FINAL

ADDENDUM FOR SWMU 27T: 293 MP COMPANY

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TO THE

REVISED FINAL PHASE II RCRA FACILITY INVESTIGATION REPORT FOR 16 SOLID WASTE MANAGEMENT UNITS AT FORT STEWART, GEORGIA

Prepared for

U.S. ARMY CORPS OF ENGINEERS
SAVANNAH DISTRICT

Contract No. DACA21-95-D-0022
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Prepared by:
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September 2000

The undersigned certifies that I am a qualified groundwater scientist who has received a baccalaureate or postgraduate degree in the natural sciences or engineering and have sufficient training and experience in groundwater hydrology and related fields, as demonstrated by state registration and completion of accredited university courses, to enable me to make sound professional judgments regarding groundwater monitoring and contaminant fate and transport. I further certify that this report was prepared by myself or a subordinate working under my direction.

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

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ACRONYMS

ADD	average daily dose
amsl	above mean sea level
AT123D	Analytical Transient 1-, 2-, 3-Dimensional
AUF	area use factor
bgs	below ground surface
CAP	Corrective Action Plan
CMCOC	contaminant migration constituent of concern
CMCOPC	contaminant migration contaminant of potential concern
COC	constituent of concern
COPC	contaminant of potential concern
CSF	cancer slope factor
DF	dilution factor
DPT	direct-push technology
ECOPC	ecological contaminant of potential concern
EPA	U.S. Environmental Protection Agency
EPRE	ecological preliminary risk evaluation
ERA	ecological risk assessment
ESV	ecological screening value
FSMR	Fort Stewart Military Reservation
GEPD	Georgia Environmental Protection Division
GSSL	generic soil screening level
HHBRA	human health baseline risk assessment
HHCOPC	human health contaminant of potential concern
HHPRE	human health preliminary risk evaluation
HI	hazard index
HQ	hazard quotient
ILCR	incremental lifetime cancer risk
LOAEL	lowest observed adverse effect level
MCL	maximum contaminant level

NFA	no further action
NGTC	National Guard Training Center
NOAEL	no observed adverse effect level
NTU	nephelometric turbidity unit
OWS	oil/water separator
PAH	polycyclic aromatic hydrocarbon
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RFI	RCRA Facility Investigation
SAP	Sampling and Analysis Plan
SESOIL	Seasonal Soil Compartment
SRC	site-related contaminant
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TEF	toxicity equivalence factor
TRV	toxicity reference value
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound

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1.0 INTRODUCTION

This addendum to the revised final Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for 16 Solid Waste Management Units (SWMUs) at Fort Stewart, Georgia, (dated April 2000) presents the results for the Phase II RFI for the 293 MP Company (SWMU 27T) performed in June through August 2000. A Phase I RFI was performed at SWMU 27T in January 1998, and the results are presented in Section 10.14 of the revised final Phase II RFI Report (SAIC 2000). The results of the Phase I RFI indicated that additional investigation of the site was required to evaluate the nature and extent of potential sediment contamination.

This report has been prepared by Science Applications International Corporation for the U.S. Army Corps of Engineers (USACE)–Savannah District under Contract DACA21-95-D-0022, Delivery Order No. 0009. The RFI was conducted in accordance with USACE Guidance EM 200-1-3.

1.1 OBJECTIVES AND SCOPE OF THE INVESTIGATION

The specific objectives of this Phase II RFI for SWMU 27T at Fort Stewart, Georgia, as defined in the conclusions and recommendations in Section 10.14.8 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000) and the Phase II RFI Sampling and Analysis Plan (SAP) (SAIC 1997) [approved by the Georgia Environmental Protection Division (GEPD) in October 1997], are listed below.

- Determine the horizontal and vertical extent of groundwater contamination.
- Determine whether groundwater contaminants present a threat to human health or the environment.
- Determine the need for future action and/or no further action (NFA).
- Gather data necessary to support a Corrective Action Plan (CAP), if warranted.

The information provided in this addendum report is based upon data collected previously during the Phase I RFI (January 1998) and data collected as part of the Phase II field sampling and analysis (June through August 2000). The scope of the fieldwork for the Phase II sites included the activities listed below.

- Installation of a permanent groundwater monitoring well in the area of potential sediment contamination at the site.
- Groundwater sampling at a newly installed monitoring well at the SWMU.
- Collection of sediment samples.
- Surveying of the positions of all sample locations.

1.2 ADDENDUM REPORT ORGANIZATION

This report is an addendum to the revised final Phase II RFI Report for 16 SWMUs that was issued in April 2000. General procedures and/or methodologies for field investigation, fate and transport analysis, human health risk assessment, and ecological risk assessment (ERA) are presented in the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000) and are referenced in the appropriate addendum sections. The revised final Phase II RFI Report for 16 SWMUs consists of three volumes: 12 chapters of text in Volume I, seven appendices in Volume II, and five appendices in Volume III. Chapter 1.0 describes the purpose of the investigation, summarizes the scope of work performed, and presents the organization of the report. General information is presented in Chapters 2.0 through 8.0. Chapter 2.0 describes the Fort Stewart Military Reservation (FSMR) Installation and discusses the history of the FSMR and the FSMR's regulator history. Chapter 3.0 presents the regional setting of the FSMR, including the demographics, topography, regional geology and hydrogeology, surface drainage, soil, and ecology. Chapter 4.0 summarizes the investigative activities and methodologies used in completing the Phase II RFI fieldwork. Chapter 5.0 describes the results of the background interpretation for surface soil, subsurface soil, groundwater, surface water, and sediment and their relationship to each site. Chapter 6.0 identifies general considerations affecting contaminant fate and transport. Chapter 7.0 presents the general methodology for the human health preliminary risk evaluation (HHPRE), and Chapter 8.0 presents the general methodology for the ecological preliminary risk evaluation (EPRE).

Chapter 9.0 designates in sequential order the SWMUs that are recommended for NFA and for which, therefore, additional investigation and/or evaluation is not required. Chapter 10.0, in which SWMU 27T is addressed (Section 10.14), designates in sequential order the SWMUs that are recommended for additional investigation or a CAP. Chapter 11.0 presents general conclusions and recommendations identifying the SWMUs that are recommended for NFA or SWMUs that indicated risk to human health or environment and are recommended for additional investigation or a CAP. References are presented in Chapter 12.0.

Volume II of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000) contains seven appendices. Appendix A contains the direct-push technology (DPT) and boring logs. Appendix B contains monitoring well construction diagrams. Appendix C is the Quality Control Summary Report. Appendix D provides a comparison of metal data from the Phase I and Phase II RFIs. Appendix E contains the geotechnical laboratory test results. Appendix F is the background data summary. Appendix G contains the chain-of-custody forms.

Volume III of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000) contains five appendices. Appendix H provides the analytical data results. In addition, the analytical data are provided in electronic format (i.e., on a CD). Appendix I presents the methodology for the human health baseline risk assessment (HHBRA). Appendix J contains the toxicity profiles for contaminants of potential concern (COPCs). Appendix K presents fate and transport input data and model descriptions. Appendix L presents the revised responses to GEPD comments received on the final version of the Phase II RFI Report for 16 SWMUs submitted in February 1999 and the meeting minutes for the comment response meeting with GEPD held on September 14, 1999.

The results of the Phase I RFI for SWMU 27T are presented in Section 10.14 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000). This addendum follows the same organization as that of the revised final Phase II RFI Report.

2.0 HISTORY AND DESCRIPTION OF SWMU 27T, 293 MP COMPANY

SWMU 27T is located in the 293 MP Company along Troupe Avenue and is one of 32 OWSs distributed across 29 sites that support vehicle maintenance facilities within the garrison area (Figure 1). The OWS is located in the southeastern corner outside the fenced boundary of the motorpool at the corner of Troupe Avenue and West 4th Street (Figure 2). The OWS receives wastewater from a vehicle wash rack located to the northwest. The effluent from the OWS discharges to the National Guard Training Center (NGTC) Equalization Basin (SWMU 37), and the waste oil is pumped out of the holding unit and burned at the Central Energy Plant. No previous investigations have been performed at the site.

SWMU 27T is regulated under a RCRA Permit [HW-045 (S&T)] issued to Fort Stewart in August 1987 for storage and treatment of hazardous waste. Detailed regulatory history of Fort Stewart is presented in Section 2.2 of the revised final Phase II RFI Report (SAIC 2000). A Phase I RFI was conducted at SWMU 27T in January 1998, and the results are discussed in the following section.

2.1 SUMMARY OF PHASE I RCRA FACILITY INVESTIGATION

A Phase I RFI was conducted in January 1998. DPT techniques were used to collect four soil and groundwater samples at SWMU 27T. The locations of the soil and groundwater sampling are presented in Figure 2. The four soil samples were collected based on field headspace screening for volatile organic compounds (VOCs). The analytical laboratory inadvertently missed the holding times for VOCs and semivolatile organic compounds (SVOCs) for soil at GP1, GP2, and GP3 during the initial sampling endeavor (January 1998). Soil was resampled on May 6, 1998. The soil and groundwater samples were analyzed for VOCs, SVOCs, and lead.

Three sediment samples were collected from the drainage ditch. Initially, only a sediment sample downstream of the OWS was collected on February 2, 1998. To confirm that upstream sources were impacting the sediment downstream of the OWS, an upstream and a downstream sediment sample were collected September 23, 1999. The February 1998 sediment sample was analyzed for VOCs, SVOCs, and lead. The September 1999 samples were analyzed for VOCs, SVOCs, and RCRA metals. No surface water was available during the Phase I RFI.

2.1.1 Surface Soil

Three surface soil samples were collected based on field headspace screening for VOCs. The analytical laboratory missed the holding times for VOCs and SVOCs for soil at GP2 and GP3 during the initial sampling endeavor (January 1998), so the soil was resampled in May 1998. The results of the Phase I RFI soil analysis are presented in Table 1 and Figure 3.

VOCs. No VOCs were detected in surface soil during the Phase I RFI.

SVOCs. Benzo(*b*)fluoranthene and phenanthrene were detected in the sample collected from GP3 at concentrations of 1.14 mg/kg and 0.79 mg/kg, respectively. The sample collected from GP4 indicated the presence of chrysene at a concentration of 0.215 mg/kg. Pyrene was detected in the samples collected from GP3 and GP4 at concentrations of 1.33 mg/kg and 0.22 mg/kg, respectively. Benzo(*b*)fluoranthene, chrysene, phenanthrene, and pyrene are considered to be site-related contaminants (SRCs) in surface soil based on the Phase I RFI.

Lead. Lead was detected in the samples taken from all three locations at concentrations ranging from 6.1 mg/kg at GP3 to 7.5 mg/kg at GP2. None of the concentrations exceeded the respective reference background criteria; therefore, lead is not considered to be an SRC for surface soil based on the Phase I RFI.

2.1.2 Subsurface Soil

One subsurface soil sample was collected based on field headspace screening for VOCs. The analytical laboratory missed the holding times for VOCs and SVOCs for soil at GP1 during the initial sampling endeavor

(January 1998), so the soil was resampled in May 1998. The results of the Phase I RFI soil analysis are presented in Table 2 and Figure 3.

VOCs. No VOCs were detected in subsurface soil during the Phase I RFI.

SVOCs. No SVOCs were detected in subsurface soil during the Phase I RFI.

Lead. Lead was detected in the sample taken from GP1 at a concentration of 5.5 mg/kg, which does not exceed the reference background criterion; therefore, lead is not considered to be an SRC in subsurface soil based on the Phase I RFI.

2.1.3 Groundwater

Four groundwater samples were collected from the four Geoprobe locations at the site. The results of the groundwater analysis are presented in Table 3 and Figure 3.

VOCs. Acetone was detected in GP3 at a concentration of 50.2 μg/L. Acetone is considered to be an SRC in groundwater based on the Phase I RFI.

SVOCs. Pyrene was detected in the sample collected from GP4 at a concentration of 26.2 μg/L; therefore, pyrene is considered to be an SRC in groundwater based on the Phase I RFI.

Lead. Lead was below the reference background criterion at GP1 and GP2 and was not detected at GP3 and GP4; therefore, lead is not considered to be an SRC in groundwater based on the Phase I RFI.

2.1.4 Surface Water

There was no surface water present at the site during the Phase I field investigation.

2.1.5 Sediment

Three sediment samples were collected during the Phase II RFI. Initially, only one sediment sample was collected (February 1, 1998) downstream of the OWS and analyzed for VOCs, SVOCs, and lead. The sediment was resampled on September 23, 1999, and both an upstream and a downstream sample were collected [see Section 10.14.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000)]. The sediment samples from the resampling event were analyzed for VOCs, SVOCs, and RCRA metals. The results of the sediment analyses are presented in Table 4 and Figure 3.

VOCs. No VOCs were detected in the initial downstream sediment sample. However, four VOCs were detected in the sediment samples collected September 23, 1999. 2-Butanone, 2-hexanone, 4-methyl-2-pentanone, and acetone were detected at concentrations of 0.0227 mg/kg, 0.0023 mg/kg, 0.0052 mg/kg, and 0.099 mg/kg, respectively, in SWS2 (downstream location). 2-Butanone and acetone were also detected in the upstream sediment sample at concentrations of 0.0206 mg/kg and 0.391 mg/kg, respectively. 2-Butanone, 2-hexanone, 4-methyl-2-pentanone, and acetone are considered to be SRCs in sediment based on the Phase I RFI; however, only two of the VOCs (2-hexanone and 4-methyl-2-pentanone) were detected above their site-specific background criteria, indicating that a source upstream of the OWS is impacting the sediment characteristics. The probable source is surface runoff from the parking area of the adjacent motorpool that drains into the drainage ditch upstream of the OWS.

SVOCs. Benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*g,h,i*)perylene, benzo(*k*)fluoranthene, fluoranthene, indeno(*1,2,3-cd*)pyrene, and pyrene were detected in the downstream sediment samples. Chrysene was also detected at a concentration of 2.54 mg/kg in the downstream sediment sample collected on February 1, 1998. All of these constituents were detected in the upstream sediment sample as well. The sediment sample initially collected (February 1998) had the higher concentrations of detected SVOCs. The concentrations of benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*g,h,i*)perylene, benzo(*k*)fluoranthene, fluoranthene, indeno(*1,2,3-cd*)pyrene, and pyrene from the February 1998 and September 1999 samples were 1.07 mg/kg and 0.405 mg/kg, 1.95 mg/kg and 0.677 mg/kg, 3.51 mg/kg and 1.06 mg/kg, 1.81 mg/kg and 0.633 mg/kg, 2.4 mg/kg and 0.851 mg/kg, 2.92 mg/kg and 1 mg/kg, 1.65 mg/kg and 0.582 mg/kg, and 3.25 mg/kg and 1.12 mg/kg, respectively. Except for benzo(*a*)anthracene, all of the constituents detected in the sediment samples collected February 1998 were at concentrations that were above the site-specific background criteria of September 1999. No site-specific background sample was collected during the February 1998 sampling endeavor. Benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*g,h,i*)perylene, benzo(*k*)fluoranthene, chrysene, fluoranthene, indeno(*1,2,3-cd*)pyrene, and pyrene are considered to be SRCs in sediment based on the Phase I RFI; however, the presence of these constituents in the upstream sediment sample indicates that a source upstream of the OWS is impacting the sediment characteristics. The probable source is surface runoff from the parking area of the adjacent motorpool that drains into the drainage ditch upstream of the OWS.

RCRA Metals. Arsenic, barium, cadmium, chromium, lead, mercury, and selenium were detected in the upstream and downstream sediment samples. However, only cadmium was detected above the site-specific reference background criterion. Cadmium is an SRC in sediment based on the Phase I RFI; however, the presence of these constituents in the upstream sediment sample indicates that a source upstream of the OWS is impacting the sediment characteristics. The probable source is surface runoff from the parking area of the adjacent motorpool that drains into the drainage ditch upstream of the OWS.

2.1.6 Conclusions and Recommendations of the Phase I RFI

Benzo(*b*)fluoranthene, chrysene, phenanthrene, and pyrene were identified as SRCs in surface soil; however, none of these were determined to be contaminant migration contaminants of potential concern (CMCOPCs), or ecological contaminants of potential concern (ECOPCs). Benzo(*b*)fluoranthene was determined to be a human health contaminant of potential concern (HHCOPC). No SRCs were identified in subsurface soil. Acetone and pyrene were identified as SRCs in groundwater. However, neither of these constituents was identified as an HHCOPCs in groundwater. Pyrene was identified as an ECOPC [by default because there is no ecological screening value (ESV)] in groundwater based on the potential hazards to aquatic biota if groundwater discharges to a nearby surface water body. 2-Butanone, 2-hexanone, 4-methyl-2-pentanone, acetone, benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*g,h,i*)perylene, benzo(*k*)fluoranthene, chrysene, fluoranthene, indeno(*1,2,3-cd*)pyrene, pyrene, and cadmium were identified as SRCs for sediment. Of these, cadmium and the following SVOCs [all polycyclic aromatic hydrocarbons (PAHs)]: benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*a*)anthracene, and indeno(*1,2,3-cd*)pyrene were identified as HHCOPCs. Cadmium in sediment was identified as a CMCOPC and an ECOPC to terrestrial receptors. Therefore, the Phase I RFI [see Section 10.14.8.2, page 10.14-8 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000)] concluded that the horizontal extent of potential sediment contamination had not been determined and recommended that up to six sediment samples and three shallow groundwater monitoring wells be installed.

