text will be added to Section 4.1.4 Include information here regarding RGO and PRG revision guidance. Some discussion was in the 2001 RMD, but this was deleted during revision because the language was not accurate.

Any revision of PRGs needs to be clear as to the reason for revision. Revising PRGs after the FS is final is not likely. The general expectation is that cleanup goals in the ROD would be the revised PRGs in the FS.

Jerri will send state guidance if there is any.

\*Revised text will be sent out to RAWG.

2. KY Risk Assessment Branch Comments (see Pages 8-10).

Include in Section 3.3.4.3. "(2a) General discussion of options to determine the ten or more samples." Write-up on how to handle soils data. Include example determination of EPC from grid values (from Soils OU). Revised text to be sent as scheduled. Adding this discussion for EPC calculations for soils is consistent with the groundwater EPC discussion found later in Section 3.3.4.3.

Include rationale for choosing KDEP-specific values for dermal absorption as a footnote or text box to Section 3.3.5.2.

Add 8b and 11b equations for inhalation pathways, since they are different using RAGS Part F guidance. Send revisions to RAWG as scheduled.

— Appendix A

1. Revised Table A.14 was sent for review.

See comments from Jon Richards from CERCLA Cell. EPA prefers Table A.14 list 900 pCi/L as the MCL for Tc-99 and footnote the uncertainty. Other comments (especially for uranium isotopes) can be e-mailed.

— Appendix B

1. KY Risk Assessment Branch Comments (see Pages 8-10).

Need to correct non-cancer AT (days x years), as appropriate. This is a table (presentation) error and not a AL/NAL calculation error.

Jerri has sent a list of surrogate chemicals as follows.

Acenaphthylene → Acenaphthene

Benzo(g,h,i)perylene → Pyrene or Fluoranthene

Phenanthrene → Acenaphthene or Fluoranthene

Send revision to Appendix B as scheduled.

- 2.

— Appendix D

Highlight in introduction to Appendix D that the parameters shown in equations may not be the same as those used in PRG calculations and why. Revisions to be sent to RAWG as scheduled.

Also see Items 3 and 7.

**Follow-up on radionuclides calculations from June meeting minutes.**

Discussion regarding the addition of decay correction (i.e.,  $\lambda$  and  $t$ ) to the equations in the Paducah Risk Methods Document.

The following is taken from the June meeting minutes:

**“Difference (in calculations for exposure to Rads) between what is currently used in the (1) PORTS Risk Calculator and is used by the (2) Oak Ridge Risk Analysis Information System (RAIS);  $\lambda$  and  $t$  are used.**

Example equations from RAIS documentation are shown on Pages 11 and 12.

PORTS and RAIS equations correct for decay and time of release. Equations in the RMD are simpler. Paducah radionuclides of interest (specifically uranium and technetium) do not decay very fast; therefore, while the preliminary remediation goal (PRG) would be lower than if the decay rate were used, the simpler equation will be used for Paducah. If the PORTS calculator is used for Paducah in the future, their equation will need to be changed.

NOTE: These equations were not changed for the NALs to be reviewed for the September 2012 meeting. RAIS equations were used as is with no changes, unless otherwise noted.

This calculation needs further discussion with respect to decay correction.”

Revision to Appendix D should include  $\lambda$  and  $t$ . Note that PRG calculations include use of  $\lambda$  and  $t$ . Revised Appendix D to be sent to RAWG as scheduled.

**3. Provisional Groundwater Background**

Values have been used as a screening tool even though they are still provisional. Should these be called final?

Many values in Table A.13 are not truly background, they are detection limits. If analyzed today, these may be lower. This is not a problem for most metals [note Arsenic background value is listed as 0.005 mg/L (a detection limit), but the MCL for Arsenic is 0.01 mg/L]. For chromium, results may need additional evaluation.

\*Calculation for background value for Nickel needs to be checked.

\*In Table A.13, highlight the background values based on detection limits that are greater than the MCL or, if no MCL, the residential GW NAL.

\*Since the background values were originally included in Groundwater OU FS and they were never approved, leave values as “provisional.”

**4. An issue to consider is how to screen XRF and isotope-specific rad detector results against background. The background we have are really not appropriate to use with results from these field techniques.**

Difference in fixed-base and field-base results should be noted in RMD as an uncertainty—XRF results are likely higher than fixed-base results. If it is agreed that the XRF data is of sufficient quality to determine risk, the uncertainty should not drive decision.

Add this as a bullet to Section 3.3.1. Also add to page 3-16 (discussion of XRF).

**5. For SSLs derived from RESRAD, consider verification that the DCFs and dose calculation are consistent with requirements in DOE Order 458.1. Thus must make sure ICRP 60 and ICRP 72 were used.**

SSL are derived using a spreadsheet from RESRAD inputs. Need to make sure the dose-based PRGs are correct. Tables in Appendix A will be evaluated with an update and/or revised tables to the RAWG as scheduled. See #7, below.

**6. Review exposure times for residents; currently we are using 24 hours/day.**

Table D.8 in the Risk Methods Document lists the equation and reasonable maximum exposure assumptions for external exposure to ionizing radiation from soil.

The exposure frequency (EF) is 350/365 day/day.

The gamma exposure time (ET) factor is 24/24 hr/hr.

A question was raised during review of the proposed Paducah Soil/Sediment No Action Levels as to why outdoor and indoor exposure times encoded by RAIS (0.073 hr/hr and 0.683 hr/hr, respectively) for the rad PRGs did not equal 1 hr/hr. The exposure time for the resident outside (ET<sub>ro</sub>) and exposure time for the resident inside (ET<sub>ri</sub>) assumed by RAIS allows for time spent away from home. The default scenario for the resident is 18 hr/day, 350 days/yr.

Should the Paducah default scenario remain as it is or should the equation and exposure assumptions be revised to account for indoor and outdoor time (i.e., gamma shielding applied for indoor time and not for outdoor time) and should the time be 18 hr/day instead of 24?

Exposure time in this instance only applies to external gamma exposure. These exposure times should be changed to be consistent, so that the default scenario is 18 hr/day, 350 days/yr. Changes will be reflected in Appendix D and Table B.4. Additionally, revisions to dose PRGs/SSLs will be necessary (see #6 above).

**7. Reporting soil sample results on a dry weight basis.**

LATA has noted that the industry accepted practice is for laboratories to report soil samples on a dry weight corrected basis. Because of the increase in soil projects going to the field, we believed that this was a good time to discuss a change with the USEC Analytical Lab.

The topic was discussed at length with the USEC lab recently and also input was enlisted from DOE CAP auditors who were on sight at the time. As a result of those conversations, we believe we have a path forward on this process; LATA has asked them to analyze one aliquot for moisture and enter that result in LIMS. Then, as other analyses are completed (metals, volatiles, etc) are completed, the LIMS system will perform a dry weight correction utilizing the one moisture result that was entered in the system. This way, all analyses for the sample are adjusted utilizing the same correction factor. Therefore, the resulting values reported by the lab will be based on a dry weight basis.

These changes may take a little while, so they may not be able to make the corrections within LIMS to start the process immediately, but we directed them to conduct (and report) moisture analysis on our next upcoming project (SWMU 4). This data can be presented on either an "as received" basis or dry weight corrected basis.

The key for this will be how to use historical data.

\*Uncertainties will need to be captured in project-specific documents. Also include in RMD as a potential uncertainty in Section 3.3.7.1 and also Step 2 on page 3-16. Revision to be sent as scheduled.

\*Send update to RAWG with method the lab is using to determine moisture.

Drying samples is part of CLP

As an update, the method shown below was sent to the group on 12/17/2012, as the method the USEC lab will be using to determine moisture:

ASTM D2974-07a, Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils

EPA supplied the following information:

Usually, each method would include the % moisture, but if the sample is reasonably homogenous, then one analysis applied to all aliquots should work. In the methods, VOAs do not require drying as it is a closed-system and the vial is loaded directly to the machine with any interaction being performed via the septum seal. Drying would create loss of contaminants. For extractables (SemiVOA, Pest, PCB, etc), the sample does have any standing water decanted off and then is mixed with sodium sulfate or Hydromatrix, so it doesn't go into the extraction all soupy exactly. For Metals, there isn't really a discussion or rationale and usually we don't even decant, though that optionally be done. There are definitely arguments out there that we should be doing better homogenization and particle size partitioning for Metals and drying would be a part of that. (Hg might not be amenable to drying without contaminant loss.) Overall, I think it comes down to trying to bring the sample into the process as close to its natural state in the environment as possible. A high moisture sample is often problematic, though, and we do ask the field to try to minimize the moisture content to the extent possible when collecting. Some references are SW-846 3500 (generic extraction methodology) at <http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm>. In the CLP SOWs, most relevant discussion is in Exhibit D, Section 10 of each method where the sample prep is discussed. See SOM01.2 and ISM01.3 at [www.epa.gov/superfund/program/clp](http://www.epa.gov/superfund/program/clp).

## **8. Add PAH discussion to agenda.**

The intent of the PAH paper was to send a recommendation to the FFA managers for how we propose to handle PAHs in risk assessments and why. A map of existing PAH samples is due to the RAWG January 4. Comments from EPA on paper may be available mid January.

**Next meeting: March 6. Between now and then individual meetings may need to take place in order to facilitate revisions to RMD.**

**\*Schedule for Revisions will be sent following this meeting.**

## Revisions to Risk Methods Document

### Excerpts from Guidance Documents Regarding RGO Text

In RAGS Volume 1 Part B it is stated:

**From Section 2.3 Future Land Use**

"When waste will be managed onsite, land-use assumptions and risk-based PRG development become more complicated because the assumptions for the site itself may be different from the land use in the surrounding area. For example, if waste is managed onsite in a residential area, the risk-based PRGs for the ground water beneath the site (or at the edge of the waste management unit) may be based on residential exposures, but the risk-based PRGs for the site soils may be based on an industrial land use with some management or institutional controls."

**From Section 2.8 Modification of Preliminary Remediation Goals**

"Upon completion of the baseline risk assessment (or as soon as data are available), it is important to review the future land use, exposure assumptions, and the media and chemicals of potential concern originally identified at scoping, and determine whether PRGs need to be modified. Modification may involve adding or subtracting chemicals of concern, media, and pathways or revising individual chemical-specific goals."

RAGS Volume 1 Part B also includes the following in a text box:

**NCP PREAMBLE: EXPOSURE, TECHNICAL, AND UNCERTAINTY FACTORS (55 Federal Register 8717, March 8, 1990)**

"Preliminary remediation goals ... may be revised ... based on the consideration of appropriate factors including, but not limited to: exposure factors, uncertainty factors, and technical factors. Included under exposure factors are: cumulative effect of multiple contaminants, the potential for human exposure from other pathways at the site, population sensitivities, potential impacts on environmental receptors, and crossmedia impacts of alternatives. Factors related to uncertainty may include: the reliability of alternatives, the weight of scientific evidence concerning exposures and individual and cumulative health effects, and the reliability of exposure data. Technical factors may include: detection/quantification limits for contaminants, technical limitations to remediation, the ability to monitor and control movement of contaminants, and background levels of contaminants. The final selection of the appropriate risk level is made when the remedy is selected based on the balancing of criteria .... "

**Revisions to Risk Methods Document**  
**Excerpts from Guidance Documents Regarding RGO Text**  
**Continued**

Finally, OSWER DIRECTIVE 9355.0-30 "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" states:

**In USE OF BASELINE RISK ASSESSMENT TO MODIFY PRELIMINARY REMEDIATION GOALS**

"Remediation goals developed under CERCLA section 121 are generally medium-specific chemical concentrations that will pose no unacceptable threat to human health and the environment. Preliminary remediation goals are developed early in the RI/FS process based on ARARs and other readily available information, such as concentrations associated with  $10^{-6}$  cancer risk or a hazard quotient equal to one for noncarcinogens calculated from EPA toxicity information. These preliminary goals may be modified based on results of the baseline risk assessment, which clarifies exposure pathways and may identify situations where cumulative risk of multiple contaminants or multiple exposure pathways at the site indicate the need for more or less stringent cleanup levels than those initially developed as preliminary remediation goals. In addition to being modified based on the baseline risk assessment, preliminary remediation goals and the corresponding cleanup levels may also be modified based on the given waste management strategy selected at the time of remedy selection that is based on the balancing of the nine criteria used for remedy selection (55 Fed. Reg. at 8717 and 8718)."

## Comments to Risk Methods Document

### Received from KY Risk Assessment Branch

#### Main Text

##### 3.3.4.3 Quantification of Exposure

- Discussion of how the grid values will be determined should be included, similar to the following:

Grid values were determined following guidance in the work plan. Basically, the maximum detected result from within the grid applies to the grid. If not detected, the minimum detection limit applies to the grid.

If a grid had no result (detect or non-detect) for the COPC, an average of the results for the grids with results was used.

NO RESULT	RESULT = 9	NO RESULT	RESULT = 2
RESULT = 7	NO RESULT	RESULT = 3	NO RESULT
RESULT = 3	NO RESULT	RESULT = 5	RESULT = 5

For grids with "NO RESULT," the average of the grids with results was used.  
 $(9+2+7+3+3+5+5)/7 = 4.857143$

The UCL95 would be calculated from the following:

4.857143	9	4.857143	2
7	4.857143	3	4.857143
3	4.857143	5	5

##### 3.3.5.2 Sources of toxicity information

- Discussion of the "KDEP-specific values for dermal absorption" should be included, such as the following:

In RAGS E 2004, Exhibit 4-1, the following GI absorption efficiencies are listed that are below the 5% dermal absorption KDEP has recommended as a default value for inorganics. For these constituents, the dermal absorption value should be modified from 5% to mimic the GI absorption efficiencies, as follows:

Beryllium	0.007 = 0.7%
Chromium III	0.013 = 1.3%
Chromium VI	0.025 = 2.5%
Manganese	0.04 = 4%
Nickel	0.04 = 4%
Silver	0.04 = 4%
Vanadium	0.026 = 2.6%

This is in addition to the chemical-specific dermal absorption fractions listed in Exhibit 3-4, including:

Arsenic	0.03 = 3%
Cadmium	0.001=0.1%

Equation 8, Page 64

- The  $RfD_i$  is not interchangeable with the  $RfC$ .  

$$RfD_i \text{ (mg/kg-day)} = RfC \text{ (mg/m}^3\text{)} \times 20 \text{ m}^3\text{/day} \div 70 \text{ kg}$$

Equation 11, page 64

- The  $SF_i$  is not interchangeable with the inhalation unit risk (IUR)  

$$SF_i \text{ (kg-day/mg)} = IUR \text{ (m}^3\text{/}\mu\text{g)} \times (20 \text{ m}^3\text{/day)}^{-1} \times 70 \text{ kg} \times 10^3 \mu\text{g/mg}$$

## Appendix B

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs

- General Parameters - Averaging time - noncancer (AT-N)

It appears that instead of multiplying the number of years times the number of days in the year, the number of years is multiplied by 70 instead of 365...this must be corrected.

- Inhalation RGA Groundwater (Table D.2, D.27)

It appears that instead of multiplying the number of years times the number of days in the year times the number of hours in the day, the number of years times the number of hours in the day is multiplied by 70 instead of 365...this must be corrected.

Table B.5 Toxicity Values and Information Used in PRG Derivation

- Acenaphthylene → use acenaphthene toxicity values (e.g., oral reference dose, absorbed dose)
- Acrylonitrile → absorbed dose slope factor (5.4E-01) should be added to the table



- Carbazole → absorbed dose slope factor (2.0E-02) should be added to the table
- U-235+D → the external exposure slope factor listed is for U-235, not U-235+D; the SFe Reference lists FGR12\*, but there is no explanation of the "\*"

#### Notes on Table B.5

- Note 15 should include information (or location of such) given above in the comment for the main text Section 3.3.5.2 (copied below)

In RAGS E 2004, Exhibit 4-1, the following GI absorption efficiencies are listed that are below the 5% dermal absorption KDEP has recommended as a default value for inorganics. For these constituents, the dermal absorption value should be modified from 5% to mimic the GI absorption efficiencies, as follows:

Beryllium	0.007 = 0.7%
Chromium III	0.013 = 1.3%
Chromium VI	0.025 = 2.5%
Manganese	0.04 = 4%
Nickel	0.04 = 4%
Silver	0.04 = 4%
Vanadium	0.026 = 2.6%

This is in addition to the chemical-specific dermal absorption fractions listed in Exhibit 3-4, including:

Arsenic	0.03 = 3%
Cadmium	0.001=0.1%

## Radionuclides Calculations

### Residential Soil from RAIS

The residential soil land use equations, presented here, contain the following exposure routes:

incidental ingestion of soil,

$$PRG_{res-sol-rad-ing} (pCi/g) = \frac{TR \times t_{res} \times \lambda}{\left(1 - e^{-\lambda t_{res}}\right) \times SF_s \left(\frac{risk}{pCi}\right) \times IFS_{adj} \left(\frac{120 \text{ mg}}{\text{day}}\right) \times EF_r \left(\frac{350 \text{ days}}{\text{year}}\right) \times ED_r (30 \text{ years}) \times \left(\frac{g}{1000 \text{ mg}}\right)}$$

where

$$IFS_{adj} \left(\frac{120 \text{ mg}}{\text{day}}\right) = \frac{\left(IRS_c \left(\frac{200 \text{ mg}}{\text{day}}\right) \times ED_c (6 \text{ years}) + IRS_a \left(\frac{100 \text{ mg}}{\text{day}}\right) \times ED_r - ED_c (24 \text{ years})\right)}{ED_r (30 \text{ years})}$$

inhalation of particulates emitted from soil,

$$PRG_{res-sol-rad-inh} (pCi/g) = \frac{TR \times t_{res} \times \lambda}{\left(1 - e^{-\lambda t_{res}}\right) \times SF_i \left(\frac{risk}{pCi}\right) \times IFA_{adj} \left(\frac{18 \text{ m}^3}{\text{day}}\right) \times EF_r \left(\frac{350 \text{ days}}{\text{year}}\right) \times ED_r (30 \text{ years}) \times \frac{1}{PEF \left(\frac{\text{m}^3}{\text{kg}}\right)} \times \left[ET_{ro} \left(\frac{0.073 \text{ hour}}{\text{hour}}\right) + \left(ET_{ri} \left(\frac{0.683 \text{ hour}}{\text{hour}}\right) \times DF_i (0.4)\right)\right] \times \left(\frac{1000 \text{ g}}{\text{kg}}\right)}$$

where

$$IFA_{adj} \left(\frac{18 \text{ m}^3}{\text{day}}\right) = \frac{IRA_c \left(\frac{10 \text{ m}^3}{\text{day}}\right) \times ED_c (6 \text{ years}) + IRA_a \left(\frac{20 \text{ m}^3}{\text{day}}\right) \times ED_r - ED_c (24 \text{ years})}{ED_r (30 \text{ years})}$$

external exposure to ionizing radiation and

$$PRG_{res-sol-rad-ext} (pCi/g) = \frac{TR \times t_{res} \times \lambda}{\left(1 - e^{-\lambda t_{res}}\right) \times SF_x \left(\frac{risk/year}{pCi/g}\right) \times ACF (0.9) \times \left[ET_{ro} + \left(ET_{ri} \times GSF (0.4)\right)\right] \times EF_r \left(\frac{350 \text{ days}}{\text{year}}\right) \times \left(\frac{1 \text{ year}}{365 \text{ days}}\right) \times ED_r (30 \text{ years})}$$

Total.

$$PRG_{res-sol-rad-tot} (pCi/g) = \frac{1}{\frac{1}{PRG_{res-sol-rad-ing}} + \frac{1}{PRG_{res-sol-rad-inh}} + \frac{1}{PRG_{res-sol-rad-ext}}}$$

## Radionuclides Calculations Continued

### RADIONUCLIDE SOIL SCREENING LEVELS FOR RESIDENTS from PORTS calculator

Soil Ingestion

$$SL_{r-ing} \left( \frac{pCi}{g} \right) = \frac{TR \times t_r \times \lambda}{(1 - e^{-\lambda t_r}) \times SF_s \times IFS_{r-adj} \times EF_r \times ED_r \times \frac{g}{1000mg}}$$

$$IFS_{r-adj} \left( \frac{mg}{day} \right) = \frac{ED_{r-c} \times IRS_{r-c} + ED_{r-a} \times IRS_{r-a}}{ED_{r-a}}$$

Inhalation

$$SL_{r-inh} \left( \frac{pCi}{g} \right) = \frac{TR \times t_r \times \lambda}{(1 - e^{-\lambda t_r}) \times SF_i \times IFA_{r-adj} \times EF_r \times ED_r \times \frac{1}{PEF} \times \frac{1000g}{kg} \times ET_r \times \frac{1day}{24hours}}$$

$$IFA_{r-adj} \left( \frac{m^3}{day} \right) = \frac{ED_{r-c} \times IRA_{r-c} + ED_{r-a} \times IRA_{r-a}}{ED_{r-a}}$$

External

$$SL_{r-ext} \left( \frac{pCi}{g} \right) = \frac{TR \times t_r \times \lambda}{(1 - e^{-\lambda t_r}) \times SF_{ext-sv_i} \times ACF \times EF_r \times \frac{1year}{365days} \times ED_r \times [ET_{r-o} + (ET_{r-i} \times GSF_i)]}$$

**ATTACHMENT 1**  
**LEAD-210 at PGDP**  
**Sent by e-mail 11/14/2012**

## 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 1). 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).

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. Since 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.

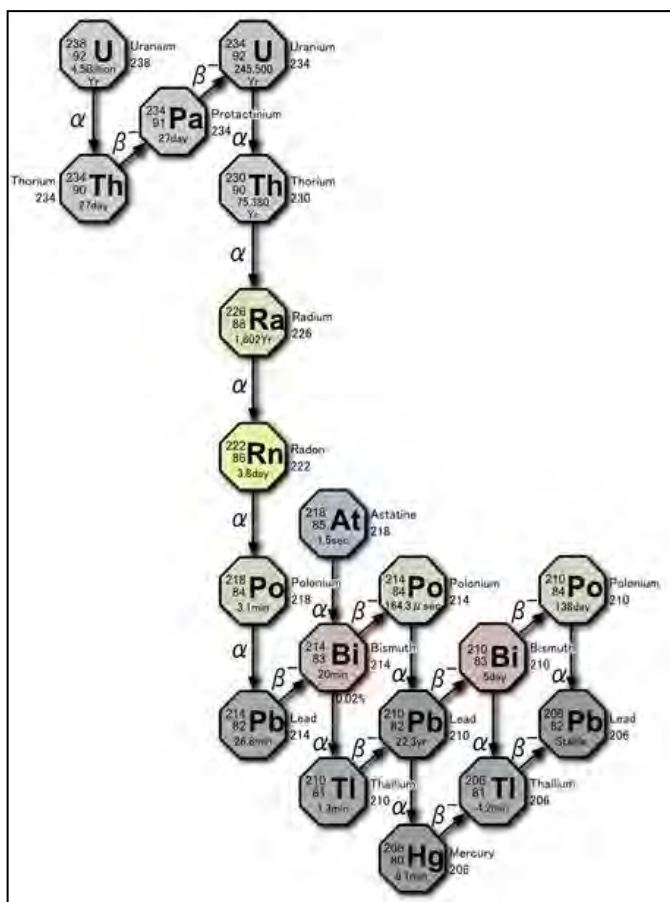


Figure 1. Lead-210 Decay Chain

Available PGDP lead-210 data was plotted to estimate an approximate background value. This map is shown in Figure 2. Since 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.

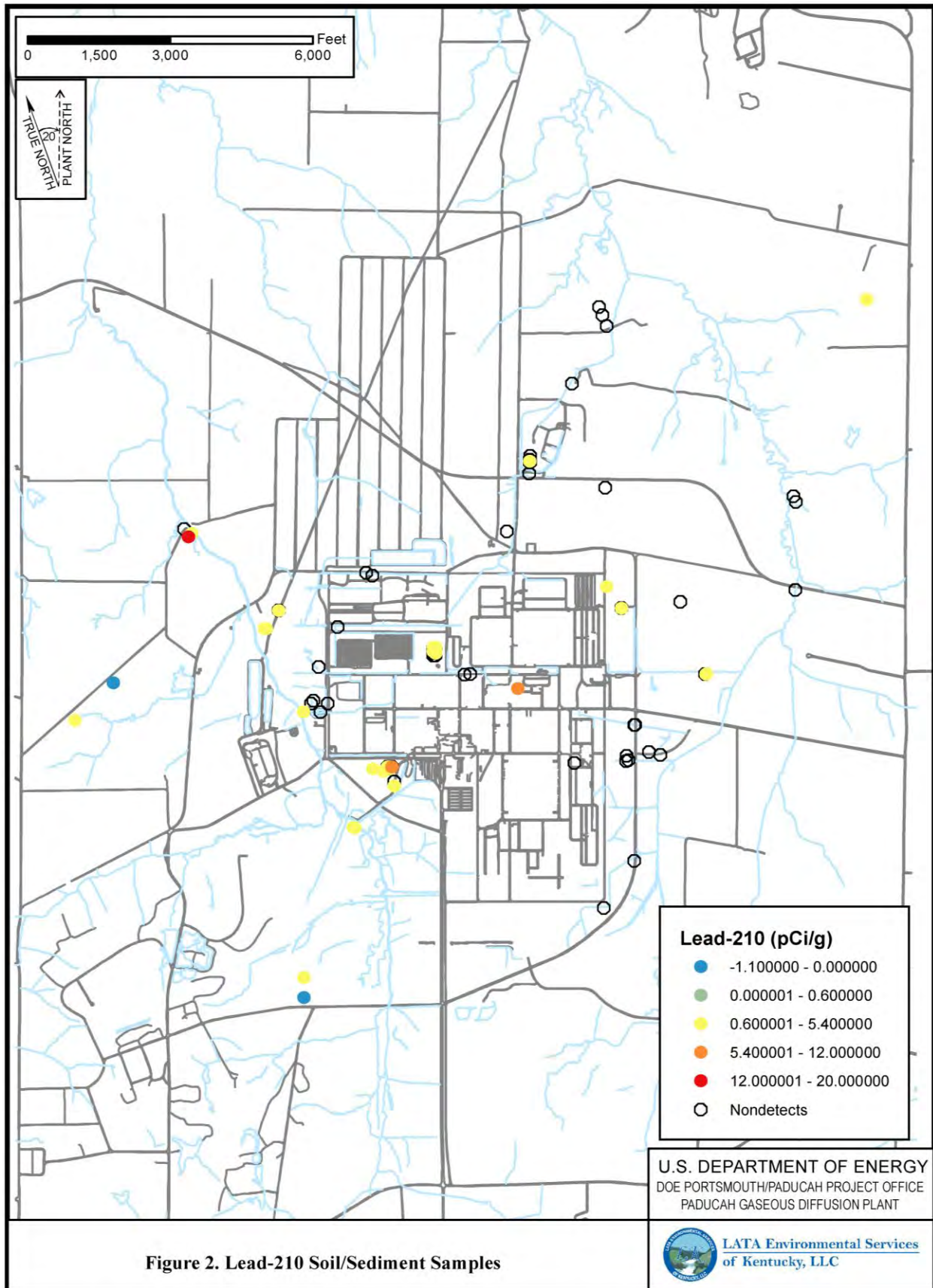


Figure No. Lead-210\_Soil.mxd  
DATE 11-01-2012

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 Pb-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 are typically present with radium-226.

After processing, radionuclides with half-lives 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 1. 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 2. Recent Soils OU soils data passed both checks.