3.0 SUMMARY OF PHASE II RCRA FACILITY INVESTIGATION

Three sediment samples (one upgradient and two downgradient) were collected and analyzed for cadmium at an off-site analytical laboratory in June 2000. With the concurrence of GEPD (see Attachment A of this addendum), only one monitoring well was installed as close as possible to the sediment location indicating the most elevated cadmium concentration. In addition, no soil samples were collected for chemical analysis during the installation of the monitoring well. The Phase II RFI sampling locations are presented in Figure 4. The boring log and monitoring well diagram are presented in Attachment B of this addendum. Monitoring well construction details are shown in Table 5.

A geotechnical sample was collected from the monitoring well, and the results are presented in Table 5. The monitoring well was developed for approximately 16 hours with a final turbidity of 27.1 nephelometric turbidity units (NTUs). Monitoring well development data are presented in Table 5. The monitoring well was sampled using low-flow techniques following the procedures outlined in the revised final SAP for Phase II RFIs for 16 SWMUs (SAIC 1997). With the concurrence of GEPD, the groundwater sample was analyzed for only cadmium. Conductivity, temperature, pH, dissolved oxygen, oxidation-reduction potential, and turbidity were measured in the field during sampling, and the results are presented in Table 5.

4.0 PHYSICAL CHARACTERISTICS OF THE SITE

4.1 TOPOGRAPHY

The topography of the site is essentially flat. The surface elevation is approximately 85 feet above mean sea level (amsl). The OWS is surrounded by grass that extends to a paved portion of Troupe Avenue to the southeast.

4.2 SURFACE DRAINAGE

A drainage ditch is located between the OWS and the wash rack (Figure 2). The effluent (i.e., separated water) from the OWS discharges to the NGTC Equalization Basin (SWMU 37). Surface water is present in the drainage ditch only during rainfall events. The closest surface water body is an unnamed tributary to Melvin Swamp located approximately 1,320 feet to the southeast of the site. Melvin Swamp ultimately flows into Peacock Creek approximately 5 miles to the southeast.

4.3 SOILS

The soil across the site consists of alternating layers of sand and silty to clayey sands, as indicated in the DPT logs [see Appendix A of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000)].

4.4 HYDROGEOLOGY

Groundwater was encountered at approximately 4.4 feet to 6.0 feet below ground surface (bgs). The groundwater gradient could not be determined from the Phase II RFI because only one monitoring well was installed. A CAP-Part A was preformed for Underground Storage Tank 207, Facility ID #9-089038, located at Building 232 (SAIC 1998), which is approximately 150 feet to the northwest of SWMU 27T (Figure 2). The CAP for UST 207 at Building 232 determined the groundwater flow direction to be to the northeast with a hydraulic gradient of 0.0059 foot/foot.

4.5 ECOLOGY

As stated in Section 8.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000), SWMU 27T is classified as an "industrialized area with managed grasslands." SWMU 27T comprises approximately 0.01 acre (Figure 2), is covered largely by concrete, and includes an area of managed grass within its boundaries. Additionally, a storm water ditch separates the SWMU from the paved road (Troupe Avenue).

5.0 NATURE AND EXTENT OF CONTAMINATION

5.1 SURFACE SOIL

With the concurrence of GEPD (see Attachment A of this addendum), no surface soil samples were collected during the Phase II RFI.

5.2 SUBSURFACE SOIL

With the concurrence of GEPD (see Attachment A of this addendum), no subsurface soil samples were collected during the Phase II RFI.

5.3 GROUNDWATER

One monitoring well (MW1) was installed as close as possible to the area of the highest measured cadmium concentration in sediment. With the concurrence of GEPD, the groundwater was analyzed for only cadmium. The results of the groundwater analyses are presented in Table 6 and Figure 5. The chain-of-custody form and complete analytical results are presented in Attachment C of this addendum.

Cadmium. Cadmium was not detected in either the total or the filtered groundwater sample from MW1; therefore, cadmium is not an SRC in groundwater.

5.4 SURFACE WATER

No surface water was present in the drainage ditch at the time of the field activities; therefore, no surface water samples were collected during the Phase II RFI. As discussed in Section 4.2 of this addendum, water is present in the drainage ditch only after rainfall events.

5.5 SEDIMENT

Three sediment samples (one upgradient and two downgradient) were collected during the Phase II RFI. With the concurrence of GEPD, the sediment was analyzed for only cadmium. The results of the sediment analyses are presented in Table 7 and Figure 5. The chain-of-custody form and complete analytical results are presented in Attachment C of this addendum.

Cadmium. Cadmium was detected above the site-specific reference background criterion at SWS5. Cadmium was detected at a concentration of 5.81 mg/kg at SWS5; therefore, cadmium is an SRC in sediment based on the Phase II RFI.

5.6 SITE-RELATED CONTAMINANT SUMMARY

No soil samples were collected during the Phase II RFI; therefore, the SRCs in surface and subsurface soil were the same as those indicated in the Phase I RFI. SRCs for groundwater were determined using both the Phase I RFI data and the Phase II RFI data. The SRCs for sediment were determined using data collected during both the Phase I and Phase II RFIs. The SRCs by medium and the corresponding maximum concentrations are presented in Table 8.

6.0 FATE AND TRANSPORT CONSIDERATIONS

The potential for soil and sediment contaminants to migrate (i.e., their leachability) to groundwater was evaluated by comparing the maximum concentrations of soil and sediment SRCs to their respective generic soil screening levels (GSSLs).

Of the SRCs identified in soil and sediment, only cadmium exceeded its GSSL (Table 9). Cadmium is a CMCOPC in sediment based on leaching to groundwater.

7.0 HUMAN HEALTH PRELIMINARY RISK EVALUATION, SWMU 27T

SRCs for SWMU 27T were identified for the following media: surface soil, groundwater, and sediment. Evaluation of the potential risks resulting from exposure to these constituents and the identification of HHCOPCs are addressed in this section.

7.1 EXPOSURE EVALUATION

The exposure evaluation addresses what human receptor populations, both on-site and off-site, might be exposed to contaminants present at the site. The exposure evaluation also addresses how contaminants might migrate and the potential exposure pathways for the various receptors.

7.1.1 Receptor Assessment

This is an active site within the garrison area. The potential receptor populations include:

- occupational populations (individuals working on the site),
- construction workers, and
- off-site occupational receptors.

Land use at this site is not likely to change; therefore, future receptor populations are likely to be the same as the current ones.

7.1.2 Migration and Exposure Pathway Analysis

Potential migration pathways for soil include leaching into groundwater and release of volatile compounds into the air. The site is relatively flat and is covered largely by concrete. An area of managed grass occurs within the SWMU's boundaries. Additionally, a storm water ditch separates the SWMU from the road. Therefore, soil erosion via fugitive dust is not a viable migration pathway. Given the proximity of the OWS to the storm water ditch, contaminants in surface soil might migrate to the drainage ditch. However, a paved road is located alongside the ditch, and this road may be contributing to the organic and lead concentrations detected in the drainage ditch sediment. In addition, the storm water drainage system for all the 200-block motorpools discharges to this ditch.

The elevation of groundwater is lower than that of the adjacent drainage ditch; therefore, groundwater is not likely to migrate to the drainage ditch. There are no other permanent surface water features near this site. The nearest surface water body is an unnamed tributary to Melvin Swamp located approximately 1,320 feet to the southeast of the site. Given the distance to this tributary, it is unlikely that constituents present in groundwater will migrate to this surface water body.

The on-site resident scenario is not considered to be a viable scenario for this site; however, in accordance with Risk-based Corrective Action guidance, it is used to derive screening values. The exposure pathways associated with this scenario are presented to show what pathways would be associated with an on-site resident exposure scenario.

7.2 RISK EVALUATION

The results of the human health risk screening are given below.

Four SVOCs [PAHs benzo(*b*)fluoranthene, chrysene, phenanthrene, and pyrene] were identified as SRCs in surface soil. The maximum concentration for benzo(*b*)fluoranthene (1.14 mg/kg) exceeded its screening criterion for ingestion (0.88 mg/kg) (Table 10). All of the concentrations for the remaining compounds were below their respective screening values. Therefore, benzo(*b*)fluoranthene is an HHCOPC in surface soil.

Acetone and pyrene were identified as SRCs for groundwater. The maximum concentrations of these constituents were below their respective screening values (Table 10); therefore, there are no HHCOPCs for groundwater.

Four VOCs, nine SVOCs (PAHs), and cadmium were identified as SRCs in sediment. None of the maximum concentrations of VOCs exceeded their respective screening criteria for exposure via ingestion (Table 10). The maximum concentrations of the SVOCs benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, and indeno(*1,2,3-c,d*)pyrene (all PAHs) were above the screening criteria for exposure via ingestion (Table 10). The remaining SVOCs were below their respective screening values. The maximum concentration of cadmium was also above its screening value. Benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, indeno(*1,2,3-cd*)pyrene, and cadmium are considered to be HHCOPCs for sediment.

The maximum value for benzo(*a*)pyrene in sediment was more than an order of magnitude greater than the screening value for ingestion. The maximum concentrations for the other SVOCs identified as HHCOPCs and for cadmium were within an order of magnitude of their respective screening values.

7.3 UNCERTAINTIES

A screening value for a surrogate compound was used for phenanthrene, possibly resulting in exclusion of this PAH when it should be an HHCOPC. Other human health uncertainties are addressed in Section 7.5 of the HHPRE (Chapter 7.0) of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

8.0 ECOLOGICAL PRELIMINARY RISK EVALUATION, SWMU 27T

The EPRE of SWMU 27T was conducted in accordance with GEPD (1996) guidance [see Chapter 8.0 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000)]. At sites where surface water, sediment, or groundwater was collected, an ESV comparison was conducted. If ECOPCs for aquatic biota were identified in surface water, sediment, or groundwater based on the ESV comparison (Step i), then further evaluation was required for those media. If no ECOPCs were identified based on the Step i screening of those media, then those ECOPCs were not considered further. At sites where surface soil was collected, substances detected in surface soil were evaluated in EPRE Steps ii through v because there are no ESVs for surface soil. The results of the five steps of the EPRE are presented below.

8.1 ECOLOGICAL SCREENING VALUE COMPARISON (STEP i)

There is no surface water at SWMU 27T. The sediment in the drainage ditch is treated as surface soil (see Section 8.5 of this addendum).

One VOC and one SVOC were detected in groundwater. The results of the ESV comparison for groundwater are presented in Table 11. The only ECOPC identified by the ESV comparison for groundwater was pyrene. Pyrene is an ECOPC by default because it has no ESV (GEPD 1997).

Because there are no ESVs for soil, all analytes detected in soil and drainage ditch sediment were evaluated further in EPRE Steps ii through v.

8.2 PRELIMINARY PROBLEM FORMULATION (STEP ii)

The ecological habitat is described in Section 4.5 of this addendum. The preliminary assessment endpoints, ecological receptors, and surrogate species representative of those receptors selected for evaluation in the preliminary risk calculation are described in Section 8.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

8.3 PRELIMINARY EFFECTS (STEP iii)

In the EPRE, toxicity reference values (TRVs) were required for shrews and robins ingesting contaminated biota exposed to surface soil or drainage ditch sediment at the site and for raccoons ingesting water. The derivation of TRVs is discussed in Section 8.3 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000). The derivation of no observed adverse effect levels (NOAELs) for test species is shown in Table 12 for mammals and Table 13 for birds. The derivation of TRVs for surrogate species from the test species NOAELs is shown in Table 14 for shrews and raccoons and in Table 15 for robins.

For the uncertainty discussion, the derivation of lowest observed adverse effect levels (LOAELs) for test species is shown in Table 16 for mammals and Table 17 for birds. The derivation of TRVs for surrogate species from the test species LOAELs is shown in Table 18 for shrews and raccoons and in Table 19 for robins.

8.4 PRELIMINARY EXPOSURE (STEP iv)

Ecological receptors are probably exposed by ingestion of contaminated soil or drainage ditch sediment, of biota exposed to contaminated soil or drainage ditch sediment, or of drinking water if groundwater discharges to the nearby drainage ditch. The exposure parameters for the surrogate species—shrews, raccoons, and robins—are presented in Table 8-7 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

8.5 PRELIMINARY RISK CALCULATION (STEP v)

The preliminary risk calculation (Step v) uses hazard quotients (HQs), the ratios of the measured maximum concentrations and the TRVs, to evaluate the potential for risk. The HQs of ECOPCs with consistent modes of toxicity and effects endpoints are added to calculate a hazard index (HI). Metals are assumed to have distinct modes of toxicity and effects endpoints; therefore, HIs are calculated for only VOCs and SVOCs when no individual ECOPC has an HQ greater than one and HQs are calculated for more than one chemical. ECOPCs with HQs and HIs less than one indicate little to no likelihood of risk to the ecological receptors. An ERA using site-specific data is indicated for those ECOPCs with calculated HQs or HIs exceeding one (GEPD 1996).

Surface Soil. The preliminary risk calculations for shrews and robins exposed to ECOPCs detected in surface soil and drainage ditch sediment are presented in Tables 20 and 21, respectively. These tables show the maximum detected concentrations, average daily doses (ADDs), TRVs, and HQs for shrews and robins. HQs exceeding one are shown bordered by a double line.

There are no ECOPCs present in surface soil at concentrations resulting in ADDs exceeding the TRV for the surrogate species (Table 20). The HIs calculated for VOCs and SVOCs do not exceed one.

Cadmium is the only ECOPC in sediment from the drainage ditch that has an HQ exceeding one (Table 21). The cadmium HQs are 53.1 for shrews and 223 for robins. The HIs calculated for VOCs and SVOCs do not exceed one.

Groundwater. The preliminary risk calculations for raccoons exposed to ECOPCs detected in groundwater are presented in Table 22. This table shows the maximum detected concentrations, ADDs, TRVs, and HQs for the receptors. There are no ECOPCs present in groundwater at concentrations resulting in ADDs exceeding the TRVs for the surrogate species.

8.6 UNCERTAINTIES

The risks to ecological receptors from ECOPCs in drainage ditch sediment at SWMU 27T are overestimated by the preliminary risk calculations (see Section 8.5 of this addendum). The supplemental risk calculations for shrews or robins exposed to cadmium in drainage ditch sediment are presented in Tables 23 and 24, respectively. The ADDs calculated using a realistic diet (EPA 1993), the site-specific area use factor (AUF), and the mean cadmium concentration (9.65 mg/kg) do not exceed lowest observed adverse effect level (LOAEL)–based TRVs (HQs of less than one); therefore, cadmium in drainage ditch sediment at SWMU 27T is unlikely to pose a risk to wildlife receptors.

The risks to ecological receptors from ECOPCs in groundwater at SWMU 27T are overestimated by the preliminary risk calculations; therefore, fate and transport modeling was performed to estimate future concentrations for pyrene in groundwater at the receptor location. The nearest surface water receptor is an unnamed tributary to Melvin Swamp, which is located approximately 1,320 feet from the site. Analytical Transient 1-,2-,3-Dimensional (AT123D) modeling (see Attachment D of this addendum) was performed to estimate the 100-year maximum exposure concentration of pyrene (an ECOPC) in the surface water at the receptor location.

AT123D input parameters are presented in Table D-6, Attachment D of this addendum. The AT123D models were calibrated to the maximum observed concentration of pyrene in groundwater (26.2 μg/L) at the source. AT123D modeling assumed a steady-state, constant concentration at the source. AT123D modeling results are presented in Table D-7, Attachment D; the modeling results estimated the concentration of pyrene at the surface water receptor to be 0.00 μg/L; therefore, pyrene in groundwater at SWMU 27T does not pose a risk to aquatic biota.

9.0 HUMAN HEALTH BASELINE RISK ASSESSMENT, SWMU 27T

The purpose of the HHBRA is to quantify potential risk associated with COPCs identified in the previous screening assessments (i.e., fate and transport analysis and human health preliminary risk assessment). If the estimated risk value for a receptor exceeds the target risk values, constituents of concern (COCs) will be selected based on the risk value for that constituent. Remedial levels will be derived for each of the COCs identified.