Table 1. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment

Station	Sample ID	Depth (ft bgs)	Lab Code	Lead-210 (pCi/g)			Radium-226 (pCi/g)			Uranium-238 (pCi/g)								
				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		29.10	Yes	0.77	0.31	1.53	1.53	No	0.60	4.20	89.00	1117.00	Yes
JP-0092	DOJ1-99-0092		PGDP	14.55	18.18	29.10	29.10	No					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 <sup>a</sup>		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 <sup>b</sup>		KYRAD	8.60	1.47	0.76		Yes					No	32.30	0.04	2.66		Yes
SWMU222-1	2010-53090 <sup>b</sup>		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 <sup>b</sup>		KYRAD	6.98	1.41	0.71		Yes					No	22.10	0.04	1.94		Yes
SWMU222-3	2010-53092 <sup>b</sup>		KYRAD	6.81	1.14	0.61		Yes					No	16.70	0.03	1.51		Yes
SOU195-120A	2010-51253 <sup>a</sup>	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 <sup>a</sup>	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 <sup>b</sup>		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 <sup>a</sup>		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 <sup>c</sup>		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 <sup>a</sup>	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 <sup>c</sup>		STLMO	3.50	1.40	1.20		Yes					No					No
BCSKYRAD01	2010-50537 <sup>a</sup>		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 <sup>d</sup>	2	LOCK	3.20	0.00			Yes					No	0.97		0.09		Yes
PLDINSA10-01SO	301025	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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>d</sup>	0.9	LOCK	2.70	0.00			Yes					No	1.04		0.09		Yes
NSNST2S04	BIC2041SS	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 <sup>a</sup>	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 <sup>a</sup>		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 <sup>d</sup>	0.8	LOCK	2.40	0.00			Yes					No	1.06		0.10		Yes
I96-03,04	301038	6.67	LOCK	2.40	0.00			Yes					No	0.80		0.12		Yes
C01,10,24	301017 <sup>d</sup>	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 <sup>d</sup>	0.9	LOCK	2.09	0.00			Yes					No	1.00		0.10		Yes



Table 1. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

Station	Sample ID	Depth (ft bgs)	Lab Code	Lead-210 (pCi/g)				Detect?	Radium-226 (pCi/g)				Detect?	Uranium-238 (pCi/g)			
				Results	MDA	Rad Error	TPU		Results	MDA	Rad Error	TPU		Results	MDA	Rad Error	TPU
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
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
H04,06,09	301022	2.6	LOCK	1.90	0.00			Yes					No	1.01		0.10	
F12,20,22	301001	0.8	LOCK	1.90	0.00			Yes					No	0.90		0.08	
SOU195-014A	2010-51256 <sup>a</sup>	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	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 <sup>d</sup>	0.7	LOCK	1.80	0.00			Yes					No	1.03		0.10	Yes
BC5KYRAD02	2010-50538 <sup>a</sup>		KYRAD	1.74	0.90	0.42		Yes	2.01	1.56	0.70		Yes	0.69	0.93	0.55	Yes
I94-05,06	301039	9	LOCK	1.72	0.00			Yes					No	0.79		0.12	Yes
I94-03,04	301045 <sup>e</sup>	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	No
F01,21,23	301009	0.8	LOCK	1.60	0.00			Yes					No	0.92		0.08	Yes
C02,03,20	301020 <sup>d</sup>	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 <sup>d</sup>	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
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
C07,08,09	301016 <sup>d</sup>	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 <sup>a</sup>		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
I94-03,04	301036 <sup>e</sup>	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 <sup>a</sup>	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
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	Yes
SOU195-014C	2010-51262 <sup>a</sup>	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
F01,21,23	301010	1.6	LOCK	1.26	0.00			Yes					No	0.82		0.08	Yes
SWMU222-4	2010-52458 <sup>a</sup>		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
NST2S02	B/C2021SS	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
I94-01,02	301040	6.75	LOCK	1.20	0.00			Yes					No	0.79		0.12	Yes
I94-05,06	301050	17.5	LOCK	1.20	0.00			Yes					No	0.71		0.11	Yes
SOU195-014	2010-51255 <sup>a</sup>	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 <sup>a</sup>	7	KYRAD	1.17	0.64	0.30		Yes	2.25	0.91	0.43		Yes	0.79	0.56	0.35	Yes
I94-05,06	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 1. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

Station	Sample ID	Depth (ft bgs)	Lab Code	Lead-210 (pCi/g)				Detect?	Radium-226 (pCi/g)				Detect?	Uranium-238 (pCi/g)				Detect?
				Results	MDA	Rad Error	TPU		Results	MDA	Rad Error	TPU		Results	MDA	Rad Error	TPU	
H03.07.13	301029	0.7	LOCK	1.10	0.00			Yes					No	1.10				Yes
SOU195-006	2010-51265 <sup>a</sup>	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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>e</sup>	12	LOCK	1.04	0.00			Yes					No	0.81		0.12		Yes
SOU200-005	2010-51271 <sup>a</sup>	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 <sup>a</sup>	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 <sup>a</sup>	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	B3C1011SS	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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>a</sup>	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	B3C1031SS	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 <sup>a</sup>	7	KYRAD	0.71	0.74	0.33		No	1.72	1.50	0.66		Yes	0.54	0.70	0.44		Yes
LBC21L005	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 <sup>a</sup>	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 <sup>a</sup>	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 <sup>e</sup>	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 1. Sample Results for Lead-210, Radium-226, and Uranium-238 in Soil and Sediment (Continued)

Station	Sample ID	Depth (ft bgs)	Lab Code	Lead-210 (pCi/g)				Radium-226 (pCi/g)				Uranium-238 (pCi/g)						
				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
ISOCSSOFFST	ISOCSSBKGR08-01	0	PGDP	0.34	1.04	0.68	0.68	No					No	1.58	0.47	0.25	0.33	Yes
	BIC2031SS	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
	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
	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 <sup>d</sup>	2.8	LOCK	0.20	0.00			Yes					No	1.03		0.09		Yes
NST2S05	BIC2052SS	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	BIC1021SS	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
	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 <sup>f</sup>	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	BIC2011SS	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 <sup>f</sup>	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 <sup>f</sup>	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	BIC2051SS	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.

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

<sup>a</sup> The uranium-238 results were reported by the lab as thorium-234/uranium-238.

<sup>b</sup> The maximum uranium-238 result was used for comparison.

<sup>c</sup> This sample is not plotted in Figure 2, the coordinates place the sample in Illinois. The available coordinates are likely incorrect.

<sup>d</sup> This sample is not plotted in Figure 2, no coordinates are available.

<sup>e</sup> This sample is not plotted in Figure 2, the coordinates place the sample in Ballard County, which is outside the scale of the map.

<sup>f</sup> This result is set as a nondetect because the reported result is less than the MDA.

Table 2. 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-C-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 2. 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 2. 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 3<sup>rd</sup> party validation was performed

U = not detected above the MDA

R = result rejected

“=” = result accepted by 3<sup>rd</sup> party validation

**Paducah Risk Assessment Working Group  
February 6, 2013  
Minutes for Risk Methods Document Revisions**

**Present:**

**Jerri Martin  
Gaye Brewer  
Todd Mullins  
Stephanie Brock  
Nathan Garner  
Mike Guffey**

**Tim Frederick**

**Rich Bonczek  
Bobette Nourse  
LeAnne Garner  
John Volpe**

1. **PAH Recommendation paper.** The paper received comments from EPA and the state. A revised paper should be sent (included in schedule at the end of these meeting notes). Once agreement is reached among the group, the paper will be presented to the FFA managers. If agreed to by the FFA managers, the paper can be appended to Risk Methods Document, Appendix E, upon decision of the RAWG.
2. **Ensure text that follows** is consistent with the rest of the document and with what we intend:  
“The dermal absorption of 5% for inorganic chemicals (or revised dermal absorption to reflect intestinal absorption) may be replaced with a lower value from EPA dermal guidance. These revised calculations may be considered in the development of revised PRGs and remediation levels to be used in the preparation of remedy selection documents. These types of decisions would be a product of the consensus of the FFA parties arrived at during project discussions at the appropriate stage in document development.”
3. **Whether to include the statement currently in the main text**—“Any radionuclide for which no analytical results exceed its MARLAP MDC also will be deleted from the dataset.”  
Text has been revised and footnoted as follows (red indicates added text):  
  
Any radionuclide for which no analytical results exceed its MARLAP MDC also will be deleted from the project dataset, **provided the MDC is an acceptable level for the project.**<sup>6</sup>  
  
<sup>6</sup> These types of decisions (acceptable MDCs) would be a product of the consensus of the FFA parties arrived at during project discussions at the appropriate stage in document development.
4. **Whether to add a note to the main text regarding negative values for radionuclide results.** Include footnote to text regarding radionuclides on page 3-18, if text can be agreed to. DOE/LATA Kentucky will e-mail to group for comments, but the starting point will adopt text from Soils OU RI, which is as follows: “Negative results may be reported due to a statistical determination of the counts seen by a detector, minus a background count.”

Text for comments is as follows: "Negative results may be reported due to a statistical determination of the counts seen by a detector, minus a background count seen by the same detector."

5. **NOTE with respect to correcting incidental ingestion of sediment by a recreational user:** the recreational user and the resident should not be considered additive because the ingestion rates are independent.
6. **Appendix D with respect to updating equations to be consistent with RAGs Part F:** Ensure units cancel correctly in inhalation equations (e.g., D.17). Averaging Time units have been revised for inhalation equations from “hours × yr × day/yr” to “hours/day × yr × day/yr.” No changes to values. This also will affect Table B.5. Current Table B.5 lists units for Averaging Time as “hours × days” (which is “hours × yr × day/yr” with the yr canceled out). This will be revised to “hours,” where both yr and days cancel out.
7. **Lead-210:** Need cost estimate for analyzing lead-210 at whatever level is possible (i.e.,  $10^{-5}$ ) and at  $10^{-6}$  levels. “Other COPCs should be identified during project scoping” added to Table 2.1. Look further into potential Lead-210 sources at PGDP and define use of the term “AL” in the response. Additionally, see markup below (red indicates added text, strikethrough font indicates text to be removed):

However,

~~(1) There is no known PGDP source for lead-210 at Paducah; and~~

~~(2)~~ In regard to GDP process, 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 the GDP processes at PGDP contribute to presence of lead-210 as a potential contaminant/risk at PGDP.

NOTE: Additional comments resulted from this item indicating the Lead-210 paper is not complete.

8. **Updates to RAIS that affect NALs and ALs in Appendix A.** Updates of these screening values will be locked in with annual update cycle. The 2012 updates were made in October. Subsequent updates will reflect the November updates (consistent with RSL revisions). Risk assessors must ensure toxicity values used in risk assessments are up-to-date.

#### Remaining Schedule:

DATE	RESPONSIBLE	DESCRIPTION
February 6, 2013	meeting	Interim meeting re: Final Page Changes for main text, Appendix B and Appendix D
February 18, 2013	DOE/LATA Kentucky	Revised PAH paper.
February 20, 2013	DOE/LATA Kentucky	Appendix A remaining tables.
February 26, 2013	DOE/LATA Kentucky	Revised Nickel Groundwater Background values.
March 6, 2013	meeting	8:30-11:00 central (9:30-12:00 eastern) Update on lead-210 information
March 8, 2013	RAWG	Final comments due to DOE/LATA Kentucky for all draft page changes to RMD



DATE	RESPONSIBLE	DESCRIPTION
April 8, 2013	DOE/LATA	Final Revised Risk Methods Document - D2/R2/V1 sent to RAWG for final review
April 22, 2013	RAWG	RAWG approval of D2/R2/V1 document
April 29, 2013	DOE/LATA	Initiate DOE review of D2/R2/V1 document
May 13, 2013	DOE/LATA	DOE comments due
May 20, 2013	DOE/LATA	Transmit D2/R2/V1 document changes due to DOE comments to RAWG
June 5, 2013	meeting	8:30-11:00 central (9:30-12:00 eastern) RAWG to discuss and approve revisions to D2/R2/V1 document due to DOE comments
June 17, 2013	DOE/LATA Kentucky	Final D2/R2/V1 document to DOE for concurrence
June 30, 2013	DOE/LATA Kentucky	Transmit D2/R2/V1 document to FFA Managers (EPA/KY) for approval
September 11, 2013	meeting	8:30-11:00 central (9:30-12:00 eastern) Consider face-to-face meeting (probably in Kentucky)

**Paducah Risk Assessment Working Group**  
**March 6, 2013**  
**Minutes for Quarterly Meeting**

**Present:**

**Jerri Martin**  
**Gaye Brewer**  
**Nathan Garner**  
**Todd Mullins**

**Tim Frederick**  
**Jon Richards**

**Rich Bonczek**  
**Bobette Nourse**  
**Joe Towarnicky**  
**LeAnne Garner**

**1. Additional changes to December 2012 Meeting Minutes or February 2013 Meeting Minutes.**

- a. Comments received from Stephanie Brock and Nathan Garner for February meeting minutes, incorporated. SEE NOTE.  
-Struck through text in Lead-210 paper “~~(1) There is no known PGDP source for lead-210 at Paducah; and~~”  
-Need to add additional information regarding recreational user and residential user not being additive. This information will be included in the revised RMD, if not already in there. The recreational user is assumed to be a local resident.
- b. Considered final. SEE NOTE.

NOTE: The comment to strike through the text “There is no know PGDP source for lead-210 at Paducah” resulted in additional comments from others. The February 2013 Meeting Minutes have been changed to reflect additional comments resulted and that the Lead-210 paper is not complete.

**2. Updates to Appendix A.**

Sent by e-mail to RAWG for review on 2/22. All draft comments due March 8, 2013.

**3. Discussion regarding PAHs text. Revised file sent February 18.**

- a. Comments received from Todd Mullins incorporated. Use of “coal” removed.

“Due to the nature of polycyclic aromatic hydrocarbons (PAHs), as described in the *Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs)*,<sup>1</sup> the presence of PAHs in Paducah Gaseous Diffusion Plant (PGDP) in some soils and sediments (e.g., along roads, including roadside ditches and around buildings) is not directly related to PGDP releases, but rather from other on- or off-site activities, including airborne deposition of PAHs that result from the incomplete burning of ~~coal~~, oil, gas, wood, garbage, or other organic substances or deposition due to the use of rubber, asphalt, ~~coal~~, crude oil, coal tar, creosote, and roofing tar.”

- b. Comments received from Tim Frederick: revise text to “At the Oak Ridge Reservation, an early document proposed that DOE manage PAHs as if they were wholly associated with background.<sup>4</sup> However, currently at the Oak Ridge Reservation, PAHs are being addressed on a case-by-case basis and anthropogenic sources are considered.”  
Tim will look for a reference. If none is found, personal communication with RPM may be used.

- c. Need to look for additional reference to “The most common source of PAHs in the environment currently is deposition of automobile exhaust.2” Change “The most” to “A”.
- d. Also note Tim’s editorial comments.

Once Tim’s comments addressed, send for final approval.

**4. Update on Lead-210 paper.**

- Need cost estimate for analyzing lead-210: working.
- Look further into potential Lead-210 sources at PGDP: working. “There is no known PGDP source for lead-210 at Paducah” was removed from paper. Still need list of potential sources (e.g., equipment from other sites). Need anecdotal references. SEE NOTE to Item 1.
- Define use of the term “AL”: Analytical Laboratory

**5. Remaining schedule for Risk Methods Document Revision:**

March 8, 2013	RAWG	Final comments due to DOE/LATA for all draft page changes to RMD
April 8, 2013	DOE/LATA	Final Revised Risk Methods Document—D2/R2/V1 sent to RAWG for final review
April 22, 2013	RAWG	RAWG approval of D2/R2/V1 document
April 29, 2013	DOE/LATA	Initiate DOE review of D2/R2/V1 document
May 13, 2013	DOE/LATA	DOE comments due
May 20, 2013	DOE/LATA	Transmit D2/R2/V1 document changes due to DOE comments to RAWG

Need to let Jana White know that updates are coming so that she can let FFA Managers know.

**6. Discussion regarding including RAWG Meeting Minutes in Appendix E**

Draft consolidation of final meeting minutes to be sent for comment and additional discussion of whether they will all be incorporated. Most recent minutes (i.e, 2012 and 2013) will be included.

**7. Discussion of Ni background for groundwater**

Change was made in Appendix A to correct value. Old calculations are not able to be revised. The revised background value will be footnoted in the Risk Methods Document with the text, “Nickel background value varies from previous Risk Methods Documents due to an error in calculation.”

Add groundwater background to future agendas. Need to look at differences in analytical methods. There may be data currently in the database that already have lower detection level. Bobette Nourse will provide update at next meeting.

**8. Next Meeting: June 5, 2013. 9:30-12:00 EST. Following that, the next meeting is September 11, 2013.**

**From:** Garner, Leanne K (YLN)  
**Sent:** Friday, August 02, 2013 2:48 PM  
**To:** Rich Bonczek; 'Bobette Nourse'; John Volpe; 'Brewer, Gaye (EEC)'; 'Higginbotham, Jeri (EEC)'; 'Martin, Jerri (EEC)'; Todd Mullins; Stephanie Brock; 'Garner, Nathan (CHS-PH)'; Guffey, Mike (EEC) (Mike.Guffey@ky.gov); Towarnicky Joseph; Redfield, Myrna E (MXN); 'Frederick.Tim@epamail.epa.gov'; 'Richards.Jon@epamail.epa.gov'; White, Jana L (FMT); 'Tufts, Jennifer (Tufts.Jennifer@epa.gov)'  
**Subject:** Paducah Risk Assessment Working Group Meeting Minutes - Comments on Risk Methods Document  
**Attachments:** Proposed Text Revisions (outdoor worker-gardener).docx

**Paducah Risk Assessment Working Group  
July 31, 2013  
Minutes for Risk Methods Document Comment Meeting**

**Present:**

**Jerri Martin  
Gaye Brewer  
Nathan Garner  
Mike Guffey**

**Tim Frederick  
Jon Richards**

**Rich Bonczek  
Bobette Nourse  
John Volpe  
Joe Towarnicky  
LeAnne Garner**

**1. Outdoor Worker/Gardener**

Comments on attached material are requested. If no changes to current materials (attached), then materials can be put into final Risk Methods Document (RMD) update. If not, plan to include in next year's update. The following additional summary information is to be included in Appendix A.

- Outside industrialized area—surface only and surface/subsurface soils, default exposure parameters (or as agreed to by project) (e.g., wildlife management area worker or farmer).
- Inside industrialized area—surface only soils, default exposure parameters (or as agreed to by project) (e.g., unprotected worker).
- Inside industrialized area—surface/subsurface soils, default exposure parameters with the exception of shorter exposure duration/exposure frequency consistent with civil engineering estimates, as agreed to by project (e.g., excavation worker).

Kentucky expressed some concern about the excavation worker/outdoor worker/gardener issue in regard to possibly being overly definitive. Additional comments on the issue might be forthcoming.

**2. FY 2013 RMD Approval**

No issues have been identified to date.

Approval with comments is acceptable (comments can include the understanding that the revised text regarding outdoor worker/gardener sent by e-mail will be added to the next revision).

Reminder will be sent in 2 weeks!

**3. Upcoming Schedule**

- To align the RMD with the Environmental Monitoring Plan and Programmatic QAPP schedules, need approval of the FY 13 RMD update by the FFA Managers by the end of August 2013.
- For next year, quarterly meetings will be planned; do not expect significant text changes to Human Health RMD, like this year. Hope to have FFA Managers' approval of RMD by July 2014.

#### Footnote on page 3-27:

<sup>7</sup> ~~Although a~~ single set of exposure equations and parameters are ~~used~~provided for the outdoor worker/gardener scenario, ~~the gardener scenario in Appendix D. The exposure parameters provided in Appendix D should only be considered be used without changes when assessing risk from exposure to be a reasonable scenario for are~~surface soils in locations outside the ~~limited industrialized~~ area at the Paducah site. ~~Additionally, When assessing risk from exposure to both surface and subsurface soil in locations outside the industrialized areas, however, all exposure parameters for, except exposure duration (ED) and exposure frequency (EF), should be used without changes to assess an outdoor worker. ED and EF for exposure by the outdoor worker/gardener scenario, except exposure duration (ED), can to surface and subsurface soil in locations outside the industrialized area should be used fore~~established considering guidance in the Exposure Factors Handbook (EPA 1997b), or similar sources, and be documented. Similarly, when assessing risk from exposure to either surface soil or subsurface soil or both in locations inside the industrialized area, all exposure parameters, except ED and EF, should be used without changes to assess both an outdoor worker and a construction/excavation worker. ~~When used~~As above, ED and EF for exposure by the outdoor worker or a construction/excavation worker ~~scenario, to surface soil or subsurface soil or both in locations inside the ED industrialized area should be reduced to 1 and 5 years (based on established considering guidance from in the Exposure Factors Handbook), (EPA 1997b), or similar sources, and be documented.~~

#### Text on page B-3:

##### **B.1.2.1 Receptors**

Table B.1 provides a matrix ~~of~~ showing the medium-receptor combinations for which PRGs were derived. As shown there, over all media, the receptors for which no action and action direct contact risk-based PRGs were derived are the industrial worker, the resident, the recreational user, and the outdoor worker/gardener. ~~The outdoor worker/gardener scenario replaces the “excavation worker” in the 2001 version of this document. The outdoor worker/gardener uses the same exposure parameters as the former excavation worker; the receptor name was changed to better reflect that the exposure parameters are designed to assess a long term plant worker conducting outdoor maintenance activities. The 25 year exposure duration for the outdoor worker/gardener can be modified to a value between one and five years to generate site specific values for exposures during exeavation.~~ These receptors were chosen because they represent the most likely current and future receptors for most areas and units at the Paducah Gaseous Diffusion Plant (PGDP). Also, it is believed that the PRGs derived for these receptors yield a range of values that is most useful for determining the clean-up priority for the various areas and units at PGDP. (Note that outdoor worker/gardener PRGs can be used for a construction/excavation worker; however, because the duration and frequency of exposure for a construction/excavation worker would be markedly less than that for an outdoor worker/gardener, a better approach would be to derive scenario-specific PRGs for the construction/excavation worker based on site-specific conditions, as appropriate. See discussion in Section 3.3.4.3.)

#### Footnote to Table B.1. on page B-4:

3. Determining which soil and sediment screening value is appropriate is a location-specific decision. For all ~~areas~~locations inside the industrialized areas at PGDP where surface soil contamination is of concern, use of the industrial worker values is appropriate. For ~~areas~~locations inside the industrialized areas at PGDP where contact with surface soil and subsurface soil is of concern (~~i.e.e.g., soil from the surface~~ down to 16 ft bgs), use of the outdoor worker/gardener values is appropriate. ~~Site-specific values should be developed for sites at which a construction/excavation worker is expected (see~~A better approach, however, would be to derive scenario-specific PRGs for the construction/excavation worker based on site-specific conditions, as appropriate. See discussion in Section 4.2.1.)-3.3.4.3.) For ~~areas~~locations outside the industrialized area, ~~use of where surface soil contamination is of concern, screening using~~ the recreator and/or resident values is appropriate. As with the surface water values, the child resident values are the most “conservative.” (in terms of protecting human health).” Generally, the recreator values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident values are more appropriate for grassy fields. ~~Also, note that the recreator and resident values are actually only applicable to surface soil. Finally, the outdoor worker/gardener values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. (If screening considers both surface and subsurface soil in locations outside the industrialized area, however, development of scenario-specific PRGs for the outdoor worker based on site-specific conditions is a better approach. See discussion in Section 3.3.4.3.)~~

## Risk Assessment Working Group Meeting Minutes—September 2013

**Present:**

**Jerri Martin**  
**Mike Guffey**  
**Nathan Garner**

**Tim Frederick**  
**Jon Richards**

**Rich Bonczek**  
**Bobette Nourse**  
**LeAnne Garner**

**1. Call for Issues from RAWG Members**

No additional issues.

**2. Discussion of FY 2014 Schedule**

Revisions made as follows:

Quarterly Meeting (September)	9/18/2013
Submit Work Plan (this schedule)	9/25/2013
Approve Work Plan (this schedule)	10/23/2013
Submit Appendix A (PRGs) to RAWG for Review	11/13/2013
Submit Suggested Deletions/Changes from Appendix E	12/4/2013
Comments Due for Appendix A	12/4/2013
Quarterly Meeting (December)	12/11/2013
Submit Revised Appendix B, D, and Main Text to RAWG for Review	12/11/2013
Submit Revised Appendix E	1/15/2014
RAWG Approve Appendix A	2/12/2014
Comments Due for Appendix B, D, and Main Text	2/12/2014
Comments Due for Appendix E	2/26/2014
Quarterly Meeting (March)	3/5/2014
RAWG Approve Appendix E Deletions/Changes	3/5/2014
RAWG Approve Appendix B, D, and Main Text	4/9/2014
Submit Entire Revised RMD to RAWG for Review	4/16/2014
Quarterly Meeting (June)	6/4/2014
Comments Due for Entire Revised RMD	5/16/2014
<b>Submit RMD to FFA Managers (DOE/LX/07-0107&amp;D2/R3/V1)</b>	6/13/2014
<b>FFA Managers Approve RMD (DOE/LX/07-0107&amp;D2/R3/V1)</b>	7/17/2014
Quarterly Meeting (September)	9/10/2014

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 a.m. (eastern)

Approval of the revised Risk Methods Document (at least Appendix A) is needed by end of June (approximately) to support Programmatic QAPP revision.

3. **Proposed Revisions to the 2013 Risk Methods Document for the 2014 Version re: Outdoor Worker. Text attached (from e-mail sent 6/27/2013).**

**Kentucky Division of Waste Management Comment:**

The Division has discussed inconsistent language regarding the outdoor worker/gardener contained in the document (page 3-27 vs. page B-3 and B-4) with DOE and their contractors. Per our discussion, this issue will be placed on the next Risk Working Group meeting agenda.

**Double-check that page 3-27 vs. page B-3 and B-4 are the only locations in the RMD where there is inconsistent language regarding the outdoor worker/gardener.**

**Comments on language included will be included with RAWG member comments to the meeting minutes.**

4. **Status of Lead-210 Paper**

**Comments on language included will be included with RAWG member comments to the meeting minutes.**

**Text attached (reworked from previous version)**

**Kentucky Cabinet for Health Services—Radiation Health Branch Comment:**

This document does not yet contain a consistent and defensible method for handling contaminants not on the sitewide COPC list, but which may be present in a unit based upon new data and/or are found at unexpected levels during sampling efforts (e.g., Pb-210 contamination at SWMU 222). It would be in the best interest of all parties to develop such a method and integrate it into the document.

**Write-up/flow chart of how the potential for additional COPCs are identified consistently during project scoping; possibly add to Section 2. The write-up/flow chart will be sent to RAWG for comments on October 15. Comments will be due with main text/Appendix B comments.**

5. **Background Groundwater**

- Nickel value was updated for the 2013 RMD.
- No additional activity planned for FY 2014; plan to use existing values for now.
- Review addressing new values in FY 2015.

6. **Update WKWMA/Wildlife and Hunting Information in Appendix E**

**Update Agricultural Extension Information in Appendix E**

Provide RAWG a plan for update at December meeting. Work plan schedule revised to accommodate.

**7. Revisit Qualitative Assessment of High Sample Quantitation Limits (Section 3.3.3.2, Step 3)**

The subject matter expert raising the issue was not on the call, so discussion was postponed until the December quarterly meeting.

**8. Revisit Use of Negative XRF Results**

Currently these results are included for statistical calculations.

The RAWG will explore other options for use. RAWG will follow-up at December meeting. Any input should be given to LeAnne. See KRCEE paper regarding AOC 492 and the first soil piles report for background information. The EPA representative stated he was against using proxy values.

**9. Deletion of Groundwater Exposure in Industrial Worker Scenario (Tables D.26 and D.27 in the Risk Methods Document)**

Table D.26, “Reasonable Maximum Exposure Assumptions for Ingestion of Water by an Industrial Worker”

Table D.27, “Reasonable Maximum Exposure Assumptions for Inhalation of VOCs in Water while Showering by an Industrial Worker”

Table D.28, “Reasonable Maximum Exposure Assumptions for Dermal Contact with Water while Showering by an Industrial Worker”

**Equations should be left in place for now, but they most likely will not be the driver for remedial action. Results could affect future land use control discussions.**

**Need to develop a footnote to these equations regarding their use. This will be submitted for review as part of the Risk Methods Document, Appendix D revision.**

**10. Round Table Issues/Comments**

**EPA is looking at making updates to the default exposure parameter handbook in February 2014. PRGs may be affected; will need to look at our site-specific parameters to see if we want to make changes.**

**On the December agenda, consider if there is anything that needs to be addressed in the Eco Risk Methods document. Invitee list will be checked to ensure Jeri Higginbotham is invited.**



## Proposed Text Revisions (Outdoor Worker-Gardener)

### Footnote on page 3-27:

<sup>7</sup> A single set of exposure equations and parameters are provided for the outdoor worker/gardener scenario in Appendix D. The exposure parameters provided in Appendix D should be used without changes when assessing risk from exposure to surface soils in locations outside the industrialized area at the Paducah site. When assessing risk from exposure to both surface and subsurface soil in locations outside the industrialized areas, however, all exposure parameters, except exposure duration (ED) and exposure frequency (EF), should be used without changes to assess an outdoor worker. ED and EF for exposure by the outdoor worker/gardener to surface and subsurface soil in locations outside the industrialized area should be established considering guidance in the Exposure Factors Handbook (EPA 1997b), or similar sources, and be documented. Similarly, when assessing risk from exposure to either surface soil or subsurface soil or both in locations inside the industrialized area, all exposure parameters, except ED and EF, should be used without changes to assess both an outdoor worker and a construction/excavation worker. As above, ED and EF for exposure by the outdoor worker or a construction/excavation worker to surface soil or subsurface soil or both in locations inside the industrialized area should be established considering guidance in the Exposure Factors Handbook (EPA 1997b), or similar sources, and be documented.

### Text on page B-3:

#### B.1.2.1 Receptors

Table B.1 provides a matrix showing the medium-receptor combinations for which PRGs were derived. As shown there, overall media, the receptors for which no action and action direct contact risk-based PRGs were derived, are the industrial worker, the resident, the recreational user, and the outdoor worker/gardener. These receptors were chosen because they represent the most likely current and future receptors for most areas and units at the Paducah Gaseous Diffusion Plant (PGDP). Also, it is believed that the PRGs derived for these receptors yield a range of values that are most useful for determining the cleanup priority for the various areas and units at PGDP. (Note: Outdoor worker/gardener PRGs can be used for a construction/excavation worker; however, because the duration and frequency of exposure for a construction/excavation worker would be markedly less than that for an outdoor worker/gardener, a better approach would be to derive scenario-specific PRGs for the construction/excavation worker based on site-specific conditions, as appropriate. See discussion in Section 3.3.4.3.)

### Footnote to Table B.1. on page B-4:

- Determining which soil and sediment screening value is appropriate is a location-specific decision. For all locations inside the industrialized area at PGDP where surface soil contamination is of concern, use of the industrial worker values is appropriate. For locations inside the industrialized area at PGDP where contact with surface soil and subsurface soil is of concern (e.g., soil from the surface down to 16 ft bgs), use of the outdoor worker/gardener values is appropriate for a construction/excavation worker. A better approach, however, would be to derive scenario-specific PRGs for the construction/excavation worker based on site-specific conditions, as appropriate. See discussion in Section 3.3.4.3.) For locations outside the industrialized area where surface soil contamination is of concern, screening using the recreator and/or resident values is appropriate. As with the surface water values, the child resident values are the most "conservative (in terms of protecting human health)." Generally, the recreator values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident values are more appropriate for grassy fields. Finally, the outdoor worker/gardener values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. (If screening considers both surface and subsurface soil in locations outside the industrialized area, however, development of scenario-specific PRGs for the outdoor worker based on site-specific conditions is a better approach. See discussion in Section 3.3.4.3.)

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Deleted: Also, note that the recreator and resident values are actually only applicable to surface soil.

## **Additional Information to RAWG Regarding Lead-210 (Revised September 2013)**

In response to discussion during the December 2012 Risk Assessment Working Group, we researched the potential for reporting analytical results of lead-210 and the potential value of this information. The two action items for the Risk Assessment Working Group below were taken from that discussion.

- What is the risk for lead-210 at the minimum detectable concentration (MDC) with no special detector?
- Check to see if labs would need to recalibrate equipment to analyze lead-210 by gamma spectroscopy.

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 (see Web site <http://www.lrb.usace.army.mil/Portals/45/docs/FUSRAP/DaytonIII/day3-si-2004-12.pdf>, Table 2). See attached spreadsheets for the Radiation Health Branch (RHB) lead-210 analysis. Only data with a sample-specific 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.,  $10^{-6}$  values calculated using RAIS and Paducah-specific parameters) are as follows:

- Resident, 0.66 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, the MDC obtained by liquid scintillation counting (LSC) is approximately 5 pCi/g. TestAmerica indicates this is the target MDC by LSC; 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."

However, soil analysis by the Kentucky RHB using gamma spectroscopy and a thin window HPGe detector achieved a 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. Since 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. Since 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.

Since analysis of lead-210 by LSC 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 current equipment used by the USEC laboratory, gamma spectroscopy analysis for lead-210 is not possible because the primary energy line is below the analytical laboratory normal energy calibration range. It would require the purchase of a new calibration mixture to include the lead-210 line-at 46 KeV. The analytical laboratory has only 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  $10^{-5}$ .

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, the uranium enrichment processes at PGDP contribute to the presence of lead-210 as a potential contaminant/risk at PGDP; therefore, 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 a project-by-project basis.

## Risk Assessment Working Group Meeting Minutes—December 2013

**Present:**

✓ Gaye Brewer

✓ Nathan Garner

✓ Mike Guffey

✓ Jeri Higginbotham

✓ Jerri Martin

✓ Todd Mullins

✓ Tim Frederick

✓ Rich Bonczek

✓ Martin Clauberg

✓ LeAnne Garner

✓ Bobette Nourse

✓ Joe Towarnicky

### 1. Call for Issues from RAWG Members

No additional issues were raised from Risk Assessment Working Group (RAWG) members.

### 2. Remainder of Fiscal Year (FY) 2014 Schedule

One revision made to submittal date for Appendix E. The revised date is shown in the table.

Submit Suggested Deletions/Changes from Appendix E	12/4/2013
Comments Due for Appendix A	12/4/2013
Quarterly Meeting (December)	12/11/2013
Submit Revised Appendix B, D, and Main Text to RAWG for Review	12/11/2013
Submit Revised Appendix E	1/29/2014
RAWG Approve Appendix A	2/12/2014
Comments Due for Appendix B, D, and Main Text	2/12/2014
Comments Due for Appendix E	2/26/2014
Quarterly Meeting (March)	3/5/2014
RAWG Approve Appendix E Deletions/Changes	3/5/2014
RAWG Approve Appendix B, D, and Main Text	4/9/2014
Submit Entire Revised RMD to RAWG for Review	4/16/2014
Quarterly Meeting (June)	6/4/2014
Comments Due for Entire Revised RMD	5/16/2014
Submit RMD to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	6/13/2014
FFA Managers Approve RMD (DOE/LX/07-0107&D2/R3/V1)	7/17/2014
Quarterly Meeting (September)	9/10/2014

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 a.m. (eastern)

An e-mail confirmation was requested from each RAWG member whether additional comments on Appendix A are expected.

### 3. Discussion of Outdoor Worker/Gardener Text (update) and Other Comments Received

KDWM requested the Risk Methods Document (RMD) be double-checked that page 3-27 vs. pages B-3 and B-4 are the only locations in the RMD where there is inconsistent language regarding the outdoor worker/gardener. One additional location for change was sent in October 15 e-mail to the RAWG.

The following was presented as a suggested response to comments that were received for the proposed text changes:

#### **B.1.2.1 Receptors**

“~~Note: Outdoor worker/gardener PRGs can be used for a construction/excavation worker; however, because the duration and frequency of exposure for a construction/excavation worker would be markedly less than that for an outdoor worker/gardener, a better approach would be to derive scenario-specific PRGs for the construction/excavation worker based on site-specific conditions should be derived, as appropriate.~~”

Throughout the footnote on page 3-27, “risk,” was replaced with “potential risk.”

Additional editorial changes were made to provide clarity.

#### **4. Status of Lead-210 Paper**

No comments on language provided in previous meeting were made. The paper will be added to Appendix E. Comments can be made on Appendix E when it is submitted.

The write-up/flowchart of how the potential for additional chemicals of potential concern (COPCs) are identified consistently during project scoping was sent to RAWG for comment on October 15. Comments will be due with main text comments.

#### **5. Risk Methods Document Appendix E Update**

A proposal was made that Appendix E be put on compact disc (CD) or a separate volume; the group agreed.

The plan for updating Appendix E is as follows:

##### **E.1. DATA AND DOCUMENTS USED TO ESTABLISH BACKGROUND**

**CONCENTRATIONS:** Leaving in 2014 RMD with no changes.

**E.2. SITE-SPECIFIC EXPOSURE INFORMATION:** Updating for the 2014 RMD with more current information, as follows.

- Letter and survey form used during the Phase I Site Investigation (CH2M Hill 1991) to determine groundwater use near PGDP:

Clarify the purpose for having the survey forms in this document (i.e., to address the question of how groundwater would be used if municipal water were not provided for developing the exposure scenarios in the RMD).

- Summary of the interview with Mr. Kenny E. Perry, Agricultural Extension Agent, Ballard County, Kentucky, regarding agricultural practices in Ballard County held in February 1994:

Update in 2014 RMD with revised interview/information for Ballard County.

- Summary of the interview with Mr. Douglas A. Wilson, Agricultural Extension Agent, McCracken County, Kentucky, regarding agricultural practices in McCracken County held in February 1994:

Update in 2014 RMD with revised interview/information for McCracken County.

- Letter dated February 24, 1994, from Mr. Douglas A. Wilson, Agriculture Extension Agent, McCracken County, Kentucky, to Mr. Fred Dolislager, Risk Analyst, Oak Ridge National Laboratory, regarding area of crop land in McCracken County:

Update in 2014 RMD with revised information for McCracken County.

- Questionnaire dated October 26, 1995, sent to Mr. Charles Logsdon, Kentucky Department of Fish and Wildlife Resources (KDFWR), by FMSM Engineers, Inc., regarding recreational use of Little and Big Bayou Creeks near PGDP:

Update in 2014 RMD with revised information from KDFWR.

- Facsimile dated November 8, 1995, sent to Mr. Stephen Scott, FMSM Engineers, Inc., containing responses from Mr. Charles Logsdon, KDFWR, to the aforementioned questionnaire:

Update in 2014 RMD with revised information from KDFWR.

- Letter dated April 5, 1994, from KDFWR to Mr. Fred Dolislager, Risk Analyst, Oak Ridge National Laboratory, containing annual harvests of geese, ducks, turkeys, and deer in McCracken and Ballard Counties, Kentucky:

Update in 2014 RMD with revised information from KDFWR (most information should be available from KDFWR Web site).

- 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:

Leave in 2014 RMD. Attempt to find better quality copy.

**E.3. KENTUCKY REGULATORY GUIDANCE:** Leaving in 2014 RMD, especially if putting Appendix E on CD.

**E.4. FLOWCHART FOR UNCERTAINTY MANAGEMENT FOR UNKNOWN AREAS OF CONTAMINATION:** Leaving in 2014 RMD, especially if putting Appendix E on CD.

LATA Kentucky is checking into whether adding this flowchart to the RMD was a commitment for the Environmental Indicators (EI) project. A cover letter may be added indicating that. The main text also has flowcharts for scoping that could be used for other projects. Mike Guffey will check whether the existing flowcharts in the main text are adequate and sufficient for the uncertainty management of burial ground nature and extent identification.

**E.5. DATA QUALITY OBJECTIVE MATERIALS:** Removing material from 2014 RMD, but adding introductory information and Web link to Hanford information to the main text where DQOs are discussed.

**E.6. COMPILED PARAMETERS FOR PROBABILISTIC RISK ASSESSMENTS:** Leaving in 2014 RMD, especially if putting Appendix E on CD.

**E.7. MEETING MINUTES FROM PADUCAH RISK ASSESSMENT WORKING GROUP:**

Leaving in 2014 RMD. This section will continue to be updated.

**E.8. LEAD-210 AT PGDP:** Leaving in 2014 RMD. Replace “placeholder” with information agreed to by RAWG; any comments to be made as part of this submittal.

**E.9. PAH CONTAMINATION AND ESTABLISHMENT OF REMEDIAL GOALS:** Leaving in 2014 RMD. Replace “placeholder” with information agreed to by RAWG; any comments to be made as part of this submittal.

**6. Revisit Qualitative Assessment of High SQLs (Section 3.3.3.2, Step 3)**

No changes were proposed to Human Health assessment as a result of using high sample quantitation limits (SQLs). Exposure point concentrations (EPCs) are calculated using ProUCL.

The issue may need to be addressed in an update to the Paducah Ecological RMD, because the Ecological RMD still uses one-half the detection limit to calculate EPC, while the ProUCL is used for EPCs for the human health evaluations.

It was noted that there is a new version of ProUCL (i.e., Version 5).

**7. Revisit Use of Negative XRF Results**

Following-up from previous quarterly meeting, use of negative X-ray fluorescence (XRF) results was discussed. No changes were proposed to their use. It is not anticipated that negative XRF results should occur in the future, due to changes in instrumentation; this issue affects only historical data (specifically soil piles data, such as chromium). The group believes that data should not be thrown out. The group needs to ensure this issue is documented as an uncertainty, if it applies to a project. EPA recently had XRF project at another site; Tim Frederick will share information at next RAWG quarterly meeting. Joe Towarnicky will review findings from XRF results in relation to laboratory results that were documented in the Soils Operable Unit Remedial Investigation on an element-by-element basis so that we know how to use XRF data (e.g., can XRF be used for selenium); these findings will be added to Appendix E.

**8. Anything that needs to be addressed in the Eco Risk Methods document?**

Brett Thomas needs to be added to meeting distribution. The Paducah Ecological RMD needs to be revised in FY 2015. See above regarding EPC calculation. Jeri Higginbotham will send additional changes for the Paducah Ecological RMD to LeAnne. These suggestions will be included in the next RAWG quarterly meeting agenda (to be held on March 5, 2014).

## Risk Assessment Working Group Meeting Minutes—March 2014

**Present:**

✓Gaye Brewer  
✓Stephanie Brock  
✓Nathan Garner  
✓Mike Guffey  
✓Jeri Higginbotham  
✓Jerri Martin  
✓Todd Mullins

✓Tim Frederick  
✓Jon Richards  
✓Brett Thomas

✓Rich Bonczek  
✓Martin Clauberg  
✓LeAnne Garner  
✓Bobette Nourse  
✓Joe Towarnicky

**1. Call for Issues from RAWG Members**

An electronic link for most recent Ecological Risk Methods Document (RMD) was sent to the Risk Assessment Working Group (RAWG). Any additional comments on the document will be sent in to the group. An explanation was provided that clarified that any changes to the current, approved Ecological RMD would be part of next year's work plan that will be developed in September and approved in October 2014.

**2. Remainder of Fiscal Year 2014 Schedule**

A proposal was made to postpone incorporation of recreational user lifetime excess lifetime cancer risk (ELCR) no action levels (NALs) and action levels (ALs) and excavation worker site-specific scenario until the next revision of the RMD.

The excavation worker site-specific scenario information would be adopted into the RMD from the Burial Grounds Operable Unit (BGOU) Solid Waste Management Units (SWMUs) 2, 3, 7, and 30 Feasibility Study (FS). The BGOU FS will use the "2 men and a backhoe" concept. The concept of how the individual units fit in with the whole site needs to be considered.

It was highlighted that the entire revised Human Health (HH) RMD will be sent for review on April 16 and that comments will be due May 16. This schedule needs to be met in order to incorporate HH RMD changes (including revised NALs) into the year's revision of the programmatic Quality Assurance Project Plan.

RAWG Approve Appendix E Deletions/Changes	3/5/2014
RAWG Approve Appendix B, D, and Main Text	4/9/2014
Submit Entire Revised RMD to RAWG for Review	4/16/2014
Comments Due for Entire Revised RMD	5/16/2014
Quarterly Meeting (June)	6/4/2014
Submit RMD to FFA Managers (DOE/LX/07-0107&D2/R3/V1)	6/13/2014
FFA Managers Approve RMD (DOE/LX/07-0107&D2/R3/V1)	7/17/2014
Quarterly Meeting (September)	9/10/2014

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 a.m. (eastern)

**3. Summary of RAWG review and comments received.**

All portions of the 2014 RMD with revisions have been sent. Due dates for comments for all sections have passed. Below is a summary of the comments received.



**Main Text:**

- Vapor intrusion analysis/scenario needs to be added to text—  
Add the guidance “2008 Brownfields Technology Primer: Vapor Intrusion Considerations for Redevelopment, EPA 542-R-08-001.”  
A newer reference is expected soon from the U.S. Environmental Protection Agency (EPA). The current RMD should use the 2008 guidance, for now, and it will be replaced in the next version of the RMD.
- To keep in mind, default exposure parameters will be updated soon (likely in June 2014) for EPA’s Regional Screening Levels. The Paducah RMD will, in turn, need to incorporate these changes in the next revision of the RMD.
- References to data quality assessment/data quality objectives and other items in Appendix E need revision. References will need to be made to EPA and U.S. Department of Energy (DOE) guidance instead of the Hanford example previously used.
- Based on discussion in the February 7, 2014, meeting, revise use of “outdoor worker/gardener” to “outdoor worker” and “excavation” to “site-specific.”  
The word “gardener” will not be used. Additionally, the scenarios should be for the future outdoor and excavation workers. A follow-up e-mail will be sent to the group with details about how the term “site-specific” is to be used (i.e., with respect to “site-specific” and “unit-specific”).
- Based on discussion in the February 7, 2014, meeting, revise previously agreed footnote for
  - (1) “Outdoor worker” and associated soil depth to be evaluated.
  - (2) “Excavation worker” and associated soil depth to be evaluated.
  - (3) Site-specific excavation worker with respect to soil depth and the application of varying exposure durations (EDs) (“two men and a backhoe”).

This year’s RMD will say the excavation worker will use site-specific parameters [e.g., depths, EDs, and exposure frequencies (EFs)]. All subsequent RMD revisions will adopt the agencies-approved BGOU SWMUs 2, 3, 7, and 30 FS project approach.

A follow-up e-mail will be sent to the group with details about how the site-specific term is to be used.

**Appendix A:**

Recreational Scenario ELCR Preliminary Remediation Goals (PRGs) (i.e., NALs and ALs) need to be developed for a lifetime exposure. Subsequent RMD revisions will address this addition.

**Appendix B:**

- Table B.5. Toxicity Values and Information Used in PRG Derivation: Mercury, Inorganic Salts. Inhalation reference concentration 3.00E-05 was deleted, but no replacement value was given. The RSL table lists 3.0E-04 for RfC, and the key is marked “S” indicating that the User Guide, Section 5 should be seen, but there is nothing in the User Guide, Section 5 on mercury.  
As a follow-up, “Mercuric Sulfide” and “Mercury, Inorganic Salts” were removed from the table and “Mercuric Chloride” was renamed “Mercuric Chloride (and other Mercury salts).” EPA plans to correct the reference on their table.

- Based on discussion in the February 7, 2014, meeting, revise previously agreed text note and footnotes for outdoor worker/gardener for
  - (1) “Outdoor worker” and associated soil depth to be evaluated.
  - (2) “Excavation worker” and associated soil depth to be evaluated.
  - (3) Site-specific excavation worker with respect to soil depth and the application of varying EDs (“two men and a backhoe”).

(See notes on main text, above, where this comment is discussed.)
- Based on discussion in the February 7, 2014, meeting, revise use of “outdoor worker/gardener” to “outdoor worker” and “excavation” to “site-specific.” (See notes on main text, above, where this comment is discussed.)

#### **Appendix D:**

Add information for the excavation worker to the outdoor worker equations.

(See notes on main text, above, where this comment is discussed.)

#### **Appendix E:**

- **Section E.4: Flowchart for Uncertainty Management for Unknown Areas of Contamination**  
 While the decision to proceed with a remedial investigation (RI) (including a baseline risk assessment), FS, proposed remedial action plan, etc., without source term data must be dealt with by risk and uncertainty managers; the RMD addresses risk assessment (communication) at these various stages. When the parties agree to proceed with remedy selection without source term data (i.e. without defined nature and extent), care should be taken not to present risk in accordance with protocol [e.g., no contaminants of concern (COCs)] developed under the assumption that nature and extent are defined. Any presentations of risk at the various stages must be strongly qualified and coupled with a firm bias (presumption?) for action. COC selection must be governed by conservatism.  

When projects have limited data, the baseline risk assessment needs to qualify information regarding the source term.  
 See if text above can fit into the FS section of the main text referencing Risk Assessment Guidance for Superfund (RAGS). If possible, language from RAGS or other risk assessment guidance (e.g., DOE guidance on uncertainty) will be used as an addition to the main text.  
 See if Site Management Plan has similar language.  
 An opinion was expressed by DOE that the text above goes to risk management and not risk assessment. The HH RMD and its references include guidance on the need to address uncertainties in the risk characterization in the baseline human health risk assessment. How those uncertainties are addressed by the risk managers is a follow-up concern.

#### **4. Revisit use of negative XRF results**

Joe Towarnicky reviewed findings from X-ray fluorescence (XRF) results in relation to laboratory results that were documented in the Soils Operable Unit RI on an element-by-element basis so that we know how to use XRF data (e.g., can XRF be used for selenium); these findings will be added to Appendix E. Joe’s findings are attached.

The group should send any comments they have to LeAnne. This information will be included in this Risk Methods Document, Appendix E.

**5. Excavation Worker Scenario (chronic versus subchronic toxicity values)**

Chronic toxicity values are more conservative, in terms of protecting human health, and not many subchronic values are available. The RAWG prefers to stay with chronic values.

Ensure the RMD states that we use chronic values as a layer of protectiveness even if subchronic values are available. The BGOU FS should not add a footnote to explain that subchronic values were not used.

**6. Topics that need to be addressed in the Eco Risk Methods document (Review of Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky. Volume 2. Ecological. DOE/LX/07-0107&D2/V2)**

Jeri Higginbotham had the following suggestions:

- a. On page 2-9, Sample et al is cited with an incorrect date of 1998. The date is listed correctly (1997) in the reference section on page 4-2. Please correct.
- b. On page 2-11, change “using one-half the reported detection limit for all results reported as nondetected concentrations.” Methodology now available in Pro-UCL or an equivalent statistical package is preferable. An exception to this is when a sample contains a small fraction of non-detects (i.e., no more than 10-15%), simple substitution of half the reporting limit is generally adequate (USEPA 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*. U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, EPA 530/R-09-007).
- c. On page 2-12, the sentence, “Toxicity profiles for COPCs should include a discussion of published data on the relative toxicity of various groups of organisms” should be changed to, “Toxicity profiles for COPCs should include a discussion of published data on the relative toxicity to various groups of organisms”.
- d. On page 2-19, there are 4 bullets, but the sentence preceding the bullets indicates there should be three. The second bullet may be more clearly treated as an if-then statement subsequent to the bulleted information.
- e. On page A-9 in Table A.2, the no further action (NFA) screening values for sulfur, thiocyanates, benzene, ethylbenzene, toluene, and xylene are listed as 500, 1, 0.01, 0.03, 0.01, and 0.1, respectively. The source for all six values is listed as EPA Region 4. The screening values listed by EPA Region 4 are 2, 2, 0.05, 0.05, 0.05, and 0.05 respectively, as can be seen at <http://www.epa.gov/region04/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf>.
- f. On page A-10 in Table A.2, the NFA screening values for carbon tetrachloride, 1,2-dichloroethane, 1,2-dichloropropane, chlorobenzene, chloroform, dichlorobenzene, dichloromethane, hexachlorobenzene, pentachlorobenzene, tetrachloroethylene, and aldrin are listed as 0.4, 0.02, 0.1, 0.1, 0.02, 0.1, 0.4, 0.05, 0.05, 0.002, and 0.0006 respectively. The source for all is listed as EPA Region 4. The screening values listed by EPA Region 4 are 1.0, 0.4, 700, 0.05, 0.001, 0.01, 2, 0.0025, 0.0025, 0.01, and 0.0025 respectively, as can be seen at <http://www.epa.gov/region04/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf>.
- g. On page A-11 in Table A.2, the NFA screening values are 0.0002 for atrazine, 0.009 for BHC-beta, 0.00003 for carbaryl, 0.00002 for carbofuran, 0.0049 for dieldrin, 0.00004 for endrin, 0.002 for maneb, 0.000007 for acrylonitrile, 0.05 for catechol, 960 for ethylene glycol, and 0.3 for styrene. The source for all is listed as EPA Region 4. The screening values listed by EPA Region 4 are 0.00005, 0.001, 0.5, 0.2, 0.0005, 0.001, 3.5, 1000, 20, 97, and 0.1 respectively, as can be seen at <http://www.epa.gov/region04/superfund/images/allprogrammedia/pdfs/tsstablesoilvalues.pdf>.
- h. On page A-11 in Table A.2, cresols has a b superscript, but there is no corresponding b footnote. Please add the b footnote.

- i. In Table A.6, on page A-17, change the selenium NFA Screening Value Type from “Kentucky State ‘warm water’” to “Region 4 Freshwater ESV.”
- j. On page A-19, change the Polychlorinated biphenyls Screening Value from “0.0014” to “0.014”.

LeAnne will prepare a schedule for the Ecological RMD revision before the June 2014, quarterly meeting to include incorporation of the above-referenced revisions. The group should consider whether the Ecological RMD needs to include the revised guidance for the later steps of the ecological risk assessment methodology.

**7. Validation needed for closure activities [CERCLA 120(h)]**

Typical validation (i.e., 3<sup>rd</sup> party validation) currently is 10%. What is appropriate for closure activities? RAWG will develop a recommendation during the next quarterly meeting. Also, DOE agreed to ask the PGDP Site Manager about scheduling a CERCLA 120() training.

**8. Derivation of Risk-based Surface Water Effluent Limits**

Based upon the most recent resource use information developed for the revised Appendix E, in consideration of surface water, the recreational user wading, swimming, and fishing and outdoor worker exposure scenarios apply to Bayou and Little Bayou Creek. Of these, fishing is likely implausible for Little Bayou Creek due to the lack of catchable fish. Subsistence fishing is unlikely for Bayou Creek because the fishery is too small to allow subsistence catches without considering that many of the fish caught would be from the Ohio River. Wading and swimming are plausible but only swimming allows for derivation of a risk-based value for radionuclides (dose is from incidental ingestion of water). The RAWG needs to consider this and other information and develop a recommendation on how best to develop risk-based effluent limits.

Just because a scenario is not plausible, we don’t need to do away with rad effluent limits.

RAWG will develop a recommendation during the next quarterly meeting.

Some inputs to consider are the following:

- How were NPDES limits developed? Are their scenarios reasonable to use at this site?
- Are there similar ways to calculate rad limits?
- Can we extrapolate 1E-04, 1E-05, and 1E-06 values for the Risk Methods Document?
- Does Oak Ridge have an ALARA implementation procedure that we could use here?
- What scenarios do we need to use to set limits?
- What are the risk-based inputs?

**9. Status of RAWG SWMUs 2, 3, 7 and 30 FS Remedial Action Objective Revision Recommendation**

The revision that was recommended by the RAWG during special-called meetings January 31 and February 7, has been incorporated into the draft document. This recommendation may be put into the comment resolution summary that includes the tables (comparing the outdoor worker and excavation worker numbers) presented during those meetings in January and February.

**10. Poll RAWG Members/Open Discussion**

It was highlighted that the next meeting will be on June 4. No additional discussion occurred.

## ***DRAFT Discussion Concerning Use of XRF Data with Negative Values***

### **Issue:**

X-ray fluorescence (XRF) analyses for a few constituents (chromium, lead, and uranium) at the Paducah Gaseous Diffusion Plant (PGDP) historically have reported negative (less than zero) concentration values [See attached excerpt from Soils Operable Unit (OU) Remedial Investigation (RI) Report Comment Response Summary]. Because an element concentration cannot be less than zero, there is concern over how best to use the raw XRF data. In the Soils OU RI, the negative values were used in the calculation of the means and standard deviations.

### **Background:**

- XRF data have been used at PGDP to supplement laboratory analyses of soil samples to define better the nature and extent of the presence of elements. Some of the reported results have been less than zero.
- *The less-than-zero values for chromium, lead, and uranium all were from XRF analyses conducted in 2007.*
- The less-than-zero values had no detection limits reported in the database; however, 2010 XRF data report XRF detection limits of 85 mg/kg (chromium), 13 mg/kg (lead), and 20 mg/kg (uranium). The detection limit for lead (13 mg/kg) is less than the background concentration of lead at PGDP (per Table A.12 of the Risk Methods Document).
- The data set includes 590 less-than-zero chromium (~4794 total results), 27 lead (~4917 total results), and 129 uranium (~4,700 total results) results.
- The Soil Piles Investigation, Appendix B (Section 9.6) summarizes the data management for that project using Kaplan-Meier, the EPA recommended method of handling nondetects (Singh 2006) and compares that to using the raw values (including negative values) as reported from the XRF method.
- The Soil Piles Investigation compared the use of the raw data to the use of the Kaplan-Meier approach and found that for elements with most values above the detection limits, the means and standard deviations are comparable; however, for elements with few (or no) detects, the two methods yielded different results. For example, the chromium mean value for the concentration was negative (from the XRF data set with no detectable chromium results). As a result, the conclusions section of Section B.9.6 stated: “Thus, it is not recommended substituting the raw values in place of undetected values for computation of summary statistics and UCLs” (for those elements with few detected values).

### **Discussion:**

*Module 2 – Basic XRF Concepts XRF Web Seminar* discusses the application of XRF analysis ([http://www.clu-in.org/conf/tio/xrf\\_080408/prez/XRF\\_02pdf.pdf](http://www.clu-in.org/conf/tio/xrf_080408/prez/XRF_02pdf.pdf)). The page reproduced (below) from this module discusses how negative values can be reported when there is none of the element present. Counting statistics will report values that cluster around zero, with half the results being positive and half the results being negative.

A second page (reproduced below) describes recommendations for use of data reported at concentrations below the detection limit. Some instruments do not report these data. Some manufacturers advise against using these data. These values can be valuable information if careful about its use...particularly true if one is trying to calculate average values over a set of measurements.

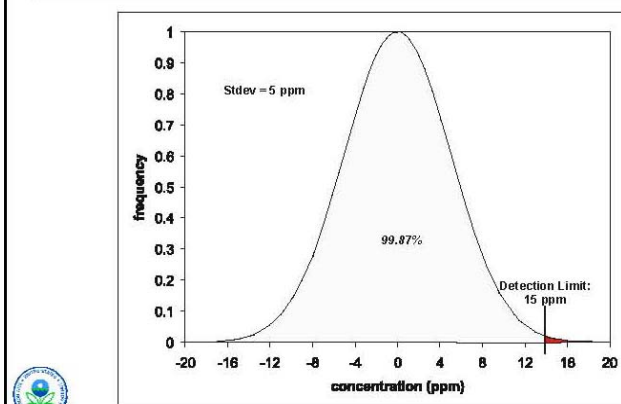
The XRF measurements represent concentrations near the surface of the sample, while laboratory results are volumetric in nature. Thus, one can expect some differences between the XRF and the lab results, except in those cases where the concentrations of elements are homogeneously dispersed in the soil.

**Impacts on Soils OU RI Results:**

1. The more recent XRF results did not have any negative results reported; thus, this may not be an issue going forward except when trying to use older historical results.
2. The less-than-zero results only occur when the true value is near zero.
3. The detection limit for the recent results is a more positive value than the average less-than-zero value. Thus, the use of negative values somewhat balances the positive bias introduced when using a detection limit (e.g., 85 mg/kg) as the nondetected value.
4. The 1,049 **lab** results (including one nondetect) had an average chromium concentration of 32 mg/kg.
5. The 4,794 lab and XRF results (including the 2,362 XRF nondetect results of which 590 were less-than-zero values) had an average concentration of 50 mg/kg. It appears that even when the negative values are used, the XRF results tend to yield a somewhat false positive result for chromium.
6. If remedial actions are taken for chromium, the use of XRF in confirmation sampling may need to be limited.

### The 3 Standard Deviation Concept

Frequency of XRF Responses When Element Not Present



2-17

#### Notes



- ◆ The graphic above illustrates the frequency of XRF responses when the element is not present. Assume that a sample does not have an element present (or that it is present at trace levels). If one were to take a measurement of the sample with the XRF, the XRF would record a concentration present for that element just because of the random nature of x-ray counting statistics. If one did a large number of repeat measurements, one could generate a distribution or frequency plot of those "random" concentrations such as is shown here, with a measurable standard deviation. Notice that the frequency distribution is centered around zero, indicating that this instrument is providing an unbiased estimate of the concentration for the element of interest. Notice too that half the time the instrument would report positive values, and half the time it would report negative values...an important fact that will be discussed later. If one moves three standard deviations up from zero and calls that the detection limit (consistent with SW846 Method 6200), then almost 100% of the concentration values generated when the element is not present would be less than the detection limit. In other words, if the instrument records a result greater than this detection limit, then it is very likely that in fact the element is present.