The HHPRE has identified HHCOPCs in surface soil and sediment that might present a potential risk to human health. The fate and transport analysis has identified a CMCOPC that might leach into groundwater at concentrations that could present a significant risk to human health as a result of using groundwater as a source of residential drinking water. Based on GEPD (1996) and U.S. Environmental Protection Agency Region IV

(EPA 1995) guidance, an HHBRA is required for those constituents identified as COPCs, which include both HHCOPCs and CMCOPCs.

The HHBRA given below has quantified the potential risk associated with constituents identified in the fate and transport analysis and the HHPRE as presenting a potential risk to human health. The potential risk for site-specific human receptor populations is quantified for those potential exposure pathways identified for each receptor population.

The HHBRA consists of five elements: (1) identification of COPCs, (2) exposure assessment, (3) toxicity assessment, (4) risk characterization, and (5) assessment of uncertainty. The discussion in the following sections presents the information required to evaluate the human health risks associated with COPCs at SWMU 27T. A detailed discussion of each of the five elements, including methodology, selection of exposure parameters, and analysis of inherent uncertainties, is provided in Appendix I of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

9.1 IDENTIFICATION OF COPCS

The CMCOPCs and HHCOPCs have been discussed in the sections on contaminant fate and transport (Chapter 6.0) and the HHPRE (Chapter 7.0), respectively. Cadmium was identified as a CMCOPC in sediment. No CMCOPCs were identified for soil.

HHCOPCs were identified in surface soil and sediment. Benzo(*b*)fluoranthene was identified as an HHCOPC in surface soil. The HHCOPCs identified in sediment include cadmium and the following PAHs: benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, and indeno(*1,2,3-cd*)pyrene.

9.2 EXPOSURE ASSESSMENT

The exposure assessment quantifies the amount of a COPC an individual may come in contact with at each site. The exposure assessment considers all pathways of potential human exposure, the magnitude of exposure, and the frequency and duration of exposure. The process for estimating exposure consists of the following elements: (1) characterization of the exposure setting in terms of the physical and demographic characteristics of the site, (2) identification of receptor populations, (3) identification of the exposure pathways by which an individual may come in contact with a COPC, (4) estimation of the exposure point concentration, and (5) quantification of the intake or dose to which an individual may be exposed.

9.2.1 Exposure Setting

The exposure setting describes the physical features at the site that are important when identifying the human populations that may be exposed to COPCs, either currently or in the future.

SWMU 27T is one of 29 OWS sites located in the garrison area. This OWS site encompasses an area of approximately 0.01 acre, covered primarily by concrete and gravel. Maintained grass covers the remainder of the site. An open drainage ditch, which runs parallel to Troupe Avenue, is located adjacent to the site. The OWS is located between Troupe Avenue and the drainage ditch. The site is not secured and can be accessed from Troupe Avenue.

The elevation of groundwater is lower than that of the adjacent drainage ditch; therefore, groundwater is not likely to migrate to the drainage ditch. There are no other permanent surface water features near this site. The nearest surface water body is an unnamed tributary to Melvin Swamp located approximately 1,320 feet to the southeast of the site. Analysis of potential groundwater migration concluded that cadmium, which has leached into groundwater, is not likely to migrate to this tributary (see Section 9.2.3 of this addendum).

9.2.2 Identification of Potential Receptor Populations and Exposure Pathways

A complete exposure pathway consists of four elements: (1) a source of contamination, (2) a transport or retention medium, (3) a point of contact with the chemical, and (4) a route of exposure (ingestion, dermal absorption, or inhalation) at the point of contact through which the chemical may be taken into the body. When all of these elements are present, the pathway is considered to be complete.

A detailed discussion of the potential exposure pathways for the various receptor populations identified for 16 SWMUs is given in Section I.2.2, Appendix I of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000). The migration and exposure pathways for potential receptors at SWMU 27T are presented in Figure 6.

Impacted environmental media at this site include surface soil and sediment. Cadmium present in sediment may migrate to groundwater as a result of leaching. Groundwater at this site is not likely to migrate to surface water.

Current Land-use Populations. Given that the site is not secured and that COPCs have been identified in both surface soil and sediment, current on-site receptor populations would be represented by an Installation worker and a juvenile trespasser. The on-site Installation worker is representative of an individual who is employed by Fort Stewart and is present on the site for work purposes. The on-site Installation worker may be exposed to COPCs in surface soil via incidental ingestion and dermal contact. It is unlikely that the Installation worker would spend any significant amount of time in the drainage ditch; therefore, exposure to sediment is likely to be minimal. The current site cover is likely to limit the generation of fugitive dust; therefore, exposure via inhalation of fugitive dust is not considered to be a viable pathway.

The juvenile trespasser may be exposed while playing at the site and in the adjacent ditch. The juvenile trespasser may be exposed to HHCOPCs in surface soil via incidental ingestion and dermal contact and to constituents in sediment via incidental ingestion.

There are no current off-site receptor populations.

Future Land-use Receptor Populations. The potential on-site receptor populations for the future land-use scenario include an on-site Installation worker, off-site Installation worker, on-site juvenile trespasser, and both an on-site and an off-site resident. Although no changes in land use are expected at this site, for the purposes of this risk assessment, it was assumed that groundwater drinking wells had been placed at the site and the vegetative cover had been removed.

The on-site Installation worker might be exposed to COPCs in surface soil and groundwater (i.e., cadmium that has leached from sediment to groundwater). The potential exposure pathways for surface soil include ingestion, dermal contact, and inhalation of fugitive dust. The exposure pathway for groundwater is ingestion of drinking water.

The on-site trespasser might be exposed to COPCs in surface soil and sediment. The exposure pathways for surface soil include incidental ingestion, dermal contact, and inhalation of fugitive dust. The exposure pathways for sediment include incidental ingestion.

The on-site resident is presented for baseline purposes and is not considered to be a viable receptor population. The on-site resident might be exposed to COPCs in surface soil and groundwater. Potential exposure pathways for the on-site resident include incidental ingestion of soil, dermal contact with soil, inhalation of fugitive dust, ingestion of groundwater, and dermal contact with groundwater. The absence of volatile COPCs in groundwater excludes inhalation as a potential exposure pathway. If the site was developed for residential purposes, it would be landscaped and vegetated; therefore, exposure via inhalation of fugitive dust is not a likely exposure pathway. However, as a conservative assumption, this pathway will be evaluated.

Off-site migration includes fugitive dust and the migration of COPCs in groundwater. Future off-site receptor populations include an Installation worker and a resident.

The off-site Installation worker might be exposed to COPCs in surface soil via inhalation of fugitive dust. This receptor might also be exposed to COPCs in groundwater via ingestion.

The off-site resident is likely to be exposed via inhalation of fugitive dust and exposure to COPCs in groundwater. Groundwater exposure pathways include ingestion and dermal contact.

9.2.3 Estimation of Exposure Concentrations

The estimation of exposure concentrations for on-site receptors to COPCs in surface soil and sediment is discussed in Appendix I, Section 1.2.3 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000). Exposure concentrations were calculated using either analytical results or environmental fate and transport models. The analytical results from the surface soil and sediment samples were used to calculate the exposure concentrations for HHCOPCs in surface soil and sediment, respectively. The exposure point concentrations are equal to the upper 95 percent confidence limit on the mean, unless this value was greater than the maximum detected concentration, in which case the exposure concentration defaulted to the maximum concentration. The exposure concentrations are given in Table 25.

Exposure concentrations of fugitive dust in air were calculated using the formulas described in Appendix I, Section I.2.3 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000). These values were based on the exposure concentrations for surface soil. For the purposes of estimating exposure of an off-site receptor to fugitive dust, it was assumed that no dilution of the air concentrations occurred and that the exposure concentrations for both on-site and off-site receptors were the same.

Migration to Groundwater beneath the Source. The estimated groundwater concentration resulting from the leaching of cadmium from sediment was estimated using the Seasonal Soil Compartment (SESOIL) Model (see Attachment D of this addendum). The SESOIL Model is used to estimate the concentrations of constituents leaching from soil as a result of rainwater percolating through the soil before it reaches the water table. The SESOIL results are then converted into the groundwater concentrations by using a site-specific dilution factor (DF). The DF is developed using the hydraulic analysis method (EPA 1996a), which uses the estimated rate of groundwater flow through the aquifer system and the estimated rate of rainwater percolating into the aquifer to calculate the rate of dilution. The fate and transport analysis discussion and the associated results are presented in Attachment D of this addendum.

Based on the SESOIL results, cadmium (0.100 mg/L) is likely to leach to groundwater (Table D-3 and Figure D-1, Attachment D of this addendum). The estimated groundwater concentration (0.100 mg/L) was above the maximum contaminant level (MCL) of 0.005 mg/L (see Table D-3, Attachment D); therefore, the potential risks associated with the leaching of cadmium from sediment to groundwater were assessed.

Migration of Groundwater to Surface Water. Cadmium in groundwater may migrate to surface water. The closest surface water body that may potentially be a point of groundwater discharge is an unnamed tributary to Melvin Swamp located approximately 1,320 feet southeast from the site. For the purposes of the groundwater modeling, it was assumed that the tributary is located downgradient of the SWMU.

The One-dimensional Analytical Solute Transport (ODAST) Model (Attachment D) was used to estimate the concentration of cadmium in groundwater adjacent to the tributary. The groundwater concentration of this constituent would be diluted upon discharge into the tributary; however, as a conservative measure, it was assumed that there is no dilution by the upstream surface water. The concentration of cadmium in the surface water was assumed to be equal to the modeled concentration present in groundwater adjacent to the tributary.

The physicochemical and modeling parameters for the ODAST modeling are presented in Table D-4, Attachment D of this addendum. The ODAST modeling of cadmium assumed a constant concentration at the source for a period of 70 years, and the modeling was simulated for a period of 1,000 years.

The modeling results indicate that cadmium will not migrate to the unnamed tributary of Melvin Swamp (Table D-5, Attachment D); therefore, the risk associated with cadmium in groundwater migrating to surface water was not addressed further in this HHBRA.

9.2.4 Quantification of Exposure

The equations used to estimate exposures to receptor populations are discussed in Appendix I, Section I.2.4 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000). The default exposure factors for the current on-site trespasser assumed that the child divides his or her time between the drainage ditch and the area of the OWS. The exposure parameter values used to estimate potential exposure are given in Table 26.

Exposure of off-site receptors for SWMU 27T would be limited to inhalation of fugitive dust resulting from wind erosion of the surface soil. Benzo(*b*)fluoranthene is the only surface soil COPC, and this constituent does not have either an inhalation reference dose (RfD) or inhalation cancer slope factor (CSF); therefore, the potential risks to off-site receptors cannot be quantified. Given that the risk to these receptors cannot be evaluated, the estimated intakes for these receptors were not reported.

A potential intake was estimated for each receptor population for all applicable pathways. The estimated intakes for the current on-site receptors—the Installation worker and the juvenile trespasser—are given in Tables 27 and 28, respectively. There are no current off-site receptor populations.

Future on-site receptor populations include an Installation worker, a juvenile trespasser, and a resident. The estimated intakes for the Installation worker and the juvenile trespasser are given in Tables 29 and 30, respectively. The resident population is divided into a child and an adult resident, given the differences in behavior, exposure duration, and physiology between an adult and a child. Because of the increased amount of hand-to-mouth behavior in children, the incidental soil ingestion for a child is twice that of an adult. Given the higher ingestion rate and the lower body weight for a child, the resident child is at greater risk from incidental ingestion of surface soil than the resident adult. For the purposes of this risk assessment, the estimated intakes and potential risks were calculated for the resident child. The estimated intakes for the child resident and the adult resident are given in Tables 31 and 32, respectively.

Future off-site receptors include an Installation worker, a resident child, and a resident adult. These receptors might be exposed to benzo(*b*)fluoranthene in surface soil via inhalation of fugitive dust and off-site migration of cadmium that has leached to groundwater. The estimated intakes for the Installation worker are given in

Table 33. The estimated intakes for the off-site resident child and resident adult are given in Tables 34 and 35, respectively.

9.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to determine the increased likelihood and magnitude of adverse human health effects based on the extent of exposure to contamination. The toxicity assessment for SWMU 27T was carried out as described in Appendix I, Section I.3 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000). The toxicity values used in risk assessment are given in Table 36.

The RfD values for cadmium are given for food and water separately based on the differences in the uptake of this chemical from the different media. Given that cadmium was identified as an HHCOPC in sediment, the toxicity values for food were used because the absorption of chromium from soil is likely to be closer to the absorption from food as compared to absorption from water.

CSFs have not been directly derived for the carcinogenic PAHs benzo(*b*)fluoranthene, benzo(*a*)anthracene, and indeno(*1,2,3-cd*)pyrene. A toxicity equivalence factor (TEF) is used to estimate the CSFs. The TEF indicates the carcinogenic potency of the PAH relative to benzo(*a*)pyrene, which has a CSF; therefore, if the carcinogenic potency of a PAH is an order of magnitude less than that of benzo(*a*)pyrene, the TEF is 0.1. Benzo(*b*)fluoranthene, benzo(*a*)anthracene, and indeno(*1,2,3-cd*)pyrene have TEF values of 0.1.

The toxicity profiles for the COPCs are provided in Attachment E of this addendum.

9.4 RISK CHARACTERIZATION RESULTS

The risk characterization follows the procedures outlined in Appendix I, Section I.4 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000). Quantitative estimates of noncarcinogenic risks were calculated for each COPC for each potentially complete exposure pathway.

9.4.1 Current Land-use Scenarios

The current on-site receptor populations are an Installation worker and a juvenile trespasser. There are no current off-site receptor populations. The potential risk to each of the on-site receptor populations is discussed below.

On-Site Installation Worker. This receptor is exposed to only benzo(*b*)fluoranthene in surface soil. An RfD has not been calculated for this constituent, but this constituent does have a CSF. The total incremental lifetime cancer risk (ILCR) for this receptor is 3.00×10^{-7}, which is below the target risk value of 1×10^{-6} (Table 37); therefore, the carcinogenic risk for this receptor is within acceptable limits.

On-Site Juvenile Trespasser. The calculated risk values for the current on-site juvenile trespasser are given in Table 38.

The HI for this receptor is 7.94×10^{-4}, which is more than three orders of magnitude below the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The total ILCR is 1.21×10^{-7}, which is below the target value of 1×10^{-6}; therefore, the carcinogenic risk for this receptor is within acceptable limits.

9.4.2 Future Land-use Scenarios

Future potential on-site receptors are an Installation worker, a juvenile trespasser, and a resident (child and adult). The future potential off-site receptors include an Installation worker and a resident (child and adult). The potential risks to each of these receptor populations are discussed below.

On-site Installation Worker. The calculated risk values for the future on-site Installation worker are given in Table 39.

The HI for this receptor is 1.96, which exceeds the target value of 1.0. Cadmium leaching to groundwater is the primary risk driver.

The total ILCR is 3.00×10^{-7}, which is below the target value of 1×10^{-6}; therefore, the carcinogenic risk for this receptor is within acceptable limits.

On-site Juvenile Trespasser. The calculated risk values for the future on-site juvenile trespasser are given in Table 40.

The HI for this receptor is 7.94×10^{-4}, which is more than three orders of magnitude below the target value of 1.0; therefore, adverse systemic health risks are not expected for this receptor population.

The total ILCR is 1.21×10^{-7}, which is below the target value of 1×10^{-6}; therefore, the carcinogenic risk for this receptor is within acceptable limits.

On-site Resident Child. The calculated risk values for the on-site resident child are given in Table 41.

The HI for this receptor is 13.4, which exceeds the target value of 1.0. Cadmium leaching to groundwater is the primary risk driver.

The total ILCR for this receptor is 9.17×10^{-7}, which is below the target risk value of 1×10^{-6}; therefore, the cancer risks for this receptor are within acceptable limits.

On-site Resident Adult. The calculated risk values for the on-site resident adult are given in Table 42.

The HI for this receptor is 5.67, which exceeds the target value of 1.0. Cadmium leaching to groundwater is the primary risk driver.

The total ILCR for this receptor is 9.17×10^{-7}, which is below the target risk value of 1×10^{-6}; therefore, the cancer risks for this receptor are within acceptable limits.

Off-site Installation Worker. The calculated risk values for the future on-site Installation worker are given in Table 43.

The HI for this receptor is 1.96, which exceeds the target value of 1.0. Cadmium leaching to groundwater is the primary risk driver.

The total ILCR is 4.59×10^{-12}, which is more than five orders of magnitude below the target value of 1×10^{-6}; therefore, the carcinogenic risk for this receptor is within acceptable limits.

Off-site Resident Child. The calculated risk values for the off-site resident child are given in Table 44.