### To Report, or Not to Report: That is the Question!

- ◆ Not all instruments/software allow the reporting of XRF results below detection limits
- ◆ For those that do, manufacturer often recommends against doing it
- ◆ Can be valuable information if careful about its use...particularly true if one is trying to calculate average values over a set of measurements



2-23

#### Notes



- ◆ **Not all instruments/software allow the reporting of XRF results below detection limits:** Some instruments and associated software do not allow the reporting of measurement results that are below detection limits.
- ◆ **For those that do, manufacturer often recommends against doing it:** For those instruments that do allow reporting of results below detection limits, the manufacturer usually advises against it. Within the chemistry analytical world, the approach has been to not report values less than detection limits. Within the radionuclide analytical world, the approach has been to report values less than detection limits. The XRF is an analytical technique that has its roots in the radionuclide world (e.g., gamma and alpha spectroscopy), but has applications to the chemical world (e.g., elemental metals).
- ◆ **Can be valuable information if careful about its use . . . particularly true if one is trying to calculate average values over a set of measurements:** Values below detection limits can be useful when calculating average values over a set of measurements. If the instrument's calibration is unbiased for low levels of the element of interest, using measured values below the instrument's detection limits can yield more accurate assessments of average concentrations than flagging readings as non-detects and substituting some arbitrary value such as the detection limit, or half the detection limit, in average value calculations. Great care and full disclosure are necessary when using values below detection limits.



## Risk Assessment Working Group

### Meeting Minutes—June 2014

**Present:**

✓Stephanie Brock  
✓Nathan Garner  
✓Mike Guffey  
✓Jerri Martin

✓Tim Frederick  
✓Jon Richards

✓Rich Bonczek  
✓Martin Clauberg  
✓LeAnne Garner  
✓Bobette Nourse

**1. Call for Issues from RAWG Members**

None.

**2. Remainder of FY 2014 Schedule (revised)**

Quarterly Meeting (June)	6/4/2014
<b>Submit Risk Methods Document (RMD) to FFA Managers (DOE/LX/07-0107&amp;D2/R3/V1)</b>	7/16/2014
<b>FFA Managers Approve RMD (DOE/LX/07-0107&amp;D2/R3/V1)</b>	7/30/2014
Quarterly Meeting (September)	9/10/2014

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 a.m. (eastern)

Develop next FY's schedule by next quarterly meeting.

**3. Summary of RAWG Review and Comments Received**

Below is a summary of the comments received on the 2014 RMD. Minor editorial changes are not listed.

**Main Text:**

- (1) Page 1-1, new footnote: for clarity, added “(for example, area of concern, remediation area, and/or SWMU)” following “location.” (See also Item 4 of these minutes.)
- (2) Figure 2.2, added definition of site-specific from page 1-1.
- (3) Figure 3.1, new footnote: revise to “Because future use of groundwater at the PGDP is uncertain, the industrial worker exposure to groundwater scenario is provided here for informational purposes only.” Conforming changes to be made in Appendix D (Tables D.26, D.27, and D.28).
- (4) Page 3-12, update Human Health Evaluation Manual, Supplemental Guidance: “Standard Default Exposure Factors” (EPA 1991d) to OSWER Directive 9200.1-120 2014 (see also Item 9 of these minutes).
- (5) Page 3-13, add reference to meeting minutes in Appendix E.

- (6) Page 3-13, add reference to “Determining Groundwater Exposure Point Concentrations, Supplemental Guidance” (2014)—<http://www.epa.gov/oswer/riskassessment/pdf/superfund-hh-exposure/OSWER-Directive-9283-1-42-GWEPC-2014.pdf> (see also Item 10 of this agenda).
- (7) Page 3-46, the revised text, “As part of the uncertainty analysis for the risk assessment, risk may be recalculated with default exposure factors replaced using exposure parameters consistent with the SWMU/area of concern (AOC)” should be revised back to “consistent with site-specific values” instead of “consistent with the SWMU/area of concern (AOC).”

#### **Appendix A:**

- (1) Page A-3, “unit-specific” revised back to “site-specific,” based on a comment that we do not want to add a new term. This is to be applied globally. Site-specific is defined on page 1-1.
- (2) Table A.7a, footnotes e and f, this is a deviation from the earlier AL/NAL tables where acenaphthene is used for both acenaphthylene and phenanthrene. This variance needs to be addressed.

Plan to leave as is for 2014 RMD, but address the surrogates in 2015 RMD (see also Item 9 of these minutes).

- (3) Table A.13, revisit footnote, “Values contained in this table have not been approved for all uses by the PGDP Risk Assessment Working Group; therefore, the values presented here are provisional values and subject to change. Issues to be resolved in forthcoming meetings include the data set from which these values were derived and the statistical methods used to analyze the data set.”

Issue for nickel was resolved previously. Changes to the footnote are to the second sentence, now revised to read, “The issues to be resolved are the data set from which these values were derived and the statistical methods used to analyze the data set.”

Radionuclide MDAs are from 1990s; this information needs to be reevaluated. These issues will need to be resolved prior to restart of the Dissolved-Phase Plume Project.

- (4) Table A.14, add the following text to the Tc-99 footnote, “See Table A.9 for Tc-99 groundwater concentrations resulting in a 4 mrem/yr dose based upon more recent dosimetry.”

#### **Appendix D:**

- (1) Table D.19, remove “Notes: Chemical concentration in surface water (mg/L) times intake factor [L/(kg X day)] yields default RME dose for associated endpoint.

Radionuclide activity in surface water (pCi/L) times intake factor (L) yields default RME dose.”

This information is a leftover from when the intake factors equations were included in these tables.

- (2) These should be updated with new default exposure values (2014 OSWER Directive) (see also Item 9 of these minutes.) This will be included in the 2015 RMD.
- (3) Conforming changes from main text.

## **Appendix E:**

- (1) Section E.2.5: Received comment to state more explicitly that the information in this section is summarized and updated; actual interview information is in attachments.
- (2) Section E.2.6: Received comment from Tim Kreher to include 2013 numbers in annual harvest because 2013 included additional area near PGDP in turkey hunting, therefore numbers significantly increased.

### **4. Use of “Site-Specific” in RMD**

The “site-specific” term in the main text of the 2014 RMD will remain unchanged except for the following context (in these instances, site-specific was deleted):

“For excavation activities performed by the outdoor worker, data collected from 0 to 10 ft bgs will be used to estimate the EPC, unless ~~site-specific~~ information indicates that results from samples collected at deeper depths (i.e., 0–16 ft bgs in areas where infrastructure is found) should be included in the derivation of the EPC.”

“As part of the uncertainty analysis for the risk assessment, risk may be recalculated using exposure parameters consistent with the SWMU/AOC. The decision to recalculate risks using these alternative exposure parameters ~~site-specific values~~ would be a product of the consensus of the FFA parties arrived at during project discussions at the appropriate stage in document development.”

A footnote explaining site-specific has been added upon first use, as follows: “The term site-specific is indicative of the location for which a risk analysis is performed. The boundaries of the location (for example, area of concern, remediation area, and/or SWMU) should be defined during establishment of data quality objectives (DQOs) (see Chapter 3).”

Use of “site-specific” in the 2014 RMD is acceptable. Add use of term “site-specific” to next quarter’s agenda as an open topic.

### **5. Use of Outdoor Worker and Excavation Worker in 2015 RMD**

A comment was made to the previous RAWG meeting minutes on the text, “The excavation worker site-specific scenario information would be adopted into the RMD from the Burial Grounds Operable Unit (BGOU) Solid Waste Management Units (SWMUs) 2, 3, 7, and 30 Feasibility Study (FS).”

Todd Mullins commented as follows: “I’m still not sure that I’m entirely comfortable with incorporating this scenario into the RMD. Using it to adjust RGs when a prior baseline risk assessment has mandated that an FS evaluation of alternatives is required is one thing. Using it to potentially determine whether an action is required is something else entirely. The assumptions being made under the site-specific excavation worker scenario appear too arbitrary and unit specific to be integrated into a baseline risk assessment.”

Need discussion at the FFA manager’s level regarding appropriateness of the evaluation used for BGOU cleanup levels applied across the board in the RMD. LeAnne will ask Jana to add this to the FFA manager’s topics. This topic will be discussed next quarter. Additionally, some risk management guidance may need to be incorporated into the 2015 RMD.

## 6. Ecological RMD Proposed Schedule

The group should consider whether the Ecological RMD (*Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky. Volume 2. Ecological. DOE/LX/07-0107&D2/V2*) needs to include the revised guidance for the later steps of the ecological risk assessment methodology.

Proposed initial revision submitted to RAWG for review	10/6/2014
Comments due on initial revision	11/24/2014
Quarterly Meeting (December) (discuss comments)	12/3/2014
<b>Submit Final Ecological RMD (DOE/LX/07-0107&amp;D2/R1/V2) to FFA managers for approval</b>	1/9/2015
<b>FFA managers approve final Ecological RMD (DOE/LX/07-0107&amp;D2/R1/V2)</b>	2/9/2015

## 7. Validation Needed for Closure Activities [CERCLA § 120(h)]

RAWG will have input regarding closure activities. Typical validation at Paducah (i.e., 3rd party independent data validation) that is done on a project basis and is between 5–20%; it is not a recommendation on a programmatic basis.

LATA Kentucky is preparing a paper regarding validation that will be provided to the RAWG soon for informational purposes only. This subject will be discussed further after receipt of the paper.

Rich Bonczek is planning CERCLA § 120(h) training.

## 8. Derivation of Risk-based Surface Water Effluent Limits

The RAWG recommendation on risk-based effluent limits will be discussed further at a subsequent quarterly meeting.

## 9. Additional Proposed Revisions to 2015 RMD

- **Relook at significant COPCs for PGDP (Table 2.1 of the 2014 RMD).**
- **Revised EPA recommended exposure parameters (see attached comparison).**

The following is the definition of “Area Correction Factor” in the Risk Assessment Information System (RAIS):

The RAGS/HHEM Part B model assumes that an individual is exposed to a source geometry that is effectively an infinite slab. The concept of an infinite slab means that the thickness of the contaminated zone and its aerial extent are so large that it behaves as if it were infinite in its physical dimensions. In practice, soil contaminated to a depth greater than about 15 cm and with an aerial extent greater than about 1,000 m<sup>2</sup> will create a radiation field comparable to that of an infinite slab. (U.S. EPA. 2000a)

To accommodate the fact that in most residential settings the assumption of an infinite slab source will result in overly conservative SSLs, an adjustment for source area is considered to be an important modification to the RAGS/HHEM Part B model. Thus, an area correction factor, ACF, has been added to the calculation of SSLs (EPA 2000a).

The “Dilution Factor” is referenced to EPA 2000a (page 2-20) and EPA 2000b (page 2-13):

EPA 2000a. Soil Screening Guidance for Radionuclides: User’s Guide. Office of Emergency and Remedial Response and Office of Radiation and Indoor Air. Washington, DC. OSWER No. 9355.4-16A.

EPA 2000b. Soil Screening Guidance for Radionuclides: Technical Background Document. Office of Emergency and Remedial Response and Office of Radiation and Indoor Air. Washington, DC. OSWER No. 9355.4-16

- **Updated NALs and ALs based on updated toxicity values and potentially updated exposure values (Tables A.1 through A.6).**

The 2015 RMD should add a table of surrogates. Exposure values will be a combination of KY values and EPA updated values.

Whether NALs and ALs for the excavation worker are added is a topic for next quarter’s meeting.

- **Risk-Based SSLs for the protection of RGA groundwater (Table A.7a).**

DAFs of 1 and 20 currently are used in Table A.7a. For the 2015 RMD, a DAF of 57 may be added to the table.

- **Dose-based soil/sediment screening levels (Table A.8).**

Use of new dosimetry will be discussed at the next meeting for Tables A.8, A.9, A.10, and A.11.

- **Dose-Based Groundwater Screening Levels (Table A.9).**

- **Dose-Based Surface Water Screening Levels (Table A.10).**

- **Dose-Based Soil Screening Levels for the Protection of RGA Groundwater (Table A.11).**

- **Expand Residual Risk Assessment Discussion.**

This topic would be for the risk remaining after a cleanup activity is completed. This discussion would be a good place for risk management options and CERCLA § 120(h) inputs.

## **10. Use of Groundwater EPC EPA Directive**

Guidance is thought to be used at Paducah currently—need to ensure there are no other implications in the directive that should be included—add reference to 2015 RMD.

## **11. Poll RAWG Members/Open Discussion**

The excavation worker revision in the BGOU SWMUs 2, 3, 7, and 30 FS was in response to EPA comments. A common understanding is needed in the exposure parameters used.

**Comparison of Industrial Worker Soil/Sediment No Action Levels**  
**Using Current 2014 Risk Methods Document Default Exposure Parameters and EPA's 2014 Recommended Default Exposure Parameters**

Chemical	Units	2014 RMD Default Carcinogenic NAL TR=1.0E-6	2014 RMD Default Noncarcinogenic NAL HI=0.1	Revised Carcinogenic NAL TR=1.0E-6	Revised Noncarcinogenic NAL HI=0.1	Difference ELCR NAL	Difference HI NAL
Arsenic, Inorganic	mg/kg	3.81E+00	6.09E+01	4.36E+00	6.95E+01	13%	13%
Uranium (Soluble Salts)	mg/kg		5.98E+02		6.81E+02		13%
Polychlorinated Biphenyls, Total	mg/kg	2.86E+00		3.27E+00		13%	
Trichloroethylene	mg/kg	6.73E+00	2.04E+00	6.77E+00	2.05E+00	1%	1%
Vinyl Chloride	mg/kg	2.11E+00	4.20E+01	2.18E+00	4.23E+01	3%	1%
Tc-99	pCi/g	2.02E+03		2.02E+03		0%	
U-238+D	pCi/g	7.48E+00		7.48E+00		0%	

**Comparison of Input Parameters:**

INPUT	2014 RMD Value	Previous EPA Recommended Value	2014 EPA Recommended Value
Body weight	70 kg	70 kg	80 kg
Exposure duration	25 years	25 years	25 years
Exposure frequency	250 days	250 days	250 days
Exposure time	8 hours	8 hours	8 hours
Soil ingestion rate	50 mg/day	50 mg/day	50 mg/day
Lifetime	70 years	70 years	70 years

Yellow highlighting indicates a change between previous EPA recommended value and 2014 EPA recommended value.

<sup>a</sup> The value is not included in either the RMD or in the EPA recommended values. Default value in RAIS is used for calculating the no action level (NAL).

<sup>b</sup> 0.33 hr/hr is calculated using the 8-hour exposure time and a 24-hour day (i.e., 8/24).

<sup>c</sup> Gamma shielding factor is not included in the EPA recommended values; however, the default value in RAIS is 0.4. The 2014 RMD value for the gamma shielding factor is 0.2.

<sup>d</sup> The inhalation rate is not included in the EPA recommended values; however, the default value in RAIS is 20 m<sup>3</sup>/day (calculated from 2.5 m<sup>3</sup>/hr x 8 hr/day).

**Comparison of Resident Groundwater No Action Levels  
Using Current 2014 Risk Methods Document Default Exposure Parameters and EPA's 2014 Recommended Default Exposure Parameters**

Chemical	Units	2014 RMD Carcinogenic NAL TR=1.0E-6	2014 RMD Noncarcinogenic NAL HI=0.1	Revised Carcinogenic NAL TR=1.0E-6	Revised Noncarcinogenic NAL HI=0.1	Difference ELCR NAL	Difference HI NAL
Arsenic, Inorganic	mg/L	3.78E-05	3.13E-04	5.17E-05	5.99E-04	31%	63%
Uranium (Soluble Salts)	mg/L	-	3.13E-03	-	5.99E-03		63%
Polychlorinated Biphenyls, Total	mg/L	1.42E-04	-	1.95E-04	-	31%	
Trichloroethylene	mg/L	4.07E-04 <sup>a</sup>	2.27E-04	4.93E-04	2.82E-04	19%	22%
Vinyl Chloride	mg/L	1.11E-05	2.67E-03	1.88E-05	4.44E-03	52%	50%
Tc-99	pCi/L	1.82E+01	-	1.90E+01	-	4%	
U-238+D	pCi/L	5.75E-01	-	6.00E-01	-	4%	

<sup>a</sup>This value will not be the 2014 NAL when the RMD is published. This value reflects the February 2014 change made to RAIS; the NALs for the 2014 RMD were completed in November 2013 and will be 1.95E-04 for TCE.

**Comparison of Input Parameters:**

INPUT	2014 RMD Value	Previous EPA Recommended Value	2014 EPA Recommended Value
Body weight	Child—15 kg Adult—70 kg	Child—15 kg Adult—70 kg	Child—15 kg Adult—80 kg
Exposure duration	Child—6 yr Adult—24 yr	Child—6 yr Adult—24 yr	Child—6 years Adult—20 years
Exposure frequency	350 days	350 days	350 days
Exposure time	24 hours/day	24 hours/day	24 hours/day
Exposure time (shower)	0.2 hours/event	Child-1 hr Adult-0.58 hr	Child-0.54 hr Adult-0.71 hr
Events/Day	1 event/day	1 event/day	1 event/day

INPUT	2014 RMD Value	Previous EPA Recommended Value	2014 EPA Recommended Value
Water ingestion rate	Child—1.5 L/day Adult—2.0 L/day	Child—1.0 L/day Adult—2.0 L/day	Child—0.78 L/day Adult—2.5 L/day
Lifetime	70 yr	70 yr	70 yr
Surface area	Child—6,500 cm <sup>2</sup> Adult—18,150 cm <sup>2</sup>	Child—6,600 cm <sup>2</sup> Adult—18,000 cm <sup>2</sup>	Child—6,378 cm <sup>2</sup> Adult—20,900 cm <sup>2</sup>
Exposure duration (resident)	30 yr	30 yr	26 yr
Inhalation rate (adult)	20 m <sup>3</sup> /day*	N/A	N/A
Inhalation rate (child)	20 m <sup>3</sup> /day*	N/A	N/A

Yellow highlighting indicates a change between previous EPA recommended value and 2014 EPA recommended value.

\*The inhalation rate is not included in the EPA recommended values; however, the default value in RAIS 20 m<sup>3</sup>/day. The 2014 RMD value also is 20 m<sup>3</sup>/day (calculated from 0.833 m<sup>3</sup>/hr x 24 hr/day).

#### June 4 Quarterly Meeting Item for Discussion:

The soil ingestion rate, exposure frequency, adherence factor, and surface area currently used in the RMD are based on Kentucky Risk Assessment Guidance (Appendix E). If these exposure parameters are left as is, only the body weight potentially would change.

#### Comparison of Outdoor Worker Exposure Parameters

INPUT	2014 RMD Value	Previous EPA Recommended Value	2014 EPA Recommended Value
Adherence Factor	1 mg/cm <sup>2</sup>	0.2 mg/cm <sup>2</sup>	0.12 mg/cm <sup>2</sup>
Body weight	70 kg	70 kg	80 kg
Exposure duration	25 years	25 years	25 years
Exposure frequency	185 days	225 days	225 days
Exposure time	8 hours	8 hours	8 hours
Soil ingestion rate	480 mg/day	100 mg/day	100 mg/day
Lifetime	70 years	70 years	70 years
Surface area	4700 cm <sup>2</sup> /day	3300 cm <sup>2</sup> /day	3470 cm <sup>2</sup> /day
Indoor exposure time	0 hr/hr	N/A	N/A
Outdoor exposure time	0.33 hr/hr <sup>a</sup>	N/A	N/A
Gamma shielding factor	0.2 <sup>b</sup>	N/A	N/A
Inhalation rate	20 m <sup>3</sup> /day <sup>c</sup>	N/A	N/A

Yellow highlighting indicates a change between previous EPA recommended value and 2014 EPA recommended value.

<sup>a</sup> 0.33 hr/hr is calculated using the 8-hour exposure time and a 24-hour day (i.e., 8/24).

<sup>b</sup> Gamma shielding factor is not included in the EPA recommended values; however, the default value in RAIS is 0.4. The 2014 RMD value for the gamma shielding factor is 0.2.

<sup>c</sup> The inhalation rate is not included in the EPA recommended values; however, the default value in RAIS 60 m<sup>3</sup>/day. The 2014 RMD value is 20 m<sup>3</sup>/day (calculated from 2.5 m<sup>3</sup>/hr x 8 hr/day).



## Risk Assessment Working Group Meeting Minutes—September 2014

✓Gaye Brewer ✓Stephanie Brock ✓Nathan Garner ✓Mike Guffey ✓Jeri Higginbotham ✓Jerri Martin ✓Todd Mullins	✓Tim Frederick ✓Jon Richards ✓Brett Thomas	✓Rich Bonczek ✓Martin Clauberg ✓LeAnne Garner ✓Bobette Nourse
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### 1. Call for Issues from Risk Assessment Working Group (RAWG) Members.

None.

### 2. 2014 Risk Methods Document (RMD).

#### — Status of Approval

E-mails have been received from U.S. Environmental Protection Agency (EPA) and Kentucky Department for Environmental Protection (KDEP). The 2014 RMD is considered complete.

#### — Summarization and Discussion of Comments Received

Replacement pages were sent, changing the revision number to R4; removed footnote defining site-specific from page 1-1 and Figure 2.2. An electronic copy is available at the following Web address:

<http://www.latakentucky.com/PublicDocuments/Risk%20Methods%20Document%20D2R4V1,%202014-09/>

### 3. Draft Revised FY 2015 Schedule/Work Plan.

Submit Work Plan (this schedule)	8/25/2014
Quarterly Meeting (September)	9/23/2014
<i>Proposed initial revision of Ecological (Eco) RMD submitted to RAWG for review</i>	<i>10/6/2014</i>
Approve Work Plan (this schedule)	10/8/2014
<i>Comments due on initial revision of Eco RMD</i>	<i>11/24/2014</i>
Submit HH Appendix A [Preliminary Remediation Goals (PRGs)] to RAWG for Review	12/1/2014
Quarterly Meeting (December) — Discuss Eco RMD comments	12/3/2014
Submit Revised HH Main Text and HH Appendices B-E to RAWG for Review	12/11/2014
Comments due for HH Appendix A	1/5/2014
<i>Submit Final Eco RMD (DOE/LX/07-0107&amp;D2/R1/V2) to FFA managers for approval</i>	<i>1/9/2015</i>
<i>FFA managers approve final Eco RMD (DOE/LX/07-0107&amp;D2/R1/V2)</i>	<i>2/9/2015</i>
RAWG approve HH Appendix A	2/12/2015
Comments due for HH Main Text and HH Appendices B-E	2/12/2015
Quarterly Meeting (March)	3/4/2015
RAWG approve HH Main Text and HH Appendices B-E	4/9/2015
Submit entire Revised HH RMD to RAWG for review	4/16/2015
Comments due for entire Revised HH RMD	5/16/2015
Quarterly Meeting (June)	6/10/2015
<i>Submit HH RMD to FFA Managers (DOE/LX/07-0107&amp;D2/R3/V1)</i>	<i>6/13/2015</i>
<i>FFA Managers approve HH RMD (DOE/LX/07-0107&amp;D2/R3/V1)</i>	<i>7/17/2015</i>
Quarterly Meeting (September)	9/16/2015

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 p.m. (eastern)  
 Italics indicate Eco RMD schedule, as agreed upon during June 2014 Quarterly Meeting.

4. **Modified Solid Waste Management Units (SWMUs) 2, 3, 7, and 30 PRGs for the Excavation Worker.**

The use of the “two men and a backhoe” approach (i.e., the unit-specific assumption) to calculate PRGs vs. using truly “site-specific” exposure assumptions was discussed.

Since EPA recommends a range of 1-5 years for excavation, KDEP would prefer to use 5 years as the exposure duration to develop PRGs for the excavation worker (surface and subsurface exposure) instead of using a unit-specific duration. Exposure frequency would be 185 days per year. All other parameters would be the same as for the outdoor worker in the 2014 RMD.

For small units, the “two men and a backhoe” approach still will appear in uncertainty section in baseline risk assessments, among other uncertainties that are discussed.

Chronic toxicity values (not subchronic) will be used. For No Action Levels (NALs) in the 2015 RMD, see Item 6.

5. **Use of the Terms “outdoor worker,” “excavation worker,” and “site-specific” in 2015 RMD.**

The term “outdoor worker” will be defined as the person exposed to surface soil (0–1 ft) inside the plant and surface and subsurface soil (0–10 ft or 0–16 ft, as appropriate) outside the plant. The term “excavation worker” will be defined as the person exposed to 0–10 ft or 0–16 ft, as appropriate of soil for 5 years for 185 days/year.

A citation of what “site-specific” refers to is found in EPA RAGS Part B, which states, “...risk-based PRGs generally are modified based on site-specific data gathered during the remedial investigation/feasibility study (RI/FS)...” Whenever you develop a RI/FS, you develop site-specific parameters. This definition will not be included in 2015 RMD. (The footnote removed on page 1-1 for the 2014 version will not be reserved in future versions of the RMD. Footnotes will be renumbered, as appropriate.) In the future, the term “site-specific” will be defined, as needed, during project scoping.

**The end note 3 in Table B.1 (and Table B.2) of the RMD should be the following:**

**(Note: The text below is reflective of that discussed in the September 2014 Quarterly Meeting. Comments have been made to these minutes suggesting revisions to this text. These changes will be discussed in the December 2014 Quarterly Meeting and will be reflected in the revised Risk Methods Document text due to be sent for comments on December 11, 2014.)**

Determining which soil and sediment screening value is appropriate is a location-specific decision. For all locations inside the industrialized area at PGDP where surface soil contamination is of concern, use of the industrial worker values is appropriate. However, if the scenario involves outdoor maintenance type activities, the outdoor worker values also should be considered. For locations inside the industrialized area at PGDP where contact with surface soil and subsurface soil is of concern (e.g., soil from the surface down to 16 ft bgs), use of the outdoor excavation worker values is appropriate ~~for a construction/excavation worker. (Scenario-specific PRGs for the construction/excavation worker based on site-specific conditions should be derived, as appropriate. See discussion in Section 3.3.4.3.)~~ For locations, outside the industrialized area where surface soil contamination is of concern, screening using the recreator and/or resident values is appropriate. As with the surface water values, the child resident values are the most “conservative” (in terms of protecting human health).<sup>2</sup> Generally, the recreator values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident values are more appropriate for grassy fields. Finally, the outdoor worker values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. (If screening needs to consider shorter-term exposures to both surface and subsurface soil in locations outside the industrialized area, ~~however, development of scenario-specific~~ excavation worker

PRGs for the outdoor worker based on site specific conditions is a better approach. See discussion in Section 3.3.4.3 should be used.:-

The text of the RMD, including footnote 9 (pages 3-26 and 3-27), also should be revised to be consistent with the table footnote above. The revised text is provided in Attachment 1 to these minutes for comment by the RAWG.

## 6. Additional Proposed Revisions to 2015 RMD:

### — Discussion of Soil Vapor Intrusion.

Currently, the RMD states that the soil vapor intrusion model should be run. EPA Region 4 is finalizing new guidance; this will be revisited as soon as the guidance is final.

### — Relook at Significant Chemicals of Potential Concern for Paducah (Table 2.1 of the 2014 RMD).

This relook will be completed using more recent risk assessments. Chemicals/radionuclides are expected to be added, but none are expected to be removed. Additional chemicals/radionuclides that are not listed as COPCs in Table 2.1 of the 2014 RMD but may be of interest in some future projects (e.g., Freon at SWMU 4) may be included so that their NALs/Action Levels (ALs) will be included in the appendices. These additional chemicals/radionuclides would be footnoted.

### — Site-Specific Exposure Parameters (Table B.4 of the 2014 RMD).

For the 2015 RMD, current site-specific exposure parameters should be revised to EPA's new recommended default parameters with the following exceptions:

- Ingestion rate for the outdoor (and excavation) workers should remain at 480 mg/day.
- Adherence factors need to use 1.0 mg/cm<sup>2</sup>.
- Exposure frequencies for the outdoor (and excavation) workers should be 185 days/year.

A redline-strikeout version of the parameter table (i.e., Table B.4) is shown as Attachment 2 to these minutes for review and comment.

### — NALs and ALs (Tables A.1 through A.6).

For the 2015 RMD, values will be revised based on updated toxicity values and updated exposure values. Toxicity values will be as of November 2014. It will be ensured that RAIS is updated before calculator is used.

### — Add NALs and ALs for Excavation Worker? (If so, how to set exposure frequency and exposure duration to account for site-specific conditions?)

NALs and ALs will be added for the excavation worker using 5 year/185 day exposure period. This will be a new column in Table A.1 Soil/Sediment Action Levels for Significant COPCs at PGDP and Table A.4 Soil/Sediment No Action Levels for Significant COPCs at PGDP.

### — Update Risk-Based Soil Screening Levels (SSLs) for the Protection of Regional Gravel Aquifer Groundwater (Table A.7a).

For the 2015 RMD, a dilution attenuation factor of 57 will be added to Table A.7a. The equations from other document (i.e., SWMU 1 Feasibility Study) and parameters will be included in Appendix E. A citation for the reference will be added to the table.

### — Update Dose-based Screening Levels (Tables A.8 through A.11).

New dosimetry values were agreed to be used for Tables A.8, A.9, A.10, and A.11 for their 2015 RMD update.

— **Expand Residual Risk Assessment Discussion.**

This topic would be for the risk remaining after a cleanup activity is completed. This discussion would be a good place for risk management options and CERCLA § 120(h) inputs.

A revision of Section 4.2.3 was agreed to be drafted. A review schedule was agreed to be sent. That proposed schedule has been added below for comment.

Section 4.2.3 will be sent to the RAWG on 11/24/2014 for initial review. The section will be discussed in the December 2014 RAWG meeting. Revisions will be made, if necessary and sent with the revisions to the HH main text that is due out to the RAWG on 12/11/2014.

— **Add EPA Directive, Determining Groundwater Exposure Point Concentrations, Supplemental Guidance to References.**

The guidance will be referenced and noted that the RMD will be consistent with the guidance.

The use of the guidance will be revisited at the December 2014 RAWG meeting. The document can be found at the following Web site: <http://www.epa.gov/oswer/riskassessment/pdf/superfund-hh-exposure/OSWER-Directive-9283-1-42-GWEPC-2014.pdf>

**7. Additional EPA Risk Assessment Guidance to Potentially Include.**

— Probabilistic Risk Assessment

The following guidance documents will be added to the reference list in Section 3.3.4.6, Probabilistic Risk Assessment of the RMD:

- EPA Risk Assessment Forum Probabilistic Risk Assessment White Paper PDF (EPA/100/R-14/004, July 2014) <http://www.epa.gov/raf/prawhitepaper/pdf/raf-pra-white-paper-final.pdf>

EPA Risk Assessment Forum Probabilistic Risk Assessment FAQs (EPA/100/R-14/003, July 2014) <http://www.epa.gov/raf/prawhitepaper/pdf/raf-pra-faq-final.pdf>

— Radiation Risk Assessment at CERCLA Sites

This fact sheet (OSWER Directive 9200.4-40) provides an overview of current EPA guidance for risk assessment and related topics for radioactively contaminated CERCLA sites. This fact sheet supersedes an earlier one from December 1999 and is available at the following link: [http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/Rad%20Risk%20QA%20with%20transmit%20memo\\_June\\_13\\_2014.pdf](http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/Rad%20Risk%20QA%20with%20transmit%20memo_June_13_2014.pdf).

Dose calculations in Appendix A tables and associated text (including page 2-9) of the 2015 RMD will be changed from 15 mrem to 12 mrem.

**8. PEGASIS Demonstration.**

A link to the site is as follows: <http://padgis.latakentucky.com/padgis/>

User instructions are available from a link on the site.

Demonstration was postponed until the December 2014 RAWG meeting.

**9. Status of Programmatic Quality Assurance Project Plan (pQAPP) revision.**

— **Schedule (Relationship of pQAPP Project Action Limits and RMD NALs).**

A meeting with FFA managers regarding updating the worksheets is planned for early October 2014.

— **Summary of Revisions.**

Revisions will be discussed in the December 2014 RAWG meeting, including a cross walk table of RMD with pQAPP.

**10. Poll RAWG Members/Open Discussion.**

No other topics were discussed.

**Discussion Topics on Hold:**

Validation needed for closure activities [CERCLA 120(h)] (added 6/2014 – further discussion on this topic depends on completing presentations to Paducah Site Lead). Training tentatively is being planned for January 2015.

Derivation of Risk-based Surface Water Effluent Limits (added 6/2014 – further discussion on this topic depends on resolution of Northeast Plume Dispute). This topic may be deferred.

## Attachment 1

The following text from pages 3-26 and 3-27 are provided for comment by the RAWG. They have been revised to be consistent with end note 3 in Table B.1 (and Table B.2) of the RMD described in Item 5 of the meeting minutes.

With the revised text from pages 3-26 and 3-27, footnote 9 is proposed for deletion.

In determining the UCL when the medium is soil, data will be segregated into depth intervals relevant to receptors. For all scenarios except the outdoor worker in locations outside the industrialized area and the excavation worker inside the industrialized area, data from samples collected from 0 to 1 ft bgs will be used to estimate the EPC.<sup>9</sup> For ~~excavation~~ outdoor maintenance type activities performed by the outdoor worker in locations outside the industrialized area and the excavation worker inside the industrialized area, data collected from 0 to 10 ft bgs will be used to estimate the EPC, unless information indicates that results from samples collected at deeper depths (i.e., 0–16 ft bgs in areas where infrastructure is found) should be included in the derivation of the EPC.

~~<sup>9</sup> A single set of exposure equations and parameters is provided for the outdoor worker scenario in Appendix D. The exposure parameters provided in Appendix D should be used without changes when assessing potential risk from exposure to surface soils in locations outside the industrialized area at the Paducah site. When assessing potential risk from exposure to both surface and subsurface soil in locations outside the industrialized areas, all exposure parameters, except exposure duration (ED) and exposure frequency (EF), should be used without changes to assess an outdoor worker. ED and EF for exposure by the outdoor worker to surface and subsurface soil in locations outside the industrialized area should be established considering guidance in the Exposure Factors Handbook (EPA 1997b) or similar sources (e.g., site specific information) and should be documented. Similarly, when assessing potential risk from exposure either to surface soil or subsurface soil in locations inside the industrialized area, all exposure parameters, except ED and EF, should be used without changes to assess both an outdoor worker and a construction/excavation worker. As above, ED and EF for exposure by the outdoor worker or a construction/excavation worker to surface soil or subsurface soil or both in locations inside the industrialized area should be established considering guidance in the Exposure Factors Handbook (EPA 1997b) or similar sources and should be documented.~~

## Attachment 2

A preliminary Table B.4 from the Draft 2015 Risk Methods Document is shown below for review and comment.

Table B.4. Exposure Parameters Used in Calculation of Human Health PRGs

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User	Comment
<b>General Parameters Used in All Intake Models (unless otherwise noted)</b>										
Exposure frequency (EF)	days/year	250	185	185	350	350	104	140	140	Deleted: 24
Exposure duration (ED)	Years	25	25	5	20	6	10	10	6	Deleted: 12
Body weight (BW)	Kg	80	80	80	80	15	80	43	15	Deleted: 12
Averaging time - cancer (AT-C)	Days	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	Deleted: 70
Averaging time - noncancer (AT-N)	Days	365 × 25	365 × 25	365 × 5	365 × 20	365 × 6	365 × 10	365 × 10	365 × 6	Deleted: 70
<b>Ingestion of Water (Tables D.1, D.26)</b>										
Drinking water ingestion rate (IR)	L/day	NA	NA	NA	2.5	0.78	NA	NA	NA	Deleted: 24
<b>Inhalation RGA Groundwater (Table D.2, D.27)</b>										
Indoor inhalation rate	m <sup>3</sup> /hour	0.833	NA	NA	0.833	0.833	NA	NA	NA	Deleted: 12
Exposure time in the shower (ET <sub>shower</sub> )	hours/day	0.71	NA	NA	0.71	0.71	NA	NA	NA	Deleted: 12
Time of shower (t1)	hour	0.1	NA	NA	0.1	0.1	NA	NA	NA	Deleted: 1.5
Time after shower (t2)	hour	0.1	NA	NA	0.1	0.1	NA	NA	NA	Deleted: 0.2
Fraction volatilized while showering (f <sub>shower</sub> )	unitless	0.75	NA	NA	0.75	0.75	NA	NA	NA	Deleted: 0.2
Water flow rate (Fw)	L/h	890	NA	NA	890	890	NA	NA	NA	Deleted: 0.2
Bathroom volume (Va)	m <sup>3</sup>	11	NA	NA	11	11	NA	NA	NA	Deleted: 0.2
Averaging time - cancer (AT-C)	hours	24×70×365	NA	NA	24×70×365	24×70×365	NA	NA	NA	Deleted: 24
Averaging time - noncancer (AT-N)	hours	24×365×25	NA	NA	24×365×20	24×365×6	NA	NA	NA	Deleted: 1.815
Exposure time household use (ET <sub>house</sub> )	hours/day	NA	NA	NA	24	24	NA	NA	NA	Deleted: 0.65
Exchange rate (ER)	changes/day	NA	NA	NA	10	10	NA	NA	NA	Deleted: 0.2
Mixing coefficient (MC)	unitless	NA	NA	NA	0.5	0.5	NA	NA	NA	Deleted: 1.815
Fraction volatilized household use (f <sub>house</sub> )	unitless	NA	NA	NA	0.5	0.5	NA	NA	NA	Deleted: 0.65
Water flow rate (WHF)	L/day	NA	NA	NA	890	890	NA	NA	NA	Deleted: 0.2
House volume (HV)	m <sup>3</sup>	NA	NA	NA	450	450	NA	NA	NA	Deleted: 0.2
<b>Dermal Contact with RGA Groundwater (showering) (Tables D.4, D.28)</b>										
Body surface area exposed (SA)	m <sup>2</sup>	2.09	NA	NA	2.09	0.6378	NA	NA	NA	Deleted: 0.2
Event time (t <sub>even</sub> )	hour/event	0.71	NA	NA	0.71	0.71	NA	NA	NA	Comment [LG3]: See Item 6 of Meeting Minutes
Event frequency (EV)	events/day	1	NA	NA	1	1	NA	NA	NA	Comment [LG4]: See Item 6 of Meeting Minutes
<b>Incidental Ingestion of Soil/Sediment (Tables D.5, D.15, D.29, D.30, D.37)</b>										
Incidental ingestion rate (IR)	mg/day	50	480	480	100	200	100	100	200	Deleted: 0.47
Fraction ingested			1	1	1	1	1	1	1	Deleted: 0.47
<b>Dermal Contact with Soil/Sediment (Tables D.6, D.16, D.33, D.39)</b>										
Body surface area exposed (SA)	m <sup>2</sup> /day	0.347	0.347	0.347	0.6032	0.269	0.57	0.75	0.28	Deleted: 0.28
Soil-to-skin adherence factor (AF)	mg/cm <sup>2</sup> -day	1	1	1	1	1	1	1	1	Deleted: 0.57
<b>Comment [LG5]: See Item 6 of Meeting Minutes</b>										

Table B.4. Exposure Parameters Used in Calculation of Human Health PRGs (Continued)

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User
<b>Inhalation of Vapors and Particulates Emitted from Soil/Sediment (Tables D.7, D.17, D.31, D.32, D.38)</b>									
Total inhalation rate (IR)	m <sup>3</sup> /hour	2.5	2.5	2.5	0.833	0.833	2.5	2.5	2.5
Exposure time (ET) (soil)	hours/day	8	8	8	24	24	5	5	5
Exposure time (ET) (sediment)	hours/day	2.6	NA	NA	NA	NA	NA	NA	NA
Particulate emission factor (PEF)	m <sup>3</sup> /kg	6.20E+08	6.20E+08	6.20E+08	9.30E+08	9.30E+08	9.30E+08	9.30E+08	9.30E+08
<b>External Exposure to Ionizing Radiation from Soil/Sediment (Tables D.8, D.18, D.34, D.35, D.40)</b>									
Exposure frequency (EF)	day/year	250/365	185/365	185/365	350/365	350/365	104/365	140/365	140/365
Gamma shielding factor (Se)	unitless	0.2	0.2	0.2	0.2	0.2	0	0	0
Gamma exposure time factor (Te)	hr/hr	8/24	8/24	8/24	18/24	18/24	5/24	5/24	5/24
<b>Consumption of Home-grown Vegetables (Table D.9)</b>									
Diet fraction (FI)	unitless	NA	NA	NA	0.4	0.4	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	0.72	0.29	NA	NA	NA
<b>Consumption of Beef (Table D.10)</b>									
Diet fraction (FI)	unitless	NA	NA	NA	1	1	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	0.19	0.07	NA	NA	NA
<b>Consumption of Milk (Table D.11)</b>									
Diet fraction (FI)	unitless	NA	NA	NA	1	1	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	1.25	0.9	NA	NA	NA
<b>Consumption of Poultry (Table D.12)</b>									
Diet fraction (FI)	unitless	NA	NA	NA	1	1	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	0.17	0.07	NA	NA	NA
<b>Consumption of Pork (Table D.13)</b>									
Diet fraction (FI)	unitless	NA	NA	NA	1	1	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	0.08	0.03	NA	NA	NA
<b>Consumption of Eggs (Table D.14)</b>									
Diet fraction (FI)	unitless	NA	NA	NA	1	1	NA	NA	NA
Ingestion rate (IR)	kg/d	NA	NA	NA	0.11	0.06	NA	NA	NA
<b>Incidental Ingestion of Surface Water (swimming) (Table D.19)</b>									
Ingestion rate (IR)	L/hr	NA	NA	NA	NA	NA	0.05	0.05	0.05
Exposure time (ET)	hr/day	NA	NA	NA	NA	NA	2.6	2.6	2.6
Exposure frequency (EF)	day/year	NA	NA	NA	NA	NA	45	45	45
<b>Dermal Contact with Surface Water (wading) (Table D.20)</b>									
Body surface area exposed (SA)	m <sup>2</sup>	NA	NA	NA	NA	NA	1.06	0.75	0.33
Exposure frequency (EF)	day/year	NA	NA	NA	NA	NA	52	140	140
Exposure time (ET)	hr/day	NA	NA	NA	NA	NA	2.6	2.6	2.6

Comment [LG6]: See Item 6 of Meeting Minutes

Comment [LG7]: See Item 6 of Meeting Minutes



Table B.4. Exposure Parameters Used in Calculation of Human Health PRGs (Continued)

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User
<b>Dermal Contact with Surface Water (swimming) (Table D.21)</b>									
Body surface area exposed (SA)	m <sup>2</sup>	NA	NA	NA	NA	NA	2.09	1.31	0.6378
Exposure frequency (EF)	days/year	NA	NA	NA	NA	NA	45	45	45
Exposure time (ET)	hr/day	NA	NA	NA	NA	NA	2.6	2.6	2.6
Event (EV)	event/day	NA	NA	NA	NA	NA	1	1	1
<b>Dermal Contact with Surface Water (Table D.36)</b>									
Body surface area exposed (SA)	m <sup>2</sup>	0.347	0.347	0.347	NA	NA	NA	NA	NA
Exposure frequency (EF)	days/year	250	20	20	NA	NA	NA	NA	NA
Exposure time (ET)	hr/day	2.6	8	8	NA	NA	NA	NA	NA
<b>Consumption of Fish (Table D.22)</b>									
Diet fraction (FI)	Unitless	NA	NA	NA	NA	NA	1	1	1
Ingestion rate (IR)	kg/d	NA	NA	NA	NA	NA	0.029	0.029	0.029
Exposure Frequency (EF)	days/year	NA	NA	NA	NA	NA	365	365	365
<b>Consumption of Venison (Table D.23)</b>									
Diet fraction (FI)	Unitless	NA	NA	NA	NA	NA	1	1	1
Ingestion rate (IR)	kg/d	NA	NA	NA	NA	NA	0.032	0.032	0.007
<b>Consumption of Rabbit (Table D.24)</b>									
Diet fraction (FI)	Unitless	NA	NA	NA	NA	NA	1	1	1
Ingestion rate (IR)	kg/d	NA	NA	NA	NA	NA	0.0165	0.0082	0.0033
<b>Consumption of Quail (Table D.25)</b>									
Diet fraction (FI)	Unitless	NA	NA	NA	NA	NA	1	1	1
Ingestion rate (IR)	kg/d	NA	NA	NA	NA	NA	0.0047	0.0024	0.00094

Information compiled September 2014.

NA = not applicable

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## Risk Assessment Working Group Meeting Minutes—December 2014

✓Gaye Brewer  
✓Stephanie Brock  
✓Nathan Garner  
✓Mike Guffey  
✓Jeri Higginbotham  
✓Jerri Martin  
✓Todd Mullins

✓Tim Frederick  
✓Jon Richards

✓Rich Bonczek  
✓Martin Clauberg  
✓LeAnne Garner  
✓Bruce Meadows  
✓Bobette Nourse  
✓Joe Towarnicky

### 1. PEGASIS Demonstration (Bruce Meadows)

Portsmouth/Paducah Project Office (PPPO) Environmental Geographic Analytical Spatial Information System (PEGASIS) was designed to provide dynamic mapping and environmental monitoring data display for the U.S. Department of Energy (DOE)–PPPO.

A link to the site is as follows: <http://padgis.latakentucky.com/padgis/>

User instructions are available from a link on the site.

### 2. Call for Issues from Risk Assessment Working Group (RAWG) Members

Issues included request for discussion regarding vapor intrusion sampling. This information was added to Item 9 of these minutes.

### 3. Ecological (Eco) Risk Methods Document (RMD)

Comments have been received from Jeri Higginbotham (see [Attachment 1](#)). Specifically, Comments 3 and 10 were discussed. EPA Region 5 will be added to the hierarchy of sources for no further action values (see Comment 3). Jeri Higginbotham and Bobette Nourse will follow up regarding undocumented model inputs (see Comment 10).

### 4. Upcoming Fiscal Year 2015 Schedule/Work Plan

Revisions were made to the work plan resulting in the following remaining fiscal year 2015 schedule:

Submit Revised Human Health (HH) Main Text and HH Appendices B-E to RAWG for Review	12/11/2014
Comments due for HH Appendix A	1/5/2015
<i>Comments due on initial revision of Eco RMD</i>	1/9/2015
<b><i>Submit Final Eco RMD (DOE/LX/07-0107&amp;D2/R1/V2) to FFA managers for approval</i></b>	2/9/2015
RAWG approve HH Appendix A	2/12/2015
Comments due for HH Main Text and HH Appendices B-E	2/12/2015
Quarterly Meeting (March)	3/4/2015
<b><i>FFA managers approve final Eco RMD (DOE/LX/07-0107&amp;D2/R1/V2)</i></b>	3/9/2015
RAWG approve HH Main Text and HH Appendices B-E	4/9/2015
Submit entire Revised HH RMD to RAWG for review	4/16/2015
Comments due for entire Revised HH RMD	5/16/2015
Quarterly Meeting (June)	6/10/2015
<b><i>Submit HH RMD to FFA Managers (DOE/LX/07-0107&amp;D2/R3/V1)</i></b>	6/13/2015
<b><i>FFA Managers approve HH RMD (DOE/LX/07-0107&amp;D2/R3/V1)</i></b>	7/17/2015
Quarterly Meeting (September)	9/16/2015

Quarterly meetings will be via Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 p.m. (eastern). Italics indicate Eco RMD schedule.

5. **Comments/Discussion of Revised Table 2.1 Site Chemicals of Potential Concern (COPCs) (see Attachment 2)**

Two COPCs specifically were discussed: bis(2-ethylhexyl)phthalate and thorium-234. Additional information regarding bis(2-ethylhexyl)phthalate was sent to the group following the meeting (see Footnote 10). Thorium-234 was agreed to remain off of the site COPC list (see Footnote 27).

6. **HH RMD Appendix A [Preliminary Remediation Goals (PRGs)] Out for Review (12/2/2014)**

Revisions will be made to the Appendix as discussed in the following bullets. A revised Appendix A will be sent to the group.

- Revision to adult resident drinking water ingestion rate [from 2 liters/day to 2.5 liters/day as suggested by the new U.S. Environmental Protection Agency (EPA) guidance]. (See below circled in blue.)

Note that DOE-HQ and the Nuclear Regulatory Commission (NRC) have not adopted the change to 2.5 liters/day water ingestion rate for the dose-based calculations.

Pathway Variable	Units	Default Industrial Worker	Outdoor Worker	Excavation Worker	Adult Resident	Child Resident	Adult Recreational User	Teen Recreational User	Child Recreational User	
<b>General Parameters Used in All Intake Models (unless otherwise noted)</b>										
Exposure frequency (EF)	days/year	250	185	185	350	350	104	140	140	Deleted: 24
Exposure duration (ED)	Years	25	25	5	20	6	10	10	6	Deleted: 12
Body weight (BW)	Kg	80	80	80	80	15	60	43	15	Deleted: 12
Averaging time - cancer (AT-C)	Days	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	70 × 365	Deleted: 12
Averaging time - noncancer (AT-N)	Days	365 × 25	365 × 25	365 × 5	365 × 20	365 × 6	365 × 10	365 × 10	365 × 6	Deleted: 70
<b>Ingestion of Water (Tables D.1, D.26)</b>										Deleted: 70
Drinking water ingestion rate (IR)	L/day	NA	NA		2	0.78	NA	NA	NA	Deleted: 70
<b>Inhalation RGA Groundwater (Table D.2, D.27)</b>										
Indoor inhalation rate	m <sup>3</sup> /hour	0.833	NA	NA	0.833	0.833	NA	NA	NA	Deleted: 70
Exposure time in the shower (ET <sub>shower</sub> )	hours/day	0.71	NA	NA	0.71	0.71	NA	NA	NA	Deleted: 70
Time of shower (t <sub>1</sub> )	hour	0.1	NA	NA	0.1	0.1	NA	NA	NA	Deleted: 24
Time after shower (t <sub>2</sub> )	hour	0.1	NA	NA	0.1	0.1	NA	NA	NA	Deleted: 12
Fraction volatilized while showering (f <sub>vol</sub> )	unitless	0.75	NA	NA	0.75	0.75	NA	NA	NA	Deleted: 12
Water flow rate (F <sub>w</sub> )	L/h	890	NA	NA	890	890	NA	NA	NA	Deleted: 12
Bathroom volume (V <sub>a</sub> )	m <sup>3</sup>	11	NA	NA	11	11	NA	NA	NA	Deleted: 1.5
Averaging time - cancer (AT-C)	hours	24 × 70 × 365	NA	NA	24 × 70 × 365	24 × 70 × 365	NA	NA	NA	Formatted Table
Averaging time - noncancer (AT-N)	hours	24 × 365 × 25	NA	NA	24 × 365 × 20	24 × 365 × 6	NA	NA	NA	Deleted: 0.2
Exposure time household use (ET <sub>house</sub> )	hours/day	NA	NA	NA	24	24	NA	NA	NA	Deleted: 0.2
Exchange rate (ER)	changes/day	NA	NA	NA	10	10	NA	NA	NA	Deleted: 0.2
Mixing coefficient (MC)	unitless	NA	NA	NA	0.5	0.5	NA	NA	NA	Deleted: 0.2
Fraction volatilized household use (f <sub>house</sub> )	unitless	NA	NA	NA	0.5	0.5	NA	NA	NA	Deleted: 24
Water flow rate (WHF)	L/day	NA	NA	NA	890	890	NA	NA	NA	Formatted Table
House volume (HV)	m <sup>3</sup>	NA	NA	NA	450	450	NA	NA	NA	Deleted: 1.815
<b>Dermal Contact with RGA Groundwater (showering) (Tables D.4, D.28)</b>										
Body surface area exposed (SA)	m <sup>2</sup>	1.09	NA	NA	2.09	0.6378	NA	NA	NA	Deleted: 1.815
Event time (t <sub>event</sub> )	hour/event	0.71	NA	NA	0.71	0.71	NA	NA	NA	Deleted: 0.65
Event frequency (EV)	events/day	1	NA	NA	1	1	NA	NA	NA	Deleted: 0.2
<b>Incidental Ingestion of Soil/Sediment (Tables D.5, D.15, D.29, D.30, D.37)</b>										
Incidental ingestion rate (IR)	mg/day	50	480	480	100	200	100	100	200	Deleted: 0.2
Fraction ingested		1	1	1	1	1	1	1	1	Deleted: 0.2
<b>Dermal Contact with Soil/Sediment (Tables D.6, D.16, D.33, D.39)</b>										
Body surface area exposed (SA)	m <sup>2</sup> /day	0.347	0.347	0.347	0.6032	0.269	0.57	0.75	0.28	Formatted Table
Soil-to-skin adherence factor (AF)	mg/cm <sup>2</sup> -day	1	1	1	1	1	1	1	1	

- Revision to adult and child recreational user body surface area exposed (to 0.6032 m<sup>2</sup>/day and 0.269 m<sup>2</sup>/day, respectively). (See above circled in green.)  
Exposure is for head, hands, forearms, lower legs, and feet. This exposure is applicable to both the resident and the recreational user.

- Radionuclide PRGs calculator.

Two options are available for calculating radionuclide PRGs. Their Web addresses follow.

[http://rais.ornl.gov/cgi-bin/prg/PRG\\_search?select=rad](http://rais.ornl.gov/cgi-bin/prg/PRG_search?select=rad)

[http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg\\_search](http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search)

The group agreed to use the RAIS calculator, with an area correction factor of 0.9, as has been used previously.

- Besides soil screening levels (SSLs) based on a dilution attenuation factors (DAFs) of 1 and 20, a DAF of 58 is added to the SSL tables based on information from the Soils OU Remedial Investigation Report. (The Southwest Plume Focused Feasibility Study used a DAF of 59.) Derivation of this DAF that was included in the Soils OU Remedial Investigation Report will be included in Appendix E of the HH RMD.
- Dose-Based SSLs for Protection of Regional Gravel Aquifer Groundwater for Site-Related Radionuclides at the Paducah Gaseous Diffusion Plant (PGDP) are calculated using the equations presented for the 2015 HH RMD. For the 2011– 2014 HH RMDs, these values were generated by the Residual Radioactivity (RESRAD) model.

## **7. Use of the Terms “outdoor worker,” “excavation worker,” and “site-specific” in 2015 HH RMD**

The end note 3 in Table B.1 (and Table B.2) of the HH RMD was discussed. The suggested revision reads as follows:

Determining which soil and sediment screening value is appropriate is a location-specific decision. For all locations inside the industrialized area at PGDP where surface soil contamination is of concern, use of the industrial worker risk-based screening values is appropriate. However, if the scenario involves outdoor maintenance type activities, the outdoor worker risk-based screening values also should be considered. For locations inside the industrialized area at PGDP where contact with surface soil and subsurface soil is of concern (i.e., soil from the surface down to 10 or 16 ft bgs, as appropriate), use of the excavation worker risk-based screening values is appropriate. For locations, outside the industrialized area where surface soil contamination is of concern, screening using the recreator and/or resident risk-based screening values is appropriate. As with the surface water values, the child resident risk-based screening values are the most “conservative” (in terms of protecting human health). Generally, the recreator risk-based screening values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident risk-based screening values are more appropriate for grassy fields. Finally, the outdoor worker risk-based screening values also can be considered for contact with soil in locations outside the industrialized area if this scenario is appropriate for the locations considered. (If screening needs to consider shorter-term exposures to both surface and subsurface soil in locations outside the industrialized area, excavation worker PRGs ~~should~~ can be used.)

## **8. Expand Residual Risk Assessment Discussion**

Section 4.2.3 was sent to the RAWG on 11/24/2014 for initial review. The section was resent following the meeting, with comments due on this section only by 1/15/2015.

## **9. Vapor Intrusion**

New guidance from EPA is still in draft.

The table, “Human Health Information for the Paducah Vapor Intrusion Evaluation,” was sent to the group following the meeting. The table also will be added to Appendix E, with an explanation.

Discussion was held regarding adding minimum sampling requirements (e.g. when to sample, minimum samples, what kind of sampling) to the Human Health document.

Discussion included, with respect to sampling: sub-slab sampling should be required (not groundwater or soil). Guidance is available from ITRC and draft guidance from EPA.

Vapor intrusion pathway could be significant and should be addressed in the project DQOs.

A proposal for addition to the main text of the HH RMD will be sent to the group for comment.

**10. Summary of revisions to Programmatic Quality Assurance Project Plan (QAPP)**

The draft is being reviewed by DOE. Document scheduled to be complete in January; a meeting will be held with regulators after that.

**11. Poll RAWG Members/Open Discussion**

Discussion topics on hold were discussed.

Validation needed for closure activities [CERCLA 120(h)] (added 6/2014—further discussion on this topic depends on completing presentations to Paducah Site Lead).

Additional information is included in the Programmatic QAPP.

Derivation of Risk-based Surface Water Effluent Limits (added 6/2014—further discussion on this topic depends on resolution of Northeast Plume Dispute).

This topic still is on hold.

## Attachment 1

### Ecological Risk Methods Document Comments

Comments received from Kentucky:

**1. 2.4.1 Study Design--Exposure and Effects Measurements Toxicity Tests. (page 2-19)**

The last two sentences of the first paragraph on this page are, “Screening toxicity tests do not produce definitive benchmark concentrations associated with specific levels of adverse effects. Screening toxicity tests are considered to be chronic tests (EPA 2000b; EPA 2002; ASTM 1998), and test durations are believed to be sufficiently long for adverse effects on sensitive life stages to be observed at concentrations exceeding ecological screening values (ESVs).” Is the word “screening” necessary or appropriate here?

**2. Table 1. Model Parameters for Calculating Preliminary Hazard Quotients for PGDP ERAs (Page 2-9) and Table B.1. Exposure Parameters for PGDP Model Ecological Receptors (page B-4)**

The soil/sediment ingestion rate is listed as 10.2 and 10 for the American robin and marsh wren respectively in Table 1. Both are listed as 10.4 in Table B.1. Please clarify the discrepancy.

**3. APPENDIX A: PGDP NO FURTHER ACTION LEVELS (page A-4)**

Sediment NFA levels are stated to be from the following hierarchy of sources:

(1) “EPA Region 4 values and”

(2) “Values selected from among KDEP screening values and ORNL sediment screening values based on professional judgment”

I note in Table A.4. (PGDP Sediment NFA Screening Values) that many of the levels are from Region 5. Please clarify the discrepancy.

**4. Table A.4. PGDP Sediment NFA Screening Values (page A-11)**

The NFA screening levels for cobalt and 1,1-dichloroethane in sediment has as their source KDEP. KDEP used the Region 5 levels. Please change the source to EPA Region 5 for both.

**5. Table A.4. PGDP Sediment NFA Screening Values (pages A-11 and A-12)**

The NFA screening levels for benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and toxaphene in sediment has as their source KDEP. KDEP used the levels from a 1996 EPA Region 4 document (United States Environmental Protection Agency (USEPA). 1996 (October). Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Screening Values). This particular document seems to have been superseded. Please change the levels to those used by EPA Region 5, 10400 uk/kg for benzo(b)fluoranthene, 240 uk/kg for benzo(k)fluoranthene, 200 uk/kg for indeno(1,2,3-cd)pyrene, and 0.077 ug/kg for toxaphene.

**6. Table A.6. PGDP Surface Water NFA Screening Values (page A-13)**

The source for the selenium screening value is listed as NRWQC. However the footnote (e) indicates that the EPA Region 4 value was chosen. Please clarify.



**7. Table A.8. NOAEL-based TRVs for PGDP Wildlife Receptors (page A-17)**

Both the mammalian and bird TRV listed for 4,4'-DDT are TRVs for 4,4'-DDT and its metabolites, 4,4'-DDD and 4,4'-DDE. It does not appear that there should be a separate entry for each compound in the table. Rather, there should be one entry for 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE.

**8. Table A.8. NOAEL-based TRVs for PGDP Wildlife Receptors (page A-18)**

Table A.8 has the bird TRV for xylene listed as not available. The LANL Ecorisk database lists 107 as the bird TRV. Please use the LANL value.