The HI for this receptor is 13.4, which exceeds the target value of 1.0. Cadmium leaching to groundwater is the primary risk driver.

The total ILCR for this receptor is 4.50×10^{-12}, which is more than five orders of magnitude below the target risk value of 1×10^{-6}; therefore, the cancer risks for this receptor are within acceptable limits.

Off-site Resident Adult. The calculated risk values for the off-site resident adult are given in Table 45.

The HI for this receptor is 5.67, which exceeds the target value of 1.0. Cadmium leaching to groundwater is the primary risk driver.

The total ILCR for this receptor is 5.67×10^{-12}, which is more than five orders of magnitude below the target risk value of 1×10^{-6}; therefore, the cancer risks for this receptor are within acceptable limits.

9.5 UNCERTAINTY ASSESSMENT

A discussion of the general uncertainties associated with the analysis of risks at sites within the 16 SWMUs is provided in Appendix I, Section I.5 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

The toxicity values for many of the PAHs were not derived directly from laboratory studies, but were estimated based on the relative toxicity of the PAH to benzo(*a*)pyrene. In addition, none of the PAHs had RfDs; therefore, the potential systemic toxicity of these constituents could not be assessed.

9.6 RISK SUMMARY

The purpose of the risk summary is to provide an overview of the risk assessment results, including identification of the COPCs assessed, the receptor populations, and the risk characterization results.

The HHBRA addressed the risks associated with exposure benzo(*b*)fluoranthene in surface soil and cadmium, benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*a*)anthracene, and indeno(*1,2,3-cd*)pyrene in sediment. Cadmium in sediment is also a CMCOPC.

Environmental media that were addressed under current land-use conditions include surface soil and sediment. Current receptor populations include an Installation worker exposed to COPCs in surface soil and a juvenile trespasser playing in the drainage ditch, resulting in exposure to COPCs in sediment.

Future land-use populations include an Installation worker, a juvenile trespasser, and a resident. The Installation worker and the resident represent both on-site and off-site receptors. The juvenile trespasser is an on-site receptor only. The residential receptor population was divided into an adult and a child because the adult receptor is at greater risk from exposure to carcinogens, while the child is at greater risk from exposure to noncarcinogens. The reader is referred to Appendix I, Section I.2.2 ("Identification of Potential Receptor Populations and Associated Exposure Pathways") of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000) for a more detailed discussion on the potential exposure pathways and the differences between the exposure of the adult and child resident receptors.

The estimated risk values for the current receptor populations are below the target levels of 1.0 for the HI and 1×10^{-6} for the ILCR. The risk values for the future on-site juvenile trespasser are also below the target levels. The HIs for the remaining future receptor populations (on-site Installation worker, on-site resident child, on-site resident adult, off-site Installation worker, off-site resident child, and off-site resident adult) exceed the target level of 1.0. Exposure to cadmium that has leached into groundwater is the only risk driver for this site.

Cadmium was identified as a COC in sediment, based on its potential to leach into groundwater.

9.7 REMEDIAL LEVELS

Remedial levels were derived for cadmium in sediment that are protective of the on-site Installation worker and the on-site resident. The development of remedial levels followed the protocols given in Appendix I, Section I.6 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

The risk-based remedial levels should be based upon the most sensitive receptor population and the most significant exposure pathway. The resident child is the most sensitive receptor, with an HI of 13.4 for exposure to cadmium that has leached into groundwater.

The remedial level for a contaminant migration constituent of concern (CMCOC) represents that soil concentration that is unlikely to leach into groundwater in concentrations that present a significant threat to human health. The potential risk associated with CMCOCs is not direct exposure to soil, but exposure to the constituents in groundwater; therefore, the remedial levels in soil were based upon target groundwater concentrations. These values are the concentrations of a CMCOC in groundwater that present a defined risk to a receptor. For example, if the target groundwater concentration is based on an HI of 1.0, the risk value of 1.0 represents the potential risk to a receptor population exposed to the risk-based target concentration of the CMCOC in groundwater. The corresponding risk-based soil remedial value would represent the concentration of the CMCOC in soil that is likely to leach into groundwater, resulting in a CMCOC groundwater concentration equal to the target groundwater concentration.

The selection of a remedial level must take into consideration the target risk value for risk-based remedial levels and the regulatory standards for groundwater. The selection of a target risk value for remedial levels must take into account the total risk for that receptor population from all of the COCs present at the site. The total potential risks associated with the COCs should not result in a cumulative HI that exceeds 3.0 (GEPD 1996). Cadmium in sediment is the only COC identified for this site; therefore, a target HI of 3.0 is recommended.

Remedial levels should take into account regulatory standards such as MCLs. The MCL takes into consideration both the potential human health risks associated with exposure to the contaminant in drinking water and the technological limitations in removing that contaminant from water. An MCL that is derived based on the acceptable human health risks as defined in the Safe Drinking Water Act may be more stringent than the possible target risk values allowed under the current GEPD RCRA guidance (GEPD 1996); therefore, the recommended target groundwater concentration will not exceed the MCL for cadmium of 5 μg/L.

The target groundwater concentrations are given in Table 46. The risk-based remedial level based on an HI of 3.0 is 23.5 μg/L, as compared to the MCL for cadmium of 5 μg/L. The MCL was used as the target groundwater concentration.

The recommended remedial levels for inorganic COCs in sediment were compared to the site-specific sediment reference background concentrations. If the remedial level was lower than the site-specific reference background concentration, then the remedial level defaulted to background.

The remedial level for soil is given in Table 47. The recommend remedial level is 1.0 mg/kg, based on a target groundwater concentration of 5 μg/L (the MCL for cadmium). This value is less than the sitewide background screening concentration of 5.36 mg/kg; therefore, the recommended remedial level for cadmium in sediment is 5.36 mg/kg.

10.0 CONCLUSIONS AND RISK MANAGEMENT AND SITE RECOMMENDATIONS, SWMU 27T

10.1 SUMMARY OF FINDINGS

The Phase II RFI presented in this addendum was conducted to collect additional analytical data for determining the nature and extent of contamination in environmental media and the potential adverse effects to human health and the environment in the vicinity of SWMU 27T. The data were derived from a series of screening and primary samples collected from surface soil, sediment, and groundwater in the study area during the Phase I and Phase II RFIs. A first set of samples collected during the Phase I RFI were analyzed for VOCs, SVOCs, and lead. A second set of sediment samples collected during the Phase I RFI were analyzed for VOCs, SVOCs, and RCRA metals. The samples collected during the Phase II RFI were analyzed for cadmium only.

The following sections summarize the significant findings of the Phase I (January 1998) and Phase II (October 1999) RFI sampling and analysis activities.

10.1.1 Surface and Subsurface Soil

- No VOCs were detected in surface soil. The SVOCs benzo(*b*)fluoranthene, chrysene, phenanthrene, and pyrene were detected in surface soil and are considered to be SRCs in surface soil.
- No SRCs were identified in subsurface soil.

10.1.2 Groundwater

Groundwater was encountered at approximately 4 feet to 6 feet bgs in the monitoring well and Geoprobes.

- Acetone and pyrene were detected in groundwater and are considered to be SRCs in groundwater.
- Lead in groundwater was below the reference background criterion at GP1 and GP2 and not detected at GP3 and GP4; therefore, lead is not considered to be an SRC.
- Cadmium was not detected in the groundwater collected from MW1; therefore, cadmium is not an SRC in groundwater.

10.1.3 Surface Water and Sediment

A drainage ditch is located between the OWS and the wash rack (see Figure 2). The effluent (i.e., separated water) from the OWS discharges to the NGTC Equalization Basin (SWMU 37). Surface water is present in the drainage ditch only during rainfall events. The closest surface water body is an unnamed tributary to Melvin Swamp located approximately 1,320 feet to the southeast of the site. Melvin Swamp ultimately flows into Peacock Creek approximately 5 miles to the southeast.

- 2-Butanone, 2-hexanone, 4-methyl-2-pentanone, acetone, benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*g,h,i*)perylene, benzo(*k*)fluoranthene, chrysene, fluoranthene, indeno(*1,2,3-cd*)pyrene, pyrene, and cadmium were detected in the sediment samples and are considered to be SRCs for sediment.

- Cadmium was detected in the sediment sample at a concentration that exceeded the reference background criterion; therefore, cadmium is considered to be an SRC in sediment.

10.2 CONCLUSIONS

Several assessments were conducted to determine the significance of the contaminant concentrations found at SWMU 27T with respect to their impact on human health and the environment. The assessments included those listed below.

- An analysis of contaminant fate and transport (Chapter 6.0) evaluated the potential for SRCs to migrate from one environmental medium to another (e.g., leaching of constituents from soil and sediment into groundwater). This section provides an assessment of that potential for SRC migration from one medium to another, resulting in a potential risk to human health and the environment.

- An HHPRE (Chapter 7.0), which used a Step i risk screening, identified HHCOPCs.

- An EPRE (Chapter 8.0) was performed for terrestrial and aquatic receptors in the study area.

- An HHBRA (Chapter 9.0) was performed for CMCOPCs identified in the fate and transport analysis and HHCOPCs identified in the HHPRE.

10.2.1 Fate and Transport Analysis

Below are the conclusions regarding contaminant fate and transport.

- SRCs identified in soil did not exceed their respective GSSLs; therefore, there are no CMCOPCs in soil based on leaching to groundwater.

- Cadmium exceeded the GSSL in sediment; therefore, cadmium is a CMCOPC for sediment at the site based on leaching to groundwater.

10.2.2 Human Health Preliminary Risk Evaluation

Based on the results of the screening and the weight-of-evidence analysis, potential HHCOPCs have been identified for sediment and surface water runoff. The results of the HHPRE are summarized below.

- Benzo(*b*)fluoranthene was identified as an HHCOPC in surface soil.

- There are no HHCOPCs in groundwater.

- HHCOPCs in sediment included cadmium and the following SVOCs (all PAHs): benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*a*)anthracene, and indeno(*1,2,3-cd*)pyrene.

10.2.3 Ecological Preliminary Risk Evaluation

Based on the results of the EPRE screening analysis, ECOPCs were identified in groundwater, surface water runoff, and sediment from the depression area. Sediment samples from the depression area were evaluated as surface soil, given the similarities in the type of habitat present within the depression and the surrounding area. Those constituents identified as ECOPCs were further evaluated using realistic exposure factors, mean site concentrations, and LOAEL–based TRVs, as compared to no observed adverse effect level (NOAEL)–based TRVs. The results of the EPRE are summarized below.

- Pyrene in groundwater is an ECOPC for aquatic biota by default because there is no ESV. Pyrene is unlikely to be a potential hazard to aquatic biota living in downgradient surface water because fate and transport modeling estimated the concentration of pyrene at the surface water body to be 0.00 μg/L; therefore, pyrene is unlikely to pose a hazard to aquatic biota.

- There are no ECOPCs in groundwater for terrestrial receptors.

- Cadmium in drainage ditch sediment at SWMU 27T is an ECOPC for terrestrial receptors because the preliminary HQs exceed one. The supplemental risk calculations for cadmium result in HQs of less than one; therefore, ECOPCs in drainage ditch sediment are unlikely to pose a risk to wildlife receptors.

- There are no ECOPCs in surface soil for terrestrial receptors.

10.2.4 Human Health Baseline Risk Assessment

An HHBRA was performed to assess CMCOPCs identified in the fate and transport analysis and HHCOPCs identified in surface soil and sediment in the HHPRE. Cadmium was identified as a CMCOPC in sediment under the fate and transport analysis. Benzo(*b*)fluoranthene was identified as an HHCOPC in surface soil and sediment in the HHPRE. Cadmium, benzo(*a*)pyrene, benzo(*a*)anthracene, and indeno(*1,2,3-cd*)pyrene were identified as HHCOPCs in sediment.

The following bullets present the conclusions of the HHBRA.

- None of the estimated risk values for the HHCOPCs exceeded the target risk values for the receptor populations evaluated; therefore, these constituents do not present a significant risk to human health.

- Cadmium in groundwater due to leaching from soil may potentially migrate to surface water, an unnamed tributary to Melvin Swamp located approximately 1,320 feet southeast of the site. Modeling results indicated, however, that cadmium will not migrate to this potential point of discharge (receptor point); therefore, the risk associated with cadmium migrating to surface water was not quantified.

- Modeling estimated that cadmium (a CMCOPC) would leach from sediment to groundwater at a concentration of 100 μg/L, which was above the MCL of 5 μg/L. Future on-site and off-site receptor populations might be exposed to constituents in groundwater. These future land-use populations include an Installation worker and a resident. The Installation worker and the resident represent both on-site and off-site receptors. The residential receptor population was divided into an adult and a child because the adult receptor is at greater risk from exposure to carcinogens, while the child is at greater risk from exposure to noncarcinogens. The HIs for all of these receptors exceeded the target level of 1.0. Cadmium was identified as a COC in sediment. Remedial levels were derived for cadmium in sediment that are protective of the most sensitive receptor population—the resident child with an HI of 13.4. The remedial level for a CMCOC represents that soil concentration that is unlikely to leach into groundwater in concentrations that present a significant threat to human health. The selection of a remedial level must take into consideration the target risk value for risk-based remedial levels and the regulatory standards for groundwater (i.e., the MCL) as well as background concentrations. The MCL for cadmium (5.0 μg/L) was selected as the target groundwater concentration because it was less than the risk-based remedial level (23.5 μg/L) based on an HI of 3.0. The recommended remedial level for cadmium in sediment is 1.0 mg/kg based on a target groundwater concentration of 5 μg/L; however, this value is less than the background screening value of 5.36 mg/kg, so the recommended remedial level for cadmium in sediment will default to the background concentration of 5.36 mg/kg.

10.3 RISK MANAGEMENT AND SITE RECOMMENDATIONS

- Cadmium in sediment located at SWMU 27T, was identified as a potential COC based on its potential to leach to groundwater at a concentration that might be a risk to human health. Cadmium was not detected in the groundwater monitoring well installed at the location of the highest detected concentration in sediment, and the results of the SESOIL modeling indicated that cadmium will take more than 200 years to reach the groundwater. The cadmium concentration used for the SESOIL modeling was significantly higher than the concentrations measured in the remaining two sediment samples. A cadmium concentration of 19.3 mg/kg was used for the modeling as compared to concentrations of 5.81 mg/kg and 3.85 mg/kg in the remaining samples. The site-specific sediment background concentration is 5.36 mg/kg. Given the conservatism of the leachate modeling, the elevated concentration used in the modeling relative to median concentration, the extended period of time before any potential impact to groundwater might occur, and the fact that cadmium was not detected in groundwater, the potential threat to human health as a result of exposure via groundwater is likely to be minimal.

- Based on the information provided in this section, Fort Stewart respectfully requests that SWMU 27T be assigned an NFA status. If approved by GEPD, the Installation's Subpart B permit should be amended to annotate this change in investigative status.

- A CAP will not be required for this site. The permanent monitoring well installed at the site will be properly abandoned within 90 days of approval of this report.

11.0 REFERENCES

EPA (U.S. Environmental Protection Agency) 1985. Drinking Water Criteria Document on Cadmium, Office of Drinking Water, Washington, D.C.

EPA 1993. Wildlife Exposure Factors Handbook, Vol. I, EPA/600/R-93/187A, Office of Research and Development, Washington, D.C.

EPA 1995. Supplemental Guidance to RAGS: Region IV Bulletin, Human Health Risk Assessment (Draft), Nos. 1–5, EPA Region IV, Office of Health Assessment, November.

EPA 1996a. Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, Office of Solid Waste and Emergency Response, May.

EPA 1996b. Supplemental Guidance to RAGS, Region IV Bulletins, Ecological Risk Assessment, Nos. 1–5, EPA Region IV, Office of Health Assessment, October (Draft).

EPA 1997. Health Effects Assessment Summary Tables, FY 1997 Update, EPA 540/R-97-036, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 2000a. Integrated Risk Information System, on-line database, Office of Environmental Criteria and Assessment Office, Cincinnati, available at <http://www.epa.gov/iris>.

EPA 2000b. EPA Region III Risk-based Concentration Table, <http://www.epa.gov/reg3hwmd/risk/techdoc.pdf>.

GEPD (Georgia Environmental Protection Division) 1996. Guidance for Selecting Media Remediation Levels at RCRA Solid Waste Management Units, Georgia Environmental Protection Division, Atlanta, Georgia, November.

HAZWRAP (Hazardous Waste Remedial Actions Program) 1994. Loring Air Force Base Risk Assessment Methodology (Final), Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee.

ORNL (Oak Ridge National Laboratory) 1999. Chemical-specific Factors, Risk Assessment Information System, Oak Ridge National Laboratory, Oak Ridge, Tennessee, available at <http://risk.lsd.ornl.gov/cgi-bin/tox/TOX_select?select=csf>.