**9. APPENDIX B: EXPOSURE PARAMETERS FOR PGDP MODEL **ECOLOGICAL** RECEPTORS**

**Table B.1. Exposure Parameters for PGDP Model **Ecological** Receptors (pages B-3 to B-6)**

For a number of parameters in this table, two sources are given. The second source is often EPA 1993. If the parameter value was obtained from EPA 1993 and not the original research paper, then please insert the word "in" between the two.

**10. Table B.1. Exposure Parameters for PGDP Model **Ecological** Receptors (pages B-3 to B-6)**

Table A.8 contains a footnote explaining the source, EPA Region 4. However, Table B.1 has no such footnote explaining the source, EPA Region 4. Please add a footnote explaining this source. Also, the source, Kentucky Department of Fish and Wildlife Resources, is listed as a personal communication but the name of the individual is not given. Please add the name of the individual.

**11. Table B.1. Exposure Parameters for PGDP Model **Ecological** Receptors (pages B-3 to B-6)**

One of the FIR parameter sources for the American robin is Hazelton *et al.*, 1984. This source is not listed in the footnotes. Please add this source to the footnotes.

**12. Table B.1. Exposure Parameters for PGDP Model **Ecological** Receptors (pages B-3 to B-6)**

There are four sources listed in the footnotes which are not cited in the table. They are:

- Anthony, E. L. P. and T. H. Kunz 1977. "Feeding Strategies of the Little Brown Bat, *Myotis lucifugus*, in Southern New Hampshire," *Ecology* **58**: 775–786;
- Burt, W. H. and R. P. Grossenheider 1980. *A Field Guide to the Mammals of North America North of Mexico*, Houghton Mifflin Co., Boston, MA;
- Sample, B. E., D. M. Opresko, and G. W. Suter II 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision*, ES/ER/TM-86/R3; and
- Skorupa, J. P. and R. L. Hothem 1985. "Consumption of Commercially Grown Grapes by American Robins (*Turdus migratorius*): A Field Evaluation of Laboratory Estimates," *J. Field Ornithol.* **56**: 369–378.

Please clarify.

**13. Table B.1. Exposure Parameters for PGDP Model **Ecological** Receptors (page B-5)**

No sources are provided for the smallmouth bass parameters. Please provide sources for the smallmouth bass parameters.

## Attachment 2

### COPC Updates to Table 2.1 of the Risk Methods Document

COPC	Listed in RMD 2013 = X Add to RMD 2014 = O	WAG 28 DOE 2000	GWOU DOE 2001	BGOU DOE 2010	Soils OU DOE 2013
<b>Inorganic Chemicals</b>					
Aluminum	X	X	X	X	X
Antimony	X	X	X	X	X
Arsenic	X	X	X	X	X
Barium	X	X	X	X	
Beryllium	X	X	X	X	
Boron	X		X		
Cadmium	X	X	X	X	X
Chromium III (or total)	X	X	X	X	X
Chromium VI	X				
Cobalt	X	X		X	X
Copper	X	X	X	X	X
Fluoride <sup>2</sup>	O	X	X		
Iron	X	X	X	X	X
Lead	X		X		
Lithium <sup>3</sup>		X	X		
Manganese	X	X	X	X	X
Mercury	X	X	X		X
Molybdenum	X	X	X		
Nickel	X	X	X	X	X
Nitrate (as N) <sup>4</sup>			X		
Nitrate + Nitrite (as N) <sup>5</sup>			X		
Selenium	X			X	
Silver	X	X	X		
Strontium <sup>6</sup>			X		
Thallium	X				X
Uranium	X	X	X	X	X
Vanadium	X	X		X	X
Zinc	X	X		X	X
<b>Organic Chemicals</b>					
Acenaphthene	X				
Acenaphthylene	X				
Acetone <sup>7</sup>		X	X		
Acrylonitrile	X		X		
Aldrin <sup>8</sup>		X			
Anthracene	X				
Benzene	X	X	X		
Bis(2-chloroethyl)ether <sup>9</sup>		X			
Bis(2-ethylhexyl)phthalate <sup>10</sup>	O	X	X		X
Bromodichloromethane <sup>11</sup>	O	X	X		
Bromomethane <sup>12</sup>			X		
2-Butanone <sup>13</sup>			X		
Carbazole	X		X		X
Carbon tetrachloride	X	X	X		
Chlorobenzene <sup>14</sup>			X		
Chloroform	X	X	X		
Chloromethane <sup>15</sup>			X		



COPC	Listed in RMD 2013 = X Add to RMD 2014 = O	WAG 28 DOE 2000	GWOU DOE 2001	BGOU DOE 2010	Soils OU DOE 2013
<b>Organic Chemicals (Cont)</b>					
<b>Dibromochloromethane<sup>16</sup></b>			X		
1,1-Dichloroethene	X	X	X	X	
<b>1,2-Dichloroethane<sup>17</sup></b>	O	X	X		
1,2-Dichloroethene (mixed)	X	X	X		
<i>trans</i> -1,2-Dichloroethene	X	X	X		
<i>cis</i> -1,2-Dichloroethene	X	X	X	X	X
Dieldrin	X	X			
<b>2,4-Dimethylphenol<sup>18</sup></b>			X		
Ethylbenzene	X		X		
Fluoranthene	X				
Fluorene	X				
Hexachlorobenzene	X	X			
<b>4-Methyl-2-pentanone<sup>19</sup></b>			X		
<b>Methylene Chloride<sup>20</sup></b>			X		
Naphthalene	X		X	X	X
2-Nitroaniline	X	X			
N-Nitroso-di-n-propylamine	X	X			
<b>Pentachlorophenol<sup>21</sup></b>	O	X			
Phenanthrene	X		X		
Pyrene	X	X			
Tetrachloroethene	X	X	X		
<b>1,1,1-Trichloroethane<sup>22</sup></b>	O		X		
<b>1,1,2-Trichloroethane<sup>23</sup></b>	O	X	X		
Trichloroethene	X	X	X	X	X
Total Dioxins/Furans	X			X	
2,3,7,8-HpCDD	X				
2,3,7,8-HpCDF	X				
2,3,7,8-HxCDD	X				
2,3,7,8-HxCDF	X				
OCDD	X				
OCDF	X				
2,3,7,8-PeCDD	X				
1,2,3,7,8-PeCDF	X				
2,3,4,7,8-PeCDF	X				
2,3,7,8-TCDD	X				
2,3,7,8-TCDF	X				
Total PAHs	X			X	X
Benz(a)anthracene	X	X <sup>1</sup>		X	
Benzo(a)pyrene	X	X		X	
Benzo(b)fluoranthene	X	X <sup>1</sup>		X	
Benzo(k)fluoranthene	X				
Chrysene	X	X			
Dibenz(a,h)anthracene	X	X		X	
Indeno(1,2,3-cd)pyrene	X	X		X	
Total PCBs	X	X	X	X	X
Aroclor 1016	X	X			
Aroclor 1221	X				
Aroclor 1232	X				
Aroclor 1242	X				

COPC	Listed in RMD 2013 = X Add to RMD 2014 = O	WAG 28 DOE 2000	GWOU DOE 2001	BGOU DOE 2010	Soils OU DOE 2013
<b>Organic Chemicals (Cont)</b>					
Aroclor 1248	X				
Aroclor 1254	X	X	X	X	
Aroclor 1260	X	X		X	
<b>Toxaphene<sup>24</sup></b>		X			
Vinyl chloride	X	X	X	X	
Xylenes (Mixture)	X		X		
p-Xylene	X				
m-Xylene	X				
o-Xylene	X				
<b>Radionuclides</b>					
Americium-241	X		X		X
Cesium-137+D	X	X <sup>1</sup>	X		X
Neptunium-237+D	X	X	X	X	X
Plutonium-238	X				
Plutonium-239	X		X	X	X
Plutonium-240	X				
<b>Radium-226+D<sup>25</sup></b>			X	X	
<b>Radon-222<sup>26</sup></b>		X	X		
Technetium-99	X	X	X	X	X
Thorium-230	X				X
<b>Thorium-234<sup>27</sup></b>		X			
Uranium-234	X	X	X	X	X
Uranium-235+D	X		X	X	X
Uranium-238+D	X	X	X	X	X
<b>Other constituents to add to Appendix A</b>					
Dichlorodifluoromethane (Freon-12)					
1,1-Dichloroethane					
Toluene					
1,1,2-Trichlorotrifluoroethane (Freon-113)					

The initial list of “Significant COPCs for PGDP” is shown above in black, regular font, and includes COCs from SWMU 2 (1996a), WAGs 1&7 (1996b), WAG 6 (1999a), WAG 27 (1999b), SWOU SAP (2005), and SWOU SI (2008). Additional, potential “Significant COPCs for PGDP” are shown in red, bold font in updates to Table 2.1 and include COCs from the references listed below.

- [DOE 2000](#). Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1846/V4&D2, August.
- [DOE 2001](#). Feasibility Study for the Groundwater Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, (Table 1.9) DOE/OR/07-1857&D2, August.
- [DOE 2010](#). Remedial Investigation Report for the Burial Grounds Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-0030&D2/R1, February.
- [DOE 2013](#). Soils Operable Unit Remedial Investigation Report at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-0358&D2/R1, February.

<sup>1</sup> DOE 2000 also lists benzo(a)fluoranthene, benzo(b)anthracene, and cesium, but these are assumed to be typos, since these chemicals were not analyzed by the project.

<sup>2</sup> Fluoride will be added to the list of significant COPCs at PGDP. Fluoride was listed as a COC in both the WAG 28 RI BRA and the GWOU FS BRA (although the GWOU FS states that, based upon the minimal contribution to total HI, fluoride was not considered further as a COC in the FS). Additionally, fluoride is a component of known contamination at the site (e.g., magnesium fluoride and hydrogen fluoride).

<sup>3</sup> Lithium was listed as a COC in the WAG 28 RI and GWOU FS, but will not be listed in the “Significant COPCs for PGDP.” The WAG 28 RI states the following:

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

<sup>4</sup> Nitrate (as N) will not be considered as a Significant COPC at PGDP. Although nitrate is a significant contributor to risk in the GWOU FS baseline risk assessment, nitrates are produced by natural biological and physical oxidations and therefore are ubiquitous in the environment. Most of the excess nitrates in the environment originate from inorganic chemicals manufactured for agriculture.

<sup>5</sup> Nitrate + Nitrite (as N) will not be considered as a Significant COPC at PGDP. See Nitrate (as N) for explanation.

<sup>6</sup> Strontium was listed as a COC in the GWOU FS, but will not be listed in the “Significant COPCs for PGDP.” See Lithium for explanation.

<sup>7</sup> Acetone will not be considered a Significant COPC at PGDP because it is a common laboratory contaminant. Acetone was determined to be a COC in the WAG 28 BRA and the GWOU FS BRA. The WAG 28 BRA did not include a screen to delete COPCs if they also were detected in blank samples. Based upon the minimal contribution to total HI, acetone was not considered further as a COC in the GWOU FS. Additionally, acetone was discussed at the August 2007 RAWG for inclusion into the significant COPC list for PGDP. It was decided that it should not be added at that time.

<sup>8</sup> Aldrin will not be considered a significant COPC at PGDP because, despite its being included as a COC in the WAG 28 BRA, Aldrin is not listed as having a detected concentration in OREIS at SWMU 99 (where it is a COC in WAG 28). It is assumed that WAG 28 did not recognize the “U” qualifier because the data summary lists Aldrin with 2/2 detections (additional research regarding data use was not performed for this exercise). Only 4 surface water samples show detections in environmental samples (additionally, 15 waste samples are listed as detections).

<sup>9</sup> Bis(2-chloroethyl) ether will not be considered a significant COPC at PGDP because, despite its being included as a COC in the Northwest Plume BRA and the WAG 28 BRA, bis(2-chloroethyl) ether is not listed as having a detected concentration in OREIS for any environmental samples [8 detections of bis(2-

chloroethyl) ether are listed for waste samples]. Additionally, bis(2-chloroethyl) ether was discussed at the August 2007 RAWG for inclusion into the significant COPC list for PGDP. It was decided that it should not be added at that time.

<sup>10</sup> Bis(2-ethylhexyl)phthalate was discussed at the August 2007 RAWG for inclusion into the significant COPC list for PGDP. It was decided that it should not be added at that time. It since has been included as a COC in the Soils OU RI. During the December 2014 RAWG meeting, it was discussed that bis(2-ethylhexyl)phthalate is considered a common laboratory contaminant because of its ubiquitous use as a plasticizer. Whether to add bis(2-ethylhexyl)phthalate as a COPC for the site is under consideration.

<sup>11</sup> Bromodichloromethane will be added to the list of significant COPCs at PGDP because it was included as a COC in the WAG 28 BRA. The GWOU FS BRA found that the frequency of detection for bromodichloromethane in unfiltered samples is minimal (0.4%). Based upon the minimal contribution to total HI and total ELCR and the minimal frequency of detection, bromodichloromethane was not considered further as a COC in the GWOU FS.

<sup>12</sup> Although bromomethane was included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total HI and the minimal frequency of detection, bromomethane was not considered further as a COC in the FS. Bromomethane has not been added to the list of significant COPCs at PGDP.

<sup>13</sup> Although 2-butanone was included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total HI, 2-butanone was not considered further as a COC in the FS. 2-Butanone has not been added to the list of significant COPCs at PGDP.

<sup>14</sup> Chlorobenzene has not been added to the list of significant COPCs at PGDP. Although it is included in the list of COCs in the GWOU FS, the text of the document states that based upon the minimal contribution to total HI and the minimal frequency of detection, chlorobenzene was not considered further as a COC in the FS.

<sup>15</sup> Although chloromethane was included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total HI and the small frequency of detection, it was not considered further as a COC in the FS. Chloromethane has not been added to the list of significant COPCs at PGDP.

<sup>16</sup> Dibromochloromethane has not been added to the list of significant COPCs at PGDP. Although it is included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total HI and the small frequency of detection, dibromochloromethane was not considered further as a COC in the FS.

<sup>17</sup> 1,2-Dichloroethane will be added to the list of significant COPCs at PGDP. It is listed as a COC in both the WAG 28 RI BRA and the GWOU FS BRA. Although the GWOU FS does not consider 1,2-dichloroethane further than the initial listing, it is a degradation product of other chlorinated COPCs at PGDP.

<sup>18</sup> Although 2,4-dimethylphenol was included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total HI, 2,4-dimethylphenol was not considered further as a COC in the FS. 2,4-Dimethylphenol has not been added to the list of significant COPCs at PGDP.

<sup>19</sup> 4-Methyl-2-pentanone has not been added to the list of significant COPCs at PGDP. Although it is included in the list of COCs in the GWOU FS, no additional information is provided in the FS.

<sup>20</sup> Although methylene chloride was included in the list of COCs in the GWOU FS, the text of the document states that, based upon the minimal contribution to total ELCR, methylene chloride is not considered further as a COC in the FS. Methylene chloride has not been added to the list of significant COPCs at PGDP.

<sup>21</sup> Pentachlorophenol will be added to the list of significant COPCs at PGDP because it is listed as a COC in the WAG 28 RI BRA. Pentachlorophenol was commonly used as a wood preservative and in manufacturing pesticides. Pentachlorophenol was reported to have been used on the cooling towers at PGDP [*Report for Environmental Audit Supporting Transition of the Gaseous Diffusion Plants to the United States Enrichment Corporation* ([DOE/OR/1087&V5, June 1993](#))].

<sup>22</sup> 1,1,1-Trichloroethane will be added to the list of significant COPCs at PGDP. It is listed as a COC in the GWOU FS BRA. Although the GWOU FS does not consider 1,1,1-trichloroethane further than the initial listing, it is a degradation product of other chlorinated COPCs at PGDP.

<sup>23</sup> 1,1,2-Trichloroethane will be added to the list of significant COPCs at PGDP. It is listed as a COC in both the WAG 28 RI BRA and the GWOU FS BRA. Although the GWOU FS does not consider 1,1,1-trichloroethane further than the initial listing, it is a degradation product of other chlorinated COPCs at PGDP.

<sup>24</sup> Toxaphene will not be considered a significant COPC at PGDP because, despite its being included as a COC in the WAG 28 BRA, toxaphene is not listed as having a detected concentration in OREIS at SWMU 99 (where it is a COC in WAG 28). It is assumed that WAG 28 did not recognize the “U” qualifier because the data summary lists toxaphene with 2/2 detections (additional research regarding data use was not performed for this exercise). Only 9 liquid sludge samples show detections in environmental samples.

<sup>25</sup> Radium-226+D previously was included as a significant COPC at PGDP (DOE 2001), but it was removed from the list as part of document revision between the issuance of the September 2007 HHRMD and the January 2009 HHRMD. It was included as a COC in the BGOU RI; but because no source term for the isotope is known for PGDP, radium-226 will not be added to the list of significant COPCs at PGDP.

<sup>26</sup> Radon-222 previously was included as a significant COPC at PGDP (DOE 2001), but it was removed from the list as part of document revision between the issuance of the September 2007 HHRMD and the January 2009 HHRMD. Additional information is provided in *Paducah Groundwater Contamination, Detailed History and Summary of Future Actions* ([KY/H-41/Rev. 1, December 1988](#)), as follows:

Since Thorium-230 has a half-life of approximately 80,000 years, the production of Radon-222 is extremely slow. Uranium from plant operations cannot contribute to any significant formation of Radon-222 because all the Thorium was removed in the refining, and feed preparation processes.

Published reports by EPA for samples from public supply wells in this area show similar Radon-222 concentrations to those detected in the PGDP vicinity wells. EPA data for LaCenter and Metropolis ...offer further corroboration that Radon-222 in the plant aquifer is unrelated to plant operations.

<sup>27</sup> Thorium-234 previously was not included as a significant COPC at PGDP (DOE 2001). It was included as a COC in the WAG 28 RI; but because the isotope is a daughter product of uranium-238 with a long half-life, thorium-234 will not be added to the list of significant COPCs at PGDP. Additional information

discussed in the December 2014 RAWG meeting was that the half-life of thorium-234 is 24.1 days. While thorium-234 may be present, its risk is captured with uranium-238.

## Risk Assessment Working Group Meeting Minutes—March 2015

✓Gaye Brewer  
✓Stephanie Brock  
✓Nathan Garner  
✓Jeri Higginbotham  
✓Todd Mullins

✓Tim Frederick  
✓Jon Richards  
✓Julie Corkran  
✓Jennifer Tufts

✓Rich Bonczek  
✓Martin Clauberg  
✓LeAnne Garner  
✓Bobette Nourse  
✓Joe Towarnicky

### 1. Call for Issues from Risk Assessment Working Group (RAWG) Members

### 2. Ecological (Eco) Risk Methods Document (RMD)

A separate meeting will be held to address comments and to ensure the document progresses and schedule does not slip further.

### 3. Upcoming Fiscal Year 2015 Revised Schedule/Work Plan

Quarterly Meeting (March)	3/11/2015
<b>Eco Meeting (tentative)</b>	<b>4/2/2015</b>
<b>***Submit Final Eco RMD (DOE/LX/07-0107&amp;D2/R1/V2) to FFA managers for approval</b>	<b>5/7/2015</b>
<b>***FFA managers approve final Eco RMD (DOE/LX/07-0107&amp;D2/R1/V2)</b>	<b>6/8/2015</b>
RAWG approve HH Main Text and HH Appendices A-E	4/9/2015
Submit entire Revised HH RMD to RAWG for review	4/16/2015
Comments due for entire Revised HH RMD	5/16/2015
Quarterly Meeting (June)	6/10/2015
<b>Submit HH RMD to FFA Managers (DOE/LX/07-0107&amp;D2/R3/V1)</b>	<b>6/13/2015</b>
<b>FFA Managers approve HH RMD (DOE/LX/07-0107&amp;D2/R3/V1)</b>	<b>7/17/2015</b>
Quarterly Meeting (September)	9/16/2015

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 p.m. (eastern)  
Italics indicate Eco RMD schedule.

### 4. Summary of February 3, 2015, Meeting Regarding Dermal Absorption (ABS) Values

The resolution from the February 3, 2015, meeting is found in the Attachment to these minutes (Note: the e-mail formerly sent as “minutes” now is titled “resolution,” since e-mails following the actual meeting revised the path forward). Todd agreed to follow up with Jerri to ensure the resolution is captured correctly.

From the meeting and follow-up, the following are understood going forward:

- a. NALs/ALs will be calculated using EPA ABS values.
- b. The uncertainty section in baseline human health risk assessments will include a comparison of risks and hazard indices from metals determined using EPA ABS values and KY ABS values.
- c. The uncertainty section will include comparison of risks and hazard indices from COPCs that had been dropped by using NALs calculated with EPA ABS that would not have been dropped if KY ABS values had been used.

Additional information discussed in the February 3, meeting was a description of NALs and ALs as follows:

- NALs (i.e., the lesser of  $ELCR=10^{-6}$  and  $HI=0.1$ ) are used to tell us “where there might be a problem.”
- ALs (i.e., the lesser of  $ELCR=10^{-4}$  and  $HI=3$ ) are used to tell us “where there is definitely a problem.”

**5. Status of HH Appendix A [Preliminary Remediation Goals (PRGs)] Review**

Comments received have been included in a separate comment response summary (CRS).

**6. Status of HH Appendices B-E and Main Text Review**

Comments received and responses discussed in the meeting have been included in a separate CRS.

**7. Use of EPA RSLs as the basis for project action levels in upcoming potential vapor intrusion work**

See page 6 of the guide for equations used in the Vapor Intrusion Screening Level (VISL) Calculator

Calculator and user guide available at the following:  
<http://www.epa.gov/oswer/vaporintrusion/guidance.html>

The following equations would appear in the 2016 RMD, Appendix D.

EPA Regional Screening Levels (RSLs) would be used for screening, **if** RAWG members agree to the use of RSL exposure parameters. No site-specific values for air would be included in Appendix A of the RMD. Explanation regarding use of differing exposure parameters would need to be documented. **OR** the Ambient Air PRGs table (following) could be included in Appendix E of the 2016 RMD.

The site-specific ambient air equations would be included in Appendix D of the 2016 RMD.

Any comments on the equations or preference for use of RSLs should be sent to LeAnne and will be addressed during the June 2015 quarterly meeting.



**Ambient Air PRGs (using RAIS 03/05/2015), VISL Values (using VISL Version 3.3.1 & May 2014 RSLs), and Paducah Site-specific Levels**

<b>Analyte</b>	<b>Noncarcinogen or Carcinogen based values</b>	<b>Units</b>	<b>RAIS Resident</b>	<b>RAIS Outdoor Worker (225 d/yr for 25 yrs)</b>	<b>PAD Site- specific Outdoor Worker (185 d/yr for 25 yrs)*</b>	<b>RAIS Composite Worker (250 d/yr for 25 yrs)</b>	<b>RAIS Construction Worker (20 d/yr for 1 yr)</b>	<b>VISL Value** (Resident)</b>
Benzene	C	µg/m <sup>3</sup>	0.36	1.75	2.12	1.57	491	0.36
<i>cis</i> -1,2-DCE		µg/m <sup>3</sup>						
<i>trans</i> -1,2-DCE	NC	µg/m <sup>3</sup>	62.6	292	355	263	3290	
Ethylbenzene	C	µg/m <sup>3</sup>	1.12	5.45	6.63	4.91	1530	1.1
Toluene	NC	µg/m <sup>3</sup>	5210	24300	29600	21900	274000	5200
TCE	C	µg/m <sup>3</sup>	0.478	3.32	4.04	2.99	935	0.48
Vinyl Chloride	C	µg/m <sup>3</sup>	0.168	3.10	3.77	2.79	871	0.17
Xylenes	NC	µg/m <sup>3</sup>	104	487	592	438	5480	100

Note: The RAIS PRGs, PAD PRGs, and VISLs are the lesser of the ELCR at 1E-06 and the HI at 1.0, for comparison purposes only with the VISL calculator.  
Gray shading implies that no values are available.

\*Exposure parameters from the 2014 Paducah RMD.

\*\*VISL Target Indoor Air Concentrations (**Residential**), Version 3.3.1, RSLs from May 2014 were used in determining VISL Values.

## **8. Poll RAWG Members/Open Discussion**

Radon information for modeling pulled together for Waste Disposal Alternatives project will be included in 2016 RMD (Appendix E, similar to probabilistic modeling).

CERCLA 120(h) training session is being planned. 2016 RMD will need to include limits and information with respect to property transfer. More information will follow training.

### **Discussion Topics on Hold:**

Validation needed for closure activities [CERCLA 120(h)] (added 6/2014—further discussion on this topic depends on completing presentations to Paducah Site Lead).

Derivation of Risk-based Surface Water Effluent Limits (added 6/2014—further discussion on this topic depends on resolution of Northeast Plume Dispute).

## ATTACHMENT

NOTE: The following text (with the exception of the title) is taken directly from an e-mail sent to the Risk Assessment Working Group on February 6, 2015.

Based on e-mail comments, the meeting minutes are revised below and are now considered a resolution.

### **Risk Assessment Working Group Meeting Resolution—February 2015**

✓Gaye Brewer  
✓Nathan Garner  
✓Mike Guffey  
✓Jerri Martin  
✓Todd Mullins

Tim Frederick (comments  
provided by e-mail)

✓Rich Bonczek  
✓Martin Clauberg  
✓LeAnne Garner  
✓Joe Towarnicky

**The dermal absorption values (ABS) to use in development of no action levels (NALs) and action levels (ALs).**

**The ABS to use in the main body of a baseline human health risk assessment (BHHRA) and the ABS to use in the uncertainty calculations.**

The following was discussed as a history regarding the use of ABS values:

- 2006: In development of the Risk Methods Document, KY ABS values were used to calculate NALs, and EPA ABS values were used to calculate ALs. Baseline risks were calculated using KY ABS and then recalculated using EPA ABS.
- 2013: The Risk Methods Document used EPA ABS for both NALs, ALs, and baseline risks, with KY ABS used in uncertainty section. The 2013 version led to a misunderstanding on what was used.

Going forward, the 2015 Risk Methods Document will [continue to use EPA ABS](#) (Table B.5 of Risk Methods Document) for [inorganics with published values in RAGs Part E](#) for baseline risk and NAL/AL calculations; KY ABS will be used in uncertainty calculations. [Additionally, the uncertainty section will include a comparison of NALs using EPA ABS values and KY ABS values. If a chemical is eliminated from consideration as a contaminant of concern based on dermal assumptions, it should be clearly communicated in the risk assessment.](#)

The draft 2015 Risk Methods Document needs to be revised to be clear with the points discussed above. Sections 4 and 5 of the draft document should include this understanding. (Since the text already is with the Risk Assessment Working Group for comment, please provide comments where you feel necessary. Additionally, places for revision will be noted in the upcoming Quarterly meeting.)

It was noted [during the meeting](#) that the “outdoor worker” can assume exposure to subsurface soils outside the fence. The “excavation worker” also could be used outside the fence.

## Risk Assessment Working Group Meeting Minutes—June 2015

✓Gaye Brewer  
✓Mike Guffey  
✓Jeri Higginbotham  
✓Jerri Martin

✓Jon Richards

✓Rich Bonczek  
✓LeAnne Garner  
✓Bobette Nourse

1. **Call for Issues from Risk Assessment Working Group (RAWG) Members**
2. **Remaining Fiscal Year 2015 Schedule/Work Plan**

The remaining fiscal year (FY) 2015 schedule has been updated for dates.

<i>Submit Final Ecological (Eco) Risk Methods Document (RMD) (DOE/LX/07-0107&amp;D2/R1/V2) to FFA managers for approval</i>	<i>5/28/2015</i>
Quarterly Meeting (June)	6/17/2015
<b>Submit Human Health (HH) RMD to FFA Managers (DOE/LX/07-0107&amp;D2/R5/V1)</b>	<b>6/26/2015</b>
<i>FFA managers approve final Eco RMD (DOE/LX/07-0107&amp;D2/R1/V2)</i>	<i>6/22/2015</i>
<b>FFA Managers approve HH RMD (DOE/LX/07-0107&amp;D2/R5/V1)</b>	<b>7/17/2015</b>
Quarterly Meeting (September)	9/16/2015

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 p.m. (eastern)  
*Italics indicate Eco RMD schedule.*

3. **Ecological Risk Methods Document**

Kentucky comments were received. Jon Richards was checking with Brett Thomas on the status of EPA's review. Depending on EPA's comments, replacement pages may be sent for the Eco RMD.

4. **Human Health Risk Methods Document**

RAWG comments to the 2015 HH RMD were discussed. The entire list is found in the [Attachment](#). No significant comments were received during DOE internal review.

5. **Use of EPA RSLs as the basis for project action levels in upcoming potential vapor intrusion work**

Based on Jeri Higginbotham's comments, June 2015 meeting minutes are considered final as revised. Revisions to the table discussed in that meeting for Appendix E were sent to RAWG on 4/20/2015 and are included in the 2015 HH RMD.

Additionally, the 2016 revision of the HH RMD will include the vapor intrusion screening level (VISL) calculator and guidance to scoping and baseline sections. Other items to be updated in the 2016 HH RMD include air concentrations and equations.

## 6. RAWG Schedule/Work Plan for FY 2016

Suggested draft plan: This plan, including all dates, will be discussed by the RAWG at the September 2015 Quarterly Meeting.

Submit Work Plan (this schedule)	6/17/2015
Quarterly Meeting (September)	9/16/2015
Approve Work Plan (this schedule) by e-mail	10/30/2015
Submit HH Appendix A (Preliminary Remediation Goals) to RAWG for Review	11/12/2015
Quarterly Meeting (December)	12/2/2015
Submit Revised HH Main Text and HH Appendices B-E to RAWG for Review	12/11/2015
Comments Due for HH Appendix A	1/5/2016
RAWG Approve HH Appendix A	2/12/2016
Comments Due for HH Main Text and HH Appendices B-E	2/12/2016
Quarterly Meeting (March)	3/2/2016
RAWG Approve HH Main Text and HH Appendices B-E	4/11/2016
Submit Entire Revised HH RMD to RAWG for Review	4/18/2016
Comments Due for Entire Revised HH RMD	5/16/2016
Quarterly Meeting (June)	6/1/2016
<b>Submit HH RMD to FFA Managers (DOE/LX/07-0107&amp;D2/R3/V1)</b>	6/13/2016
<b>FFA Managers Approve HH RMD (DOE/LX/07-0107&amp;D2/R3/V1)</b>	7/17/2016
Quarterly Meeting (September)	9/7/2016

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (central), 9:30 a.m.–12:00 a.m. (eastern)

Note that an update for the Eco RMD is not planned for FY 2016, unless Region 4 has new guidance. Any topics that need to be included as part of the FY16 Work Plan, especially in regard to updating in the Eco RMD and/or the HH RMD, should be e-mailed to LeAnne for discussion at the September 2015 Quarterly Meeting.

## 7. Update on CERCLA 120(h)

Previously topic on hold: “Validation needed for closure activities [CERCLA 120(h)] (added 6/2014 – further discussion on this topic depends on completing presentations to Paducah Site Lead).”

- Additional information regarding training.
- Additional information regarding “validation needed for closure activities.” and “RMD will need to include limits and information with respect to property transfer.”
- Additional information regarding roles of the Paducah Site Lead, the FFA Managers, and the RAWG.

From March 2014 Meeting Minutes:

### **Validation needed for closure activities [CERCLA 120(h)]**

Typical validation (i.e., 3<sup>rd</sup> party validation) currently is 10%. What is appropriate for closure activities? RAWG will develop a recommendation during the next quarterly meeting. Also, DOE agreed to ask the PGDP Site Manager about scheduling a CERCLA 120(h) training.

From June 2014 Meeting Minutes:

**Validation Needed for Closure Activities [CERCLA § 120(h)]**

RAWG will have input regarding closure activities. Typical validation at Paducah (i.e., 3rd party independent data validation) that is done on a project basis and is between 5–20%; it is not a recommendation on a programmatic basis.

LATA Kentucky is preparing a paper regarding validation that will be provided to the RAWG soon for informational purposes only. This subject will be discussed further after receipt of the paper.

Rich Bonczek is planning CERCLA § 120(h) training.

From March 2015 Meeting Minutes:

CERCLA 120(h) training session is being planned. 2016 RMD will need to include limits and information with respect to property transfer. More information will follow training.

DOE does plan to transfer property prior to shutdown similar to what was done at K-25. DOE plans a training session during which Leslie Cusick describes experiences with property transfer in Oak Ridge. DOE PPPO is aware that the Paducah FFA lays out specific actions that must be followed as part of property transfer. The RAWG discussion is not in regard to these required actions.

An environmental assessment (EA) on property transfer at Paducah is forthcoming. Parcels currently in mind for transfer would be clean transfers.

**8. Poll RAWG Members/Open Discussion**

The on-hold topic, “Derivation of Risk-based Surface Water Effluent Limits,” (added 6/2014 – because further discussion on this topic depends on resolution of Northeast Plume Dispute) may require a separate working group.

## Attachment

### Comments to the *DRAFT* 2015 Risk Methods Document by the Risk Assessment Working Group

#	Commenter	Location Main Text	Comment	Resolution
1	DOE (Bobette)	General	Somewhere in the Main text of this document; perhaps in the uncertainty section or in data evaluation methods = Section 3.3.3. Please include the generic PARCCS discussion (in a text box or as a subsection) that was part of the recent 2015 Paducah Site-wide SER document.	To be added to the list to discuss for next revision.
2	DOE (Rich)	Section 3.3.1.1, page 3-13, 1 <sup>st</sup> bullet	I think these are superseded by “Region 4 Human Health Supplemental Guidance” January 2014, available at <a href="http://www.epa.gov/region04/superfund/programs/riskassess/riskassess.html">http://www.epa.gov/region04/superfund/programs/riskassess/riskassess.html</a> .	Revised.
3	DOE (Rich)	Section 4.1.2.1, 1 <sup>st</sup> full para, “impacts of continuation the”	This needs to be either “impacts of continuation of the” to be consistent with the series.	Revised.
4	DOE (Rich)	Section 4.1.4, 2 <sup>nd</sup> para, “FS follow”	To be consistent with the tone of the paragraph, this should probably be “FS will follow.”	Revised.
5	DOE (Bobette)	Section 4.1.4.2, last sentence	Consider replacing “so” with “such.”	Revised.
6	DOE (Rich)	Section 4.2.2, page 4-9, 1 <sup>st</sup> line	This sounds as if we are taking risk information and not a table format from the guidance. Consider, “In most cases, the tabular format in EPA 1999b will be used to present risk assessment/evaluation results in the ROD;”	Revised.
7	DOE (Rich)	Section 4.2.3, page 4-9, 1 <sup>st</sup> para, “in addition”	For readability, this should probably be “Thirdly” (YUCK!) or “Finally.”	Revised.
8	DOE (Rich)	Section 4.2.3, page 4-9, 1 <sup>st</sup> para, “The methods...”	Recommend new paragraph here. This is a new subject (i.e., details of the residual risk assessment).	Revised.

9	DOE (Bobette)	Section 4.2.3, where change was made	Suggest replacing “from sources” to: “from a source (or multiple sources)”.	Revised.
10	DOE (Rich)	Section 4.2.3, page 4-9, 1 <sup>st</sup> para, last sent “will”	I found this sentence confusing. Consider if “should” is better here.	Revised.
11	DOE (Rich)	Section 5	If appropriate, add new EPA Region 4 reference and delete old EPA Region 4 reference.	Revised.
<b>Appendix A</b>				
12	DOE (Rich)	Page A-4 #8	Consider adding a comma here for readability and clarification because the ED/EF apply to both locations (i.e., “area, for”).	Added.
13	DOE (Rich)	Table A.1 (and others)	If we can fit it in, I think the very important note concerning the significant COPCs should be included as a note here. That is, add “Values in this table are for significant COPCs for PGDP. Values for other chemicals can be obtained using the Risk Assessment Information System (RAIS) online calculator, as modified using PGDP-specific inputs.” as a note to all the AL/NAL tables.	Added.
14	DOE (Bobette)	Table A.4	Please explain why there are values in purple, and red, and blue in a footnote or at least in the CRS package to this review. Thank you!	Red indicated the initial changes; blue indicated changes based on the ABS values for metals; and purple indicated changes for the industrial/indoor worker. No footnotes are necessary: all values will be shown in black.
15	DOE (Rich)	Table A.8 footnote, “Screening levels are based on dose conversion factors from ICRP 72 and base external ICRP 60.”	This needs to be rephrased. Something seems to be missing.	Revised.
16	DOE (Bobette)	Table A.9	For this Child Resident, the mrem/yr was dropped from 15 to 12. Hence, why are these values larger than the 2014 RMD? Is it because of the increase in ingestion rate of water from the new EPA EFs Guidance?	Suggest adding the following to the footnotes for Table A.9:  Screening levels are based on dose



			For clarity, please explain in the text with a footnote.	conversion factors from ICRP 72 and base external ICRP 60. (See Table B.3.) Screening Value = $[\Sigma 1/(\text{Pathway-Specific Action Levels})]^{-1}$ Pathway includes ingestion. (See Table B.4 for exposure parameters.)  Footnotes for Tables A.8 through A.10 have been made consistent.
17	DOE (Bobette)	Table A.11	For clarity, at the end of this sentence, please add: “; because....”  After the “because”, please briefly explain why the three DAF values are reported.	Text revised to, “Values in this table were calculated using the best available information in November 2014, following the methods shown in Table A.7b and the values presented in Table A.9 for the Adult Resident. SSL 1 indicates the soil screening level calculated for a DAF of 1. SSL 20 indicates the soil screening level calculated for a DAF of 20. SSL 58 indicates the soil screening level calculated for a DAF of 58.”
18	DOE (Bobette)	Table A.14	The CAS# for Fluoride is 16984488 and it is accidentally missing here.	Table has been revised.
		<b>Appendix D</b>		
19	DOE (Bobette)	General	Add reference to RAIS for BAFs used in equations.	Page D-3 states, “Chemical-specific values, except for those listed in Appendix B are not reflected in this Risk Methods Document. See the RAIS website for additional information ( <a href="http://rais.orml.gov/">http://rais.orml.gov/</a> ).”
20	DOE (Bobette)	Table D.42	I still think we should add-back the BAFs values table, in Appendix B, that use to be in Appendix B.  If we don't add it in now, we should add a reference to the last time it was in the RMD: i.e., in 2001- Appendix D: Part 2 Chemical-specific Values. - OR a reference to where values can be found (e.g., RAIS, RESRAD, etc.)  Given the concerns with fish/water at Paducah, we should definitely include the updated BAFs table in the next revision of this document!	I disagree, but I will add it to the list to discuss for the next revision.
		<b>Appendix E</b>		
21	DOE	Table E.8	Please add the Version # for the VISL calculator, since it is soon to be	Added (Version 3.3.1)

	(Bobette)		updated by the EPA.	
22	DOE (Bobette)	Table E.8	Please add cis- and trans-1,2-dichloroethylene to this table. EPA is soon revising the toxicity values for at least one of these isomers. Also there are values for the 1st six columns and NA can be put in the other columns for now. That would make this table more complete for the next go-around with the 2016 RMD.	HI for resident and indoor worker added for trans-1,2-DCE. All other values added as "NA."
23	DOE (Bobette)	Table E.8 (Notes)	This should say, "For cis- and trans-1,2-dichloroethylene, toxicity ....."	Revised.

## Risk Assessment Working Group Meeting Minutes—September 16, 2015

Brian Begley  
Gaye Brewer  
Nathan Garner  
Jerri Martin

Tim Fredrick  
Jon Richards

Rich Bonczek  
Martin Clauberg  
LeAnne Garner  
Bobette Nourse

### 1. Call for Issues from Risk Assessment Working Group (RAWG) Members

LeAnne Garner will check on toll free or other options for meetings.

### 2. Remaining Fiscal Year (FY) 2016 Schedule/Work Plan

Quarterly Meeting (September)	9/16/2015
Approve Work Plan (this schedule)	9/16/2015*
Suggested revisions/corrections to Human Health (HH) Risk Methods Document (RMD) text should be sent to LeAnne	11/2/2015
Submit HH Appendix A (i.e., PRGs) to RAWG for Review	11/12/2015
Comments Due for HH Appendix A	1/5/2016
Quarterly Meeting (December)	12/2/2015
Submit Revised HH Main Text and HH Appendices B-E to RAWG for Review	12/11/2015
RAWG Approve HH Appendix A	2/12/2016
Comments Due for HH Main Text and HH Appendices B-E	2/12/2016
Quarterly Meeting (March)	3/2/2016
RAWG Approve HH Main Text and HH Appendices B-E	4/11/2016
Submit Entire Revised HH RMD to RAWG for Review	4/18/2016
Comments Due for Entire Revised HH RMD	5/16/2016
Quarterly Meeting (June)	6/8/2016
<b>Submit HH RMD to FFA Managers (DOE/LX/07-0107&amp;D2/R3/V1)</b>	6/13/2016
<b>FFA Managers Approve HH RMD (DOE/LX/07-0107&amp;D2/R3/V1)</b>	7/18/2016
Quarterly Meeting (September)	9/14/2016

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)

\*Approval is needed before October 31, 2015.

Note that an update for the Ecological RMD is not planned for FY 2016.

Having the review times spread out is helpful, so schedule will remain as it is. Updates were made to the quarterly meeting dates and to non-workday dates. These changes are reflected in the schedule above. Approval of this schedule, along with RMD changes contained in these minutes, is the RAWG FY 2016 Work Plan.

### 3. Revise RAWG Charter

The original charter developed in 2007 with proposed updates is found in [Attachment 1](#). Revisions were made to the membership during the meeting and are reflected in the attachment.

### 4. Revise Exposure Parameters

The following comment was received to the 2015 RMD from KY to update the following exposure parameters to be consistent with EPA guidance:

- **Dermal Contact with RGA Groundwater (showering)**
  - Child Resident: 0.71 hour/event should be changed to 0.54 hour/event (this needs to be changed in Table D.3 as well)
- **Dermal Contact with Soil/Sediment**
  - Default Industrial Worker: 0.347 m<sup>2</sup>/day should be changed to 0.3527 m<sup>2</sup>/day
  - Outdoor Worker: 0.347 m<sup>2</sup>/day should be changed to 0.3527 m<sup>2</sup>/day
  - Excavation Worker: 0.347 m<sup>2</sup>/day should be changed to 0.3527 m<sup>2</sup>/day
  - Child Resident: 0.269 m<sup>2</sup>/day should be changed to 0.2373 m<sup>2</sup>/day (this needs to be changed in Table D.5 as well)
  - Child Recreational user: 0.269 m<sup>2</sup>/day should be changed to 0.2373 m<sup>2</sup>/day (this needs to be changed in Table D.15 as well)
- **Dermal Contact with Surface Water**
  - Default Industrial Worker: 0.347 m<sup>2</sup>/day should be changed to 0.3527 m<sup>2</sup>/day (this needs to be changed in Table D.32 as well)
  - Outdoor Worker: 0.347 m<sup>2</sup>/day should be changed to 0.3527 m<sup>2</sup>/day (this needs to be changed in Table D.35 as well)
  - Excavation Worker: 0.347 m<sup>2</sup>/day should be changed to 0.3527 m<sup>2</sup>/day (this needs to be changed in Table D.35 as well)

The revisions above will be made in the upcoming RMD. Differences were due to two different versions on EPA's Web site. The Web site is being fixed so that only one version is available.

## 5. Integrated Exposure Uptake and Biokinetic (IEUBK) Model Lead Values

Regarding the following text in Appendix B of the HH RMD: "The PGDP median value for lead in surface soil from DOE 1995 (17.5 mg/kg) and the value for lead in RGA groundwater from Appendix A, Table A.13 (0.129 mg/L) should be used in place of the model default value," the question below was asked.

Why are the background concentrations in surface soil from Table A.12 (36 mg/kg) not being used?

Additional information was provided from Rich Bonczek: "The median was selected by the RAWG for the 2009 update because they felt the model needs to consider the most likely lead concentration encountered and not the upper end of the background range (i.e., 95% UTL), which would be rarely encountered."

In the meeting, it was pointed out that for the IEUBK model, median values are appropriate.

Additionally, Table B.6 values in the RMD may have been mislabeled. Updates may be made in the revised RMD, if necessary. LeAnne will check to determine whether a table was dropped or if there was a disconnect between a VF parameter table and the IEUBK model input table.

## 6. Revised Regulatory Values for the 2016 HH RMD

- EPA's Updated Ambient Water Quality Criteria for the Protection of Human Health [Federal Register Vol. 80, No. 124 (June 29, 2015)]. This value affects Table A.12 of the RMD; it should be footnoted that promulgation for Kentucky of this value will be in 2018.

- Are metals included in the recent EPA updates for AWQC (e.g., “Final 2015 Updated National Recommended Human Health Criteria”)? Tim Frederick to check and provide update at the December 2015 quarterly meeting. EPA values will be included in the RMD and referenced, as appropriate.

## 7. **Additional Values/Revisions to Include in 2016 HH RMD**

These will be discussed in the December meeting:

- Bioaccumulation factor (BAF) values will be added for Table 2.1 “Significant Chemicals of Potential Concern at PGDP” with primary references.
- Update Section 3.3.4.2 list of exposure pathways.
- Revise use of term “dose” to distinguish between radiation dose (i.e., rem) and absorbed/ administered dose (i.e., chemical and radionuclide intake).
- Revise “constituents of concern” so that terminology is consistent.
- Revise Figure 2.1, if necessary, for logic flow.
- Revise Figure 2.3, to show continuation of “Go to” boxes.
- Add note to Equation 1 (Section 2.1) that relationship is not applicable to non-linear based PRGs (e.g., Vapor Intrusion PRGs).
- Reorganize equations in Appendix D to consolidate receptors and reference Table B.4 for exposure parameters.
- Add errata section (e.g., adult body weight listed in Table D.4 of 2015 HH RMD).
- Suggested revisions/corrections to HH RMD text should be sent to LeAnne by November 2, 2015 (if FY 2016 schedule is unchanged).

Note that vapor intrusion screening levels (VISLs) were used for Paducah’s five-year review for CERCLA actions. The RMD needs to document that VISLs are the starting point for screening. There currently is a place holder for vapor intrusion in the RMD (Section 3.3.4.4). Input from the Portsmouth RMD can be included in Paducah’s RMD. Additional updates will be provided in the December 2015 quarterly meeting.

## 8. **Derivation of Risk-based Surface Water Effluent Limits – Status of discussions to resolve EPA Condition #3 on BGOU SWMUs 2, 3, 7, and 30 FS**

Part of EPA Condition #3 of the BGOU 2, 3, 7, and 30 RI/FS stated the following:

“The entries in ARARs Table F.2 for Effluent limits for radionuclides in wastewaters references the NRC regulation and DOE Order that are based upon annual dose limits (50 mrem and 100 mrem, respectively) that can (without adequate partitioning between all sources at the PGDP and application of ALARA that uses treatment) result in levels of radionuclides that EPA does not consider protective of human health and the environment. DOE must either delete these entries or alternatively add the following NOTE: to the requirements columns that states: “NOTE: Actual effluent limits for any radionuclide discharged into surface water will be established in accordance with ARARs, TBC and/or risk methodologies and listed in the ROD. Such limits must be within EPA’s generally accepted risk range under CERCLA and derived in a manner consistent with the designated use classifications of the receiving surface water body. These limits may be technology based and/or based upon ambient water quality equivalent levels derived using EPA and KY standard methodology used for calculating ambient water quality criteria.” In addition, Section 2.4.1.9.2 and Section F.4.5 Waste

Water Treatment must be revised to include language consistent with this condition and the explanatory NOTE language. EPA recognizes that resolution of the formal dispute for the Northeast Plume ESD related to Tc-99 discharges and/or the resolution of the Stop Work Order issued by EPA on accumulated radioactively contaminated water in the Bldg. C-410 basement may be relevant to how the FFA parties decide to address effluent limits for radionuclides in wastewater discharged into surface waters.”

DOE is calculating values for potential limits. Assumptions are incorporated into the calculations, including those for a mixing zone. Currently, calculation will use Outfalls K001 and K002 in mixing zone calculations because they are the northernmost outfalls on each side of the plant.

Additional meetings on a project-specific basis are being planned. There will be a follow-up to this item at the December 2015 quarterly meeting.

**9. Status of CERCLA 120(h) Informational Briefing in Regard to Property Transfer Requests and Activities.**

Rich Bonczek gave an update as follows:

A programmatic meeting will be held next week with Paducah and Portsmouth (DOE and contractors). Lesley Cusick (Remediation Services, Inc.) is providing training. Rich hopes to have training for the Paducah Site including KY and have presentations from EPA with respect to CERCLA 120(h) and its implementation in Oak Ridge. The training may be provided during November 2015, hopefully in Lexington.

DOE is hoping to transfer unimpacted properties that do not affect DOE’s mission. The definition of unimpacted is in the statute.

**10. Poll RAWG Members/Open Discussion**

The Paducah RMD is a helpful tool.

# Attachment 1

## Risk Assessment Working Group Charter

(Developed in 2007, Revised in 2015)

1. **Working Group's Official Designation (Title):** Paducah Gaseous Diffusion Plant (PGDP) Risk Assessment Working Group (RAWG)
2. **The RAWG will be composed of members from the following agencies**
  - a. Commonwealth of Kentucky, Cabinet for Health and Family Service, Department for Public Health, Radiation Health Branch (KY RHB)
  - b. Commonwealth of Kentucky, Energy and Environment ~~al & Public Protection~~ Cabinet (KEEC), Department for Environmental Protection (KDEP)
  - c. U.S. Environmental Protection Agency (EPA) Region 4 ~~Federal Facilities Branch~~, Superfund Division
  - d. U.S. Department of Energy (DOE) Portsmouth/Paducah Project Office (PPPO)
  - e. ~~U.S. Fish and Wildlife Service (Ecological Risk)~~
  - f. ~~Paducah Remediation Services~~ DOE Prime Contractor
3. **Workgroup Objectives:** The ~~Risk Assessment Work Group (RAWG)~~ was established as a working group to promote the efficient application of the human health and ecological risk assessment and risk evaluation processes at ~~the~~ PDGP. ~~In the near term, t~~This will be accomplished through ~~the an~~ annual revision of Risk Methods Documents for the assessment and evaluation of Human Health (Volume I) and, as needed revision of Ecological Risk Assessment (Volume II). ~~Over the longer term, t~~The RAWG will share information and help ensure the preparation of consistent and defensible risk assessments and risk evaluations prepared for ~~the~~ PDGP.

The Risk Methods Document states the following:

The RAWG is a multiagency, multidisciplinary group tasked with meeting the following goals:

  - Produce tools that can be used to prioritize remedial activities at the PGDP.
  - Develop methods to complete risk evaluations for the PGDP.
  - Make the results of the risk assessments and evaluations at the PGDP more useful to risk managers.
  - Enhance risk communication between the producers of risk assessments and risk evaluations and the users of this information (e.g., risk managers).
4. **Official(s) to Whom the Committee Reports:** The RAWG will submit the final reports to the Federal Facilities Agreement designated officials ~~Managers~~ from EPA Region 4, ~~the Department of Energy~~ DOE, ~~the U.S. Fish and Wildlife Service~~, and ~~the Commonwealth of Kentucky~~ KDEP for acknowledgement or approval, as appropriate.

5. **When revising the Risk Methods Documents, the RAWG will perform the following tasks**~~In the near term the RAWG will develop revisions to the Risk Method documents.~~

~~This will include completion of the following tasks:~~

- Propose policies, procedures, tools, methodologies, and guidance for implementing sound risk assessments and evaluations.
- Develop and recommend initiatives, methodologies, and strategies that will support the use of sound risk assessment and evaluations tools and processes.
- Share lessons learned, and experiences and develop recommendations for the most efficient and cost-effective approaches.
- Promote the integration of both ecological and human health risk assessments and evaluations throughout the environmental management process.
- Clearly delineate risk assessment issues from risk management concerns.
- Reach consensus in methods for measuring and describing cancer risks or risks of other chronic health effects from exposure to hazardous substances considering such alternative approaches as the lifetime risk of cancer or other effects.
- Identify methods to reflect uncertainties in measurement and estimation techniques, including the existence of synergistic or antagonistic effects among hazardous substances.



## Risk Assessment Working Group Meeting Minutes—December 2, 2015

✓Brian Begley  
✓Gaye Brewer  
✓Stephanie Brock  
✓Nathan Garner  
✓Mike Guffey  
✓Jeri Higginbotham  
✓Jerri Martin

✓Julie Corkran  
✓Tim Fredrick  
✓Jon Richards

✓Rich Bonczek  
✓Martin Clauberg  
✓LeAnne Garner  
✓Bobette Nourse  
✓Joe Towarnicky

### 1. Call for Issues from Risk Assessment Working Group (RAWG) Members

### 2. Remaining Fiscal Year (FY) 2016 Schedule/Work Plan

Quarterly Meeting (December)	12/2/2015
Submit Revised Human Health (HH) Main Text and HH Appendix D to RAWG for Review*	12/11/2015
Comments Due for HH Appendix A and B	1/5/2016
RAWG Concur with HH Appendix A and B	2/12/2016
Comments Due for HH Main Text and HH Appendix D*	2/12/2016
Quarterly Meeting (March)	3/2/2016
RAWG Concur with HH Main Text and HH Appendix D*	4/11/2016
Submit Entire Revised HH Risk Methods Document (RMD) to RAWG for Review	4/18/2016
Comments Due for Entire Revised HH RMD	5/16/2016
Quarterly Meeting (June)	6/8/2016
Submit HH RMD to Federal Facility Agreement (FFA) Managers (DOE/LX/07-0107&D2/R7/V1)	6/13/2016
FFA Managers Acknowledge Receipt of HH RMD	7/18/2016
Quarterly Meeting (September)	9/14/2016

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)

\*This is changed slightly from the original. Appendix B was sent with Appendix A. Appendix C does not contain changes, and the only change to Appendix E (currently) is the addition of working group meeting minutes that already have been reviewed. [Note: Also see Item 3, information regarding use of nondetect (ND) results also may be added; but if it is added, it will be reviewed separately.]

### 3. Discussion of Revisions to the 2016 HH RMD

- **Use of Nondetects in 95% UCL of the arithmetic mean (UCL95) Calculation** (*taken from comments to the Soils Operable Unit (OU) Remedial Investigation (RI) 2 Report*)

“It appears that no distinction was made between detected and nondetected values when calculating an [exposure point concentration (EPC)] for each EU. According to the ProUCL Version 5.0.00 User Guide (USEPA, 2013), ‘[a]ll ND observations in ProUCL are identified by the value ‘0’ of the indicator variable used in ProUCL to distinguish between detected (=1) and nondetected (=0) observations. It is the users’ responsibility to supply correct numerical values for NDs (should be entered as the reported detection limit or RL values) and not as qualifiers (e.g., J, U, B, UJ, ...) for ND observations in the data set.’ Although this may be due to the way some of the grid values were derived (e.g., as an average of the grid values present), it results in considerable uncertainty.”

Currently, the HH RMD does not specifically state what to do with NDs.

Below are a few excerpts from the text, for reference.

Page 3-18:

Chemicals. The sample quantitation limits for each analyte and sample will be examined to determine if these limits were below the concentration at which the analyte may pose an unacceptable risk or hazard to human health. If the maximum sample quantitation limit for an analyte (over all samples within a medium) is greater than the concentration that may pose an unacceptable risk or hazard to human health, and the analyte is not detected in any sample, then the data for that analyte will be deemed suspect. Data from these analytes will not be used quantitatively in the risk assessment, but the potential risk or hazard from exposure to media potentially containing these analytes will be examined qualitatively. In developing the qualitative assessment for these data, the maximum quantitation limit for the analyte (in all samples from a medium) will be compared to the appropriate no action residential PRG if historical or process information indicates that the analyte potentially could be present. One-half the maximum quantitation limit for the analyte (in all samples from a medium) will be used in this comparison if historical or process information indicates that the analyte is not expected to be present.

Page 3-19:

**Step 4: Evaluation of data qualifiers and codes.** ...Specifically, if chemical data are qualified 'B,' and the value is less than that defined by the '5 and 10X's Rule,' then the data will be assumed to be a nondetect and the reported value will be used to derive the EPC.

Pages 3-19 and 3-20:

**Step 5: Elimination of analytes not detected.** Generally, any chemical not detected in at least one sample from a medium will be deleted from the data set. Any radionuclide for which no analytical results exceed its MARLAP MDC also will be deleted from the project dataset, provided the MDC is an acceptable level for the project. If a chemical analyte is suspected of being present at very low concentrations (i.e., below the quantitation limit) due to cross-media contamination or is suspected of being present based on historical or process information, the analyte may remain in the data set even though the analyte was not detected. In this case, the concentrations used to determine the representative or EPC for the analyte will be the sample quantitation limits for the analyte in the medium. For classes of analytes such as polycyclic aromatic hydrocarbons (PAHs), PCBs, and dioxins/furans, if one compound is detected at a concentration greater than a screening value and is identified as a COPC, then others in that class will be assumed to be present as well. The method used to analyze these classes of compounds is presented later in this section.

Text box page 3-26:

If the SWMU/exposure unit combination had less than 10 grids, the maximum grid result was used as the EPC. If the SWMU/exposure unit combination had 10 or more grids, the grid values were used to determine the EPC. Grid values were determined following guidance in the work plan. Basically, the maximum detected result from within the grid applies to the grid. If not detected, the minimum detection limit applies to the grid.

Footnote Page 4-6 recognizes that uncertainty in detection needs to be addressed:

9 "Preliminary remediation goals...may be revised...based on the consideration of appropriate factors including, but not limited to: exposure factors, uncertainty factors, and technical factors. Included under exposure factors are: cumulative effect of multiple contaminants, the potential for human exposure from other pathways at the site, population sensitivities, potential impacts on environmental receptors, and cross-media impacts of alternatives. Factors related to uncertainty may include: the

reliability of alternatives, the weight of scientific evidence concerning exposures and individual and cumulative health effects, and the reliability of exposure data. Technical factors may include: detection/quantification limits for contaminants, technical limitations to remediation, the ability to monitor and control movement of contaminants, and background levels of contaminants. The final selection of the appropriate risk level is made when the remedy is selected based on the balancing of criteria....” [taken from the National Contingency Plan Preamble: Exposure, Technical, and Uncertainty Factors (55 Fed. Reg. 8717, March 8, 1990)]. Also, see RAGS Volume 1, Part B, Section 2.3 and 2.8 (EPA 1993a) and OSWER Directive 9355.0-30, “Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions” (EPA 1990a).

Discussion during the meeting was the following:

- An example for polychlorinated biphenyls (PCBs) is as follows: Although the maximum detected value for SWMU 13 is 1.25 mg/kg, but the EPC is 10.76 mg/kg. The result is that risk values appear higher than they actually are.
- Datasets may need to be subdivided into contaminated and noncontaminated areas in the case where there are numerous NDs and few detects of significant concentration.
- Page 2-11 of the Ecological RMD states the following:

For all activities conducted as part of Step 3a of PGDP ERAs, mean and 95% UCL concentrations for detected substances are calculated using ProUCL.<sup>2</sup> Site concentration data for PGDP sites are those data present in Paducah OREIS. All relevant concentration data for a site should be gathered and entered into Paducah OREIS before conducting Step 3a. Site concentration data used in ERAs and other ecological risk activities must be qualified as valid. An important consideration is the relationship between detection limits and benchmarks. Also, the appropriateness of using statistical manipulation of data must be considered in relation to the number of samples.