SAIC (Science Applications International Corporation) 1997. Sampling and Analysis Plan for Phase II RCRA Facility Investigations of 16 Solid Waste Management Units at Fort Stewart, Georgia (Revised Final), October.

SAIC 1998. Corrective Action Plan, Part A, Underground Storage Tank 207, Facility ID #9-089038, Building 232, Fort Stewart, Georgia, December.

SAIC 1999. Minutes of Comment Response Meeting held on September 14, 1999, at Atlanta, Georgia, issued to USACE–Savannah District, FSMR DPW, and GEPD on September 23, 1999.

SAIC 2000. Phase II RCRA Facility Investigation Report for 16 Solid Waste Management Units at Fort Stewart, Georgia (Revised Final), April.

Sample, B. E., D. M. Opresko, and G. W. Suter, II 1996. Toxicological Benchmarks for Wildlife: 1996 Revision, ES/ER/TM-86/R3, Lockheed Martin Energy Systems, Inc., Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Suter, G. W., II and C. L. Tsao 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision, ES/ER/TM-96/R2, Lockheed Martin Energy Systems, Inc., Oak Ridge National Laboratory, Oak Ridge, Tennessee.

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Table 1. Summary of Phase I RFI Analytes Detected in Surface Soil, SWMU 27T

Station	Reference Background Criteria	8FGP2[a]	8FGP3[a]	8FGP4
Sample ID		8F1212	8F1312	8F1411
Date		05/06/98	05/06/98	01/18/98
Depth (feet)		0 to 2	0 to 2	0 to 2
Sample Type		Grab	Grab	Grab
Semivolatile Organic Compounds (mg/kg)				
Benzo(*b*)fluoranthene	0.00		**1.14**	
Chrysene	0.00			**0.215**
Phenanthrene	0.00		**0.79**	
Pyrene	0.00		**1.33**	**0.22**
Metals (mg/kg)				
Lead	8.81	7.5	6.1	7.1

[a]The analytical laboratory inadvertently missed the holding times for VOCs and SVOCs for soil during the January 1998 sampling endeavor. Soil was resampled May 6, 1998.
Bold indicates concentrations above reference background criteria.

Table 2. Summary of Phase I RFI Analytes Detected in Subsurface Soil, SWMU 27T

Station	Reference Background Criteria	8FGP1[a]
Sample ID		8F1112
Date		05/06/98
Depth (feet)		2 to 3
Sample Type		Grab
Metals (mg/kg)		
Lead	11.10	5.5

[a]The analytical laboratory inadvertently missed the holding times for VOCs and SVOCs for soil during the January 1998 sampling endeavor. Soil was resampled May 6, 1998.

Table 3. Summary of Phase I RFI Analytes Detected in Groundwater, SWMU 27T

Station	Reference Background Criteria	MCL	8FGP1	8FGP2	8FGP3	8FGP4
Sample ID			8F4111	8F4211	8F4311	8F4411
Date			01/19/98	01/19/98	01/19/98	01/18/98
Sample Type			Grab	Grab	Grab	Grab
Volatile Organic Compounds (μg/L)						
Acetone	0.00				**50.2**	
Semivolatile Organic Compounds (μg/L)						
Pyrene	0.00					**26.2**
Metals (μg/L)						
Lead	4.69	15	0.86	0.81		

Bold indicates concentrations above reference background criteria.

Table 4. Summary of Phase I RFI Analytes Detected in Sediment, SWMU 27T

Station	Site-specific Reference Background Criteria[a]	8FSWS1	8FSWS2	8FSWS3[b]
Sample ID		8F2111	8F2211	8F2311
Date		02/01/98	09/23/99	09/23/99
Depth (feet)		0 to 1	0 to 1	0 to 1
Sample Type		Grab	Grab	Grab
Volatile Organic Compounds (mg/kg)				
2-Butanone	0.0412		0.0227	0.0206
2-Hexanone	0.00		**0.0023**	
4-Methyl-2-pentanone	0.00		**0.0052**	
Acetone	0.782		0.099	0.391
Semivolatile Organic Compounds (mg/kg)				
Benzo(*a*)anthracene	1.18	1.07	0.405	0.592
Benzo(*a*)pyrene	1.48	**1.95**	0.677	0.738
Benzo(*b*)fluoranthene	1.93	**3.51**	1.06	0.965
Benzo(*g,h,i*)perylene	0.996	**1.81**	0.633	0.498
Benzo(*k*)fluoranthene	1.81	**2.4**	0.851	0.907
Chrysene	0.0928	**2.54**		0.0464
Fluoranthene	1.99	**2.92**	1	0.994
Indeno(*1,2,3-cd*)pyrene	0.878	**1.65**	0.582	0.439
Pyrene	2.68	**3.25**	1.12	1.34
Metals (mg/kg)				
Arsenic	2.8	NA	1.3	1.4
Barium	73.6	NA	29.2	36.8
Cadmium	5.36[c]	NA	**19.3**	2.2
Chromium	31.2	NA	15.3	15.6
Lead	123	33.3	57.9	61.5
Mercury	0.24	NA	0.02	0.12
Selenium	1.64	NA	0.58	0.82

[a]Site-specific background criteria for sediment equal two times background concentrations (SWS3), except where noted.
[b]Site-specific background location.
[c]Site-specific background criterion for cadmium in sediment is two times the average of SWS3 collected during the Phase I RFI and SWS4 collected during the Phase II RFI.
NA = Not analyzed.
Bold indicates concentrations above site-specific reference background criteria.

Table 5. Monitoring Well Construction, Summary of Geotechnical Analyses, Well Development Summary, and Field Parameter Measurements during Groundwater Sampling for Monitoring Well MW1, SWMU 27T

MONITORING WELL CONSTRUCTION							
Well No.	Date Installed	Size/Type	Coordinates	Total Depth (feet)	Screen Interval (feet bgs)	Top of Filter Pack Elevation (feet bgs)	Top of Casing Elevation (feet)
27T-MW1	7/23/00	2-inch PVC	N678415.44 E832498.92	15.0	5.0 to 14.5	3.0	85.57

Note: All elevations are National Geodetic Vertical Datum 1929.

SUMMARY OF GEOTECHNICAL ANALYSES							
				Atterberg Limits			
Station	Sample ID	Depth (feet)	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Class
227T-MW1	8F1172	10.0 to 15.0	18.58	NP	NP	NP	NP

			Grain-size Distribution		
Station	Sample ID	Depth (feet)	Gravel (%)	Sand (%)	Fines (%)
227T-MW1	8F1172	10.0 to 15.0	4.20	92.44	3.36

NP = Non-plastic.

WELL DEVELOPMENT SUMMARY					
Well No.	Date	Total Development Time (hours)	Total Volume Removed (gallons)	Final Turbidity Reading (NTUs)	Total Well Depth (feet)
27T-MW1	7/25/00 through 7/26/00	16 hours 20 minutes	950	27.1	14.15

FIELD PARAMETER MEASUREMENTS DURING GROUNDWATER SAMPLING							
Parameter	Date	pH (su)	Conductivity (mS/cm)	Temperature (°C)	Turbidity (NTUs)	DO (mg/L)	Redox (mV)
27T-MW1	8/23/00	5.25	89	31.61	18.8	-1.49	202

Table 6. Summary of Phase II RFI Analytes Detected in Groundwater, SWMU 27T

Station	Site-specific Reference Background Criteria	8FMW1	8FMW1
Sample ID		8F4171	8F4171
Date		08/23/00	08/23/00
Filtered		Total	Filtered
Sample Type		Grab	Grab
Metals (μg/L)			
Cadmium	0.43	ND	ND

ND = Not detected.

Table 7. Summary of Phase II RFI Analytes Detected in Sediment, SWMU 27T

Station	Site-specific Reference Background Criteria[a]	8FSWS4[b]	8FSWS5	8FSWS6
Sample ID		8F2411	8F2511	8F2611
Date		06/24/00	06/24/00	06/24/00
Sample Type		Grab	Grab	Grab
Metals, mg/kg				
Cadmium	5.36	3.16	**5.81**	3.85

[a]Site-specific background criterion for cadmium in sediment is two times the average of SWS3 collected during the Phase I RFI and SWS4 collected during the Phase II RFI.

[b]Site-specific background location.

Bold indicates concentrations above site-specific reference background criteria.

Table 8. Summary of Site-related Contaminants, SWMU 27T

Analyte	Maximum Concentration (mg/kg)			Maximum Concentration (µg/L)	
	Surface Soil[a]	Subsurface Soil[a]	Sediment[a]	Groundwater[a]	Surface Water
Volatile Organic Compounds					
2-Butanone	ND	ND	0.0227	ND	NC
2-Hexanone	ND	ND	0.0023	ND	NC
4-Methyl-2-pentanone	ND	ND	0.0052	ND	NC
Acetone	ND	ND	0.099	50.2	NC
Semivolatile Organic Compounds					
Benzo(*a*)anthracene	ND	ND	1.07	ND	NC
Benzo(*a*)pyrene	ND	ND	1.95	ND	NC
Benzo(*b*)fluoranthene	1.14	ND	3.51	ND	NC
Benzo(*g,h,i*)perylene	ND	ND	1.81	ND	NC
Benzo(*k*)fluoranthene	ND	ND	2.4	ND	NC
Chrysene	0.215	ND	2.54	ND	NC
Fluoranthene	ND	ND	2.92	ND	NC
Indeno(*1,2,3-cd*)pyrene	ND	ND	1.65	ND	NC
Phenanthrene	0.79	ND	ND	ND	NC
Pyrene	1.33	ND	3.25	26.2	NC
Metals					
Cadmium	NA	NA	19.3	ND	NC

[a]Maximum concentrations of constituents were indicated during the Phase I RFI.
NA = Not analyzed.
NC = Not collected; no surface water present in February 1998 or June 2000.
ND = Not detected.

Table 9. GSSL Screening of Site-related Contaminants in Soil, SWMU 27T

Site-related Contaminant	Maximum Concentration	GSSL[a]	CMCOPC?
SOIL			
Semivolatile Organic Compounds (mg/kg)			
Benzo(*b*)fluoranthene	1.14	5	No
Chrysene	0.215	160	No
Phenanthrene[b,c]	0.79	80.4	No
Pyrene	1.33	4,200	No
SEDIMENT			
Volatile Organic Compounds (mg/kg)			
2-Butanone	0.0227	7.685	No
2-Hexanone	0.0023	6.9	No
4-Methyl-2-pentanone	0.0052	NA	NA
Acetone	0.099	16	No
Semivolatile Organic Compounds (mg/kg)			
Benzo(*a*)anthracene	1.07	2	No
Benzo(*a*)pyrene	1.95	8	No
Benzo(*b*)fluoranthene	3.51	5	No
Benzo(*g,h,i*)perylene[b]	1.81	394	No
Benzo(*k*)fluoranthene	2.4	49	No
Chrysene	2.54	160	No
Fluoranthene	2.92	4,300	No
Indeno(*1,2,3-cd*)pyrene	1.65	14	No
Pyrene	3.25	4,200	No
Metals (mg/kg)			
Cadmium	19.3	8	Yes

[a]GSSL = EPA GSSL with a dilution attenuation factor of 20 for volatile and semivolatile organics is used; unless otherwise indicated, GSSL is taken from Soil Screening Guidance: Technical Background Document (EPA 1996a).

[b]EPA–suggested GSSL is not available; GSSL is calculated following Soil Screening Guidance: Technical Background Document (EPA 1996a). GSSLs are back-calculated from MCL, if available; otherwise, GSSLs are back-calculated based on EPA Region III RBCs corresponding to 10^{-6} risk or HQ = 1 (SAIC 1999).

[c]Risk-based concentration of surrogate pyrene was used to develop GSSL for phenanthrene.

NA = Not available.

Table 10. Human Health Risk Screening for Surface Soil, Groundwater, and Sediment, SWMU 27T

SURFACE SOIL						
Analyte	Results > Detection Limit	Minimum Detect	Maximum Detect	EPA Region III Residential	HHCOPC?	Justification
Semivolatile Organic Compounds (mg/kg)						
Benzo(*b*)fluoranthene	1/3	1.14	1.14	0.88	Yes	Max Detect > Risk Criteria
Chrysene	1/3	0.215	0.215	88	No	Max Detect < Risk Criteria
Phenanthrene	1/3	0.79	0.79	235	No	Max Detect < Risk Criteria
Pyrene	2/3	0.22	1.33	230	No	Max Detect < Risk Criteria

GROUNDWATER						
Analyte	Freq. of Detection	Minimum Result	Maximum Result	Human Health Criteria	HHCOPC?	Justification
Volatile Organic Compounds (µg/L)						
Acetone	1/3	50.2	50.2	61	No	Max Detect < Risk Criteria
Semivolatile Organic Compounds (µg/L)						
Pyrene	1/3	26.2	26.2	110	No	Max Detect < Risk Criteria

SEDIMENT						
Analyte	Results > Detection Limit	Minimum Detect	Maximum Detect	EPA Region III Residential	HHCOPC?	Justification
Volatile Organic Compounds (mg/kg)						
2-Butanone	1/2	0.0227	0.0227	4,700	No	Max Detect < Risk Criteria
2-Hexanone	1/2	0.0023	0.0023	4,700	No	Max Detect < Risk Criteria
4-Methyl-2-pentanone	1/2	0.0052	0.0052	630	No	Max Detect < Risk Criteria
Acetone	1/2	0.099	0.099	780	No	Max Detect < Risk Criteria
Semivolatile Organic Compounds (mg/kg)						
Benzo(*a*)anthracene	1/1	1.07	1.07	0.88	Yes	Max Detect > Risk Criteria
Benzo(*a*)pyrene	1/1	1.95	1.95	0.09	Yes	Max Detect > Risk Criteria
Benzo(*b*)fluoranthene	1/1	3.51	3.51	0.88	Yes	Max Detect > Risk Criteria
Benzo(*g,h,i*)perylene[a]	1/1	1.81	1.81	8.8	No	Max Detect < Risk Criteria
Benzo(*k*)fluoranthene	1/1	2.4	2.4	8.8	No	Max Detect < Risk Criteria
Chrysene	1/1	2.54	2.54	88	No	Max Detect < Risk Criteria
Fluoranthene	1/1	2.92	2.92	310	No	Max Detect < Risk Criteria
Indeno(*1,2,3-cd*)pyrene	1/1	1.65	1.65	0.88	Yes	Max Detect > Risk Criteria
Pyrene	1/1	3.25	3.25	230	No	Max Detect < Risk Criteria
Metals (mg/kg)						
Cadmium	1/1	19.3	19.3	3.9	Yes	Max Detect > Risk Criteria

[a]A TEF of 0.01 was used for this PAH [see Section 7.3, Selection of Screening Values, of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000)].

Table 11. Ecological Screening Value Comparison for Analytes Detected in Groundwater, SWMU 27T

Analyte	SWMU 27T Maximum	ESV	ECOPC Aquatic Biota?	Justification
Volatile Organic Compounds (μg/L)				
Acetone	50.2	1,500[a]	No	Max Detect < ESV
Semivolatile Organic Compounds (μg/L)				
Pyrene	26.2	No ESV	Yes	ECOPC by Default

[a]Chronic National Ambient Water Quality Criteria or Tier II values as reported in Suter and Tsao (1996), Table 1 or Table 3.
ESV = EPA Region IV ESVs (EPA 1996b) and, where indicated, alternative values for analytes without ESVs.
Cells with double borders indicate concentrations exceeding ESV or, when there is no ESV, compounds that become ECOPCs by default.

Table 12. Derivation of NOAELs for Mammal Test Species, SWMU 27T

ECOPC	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kg/day)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	NOAEL (mg/kg/day) Benchmark × DCF × ECF
INORGANICS										
Cadmium	Rat	3.03E-01	1.00E-00	Chronic	NOAEL	Reproduction	Sutou et al. (1980b) in [1]	1.0	1.0	1.00E-00
ORGANICS										
Volatile Organic Compounds										
Acetone	Rat	3.50E-01	1.00E+02	Subchronic	NOAEL	Reproduction	EPA (1986c) in [1]	0.1	1.0	1.00E+01
2-Butanone	Rat	3.50E-01	1.77E+03	Chronic	NOAEL	Reproduction	Cox et al. (1975) in [1]	1.0	1.0	1.77E+03
2-Hexanone	None	None	None	None	None	None	None	None	None	No NOAEL
4-Methyl-2-pentanone	Rat	3.50E-01	2.50E+02	Subchronic	NOAEL	Liver/kidney	Microbiological Associates (1986) in [1]	0.1	1.0	2.50E+01
Semivolatile Organic Compounds										
Benzo(*a*)anthracene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [3]	1.0	1.0	1.33E+01
Benzo(*a*)pyrene	Mouse	3.00E-02	1.00E+01	Chronic	LOAEL	Reproduction	Mackenzie and Angevine (1981) in [1]	1.0	0.1	1.00E-00
Benzo(*b*)fluoranthene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [3]	1.0	1.0	1.33E+01
Benzo(*g,h,i*)perylene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [3]	1.0	1.0	1.33E+01
Benzo(*k*)fluoranthene	Mouse	3.00E-02	1.00E+01	Chronic	LOAEL	Reproduction	Opresko (1995) in [3]	1.0	0.1	1.00E-00
Chrysene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [3]	1.0	1.0	1.33E+01
Fluoranthene	Mouse	3.00E-02	5.00E+02	Chronic	LOAEL	None	ATSDR (1997) in [3]	1.0	0.1	5.00E+01
Indeno(*1,2,3-cd*)pyrene	Mouse	3.00E-02	1.33E+01	Chronic	NOAEL	None	Neal and Rigdon (1967) in [3]	1.0	1.0	1.33E+01
Phenanthrene	Mouse	3.00E-02	1.00E+01	Chronic	LOAEL	Reproduction	Opresko (1995) in [3]	1.0	0.1	1.00E-00
Pyrene	Mouse	3.00E-02	1.00E+01	Chronic	LOAEL	Reproduction	Opresko (1995) in [3]	1.0	0.1	1.00E-00

ATSDR = Agency for Toxic Substances and Disease Registry.
DCF = 1 if chronic, 0.1 if subchronic (Sample, Opresko, and Suter 1996).
ECF = 1 if NOAEL, 0.1 if LOAEL (Sample, Opresko, and Suter 1996).
[1] = Sample, Opresko, and Suter (1996).
[3] = QST (1997); all values assumed to be chronic.

Table 13. Derivation of NOAELs for Bird Test Species, SWMU 27T

ECOPC	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kg/day)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	NOAEL (mg/kg/day) Benchmark × DCF × ECF
INORGANICS										
Cadmium	Mallard duck	1.15E+00	1.45E+00	Chronic	NOAEL	Reproduction	White and Finley (1978) in [1]	1.0	1.0	1.45E+00
ORGANICS										
Volatile Organic Compounds										
Acetone	None	None	None	None	None	None	None	None	None	No NOAEL
2-Butanone	None	None	None	None	None	None	None	None	None	No NOAEL
2-Hexanone	None	None	None	None	None	None	None	None	None	No NOAEL
4-Methyl-2-pentanone	None	None	None	None	None	None	None	None	None	No NOAEL
Semivolatile Organic Compounds										
Benzo(*a*)anthracene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.24E+01
Benzo(*a*)pyrene	Composite bird	8.50E-01	9.97E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	9.97E+00
Benzo(*b*)fluoranthene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.24E+01
Benzo(*g,h,i*)perylene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.24E+01
Benzo(*k*)fluoranthene	Composite bird	8.50E-01	9.97E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	9.97E+00
Chrysene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.24E+01
Fluoranthene	Composite bird	8.50E-01	1.95E+02	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.95E+02
Indeno(*1,2,3-cd*)pyrene	Composite bird	8.50E-01	1.24E+01	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	1.24E+01
Phenanthrene	Composite bird	8.50E-01	9.97E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	9.97E+00
Pyrene	Composite bird	8.50E-01	9.97E+00	Chronic	NOAEL	None	Shortelle et al. (1997) in [2]	1.0	1.0	9.97E+00

DCF = 1 if chronic, 0.1 if subchronic (Sample, Opresko, and Suter 1996).
ECF = 1 if NOAEL, 0.1 if LOAEL (Sample, Opresko, and Suter 1996).
[1] = Sample, Opresko, and Suter 1996.
[2] = QST (1997).

Table 14. Derivation of NOAELs and Screening Toxicity Reference Values for Mammal Receptors, SWMU 27T

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Test Species $NOAEL_t$ (mg/kg/day)	Raccoon		Short-tailed Shrew	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kg/day) $NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^{0.25}$	NOAEL (mg/kg/day) $NOAEL_t \times BW_{conv}$
INORGANICS							
Cadmium	Rat	3.03E-01	1.00E+00	4.74E-01	4.74E-01	2.12E+00	2.12E+00
ORGANICS							
Volatile Organic Compounds							
Acetone	Rat	3.50E-01	1.00E+01	4.92E-01	4.92E+00	2.20E+00	2.20E+01
2-Butanone	Rat	3.50E-01	1.77E+03	4.92E-01	8.71E+02	2.20E+00	3.89E+03
2-Hexanone	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
4-Methyl-2-pentanone	Rat	3.50E-01	2.50E+01	4.92E-01	1.23E+01	2.20E+00	5.49E+01
Semivolatile Organic Compounds							
Benzo(*a*)anthracene	Mouse	3.00E-02	1.33E+01	2.66E-01	3.54E+00	1.19E+00	1.58E+01
Benzo(*a*)pyrene	Mouse	3.00E-02	1.00E+00	2.66E-01	2.66E-01	1.19E+00	1.19E+00
Benzo(*b*)fluoranthene	Mouse	3.00E-02	1.33E+01	2.66E-01	3.54E+00	1.19E+00	1.58E+01
Benzo(*g,h,i*)perylene	Mouse	3.00E-02	1.33E+01	2.66E-01	3.54E+00	1.19E+00	1.58E+01
Benzo(*k*)fluoranthene	Mouse	3.00E-02	1.00E+00	2.66E-01	2.66E-01	1.19E+00	1.19E+00
Chrysene	Mouse	3.00E-02	1.33E+01	2.66E-01	3.54E+00	1.19E+00	1.58E+01
Fluoranthene	Mouse	3.00E-02	5.00E+01	2.66E-01	1.33E+01	1.19E+00	5.95E+01
Indeno(*1,2,3-cd*)pyrene	Mouse	3.00E-02	1.33E+01	2.66E-01	3.54E+00	1.19E+00	1.58E+01
Phenanthrene	Mouse	3.00E-02	1.00E+00	2.66E-01	2.66E-01	1.19E+00	1.19E+00
Pyrene	Mouse	3.00E-02	1.00E+00	2.66E-01	2.66E-01	1.19E+00	1.19E+00

BW (kg) Raccoon = 5.98.
BW (kg) Shrew = 0.015.

Table 15. Derivation of NOAELs and Screening Toxicity Reference Values for Bird Receptors, SWMU 27T

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Test Species $NOAEL_t$ (mg/kg/day)	American Robin	
				Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	NOAEL (mg/kg/day) $NOAEL_t \times BW_{conv}$
INORGANICS					
Cadmium	Mallard duck	1.15E+00	1.45E+00	1.00E+00	1.45E+00
ORGANICS					
Volatile Organic Compounds					
Acetone	None	None	No NOAEL	None	No NOAEL
2-Butanone	None	None	No NOAEL	None	No NOAEL
2-Hexanone	None	None	No NOAEL	None	No NOAEL
4-Methyl-2-pentanone	None	None	No NOAEL	None	No NOAEL
Semivolatile Organic Compounds					
Benzo(*a*)anthracene	Composite bird	8.50E-01	1.24E+01	1.00E+00	1.24E+01
Benzo(*a*)pyrene	Composite bird	8.50E-01	9.97E+00	1.00E+00	9.97E+00
Benzo(*b*)fluoranthene	Composite bird	8.50E-01	1.24E+01	1.00E+00	1.24E+01
Benzo(*g,h,i*)perylene	Composite bird	8.50E-01	1.24E+01	1.00E+00	1.24E+01
Benzo(*k*)fluoranthene	Composite bird	8.50E-01	9.97E+00	1.00E+00	9.97E+00
Chrysene	Composite bird	8.50E-01	1.24E+01	1.00E+00	1.24E+01
Fluoranthene	Composite bird	8.50E-01	1.95E+02	1.00E+00	1.95E+02
Indeno(*1,2,3-cd*)pyrene	Composite bird	8.50E-01	1.24E+01	1.00E+00	1.24E+01
Phenanthrene	Composite bird	8.50E-01	9.97E+00	1.00E+00	9.97E+00
Pyrene	Composite bird	8.50E-01	9.97E+00	1.00E+00	9.97E+00

BW (kg) Robin = 0.08.

Table 16. Derivation of LOAEL Toxicity Reference Values for Mammal Test Species, SWMU 27T

ECOPC	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kg/day)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	TRV (mg/kg/day) Benchmark × DCF × ECF
INORGANICS										
Cadmium	Rat	3.03E-01	1.00E+01	Chronic	LOAEL	Reproduction	Sutou et al. (1980b) in [1]	1.0	1.0	1.00E+01

DCF = 1 if chronic, 0.1 if subchronic (Sample, Opresko, and Suter 1996).
ECF = 10 if NOAEL, 1.0 if LOAEL (Sample, Opresko, and Suter 1996).
[1] = Sample, Opresko, and Suter (1996).

Table 17. Derivation of LOAEL Toxicity Reference Values for Bird Test Species, SWMU 27T

ECOPC	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kg/day)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor (DCF)	Endpoint Conversion Factor (ECF)	TRV (mg/kg/day) Benchmark × DCF × ECF
INORGANICS										
Cadmium	Mallard duck	1.15E-00	2.00E+01	Chronic	LOAEL	Reproduction	White and Finley (1978) in [1]	1.0	1.0	2.00E+01

DCF = Duration conversion factor; 1 if chronic, 0.1 if subchronic (Sample, Opresko, and Suter 1996).
ECF = Endpoint conversion factor; 10 if NOAEL, 1.0 if LOAEL (Sample, Opresko, and Suter 1996).
[1] = Sample, Opresko, and Suter (1996).

Table 18. Derivation of LOAEL Toxicity Reference Values for Mammal Receptors, SWMU 27T

ECOPC	Test Species	Test Species Body Weight BW_t (kg)	TRV_t (mg/kg/day)	Raccoon: Body-weight Conversion Factor BW_{conv} $(BW_t/BW)^{0.25}$	Raccoon: TRV (mg/kg/day) $TRV_t \times BW_{conv}$	Short-tailed Shrew: Body-weight Conversion Factor BW_{conv} $(BW_t/BW)^{0.25}$	Short-tailed Shrew: TRV (mg/kg/day) $TRV_t \times BW_{conv}$
INORGANICS							
Cadmium	Rat	3.03E-01	1.00E+01	5.64E-01	5.64E+00	2.12E+00	2.12E+01

BW (kg) Raccoon = 3 per Rod Stafford (GEPD), September 1999.
BW (kg) Short-tailed shrew = 0.015 per Sample, Opresko, and Suter (1996), Table B.1.

Table 19. Derivation of LOAEL Toxicity Reference Values for Bird Receptors, SWMU 27T

ECOPC	Test Species	Test Species Body Weight BW_t (kg)	TRV_t (mg/kg/day)	American Robin: Body-weight Conversion Factor BW_{conv} $(BW_t / BW)^0$	American Robin: TRV (mg/kg/day) $TRV_t \times BW_{conv}$
INORGANICS					
Cadmium	Mallard duck	1.15E+00	2.00E+01	1.00E+00	2.00E+01

BW (kg) American robin = 0.077 (Sample, Opresko, and Suter 1996; Table B.1).

Table 20. Preliminary Risk Calculations for ECOPCs in Surface Soil, SWMU 27T

ECOPC	C_{Max} (mg/kg)	BAF_i	Short-tailed Shrew ADD (mg/kg/day) $=C_{Max} \times BAF_i \times IR_S$	Short-tailed Shrew TRV (mg/kg/day)	Short-tailed Shrew HQ = ADD/TRV	American Robin ADD (mg/kg/day) $= C_{Max} \times BAF_i \times IR_R$	American Robin TRV (mg/kg/day)	American Robin HQ = ADD/TRV
Semivolatile Organic Compounds								
Benzo(*b*)fluoranthene	1.14	5.00E-02	3.02E-02	1.58E+01	1.91E-03	8.66E-02	1.24E+01	6.99E-03
Chrysene	0.215	5.00E-02	5.70E-03	1.58E+01	3.60E-04	1.63E-02	1.24E+01	1.32E-03
Phenanthrene	0.79	5.00E-02	2.09E-02	1.19E+00	1.76E-02	6.00E-02	9.97E+00	6.02E-03
Pyrene	1.33	5.00E-02	3.52E-02	1.19E+00	2.96E-02	1.01E-01	9.97E+00	1.01E-02
				HI =	**4.95E-02**		**HI =**	**2.45E-02**

ADD = Average daily dose (mg/kg/day).
BAF_i = Soil-to-invertebrate bioaccumulation factor (HAZWRAP 1994).
C_{Max} = Maximum detected surface soil concentration (mg/kg).
HQ = Hazard quotient; HI = hazard index = sum of HQs.
IR_R = Robin food ingestion rate (kg/kg/day) = 1.52.
IR_S = Shrew food ingestion rate (kg/kg/day) = 0.53.
TRV = Toxicity reference value = NOAEL (mg/kg/day); see Tables 14 and 15.

Table 21. Preliminary Risk Calculations for ECOPCs in Drainage Ditch Sediment, SWMU 27T

ECOPC	C_{Max} (mg/kg)	BAF_i	Short-tailed Shrew			American Robin		
			ADD (mg/kg/day) = $C_{Max} \times BAF_i \times IR_S$	TRV (mg/kg/day)	HQ = ADD/TRV	ADD (mg/kg/day) = $C_{Max} \times BAF_i \times IR_R$	TRV (mg/kg/day)	HQ = ADD/TRV
Volatile Organic Compounds								
2-Butanone	0.0227	5.00E-02	6.02E-04	3.89E+03	1.55E-07	1.73E-03	No TRV	No HQ
2-Hexanone	0.0023	1.00E+00	1.22E-03	No TRV	No HQ	3.50E-03	No TRV	No HQ
4-Methyl-2-pentanone	0.0052	5.00E-02	1.38E-04	5.49E+01	2.51E-06	3.95E-04	No TRV	No HQ
Acetone	0.099	5.00E-02	2.62E-03	2.20E+01	1.19E-04	7.52E-03	No TRV	No HQ
				HI =	**1.16E-03**		**HI =**	**0.00E+00**
Semivolatile Organic Compounds								
Benzo(*a*)anthracene	1.07	5.00E-02	2.84E-02	1.58E+01	1.79E-03	8.13E-02	1.24E+01	6.56E-03
Benzo(*a*)pyrene	1.95	5.00E-02	5.17E-02	1.19E+00	4.35E-02	1.48E-01	9.97E+00	1.49E-02
Benzo(*b*)fluoranthene	3.51	5.00E-02	9.30E-02	1.58E+01	5.88E-03	2.67E-01	1.24E+01	2.15E-02
Benzo(*g,h,i*)perylene	1.81	5.00E-02	4.80E-02	1.58E+01	3.03E-03	1.38E-01	1.24E+01	1.11E-02
Benzo(*k*)fluoranthene	2.4	5.00E-02	6.36E-02	1.19E+00	5.35E-02	1.82E-01	9.97E+00	1.83E-02
Chrysene	2.54	5.00E-02	6.73E-02	1.58E+01	4.26E-03	1.93E-01	1.24E+01	1.56E-02
Fluoranthene	2.92	5.00E-02	7.74E-02	5.95E+01	1.30E-03	2.22E-01	1.95E+02	1.14E-03
Indeno(*1,2,3-cd*)pyrene	1.65	5.00E-02	4.37E-02	1.58E+01	2.76E-03	1.25E-01	1.24E+01	1.01E-02
Pyrene	3.25	5.00E-02	8.61E-02	1.19E+00	7.24E-02	2.47E-01	9.97E+00	2.48E-02
				HI =	**1.90E-01**		**HI =**	**1.24E-01**
Metals								
Cadmium	19.3	1.10E+01	1.13E+02	2.12E+00	5.31E+01	3.23E+02	1.45E+00	2.23E+02

ADD = Average daily dose (mg/kg/day).
BAF_i = Soil-to-invertebrate bioaccumulation factor (HAZWRAP 1994).
C_{Max} = Maximum detected surface soil concentration (mg/kg).
HQ = Hazard quotient; HI = hazard index = sum of HQs.
IR_R = Robin food ingestion rate (kg/kg/day) = 1.52.
IR_S = Shrew food ingestion rate (kg/kg/day) = 0.53.
TRV = Toxicity reference value = NOAEL (mg/kg/day); see Tables 14 and 15.
Cells with double borders indicate HQs > 1.