<sup>2</sup> If results from ten or more samples are available, then the most recent version of EPA’s ProUCL software will be used to determine the 95% UCL concentration. The value selected as the 95% UCL concentration will be the value recommended by ProUCL, noted as the “Suggested UCL to Use.” EPA’s ProUCL software (available at [www.epa.gov/osp/hstl/tsc/software.htm](http://www.epa.gov/osp/hstl/tsc/software.htm)) incorporates a number of different distributional tests that may be used to perform the distributional tests and calculates the most appropriate 95% UCL (EPA 2013). An exception to use of ProUCL is when a sample contains a small fraction of nondetects (i.e., no more than 10–15%), simple substitution of half the reporting limit is generally adequate (EPA 2009).

- There are two issues: how to deal with non-detects and the determination of the EPC using ProUCL with the NDs being used as if they were detected values.
- There is not a good way to handle NDs within the dataset. In the 1990s, a proxy value of half the SQL was used for NDs. Several software solutions tried to account for NDs by handling it in different ways. After the earlier software, ProUCL was designed; but still there is not a good way to handle NDs. Use of “1s” and “0s” is believed to be new, beginning with ProUCL Version 4.
- For Soils OU RI 2, ProUCL Version 5 was used and all grid values were assumed to be detects. If there are not enough “1s,” ProUCL in general will not return a value.

— Additional information regarding the statistics may be added to Appendix E. Martin, Bobette, and LeAnne will work on the issue; if added to the 2016 RMD, Appendix E, the draft text will be presented at the next quarterly meeting.

- **Use of UCL95 if Greater than Maximum Detect** (*taken from comments to the Soils OU RI 2 Report*)

“...‘[i]n some instances, ProUCL (Version 5.0) will calculate the UCL95 as greater than the maximum value. In these cases, the UCL95 was used at [sic] the EPC.’ We do not recommend using a 95% UCL value that is greater than the maximum detected concentration.”

Below are a few excerpts from the text, for reference.

Pages 3-26 and 3-27:

(2) If results from ten or more samples are available, then the most recent version of EPA’s ProUCL software version of EPA’s ProUCL software will be used to determine the EPC. The value selected as the EPC will be the value recommended by ProUCL, noted as the “Potential UCL to Use.” EPA’s ProUCL software<sup>7</sup> incorporates a number of different distributional tests that may be used to perform the distributional tests and calculates the most appropriate EPC (EPA 2013).

Page 3-27:

In determining the UCL when the medium is groundwater...If the 95% UCL is greater than the maximum detected concentration, EPA guidance recommends that the EPC default to the maximum detected concentration for that contaminant.

Discussion during the meeting included the following:

- The maximum is a value representative of the sample from the population. As such, it is incorrect to compare the UCL95 on the mean to the max of the sample to select the EPC. Language from the current ProUCL manual is included at the end of these minutes.
- Ensure that the 2016 HH RMD states that this condition (i.e., use of an EPC greater than the maximum detected value) is identified as an uncertainty in risk assessments. Use of an EPC greater than the maximum detected values errs on the side of caution. Further, ground-truthing in setting up cleanup levels is expected.
- Excerpt from page 3-27 is in reference to samples collected from within the same groundwater well. Tim looked into the latest EPA guidance, *Determining Groundwater Exposure Point Concentrations*, OSWER Directive 9283.1-42, February 2014. The guidance does still recommend defaulting to the max detect for groundwater) rather than the UCL for determination of the EPC. Additional discussion of the issue will take place during the March 2016 Quarterly Meeting.
- PCB test kits with higher detection limits may need to be further evaluated. For the role of the RMD, there needs to be a consistent method of dealing with that data.

- **Inclusion of USGS Background Values for Lithium and Molybdenum** (*taken from comments to the Soils OU RI 2 Report*)

“In 2013, the U.S. Geological Survey published, ‘Geochemical and mineralogical data for soils of the conterminous United States: U.S. Geological Survey Data Series 801’ Smith et al., 2013). Data tables can be accessed at <http://pubs.usgs.gov/ds/801/downloads/>.”

The question was asked if we can add background values for these elements. The HH RMD states non-site-specific background values can be used if site-specific values are not available (see p. 3-20, “Analytes retained as COPCs, however, may be considered with the full range of background as part of the uncertainty analysis.”) Add USGS reference to list of references in RMD, but not to table of values.

- **Use of ROPC/COPC in RAGs** (*input from Tim Frederick*)  
from [https://trainex.org/moreinfo/Radiation\\_Risk\\_Assessment\\_2015.pdf](https://trainex.org/moreinfo/Radiation_Risk_Assessment_2015.pdf).  
The 2016 HH RMD will define COPCs as inclusive of chemicals and radionuclides in one or more places.
  - **Revisions Mentioned Last Quarter**
    - Bioaccumulation factors (BAFs) for Fish have been added to Appendix B. Other BAFs will not be included in Risk Methods Document, since they are not used for annual preliminary remediation goal (PRG) development and will need verification prior to use. Appendix D will list of references providing BAFs with the equation. These likely will include the Risk Assessment Information System and RESRAD technical document.
- Changes to BAF as a result of project-specific information will be included in future HH RMD revisions.
- Section 3.3.4.2 exposure pathways have been updated.
  - Use of term “dose” has been revised to distinguish between radiation dose (i.e., rem or mrem) and absorbed/ administered dose (i.e., chemical and radionuclide intake).
  - “Constituents of concern” has been revised so that terminology is consistent.
  - Figures 2.1 and 2.3 have been revised slightly.
  - Note has been added to Equation 1 (Section 2.1) that relationship is not applicable to non-linear based PRGs (e.g., Vapor Intrusion PRGs).
  - Information has been included in Section 3.3.4.4 (previously a placeholder) for vapor intrusion.

*Suggested text to add is the following:*

Analysis of the exposure pathway for vapor intrusion due to volatile organic compound (VOC)-contaminated soils and groundwater will be evaluated on a project-specific basis, as needed. This potential exposure pathway is often considered in order to support possible future industrial missions within the PGDP industrialized area. Redevelopment with the potential for inhabited structures to be located in areas where VOC-contaminated groundwater and soil exists or has existed is considered a reasonable future use.

VISLs are risk-based screening levels used to identify sites or buildings likely to pose a health concern through the vapor intrusion pathway. The EPA VISL calculator is located on the Web site [http://www2.epa.gov/sites/production/files/2015-09/visl-calculator\\_v\\_343\\_0.xlsm](http://www2.epa.gov/sites/production/files/2015-09/visl-calculator_v_343_0.xlsm). Please refer to Table E.8 in Appendix E for vapor intrusion risk information. At sites where subsurface concentrations of vapor-forming chemicals fall below VISLs, no further action or study is warranted (EPA 2015). Conversely, exceeding a VISL generally suggests that further evaluation of the vapor intrusion pathway or a response action is appropriate.

EPA 2015. *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*, OSWER 9200.2-154, Office of Solid Waste and Emergency Response, Washington, DC, June.

Revisions to the text were recommended during the meeting and are reflected as redline in the text above. It was noted that the text still has not been through internal reviews, so the suggested text will be similar to, but may not be exactly, what appears in the HH RMD.

- Equations have been reorganized in Appendix D to consolidate receptors and reference Table B.4 for exposure parameters.
- No errata section has been added, since document is revised annually.

**4. Questions/Comments on Appendix A or Appendix B?**

Sent to RAWG for review on 11/12/2015; comments due 1/5/2016.

**5. Derivation of Risk-based Surface Water Effluent Limits**

Status of discussions to resolve EPA Condition #3 on BGOU SWMUs 2, 3, 7, and 30 FS and condition on Waste Disposal Alternative regarding effluent.

A white paper was submitted to FFA Managers in early November 2015. Further activity is pending.

**6. Status of CERCLA 120(h) Informational Briefing in Regard to Property Transfer Requests and Activities. *(input from Rich Bonczek)***

Paducah-Area Community Reuse Organization has requested disposition of property from DOE. DOE has begun briefing their management regarding implementation of transfer under 10 CFR 770 at Oak Ridge. The following activities are ongoing,

- Training sessions for contractors and DOE staff at both Paducah and Portsmouth.
- Training session for legal at Portsmouth/Paducah Project Office (PPPO).
- Development of a protocol and, subsequently, a procedure for clean parcel transfer.
- Meetings with DOE-Oak Ridge Operations (and others) regarding PPPO plans and lessons learned.

The only items/areas expected to be transferred in the near term are those that are “clean and unimpacted.”

Informational briefing for KY and EPA originally hoped to be presented in November 2015 is delayed to February or March 2016.

“Clean parcel transfer” is addressed in CERCLA Section 120(h)(4). See the following for additional information: <http://www2.epa.gov/fedfac/guidance-epa-concurrence-identification-uncontaminated-parcels-under-cercla-section-120-h4>

The activities of the RAWG are anticipated to intersect with the risk evaluation component of the clean parcel land release. RAWG involvement in the process will likely only commence once a path forward is established by the FFA Managers. DOE is offering the informational briefing to the RAWG to inform the technical SMEs of the overall CERCLA 120(h) process.

## 7. Poll RAWG Members/Open Discussion

Exposure factors are in Table B.4 (included in Appendix B), comments due 1/5/2016.

Meeting minutes for this meeting can be expected by the RAWG by 12/9/2015.

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From Item 3, Bullet 2, below is an excerpt from the current ProUCL manual *ProUCL Version 5.0.00 User Guide: Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations*, EPA/600/R-07/041, September 2013.

### *1.10.2 Use of Maximum Detected Value to Estimate EPC Terms*

Some practitioners tend to use the maximum detected value as an estimate of the EPC term. This is especially true when the sample size is small such as  $< 5$  or when a UCL95 exceeds the maximum detected values (EPA, 1992a). Specifically, the EPA (1992a) document suggests the use of the maximum detected value as a default value to estimate the EPC term when a 95% UCL (e.g., the H-UCL) exceeds the maximum value. ProUCL computes 95% UCLs of mean using several methods based upon normal, gamma, lognormal, and non-discernible distributions. In the past (e.g., EPA 1992), a lognormal distribution was used as the default distribution to model positively skewed environmental data sets; and only two methods were used to estimate the EPC term based upon: 1) normal distribution and Student's t-statistic, and 2) lognormal distribution and Land's H-statistic (1971, 1975). The use of the H-statistic often yields unstable and impractically large UCL95 of the mean (Singh, Singh, and Engelhardt, 1997; Singh, Singh, and Iaci, 2002). For skewed data sets of smaller sizes (e.g.,  $< 30$ ,  $< 50$ ,...), H-UCL often exceeds the maximum detected value. Since the use of a lognormal distribution has been quite common (e.g., suggested as a default model in a risk assessment guidance for Superfund [RAGS] document [EPA, 1992a]), the exceedance of the maximum value by an H-UCL95 is frequent for many skewed data sets of smaller sizes (e.g.,  $< 30$ ,  $< 50$ ). These occurrences result in the possibility of using the maximum detected value as an estimate of the EPC term.

It should be pointed out that in some cases, the maximum observed value actually might represent an impacted location. Obviously, it is not desirable to use a potential outlier representing an impacted location to estimate the EPC term for an AOC. The EPC term represents the average exposure contracted by an individual over an EA during a long period of time; therefore, the EPC term should be estimated by using an average value (such as an appropriate 95% UCL of the mean) and not by the maximum observed concentration. One needs to compute an average exposure and not the maximum exposure. Singh and Singh (2003) studied the performance of the max test (using the maximum observed value as an estimate of the EPC term) via Monte Carlo simulation experiments. They noted that for skewed data sets of small sizes (e.g.,  $< 10$ -20), even the max test does not provide the specified 95% coverage to the population mean, and for larger data sets it overestimates the EPC term, which may lead to unnecessary further remediation.

Today, several methods, some of which are described in EPA (2002a), are available in the various versions of ProUCL (e.g., ProUCL 3.00.02 [EPA 2004], ProUCL 4.0 [EPA 2007], ProUCL 4.00.05[EPA 2009, 2010]) to estimate the EPC terms. For data sets with NDs, ProUCL 5.0 has some new UCL (and other limits) computation methods which were not available in earlier versions of ProUCL. It is unlikely that the UCLs based upon those methods will exceed the maximum detected value, unless some outliers are present in the data set.

## Risk Assessment Working Group Meeting Minutes—February 24, 2016

✓Brian Begley  
✓Gaye Brewer  
✓Nathan Garner  
✓Mike Guffey  
✓Jeri Higginbotham  
✓Jerri Martin

✓Tim Frederick  
✓Jon Richards

✓Rich Bonczek  
✓Martin Clauberg  
✓LeAnne Garner  
✓Bobette Nourse  
✓Joe Towarnicky

### 1. Call for Issues from Risk Assessment Working Group (RAWG) Members

**Lead values:** The U.S. Environmental Protection Agency's (EPA's) regional screening level (RSL)/cleanup level is 400 mg/kg that was derived using the Integrated Exposure Uptake and Biokinetic (IEUBK) model for lead using the Center for Disease Control's (CDC's) recommendation of 10 µg/dL lead in blood. The new recommendation for lead in blood is 5 µg/dL. A new interim policy is expected. The new policy most likely will show a new RSL/cleanup level for lead at a reduction of approximately 50% (i.e., ~ 200 mg/kg). The new interim policy may be coming from Office of Land and Emergency Management (OLEM) (formerly the Office of Solid Waste and Emergency Response) this quarter. Revised values will be included in the Human Health (HH) Risk Methods Document (RMD) when available.

### 2. Remaining Fiscal Year (FY) 2016 Schedule/Work Plan

RAWG Concur with HH Appendix A and B	2/12/2016
Comments Due for HH Main Text and HH Appendix D	2/12/2016
Quarterly Meeting (March)	2/24/2016
RAWG Concur with HH Main Text and HH Appendix D	4/11/2016
Submit Entire Revised HH RMD to RAWG for Review	4/18/2016
Comments Due for Entire Revised HH RMD	5/16/2016
Quarterly Meeting (June)	6/8/2016
Submit HH RMD to Federal Facility Agreement (FFA) Managers (DOE/LX/07-0107&D2/R7/V1)	6/13/2016
FFA Managers Acknowledge Receipt of HH RMD	7/18/2016
Quarterly Meeting (September)	9/14/2016

Quarterly meetings will be Web/teleconference 8:30 a.m.–11:00 a.m. (Central), 9:30 a.m.–12:00 p.m. (Eastern)

### 3. Concurrence of HH RMD Appendices A and B (Due 2/12/2016)

- Kentucky has no further comments.
- EPA responded that they had no comments and that their concurrence was not required.

### 4. Discussion of Comments Received to the 2016 HH RMD Main Text and Appendix D (Due 2/12/2016)

- Term “radiological activity concentration” revised to “activity concentration” in Appendix D and throughout the rest of the document in order to go with the standard terminology.
- Kentucky, EPA, and U.S. Department of Energy (DOE) have no other comments at this time.



## **5. Follow-up on EPA Guidance Regarding Groundwater Exposure Point Concentration (EPC)**

The text in the draft 2016 HH RMD states the following: “If the 95% [upper confidence limit (UCL)] is greater than the maximum detected concentration, EPA guidance recommends that the EPC default to the maximum detected concentration for that contaminant.”

Ensure whether the 95% UCL being greater than the maximum detected concentration is included in the list of uncertainties. [LeAnne followed up with this; and it was added to the list of uncertainties for this draft (page 3-44 of the main text), based on the December 2, 2015, RAWG Meeting Minutes.]

Text in draft 2016 HH RMD has been revised to include the following in Section 3.3.4.3 (page 3-27): “The RAWG has concluded that the 95% UCL should be used as the EPC and if the 95% UCL exceeds the maximum detected concentration, then the uncertainty needs to be discussed in the uncertainty section of the risk assessment.”

## **6. Discussion on Polychlorinated Biphenyl (PCB) Test Kits/Higher Detection Limits**

From the December 2015 quarterly meeting, discussion was held with respect to UCL95 values being greater than the maximum detect. The meeting minutes state, “PCB test kits with higher detection limits may need to be further evaluated. For the role of the RMD, there needs to be a consistent method of dealing with that data.”

Follow-up on topic from the December 2015 meeting: “Additional information regarding the statistics may be added to Appendix E. Martin, Bobette, and LeAnne will work on the issue; if added to the 2016 RMD, Appendix E, the draft text will be presented at the next quarterly meeting.”

Recommended text for the main text of the RMD is found in the [attachment](#). No text is recommended for Appendix E.

Additionally with respect to PCB test kits with higher detection limits, the project teams will need to address the uncertainty if EPCs are inconsistent with maximum detected results, which may include getting additional sampling/analytical data. Detection limits of the PCB test kits [and similarly uranium for the X-ray fluorescence (XRF)] must be below levels consistent with expected cleanup levels; whether the kits’ detection limits are adequate should be addressed by the project teams during scoping. [LeAnne followed up on this. Section 3.3.3.2 of the main text (page 3-17) contains information regarding XRF and PCB test kit data. Additional information (from above) will be added for comment to the version scheduled for review beginning 4/18/2016.] Additionally, these requirements will be evaluated for inclusion in the Programmatic Quality Assurance Project Plan (QAPP).

## **7. Ecological RMD: Future Addition of Reference**

January’s “TechDirect” listed the information below. This information could be applied to Paducah’s Ecological RMD because it provides justification for the soil and sediment sampling depth for ecological risk assessment. Reference says 0–1 ft bgs sampling for soils and 0–6 inch sampling for sediment should be targeted [EPA 2015. *Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological Risk Assessments (Final Report)*. U.S. Environmental Protection Agency, Ecological Risk Assessment Support Center, Cincinnati, OH, EPA/600/R-15/176].

**Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological Risk Assessments.** Ecological risk assessors frequently are faced with the challenge of defining the biologically active zone, or biotic zone, in soils and sediments during the design and interpretation of soil and sediment sampling programs. With respect to terrestrial assessments, this study uses a meta-analysis approach to quantify the zone of highest biological activity for soil-dwelling ecological receptors commonly utilized in ecological risk assessments. For decisions related to ecological assessment or remediation in aquatic scenarios, we develop practical default values for the depth of the biotic zone (i.e., biologically relevant sampling depth) in various habitats based on the 80th percentile of abundance or biomass depth distributions. In areas populated by a high density of deep dwelling organisms, such as those listed in this paper, the biotic zone may be somewhat deeper than our recommended values. View or download at <http://cfpub.epa.gov/ncea/erasc/recorddisplay.cfm?deid=310058>.

This information is being considered applicable to the Ecological RMD (i.e., informally included) now, and will be included formally in the Ecological RMD during its next revision.

#### **8. Ecological RMD: Metadata Required for Sampling**

Several metadata are required for sampling to better interpret ecological impacts from metals analyses. For example, for project scoping meetings and the next Ecological RMD update will address these metadata. Metadata include soil pH for aluminum screening and water hardness for metals screening in water.

These requirements will be incorporated into Programmatic QAPP revisions, project-specific QAPPs, and eventually into the Ecological RMD when it is updated.

LeAnne has checked the Surface Water Operable Unit (off-site) Work Plan to ensure these parameters are captured. The work plan is available in the EIC at the following link: <http://paducaheic.com/Search.aspx?accession=env 1.A-00222>, and states the following:

All bioaccumulation tests will be analyzed for metals, radionuclides, PAHs, geotechnical (10% of surface samples), and PCBs. Geotechnical parameters include Total Organic Carbon (TOC), grain size, bulk density, % solids, pH, and moisture content.

Surface water samples will be analyzed for metals, radionuclides, and physical parameters (e.g., pH, hardness, dissolved oxygen, conductivity, temperature, and turbidity).

#### **9. Ecological RMD: Use of ProUCL**

In the next revision of the Ecological RMD (page 2-11, footnote 2), additional text from Item 6 could be added for consistency. Jeri Higginbotham is double-checking whether this is appropriate.

#### **10. Derivation of Risk-based Surface Water Effluent Limits**

Status of discussions to resolve EPA Condition #3 on Burial Grounds Operable Unit (BGOU) Solid Waste Management Units (SWMUs) 2, 3, 7, and 30 Feasibility Study (FS) and condition on Waste Disposal Alternative regarding effluent.

BGOU SWMUs 2, 3, 7, and 30 FS and Waste Disposal Alternative Remedial Investigation/FS are in formal dispute right now. Derivation of the surface water effluent limits is pending that outcome.

**11. Status of CERCLA 120(h) Informational Briefing in Regards to Property Transfer Requests and Activities.**

Informational briefing for KY and EPA originally hoped to be presented in November 2015 has been delayed to April or May 2016. The briefing is expected to include lessons learned from previous transfers. A programmatic procedure for determining clean parcel transfer is being developed by DOE.

**12. Poll RAWG Members/Open Discussion**

Programmatic QAPP is expected this week. A briefing will be scheduled with Kentucky and EPA on what has been changed (in March or April 2016).

## ATTACHMENT

### Recommended text (shown in red) (Agenda Item 6)

- (2) If results from ten or more samples are available, then the most recent version of EPA's ProUCL software will be used to determine the EPC. The value selected as the EPC will be the value recommended by ProUCL, noted as the "Potential UCL to Use." EPA's ProUCL software<sup>7</sup> incorporates a number of different distributional tests that may be used to calculate the most appropriate EPC (EPA 2013a). In the current version of ProUCL, the software has computation methods for handling data sets with nondetect values. Unless other determinations are made during project scoping, nondetect values should be handled according to the recommendations in the ProUCL User Guide (EPA 2013a). Additional information regarding the statistics and computation methods used in ProUCL can be found in the User Guide and in the ProUCL Technical Guide (EPA 2013b). Additionally, it is unlikely that the UCLs based upon those methods will exceed the maximum detected value, unless some outliers are present in the data set. The RAWG has concluded that the 95% UCL should be used as the EPC and if the 95% UCL exceeds the maximum detected concentration, then the uncertainty needs to be discussed in the uncertainty section of the risk assessment.

Options to determine the ten or more samples may include use of grid values. It is recommended that a geostatistical approach utilizing Spatial Analysis and Decision Assistance (SADA) or similar software be used to estimate values for empty grids. SADA is available at <http://www.tiem.utk.edu/~sada/index.shtml>. Alternately, an average value may be used. An example is shown in the text box [from Soils Operable Unit RI Report (DOE 2012)]. These options should be discussed and agreed to in the planning phases of projects.

#### References:

- EPA 2013a. *ProUCL Version 5.0.00 User Guide*. EPA/600/R-07/041, Office of Research and Development Site Characterization and Monitoring Technical Support Center, Atlanta, GA, September, model available at [www.epa.gov/land-research/proucl-software](http://www.epa.gov/land-research/proucl-software).
- EPA 2013b. *ProUCL Version 5.0.00 Technical Guide*. EPA/600/R-07/041, Office of Research and Development Site Characterization and Monitoring Technical Support Center, Atlanta, GA, September, model available at [www.epa.gov/land-research/proucl-software](http://www.epa.gov/land-research/proucl-software).

<sup>7</sup> Software is available at [www.epa.gov/land-research/proucl-software](http://www.epa.gov/land-research/proucl-software) ~~www.epa.gov/osp/hstl/tsc/software.htm~~.

**ATTACHMENT E1**

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

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ENGINEERS

409  
North Forbes Road  
Lexington, Kentucky  
40511-2050  
606-233-0574  
606-254-4800 FAX

October 26, 1995

O.1.1.94355L05

Mr. Charles Logsdon  
Kentucky Department of Fish and Wildlife Resources  
10535 Ogden Landing Road  
Kevil, Kentucky 42053

Re: PCB Risk Calculations  
Paducah Gaseous Diffusion Plant

Dear Mr. Logsdon:

FMSM is conducting a preliminary risk calculation for the Little Bayou and Big Bayou areas around the Paducah Gaseous Diffusion Plant. This subject was discussed at a meeting in which you attended on September 7, 1995. During that meeting you indicated that your office could provide information on the recreational use of these areas. In response to your suggestion, we have developed the following list of questions. Please try to research your site use data and answer as many of these questions as possible. If data is not directly available to answer these questions we would appreciate an estimate based on your best professional judgment.

Big Bayou

1. What is the average number of visitors per year to Big Bayou?
2. Of this number, how many are adults and how many are children?
3. Are most of your visitors repeat or one-time visitors on a yearly basis?
4. What is the average time (hours) spent in Big Bayou? Is there a difference in average time spent between adult and child usage?
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.)?
6. What is the number of repeat visits per year by any one individual or group of individuals? What is the average time spent (hours) in the area by the higher frequency visitors?

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?
8. Is there a harvestable fish population in Big 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?

Little Bayou

I realize that during the September 7th meeting, you stated there is little to no recreational use of the Little Bayou areas. However, it would be helpful if you could answer the same questions about Little Bayou, as asked of Little Bayou. Therefore, we are repeating the following questions.

1. What is the average number of visitors per year to Little Bayou?
2. Of this number, how many are adults and how many are children?
3. Are most of your visitors repeat or one-time visitors on a yearly basis?
4. What is the average time (hours) spent in Little Bayou? Is there a difference in average time spent between adult and child usage?
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.)?
6. What is the number of repeat visits per year by any one individual or group of individuals? What is the average time spent (hours) in the area by the higher frequency visitors?
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?
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?



Kentucky Department of Fish and Wildlife Resources  
October 26, 1995  
Page 3

We appreciate your help in answering these questions. After you have reviewed these, if you have any questions, or if the questions need clarification, please call.

Sincerely,

FULLER, MOSSBARGER, SCOTT AND MAY  
ENGINEERS, INC.



Stephen L. Scott, P.E.  
Project Manager

/esh

c: David Asburn ✓  
Tom McGee ✓  
Bob Sneed ✓  
David Brancato ✓

**facsimile**  
**TRANSMITTAL**

---

**to:** Stephen Scott, P.E.  
**fax #:** 606-254-4800  
**re:** Big Bayou & Little Bayou  
**date:** November 8, 1995  
**pages:** 4, including this cover sheet.

From the desk of...

Charles Logsdon  
WMA Supervisor  
Ky. Dept. Of Fish & Wildlife Resources  
10535 Ogden Landing Rd.  
Kovil, KY. 42053

(602)488-3233  
Fax

Stephen Scott, P.E.  
Fuller, Mossbarger, Scott and May  
Engineers, Inc.  
1409 North Forbes Road  
Lexington, Ky. 40511-2050

Dear Mr. Scott:

I have answered these question as accurately as possible. If you have any other questions, or questions about my answers feel free to contact me. Sorry about the delay, but you're letter came during some of our deer hunting seasons.

Sincerely,



Charlie Logsdon

cc: Wayne Davis  
Don Walker

### Little Bayou

1. The number of people visiting Little Bayou is essentially zero, with the exception of PGDP personnel and a few fishermen(maybe, 20 visits annually) that 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. The visitors would be adults.
3. Refer to Big Bayou question 3. Visitors to Little Bayou would be repeat users, probably less than 10 visits per year and most of them in the brief encounter scenario described in question 1.
4. Most encounters with Little Bayou would be measured in seconds. Fishermen that use the beaver pond above the outfalls, may fish on average 2 hours.
5. See Big Bayou question 5.
6. 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 would be measured in minutes for the most frequent user and most would only cross the creek on the culvert and dirt crossings.
7. All fishermen in the beaver pond would be bank fishermen as the pond is too deep to wade.
8. Other than the beaver pond above the outfalls, it would be nearly impossible to catch 0.284 kgs of fish from Little Bayou. 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).

### Big Bayou

Question 1: The number of visits by people using Big Bayou specifically, is estimated to be 150 visits. This is for a specific activity involving Big Bayou, such as fishing. More people may be in the vicinity while using the WKWMA, but their use of Big Bayou maybe for only an instant(i.e., using a log to cross Big Bayou to hunt on the other side of the creek).

Question 2: Of the 150 visits of people using Big Bayou, 100 are adults and 50 are children. This is an estimate based on our observations of people using the area.

Question 3: 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 Big Bayou, would probably be <10.

Question 4: The average time spent in Big Bayou by users is unknown. However, I feel the amount of time spent/trip would be similar to other activities. During 1994, the average number of hours spent/trip for the following activities were: Quail hunting - 3.49 hrs/trip(n= 158), rabbit hunting - 3.25(n=168), bowaunting for deer - 3.48(n=1115), duck hunting - 2.4(n=69), and raccoon hunting - 2.63(n=20). Raccoon hunting and duck hunting would be the activities most likely associated with Big Bayou. There would be little, if any, difference between adult and child usage of the area.

Question 5: This question is difficult to answer. Do you mean for WKWMA or Big Bayou? WKWMA is heavily used by a wide variety of users. Annually, the estimated number of visits for the following activities are: fishing - 5000 visits/year, hunting and dog training 4-6000, field trials - 1500, hiking - 100, berry & nut picking - 200, driving through for a variety of reasons - 50,000.

For activities involving Big Bayou alone: fishing - 150, hunting - ?(explained in question 1).

Question 6: Refer to questions 3 and 4.

Question 7: Most, if not all would be bank fishermen. Most of the fishing would occur at 3 points: 1) where the iron bridge in tract 4 crosses Big Bayou, 2) where the collapsed bridge in tract 4 crosses Big Bayou(by weir constructed by PGDP), and 3) where the concrete crossing bridges Big Bayou in tract 6. While it may occur, no wade fishing has been observed. No actual data is available, but should be similar to the length of visits noted in question 4.

Question 8: There is a harvestable fish population in Big Bayou. A person could potentially expect to catch 0.284 kgs of fish on a regular basis(depending on the skill of the fisherman), however, this is assuming that the person is not culling(throwing back extremely small fish). The frequency of being able to catch 0.248 kgs of fish would increase as one approaches the mouth of Big Bayou. Also, the only way the creek could support 128 meals a year is if there was 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.

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**ATTACHMENT E2**

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

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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](mailto:Timothy.Kreher@ky.gov)*

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**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.paducaeic.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](mailto:leanne.garner@lataky.com)  
270-441-5436

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LATA Environmental Services of Kentucky, LLC