Table 22. Preliminary Risk Calculations for ECOPCs in Groundwater, SWMU 27T

ECOPC	C_{Max} (µg/L)	Raccoon: ADD (mg/kg/day) = C_{Max} × 0.001 × IR_W	Raccoon: TRV (mg/kg/day)	Raccoon: HQ = ADD/TRV
Semivolatile Organic Compounds				
Pyrene	26.2	2.10E-03	2.66E-01	7.88E-03

0.001 (mg/µg) = Conversion from µg to mg.
ADD = Average daily dose (mg/kg/day).
C_{Max} = Maximum detected concentration (µg/L).
HQ = Hazard quotient; HI = hazard index = sum of HQs.
IR_W = Raccoon water ingestion rate (L/kg/day) = 0.080.
TRV = Toxicity reference value = NOAEL (mg/kg/day); see Table 14.

Table 23. Supplemental Risk Calculations for ECOPCs in Drainage Ditch Sediment for Short-tailed Shrew, SWMU 27T

ECOPC	Site Concentration Mean (mg/kg)	SP_v	ADD_P (mg/kg/day) = Mean × SP_v × I_P × AUF	BAF_i	ADD_A (mg/kg/day) = Mean × BAF_i × I_A × AUF	ADD_S (mg/kg/day) = Mean × I_S × AUF	ADD_{total} (mg/kg/day) = ADD_P + ADD_A + ADD_S	LOAEL TRV (mg/kg/day)	HQ = ADD_{total}/TRV
					Metals				
Cadmium	9.65E+00	1.10E-01	8.28E-04	1.10E+01	5.54E-01	7.53E-03	5.62E-01	2.12E+01	2.65E-02

ADD_A = Average daily dose; animal.
ADD_P = Average daily dose; plant.
ADD_S = Average daily dose; soil.
ADD_{total} = Average daily dose; total.
AF = Animal fraction.
AUF = 1.00E-02.
BAF_i = Soil-to-animal bioaccumulation factor; invertebrates.
HQ = Hazard quotient.
I_A = TUF × IR_f × AF.
I_A (kg/kg/day) = 5.22E-01.
I_P = TUF × IR_f × PF.
I_P (kg/kg/day) = 7.80E-02.
I_S = TUF × IR_f × SF.
I_S (kg/kg/day) = 7.80E-02.
IR_f = Food ingestion rate.
PF = Plant fraction.
SF = Soil fraction.
SP_v = Soil-to-plant bioaccumulation factor; vegetative.
TRV = Toxicity reference value = LOAEL (mg/kg/day); see Table 18.
TUF = Temporal use factor.

Table 24. Supplemental Risk Calculations for ECOPCs in Drainage Ditch Sediment for American Robin, SWMU 27T

ECOPC	Site Concentration Mean (mg/kg)	SP_r	ADD_P (mg/kg/day) = Mean × SP_r × I_P × AUF	BAF_i	ADD_A (mg/kg/day) = Mean × BAF_i × I_A × AUF	ADD_S (mg/kg/day) = Mean × I_S × AUF	ADD_{total} (mg/kg/day) = ADD_P + ADD_A + ADD_S	LOAEL TRV (mg/kg/day)	HQ = ADD_{total}/TRV
Metals									
Cadmium	9.65E+00	3.00E-02	8.69E-04	1.10E+01	3.18E-01	6.02E-03	3.25E-01	2.00E+01	1.63E-02

ADD_A = Average daily dose; animal.
ADD_P = Average daily dose; plant.
ADD_S = Average daily dose; soil.
ADD_{total} = Average daily dose; total.
AF = Animal fraction.
AUF = 5.00E-03.
BAF_i = Soil-to-animal bioaccumulation factor; invertebrates.
HQ = Hazard quotient.
I_A = TUF × IR_f × AF.
I_A (kg/kg/day) = 6.00E-01.
I_P = TUF × IR_f × PF.
I_P (kg/kg/day) = 6.00E-01.
I_S = TUF × IR_f × SF.
I_S (kg/kg/day) = 1.25E-01.
IR_f = Food ingestion rate.
PF = Plant fraction.
SF = Soil fraction.
SP_r = Soil-to-plant bioaccumulation factor; reproductive.
TRV = Toxicity reference value.
TUF = Temporal use factor = LOAEL (mg/kg/day); see Table 19.

Table 25. Exposure Concentrations for Human Health Constituents of Concern, SWMU 27T

Medium/Units	Analyte	Maximum Detected Concentration	95 Percent Upper Confidence Limit
Surface soil (mg/kg)	Benzo(*a*)fluoranthene	**1.14**	1.49
Sediment (mg/kg)	Benzo(*a*)anthracene	**1.07**	2.84
Sediment (mg/kg)	Benzo(*a*)pyrene	**1.95**	5.33
Sediment (mg/kg)	Benzo(*b*)fluoranthene	**3.51**	10
Sediment (mg/kg)	Indeno(*1,2,3-cd*)pyrene	**1.65**	4.49
Sediment (mg/kg)	Cadmium	**19.3**	

Bold indicates selected exposure concentration.

Table 26. Exposure Parameters for Potential Receptor Populations, SWMU 27T

Parameter	Units	Current On-site Installation Worker	Current On-site Trespasser	Future On-site Installation Worker	Future On-site Trespasser	Future On-site Resident Adult	Future On-site Resident Child	Future Off-site Installation Worker	Future Off-site Resident Adult	Future Off-site Resident Child
SURFACE SOIL										
Incidental Ingestion										
Soil ingestion rate	g/day	0.1	0.1	0.1	0.1	0.1	0.2	NA	NA	NA
Fraction ingested from area	unitless	1	0.25	1	0.25	1	1	NA	NA	NA
Exposure frequency	days/year	250	52	250	52	350	350	NA	NA	NA
Exposure duration	years	25	10	25	10	30	6	NA	NA	NA
Body weight	kg	70	45	70	45	70	15	NA	NA	NA
Carcinogen averaging time	days	25,550	25,550	25,550	25,550	25,550	NA	NA	NA	NA
Noncarcinogen averaging time	days	9,125	3,650	9,125	3,650	NA	2,190	NA	NA	NA
Dermal Contact										
Skin area	cm^2/event	5,000	3,700	5,000	3,700	5,000	1,700	NA	NA	NA
Adherence factor	mg/cm^2	0.2	0.2	0.2	0.2	0.2	0.2	NA	NA	NA
Exposure frequency	events/year	250	52	250	52	350	350	NA	NA	NA
Exposure duration	years	25	10	25	10	30	6	NA	NA	NA
Body weight	kg	70	45	70	45	70	15	NA	NA	NA
Carcinogen averaging time	days	25,550	25,550	25,550	25,550	25,550	NA	NA	NA	NA
Noncarcinogen averaging time	days	9,125	3,650	9,125	3,650	NA	2,190	NA	NA	NA
Inhalation of Dust										
Inhalation rate	m^3/hour	NA	NA	2.5	1.9	0.80	0.68	2.5	0.80	0.68
Exposure time	hours/day	NA	NA	8	6	18.4	18.4	8	18.4	18.4
Exposure frequency	days/year	NA	NA	250	52	350	350	250	350	350
Exposure duration	years	NA	NA	25	10	30	6	25	30	6
Body weight	kg	NA	NA	70	45	70	15	70	70	15
Carcinogen averaging time	days	NA	NA	25,550	25,550	25,550	NA	25,550	25,550	NA
Noncarcinogen averaging time	days	NA	NA	9,125	3,650	NA	2,190	9,125	NA	2,190

Note: Footnotes appear on page 48.

Table 26. Exposure Parameters for Potential Receptor Populations, SWMU 27T (continued)

Parameter	Units	Current On-site Installation Worker	Current On-site Trespasser	Future On-site Installation Worker	Future On-site Trespasser	Future On-site Resident Adult	Future On-site Resident Child	Future Off-site Installation Worker	Future Off-site Resident Adult	Future Off-site Resident Child
SEDIMENT										
Incidental Ingestion										
Sediment ingestion rate	kg/day	NA	0.1	NA	0.1	NA	NA	NA	NA	NA
Fraction ingested from area	unitless	NA	0.13	NA	0.13	NA	NA	NA	NA	NA
Exposure frequency	days/year	NA	52	NA	52	NA	NA	NA	NA	NA
Exposure duration	years	NA	10	NA	10	NA	NA	NA	NA	NA
Body weight	kg	NA	45	NA	45	NA	NA	NA	NA	NA
Carcinogen averaging time	days	NA	25,550	NA	25,550	NA	NA	NA	NA	NA
Noncarcinogen averaging time	days	NA	3,650	NA	3,650	NA	NA	NA	NA	NA
GROUNDWATER										
Drinking Water Ingestion										
Drinking water ingestion	L/day	NA	NA	1	NA	2	1	1	2	1
Fraction ingested from area	unitless	NA	NA	1	NA	1	1	1	1	1
Exposure frequency	days/year	NA	NA	250	NA	350	350	250	350	350
Exposure duration	years	NA	NA	25	NA	30	6	25	30	6
Body weight	kg	NA	NA	70	NA	70	15	70	70	15
Carcinogen averaging time	days	NA	NA	25,550	NA	25,550	25,550	25,550	25,550	25,550
Noncarcinogen averaging time	days	NA	NA	9,125	NA	10,950	2,190	9,125	10,950	2,190
Dermal Contact while Bathing										
Skin area	m^2	NA	NA	NA	NA	2	0.170	NA	2	0.170
Exposure time	hours/day	NA	NA	NA	NA	0.17	0.33	NA	0.17	0.33
Exposure frequency	days/year	NA	NA	NA	NA	350	350	NA	350	350
Exposure duration	years	NA	NA	NA	NA	30	6	NA	30	6
Body weight	kg	NA	NA	NA	NA	70	15	NA	70	15
Carcinogen averaging time	days	NA	NA	NA	NA	25,550	25,550	NA	25,550	25,550
Noncarcinogen averaging time	days	NA	NA	NA	NA	10,950	2,190	NA	10,950	2,190

NA = Not applicable; this receptor is not exposed via this pathway.

Table 27. Estimated Intakes for Current On-site Installation Worker, SWMU 27T

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a] Average Daily Dose for Noncarcinogens (mg/kg/day)	Oral Exposure[a] Average Daily Dose for Carcinogens (mg/kg/day)	Dermal Exposure[a] Average Daily Dose for Noncarcinogens (mg/kg/day)	Dermal Exposure[a] Average Daily Dose for Carcinogens (mg/kg/day)
Surface soil	Benzo(*b*)fluoranthene	1.14	mg/kg	1.12E-06	3.98E-07	1.12E-07	3.98E-08

[a]The equations used to calculate oral and dermal exposures in surface soil are presented in Appendix I, Section I.2.4.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

Table 28. Estimated Intakes for Current On-site Juvenile Trespasser, SWMU 27T

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a] Average Daily Dose for Noncarcinogens (mg/kg/day)	Oral Exposure[a] Average Daily Dose for Carcinogens (mg/kg/day)	Dermal Exposure[a] Average Daily Dose for Noncarcinogens (mg/kg/day)	Dermal Exposure[a] Average Daily Dose for Carcinogens (mg/kg/day)
Surface soil	Benzo(*b*)fluoranthene	1.14	mg/kg	9.02E-08	1.29E-08	2.67E-08	3.82E-09
Sediment	Cadmium	19.3	mg/kg	7.94E-07	1.13E-07	NA	NA
Sediment	Benzo(*a*)anthracene	1.07	mg/kg	4.40E-08	6.29E-09	NA	NA
Sediment	Benzo(*a*)pyrene	1.95	mg/kg	8.03E-08	1.15E-08	NA	NA
Sediment	Benzo(*b*)fluoranthene	3.51	mg/kg	1.44E-07	2.06E-08	NA	NA
Sediment	Indeno(*1,2,3-cd*)pyrene	1.65	mg/kg	6.79E-08	9.70E-09	NA	NA

[a]The equations used to calculate oral and dermal exposures in surface soil and sediment are presented in Appendix I, Sections I.2.4.2 and I.2.4.5, respectively, of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

NA = Not applicable; this exposure pathway is not applicable to sediment.

Table 29. Estimated Intakes for Future On-site Installation Worker, SWMU 27T

				Oral Exposure[a]		Dermal Exposure[a]		Inhalation Exposure[a]	
Environmental Medium	Chemical	Exposure Concentration	Units	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)
Surface soil	Benzo(*b*)fluoranthene	1.14	mg/kg	1.12E-06	3.98E-07	1.12E-07	3.98E-08	ND	1.48E-11
Groundwater[b]	Cadmium	0.1	mg/L	9.78E-04	ND	NA	NA	NA	NA

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil and groundwater are presented in Appendix I, Sections I.2.4.2 and I.2.4.3 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
[b]Groundwater values are based on modeled concentration.
NA = Not applicable; this exposure pathway is not assessed for groundwater.
ND = The toxicological values required to assess this pathway are not available.

Table 30. Estimated Intakes for Future On-site Juvenile Trespasser, SWMU 27T

				Oral Exposure[a]		Dermal Exposure[a]		Inhalation Exposure[a]	
Environmental Medium	Chemical	Exposure Concentration	Units	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)
Surface soil	Benzo(*b*)fluoranthene	1.14	mg/kg	9.02E-08	1.29E-08	2.67E-08	3.82E-09	ND	1.09E-12
Sediment	Cadmium	19.3	mg/kg	7.94E-07	1.13E-07	NA	NA	NA	NA
Sediment	Benzo(*a*)anthracene	1.07	mg/kg	4.40E-08	6.29E-09	NA	NA	NA	NA
Sediment	Benzo(*a*)pyrene	1.95	mg/kg	8.03E-08	1.15E-08	NA	NA	NA	NA
Sediment	Benzo(*b*)fluoranthene	3.51	mg/kg	1.44E-07	2.06E-08	NA	NA	NA	NA
Sediment	Indeno(*1,2,3-cd*)pyrene	1.65	mg/kg	6.79E-08	9.70E-09	NA	NA	NA	NA

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil and sediment are presented in Appendix I, Sections I.2.4.2 and I.2.4.5, respectively, of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
NA = Not applicable; this exposure pathway is not applicable to sediment.
ND = The toxicological values required to assess this pathway are not available.

Table 31. Estimated Intakes for Future On-site Resident Child, SWMU 27T

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a]		Dermal Exposure[a]		Inhalation Exposure[a]	
				Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)
Surface soil	Benzo(*b*)fluoranthene	1.14	mg/kg	ND	1.25E-06	ND	2.12E-08	ND	1.45E-11
Groundwater[b]	Cadmium	0.1	mg/L	6.39E-03	ND	3.62E-09	ND	NA	NA

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil and groundwater are presented in Appendix I, Sections I.2.4.2 and I.2.4.3, respectively, of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
[b]Groundwater values are based on modeled concentration.
NA = Not applicable; this pathway is not assessed for metals in groundwater.
ND = The toxicological values required to assess this pathway are not available.

Table 32. Estimated Intakes for Future On-site Resident Adult, SWMU 27T

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a]		Dermal Exposure[a]		Inhalation Exposure[a]	
				Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)
Surface soil	Benzo(*b*)fluoranthene	1.14	mg/kg	ND	6.69E-07	ND	6.69E-08	ND	1.83E-11
Groundwater[b]	Cadmium	0.1	mg/L	2.74E-03	ND	4.57E-09	ND	NA	NA

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil and groundwater are presented in Appendix I, Sections I.2.4.2 and I.2.4.3, respectively, of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
[b]Groundwater values are based on modeled concentration.
NA = Not applicable; this pathway is not assessed for metals in groundwater.
ND = The toxicological values required to assess this pathway are not available.

Table 33. Estimated Intakes for Future Off-site Installation Worker, SWMU 27T

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a]		Dermal Exposure[a]	
				Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)
Surface soil	Benzo(*b*)fluoranthene	1.14	mg/kg	NA	NA	ND	1.48E-11
Groundwater[b]	Cadmium	0.1	mg/L	9.78E-04	ND	NA	NA

[a]The equations used to calculate oral and dermal exposures in surface soil and groundwater presented in Appendix I, Sections I.2.4.2 and I.2.4.3, respectively, of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
NA = Not applicable; this exposure pathway is not applicable for this environmental medium.
ND = The toxicological values required to assess this pathway are not available.

Table 34. Estimated Intakes for Future Off-site Resident Child, SWMU 27T

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a]		Dermal Exposure[a]		Inhalation Exposure[a]	
				Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)	Average Daily Dose for Noncarcinogens (mg/kg/day)	Average Daily Dose for Carcinogens (mg/kg/day)
Surface soil	Benzo(*b*)fluoranthene	1.14	mg/kg	NA[b]	NA[b]	NA[b]	NA[b]	ND	1.45E-11
Groundwater[c]	Cadmium	0.1	mg/L	6.39E-03	ND	3.62E-09	ND	NA[d]	NA[d]

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil and groundwater are presented in Appendix I, Sections I.2.4.2 and I.2.4.3, respectively, of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
[b]NA = Not applicable; this exposure pathway is not assessed for this receptor.
[c]Groundwater values are based on modeled concentration.
[d]NA = Not applicable; this pathway is not assessed for metals in groundwater.
ND = The toxicological values required to assess this pathway are not available.

Table 35. Estimated Intakes for Future Off-site Resident Adult, SWMU 27T

Environmental Medium	Chemical	Exposure Concentration	Units	Oral Exposure[a] Average Daily Dose for Noncarcinogens (mg/kg/day)	Oral Exposure[a] Average Daily Dose for Carcinogens (mg/kg/day)	Dermal Exposure[a] Average Daily Dose for Noncarcinogens (mg/kg/day)	Dermal Exposure[a] Average Daily Dose for Carcinogens (mg/kg/day)	Inhalation Exposure[a] Average Daily Dose for Noncarcinogens (mg/kg/day)	Inhalation Exposure[a] Average Daily Dose for Carcinogens (mg/kg/day)
Surface soil	Benzo(*b*)fluoranthene	1.14	mg/kg	NA[b]	NA[b]	NA[b]	NA[b]	ND	1.83E-11
Groundwater[c]	Cadmium	0.1	mg/L	2.74E-03	ND	4.57E-09	ND	NA[d]	NA[d]

[a]The equations used to calculate oral, dermal, and inhalation exposures in surface soil and groundwater are presented in Appendix I, Sections I.2.4.2 and I.2.4.3, respectively, of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
[b]NA = Not applicable; this exposure pathway is not assessed for this receptor.
[c]Groundwater values are based on modeled concentration.
[d]NA = Not applicable; this pathway is not assessed for metals in groundwater.
ND = The toxicological values required to assess this pathway are not available.

Table 36. Summary of Reference Doses and Cancer Slope Factors for Contaminants of Potential Concern, SWMU 27T

Chemical	Oral Reference Dose (mg/kg/day)	Ref.[a]	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Ref.[a]	Gastrointestinal Absorption Factor[b]	Dermal Reference Dose[c] (mg/kg/day)	Dermal Cancer Slope Factor[d] $(mg/kg\text{-}day)^{-1}$	Inhalation Reference Dose (mg/kg/day)	Ref.[a]	Inhalation Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Ref.[a]
Cadmium (soil)[e]	1.00E-03	I	ND		0.025[f]	2.50E-05	ND	ND		6.30E+00	I
Cadmium (water)	5.00E-04	I			0.05[f]	2.50E-05	ND	ND		6.30E+00	I
Benzo(*a*)anthracene	ND		7.30E-01	E	0.31	ND	2.35E+00	ND		3.10E-01	E
Benzo(*b*)fluoranthene	ND		7.30E-01	E	0.31	ND	2.35E+00	ND		3.10E-01	E
Benzo(*a*)pyrene	ND		7.30E+00	I	0.31	ND	2.35E+01	ND		3.10E+00	E
Indeno(*1,2,3-c,d*)pyrene	ND		7.30E-01	E	0.31	ND	2.35E+00	ND		3.10E-01	E

[a]References:
I = Integrated Risk Information System (EPA 2000a).
H = Health Effects Assessment Summary Tables (EPA 1997).
E = U.S. Environmental Protection Agency, National Center for Environmental Assessment (EPA 2000b).
[b]Unless otherwise noted, ORNL 1999.
[c]Dermal RfD calculated by dividing the oral RfD by the gastrointestinal absorption factor [see Appendix H, Section H.3.3 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000)].
[d]Dermal RfD calculated by multiplying the oral RfD by the gastrointestinal absorption factor. Value for cadmium obtained from the literature [see Appendix H, Section H.3.3 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000)].
[e]Toxicity values for cadmium – food.
[f]EPA 1985.
ND = No data.

Table 37. Hazard Indices and Carcinogenic Risk for Current On-site Installation Worker, SWMU 27T

Chemical	Surface Soil[a] Oral HQ	Surface Soil[a] Dermal HQ	Surface Soil[a] Total	Total Hazard Index[a]
Benzo(*b*)fluoranthene	ND	ND	—	—
Pathway Total	ND	ND	—	—

Chemical	Surface Soil[b] Oral ILCR	Surface Soil[b] Dermal ILCR	Surface Soil[b] Total	Total Cancer Risk[b]
Benzo(*b*)fluoranthene	2.91E-07	9.02E-09	3.00E-07	3.00E-07
Pathway Total	2.91E-07	9.02E-09	3.00E-07	3.00E-07

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

ND = The toxicological values required to assess this pathway are not available.

— = No data.

Table 38. Hazard Indices and Carcinogenic Risks for Current On-site Juvenile Trespasser, SWMU 27T

Chemical	Surface Soil[a] Oral HQ	Surface Soil[a] Dermal HQ	Surface Soil[a] Total	Sediment[a] Oral HQ	Sediment[a] Total	Total Hazard Index[a]
Benzo(*b*)fluoranthene	ND	ND	—	ND	—	—
Cadmium	NA	NA	NA	7.94E-04	7.94E-04	7.94E-04
Benzo(*a*)anthracene	NA	NA	NA	ND	—	—
Benzo(*a*)pyrene	NA	NA	NA	ND	—	—
Indeno(*1,2,3-cd*)pyrene	NA	NA	NA	ND	—	—
Pathway Total	—	—	—	**7.94E-04**	**7.94E-04**	**7.94E-04**

Chemical	Surface Soil[b] Oral ILCR	Surface Soil[b] Dermal ILCR	Surface Soil[b] Total	Sediment[b] Oral HQ	Sediment[b] Total	Total Cancer Risk[b]
Benzo(*b*)fluoranthene	9.41E-09	8.63E-10	1.03E-08	1.51E-08	1.51E-08	2.53E-08
Cadmium	NA	NA	NA	ND	ND	—
Benzo(*a*)anthracene	NA	NA	NA	4.59E-09	4.59E-09	4.59E-09
Benzo(*a*)pyrene	NA	NA	NA	8.37E-08	8.37E-08	8.37E-08
Indeno(*1,2,3-cd*)pyrene	NA	NA	NA	7.08E-09	7.08E-09	7.08E-09
Pathway Total	**9.41E-09**	**8.63E-10**	**1.03E-08**	**1.10E-07**	**1.10E-07**	**1.21E-07**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

NA = Not applicable; these constituents are not present in surface soil.

ND = The toxicological values required to assess this pathway are not available.

— = No data.

Table 39. Hazard Indices and Carcinogenic Risk for Future On-site Installation Worker, SWMU 27T

Chemical	Surface Soil[a]				Groundwater Modeled Concentrations[a]		Total Hazard Index[a]
	Ingestion HI	Dermal HI	Inhalation HI	Total	Ingestion HI	Total	
Benzo(*b*)fluoranthene	ND	ND	ND	—	NA	NA	—
Cadmium	NA	NA	NA	NA	1.96E+00	1.96E+00	1.96E+00
Pathway Total	—	—	—	—	**1.96E+00**	**1.96E+00**	**1.96E+00**

Chemical	Surface Soil[b]				Groundwater Modeled Concentrations[b]		Total Cancer Risk[b]
	Ingestion ILCR	Dermal ILCR	Inhalation ILCR	Total	Ingestion ILCR	Total	
Benzo(*b*)fluoranthene	2.91E-07	9.02E-09	4.59E-12	3.00E-07	NA	NA	3.00E-07
Cadmium	NA	NA	NA	NA	ND	ND	—
Pathway Total	**2.91E-07**	**9.02E-09**	**4.59E-12**	**3.00E-07**	—	—	**3.00E-07**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

NA = This constituent not present in this environmental medium.

ND = The toxicological values required to assess this pathway are not available.

— = No data.

Table 40. Hazard Indices and Carcinogenic Risks for Future On-site Juvenile Trespasser, SWMU 27T

Chemical	Surface Soil[a]				Sediment[a]		Total Hazard Index[a]
	Oral HQ	Dermal HQ	Inhalation HQ	Total	Oral HQ	Total	
Benzo(*b*)fluoranthene	ND	ND	ND	—	ND	—	—
Cadmium	NA	NA	NA	NA	7.94E-04	7.94E-04	7.94E-04
Benzo(*a*)anthracene	NA	NA	NA	NA	ND	—	—
Benzo(*a*)pyrene	NA	NA	NA	NA	ND	—	—
Indeno(*1,2,3-cd*)pyrene	NA	NA	NA	NA	ND	—	—
Pathway Total	—	—	—	—	**7.94E-04**	**7.94E-04**	**7.94E-04**

Chemical	Surface Soil[b]				Sediment[b]		Total Cancer Risk[b]
	Oral ILCR	Dermal ILCR	Inhalation ILCR	Total	Oral ILCR	Total	
Benzo(*b*)fluoranthene	9.41E-09	8.63E-10	3.38E-13	1.03E-08	1.51E-08	1.51E-08	2.53E-08
Cadmium	NA	NA	NA	NA	ND	ND	—
Benzo(*a*)anthracene	NA	NA	NA	NA	4.59E-09	4.59E-09	4.59E-09
Benzo(*a*)pyrene	NA	NA	NA	NA	8.37E-08	8.37E-08	8.37E-08
Indeno(*1,2,3-cd*)pyrene	NA	NA	NA	NA	7.08E-09	7.08E-09	7.08E-09
Pathway Total	**9.41E-09**	**8.63E-10**	**3.38E-13**	**1.03E-08**	**1.10E-07**	**1.10E-07**	**1.21E-07**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

NA = Not applicable; these constituents are not present in surface soil.

ND = The toxicological values required to assess this pathway are not available.

— = No data.

Table 41. Hazard Indices and Carcinogenic Risks for Future On-site Resident Child, SWMU 27T

Chemical	Surface Soil[a]				Groundwater Modeled Concentrations[a]			Total Hazard Index[a]
	Ingestion HQ	Dermal HQ	Inhalation HQ	Total	Ingestion HQ	Dermal HQ	Total	
Benzo(*b*)fluoranthene	ND	ND	ND	—	NA	NA	NA	—
Cadmium	NA	NA	NA	NA	1.28E+01	5.97E-01	1.34E+01	1.34E+01
Pathway Total	—	—	—	—	**1.28E+01**	**5.97E-01**	**1.34E+01**	**1.34E+01**

Chemical	Surface Soil[b]				Groundwater Modeled Concentrations[b]			Total Cancer Risk[b]
	Ingestion ILCR	Dermal ILCR	Inhalation ILCR	Total	Ingestion ILCR	Dermal ILCR	Total	
Benzo(*b*)fluoranthene	9.12E-07	4.81E-09	4.50E-12	9.17E-07	NA	NA	NA	9.17E-07
Cadmium	NA	NA	NA	NA	ND	ND	—	—
Pathway Total	**9.12E-07**	**4.81E-09**	**4.50E-12**	**9.17E-07**	—	—	—	**9.17E-07**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

NA = This constituent not present in the environmental medium.

ND = The toxicological values required to assess this pathway are not available.

— = No data.

Table 42. Hazard Indices and Carcinogenic Risks for Future On-site Resident Adult, SWMU 27T

	Surface Soil[a]				Groundwater Modeled Concentrations[a]			
Chemical	**Ingestion HQ**	**Dermal HQ**	**Inhalation HQ**	**Total**	**Ingestion HQ**	**Dermal HQ**	**Total**	**Total Hazard Index[a]**
Benzo(*b*)fluoranthene	ND	ND	ND	—	NA	NA	NA	—
Cadmium	NA	NA	NA	NA	5.48E+00	1.86E-01	5.67E+00	5.67E+00
Pathway Total	—	—	—	—	**5.48E+00**	**1.86E-01**	**5.67E+00**	**5.67E+00**

	Surface Soil[b]				Groundwater Modeled Concentrations[b]			
Chemical	**Ingestion ILCR**	**Dermal ILCR**	**Inhalation ILCR**	**Total**	**Ingestion ILCR**	**Dermal ILCR**	**Total**	**Total Cancer Risk[b]**
Benzo(*b*)fluoranthene	9.12E-07	4.81E-09	5.67189E-12	9.17E-07	NA	NA	NA	9.17E-07
Cadmium	NA	NA	NA	NA	ND	ND	—	—
Pathway Total	**9.12E-07**	**4.81E-09**	**5.67E-12**	**9.17E-07**	—	—	—	**9.17E-07**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

NA = This constituent not present in the environmental medium.

ND = The toxicological values required to assess this pathway are not available.

— = No data.

Table 43. Hazard Indices and Carcinogenic Risk for Future Off-site Installation Worker, SWMU 27T

Chemical	Surface Soil[a] Inhalation HI	Surface Soil[a] Total	Groundwater Modeled Concentrations[a] Ingestion HI	Groundwater Modeled Concentrations[a] Total	Total Hazard Index[a]
Benzo(*b*)fluoranthene	ND	—	NA	NA	—
Cadmium	NA	NA	1.96E+00	1.96E+00	1.96E+00
Pathway Total	—	—	**1.96E+00**	**1.96E+00**	**1.96E+00**

Chemical	Surface Soil[b] Inhalation ILCR	Surface Soil[b] Total	Groundwater Modeled Concentrations[b] Ingestion ILCR	Groundwater Modeled Concentrations[b] Total	Total Cancer Risk[b]
Benzo(*b*)fluoranthene	4.59E-12	4.59E-12	NA	NA	4.59E-12
Cadmium	NA	NA	ND	ND	—
Pathway Total	**4.59E-12**	**4.59E-12**	—	—	**4.59E-12**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
NA = This constituent not present in the environmental medium.
ND = The toxicological values required to assess this pathway are not available.
— = No data.

Table 44. Hazard Indices and Carcinogenic Risks for Future Off-site Resident Child, SWMU 27T

Chemical	Surface Soil[a] Inhalation HQ	Surface Soil[a] Total	Groundwater Modeled Concentrations[a] Ingestion HQ	Groundwater Modeled Concentrations[a] Dermal HQ	Groundwater Modeled Concentrations[a] Total	Total Hazard Index[a]
Benzo(*b*)fluoranthene	ND	—	NA	NA	NA	—
Cadmium	NA	NA	1.28E+01	5.97E-01	1.34E+01	1.34E+01
Pathway Total	—	—	**1.28E+01**	**5.97E-01**	**1.34E+01**	**1.34E+01**

Chemical	Surface Soil[b] Inhalation ILCR	Surface Soil[b] Total	Groundwater Modeled Concentrations[b] Ingestion ILCR	Groundwater Modeled Concentrations[b] Dermal ILCR	Groundwater Modeled Concentrations[b] Total	Total Cancer Risk[b]
Benzo(*b*)fluoranthene	4.50E-12	4.50E-12	NA	NA	NA	4.50E-12
Cadmium	NA	NA	ND	ND	—	—
Pathway Total	**4.50E-12**	**4.50E-12**	—	—	—	**4.50E-12**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).
NA = This constituent not present in the environmental medium.
ND = The toxicological values required to assess this pathway are not available.
— = No data.

Table 45. Hazard Indices and Carcinogenic Risks for Future Off-site Resident Adult, SWMU 27T

Chemical	Surface Soil[a]		Groundwater Modeled Concentrations[a]			Total Hazard Index[a]
	Inhalation HQ	Total	Ingestion HQ	Dermal HQ	Total	
Benzo(*b*)fluoranthene	ND	—	NA	NA	NA	—
Cadmium	NA	NA	5.48E+00	1.86E-01	5.67E+00	5.67E+00
Pathway Total	—	—	**5.48E+00**	**1.86E-01**	**5.67E+00**	**5.67E+00**
Chemical	**Surface Soil[b]**		**Groundwater Modeled Concentrations[b]**			**Total Cancer Risk[b]**
	Inhalation ILCR	**Total**	**Ingestion ILCR**	**Dermal ILCR**	**Total**	
Benzo(*b*)fluoranthene	5.67E-12	5.67E-12	NA	NA	NA	5.67E-12
Cadmium	NA	NA	ND	ND	—	—
Pathway Total	**5.67E-12**	**5.67E-12**	—	—	—	**5.67E-12**

[a]The equations used to calculate noncarcinogenic risk are presented in Appendix I, Section I.4.2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

[b]The equations used to calculate carcinogenic risk are presented in Appendix I, Section I.4.1 of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000).

NA = This constituent not present in the environmental medium.

ND = The toxicological values required to assess this pathway are not available.

— = No data.

Table 46. Target Groundwater Concentrations for Contaminant Migration Constituents of Concern, SWMU 27T

CMCOCs	Units	Estimated Groundwater Concentration (μg/L)	Maximum Contaminant Level (μg/L)	Target Groundwater Concentration (μg/L) Hazard Index			
				0.1	0.5	1	3
Cadmium	μg/L	100	**5**	0.8	3.9	7.8	23.5

Bold indicates value that is the recommended target groundwater value.

Table 47. Remedial Levels for Contaminants of Migration Constituents of Concern, SWMU 27T

CMCOCs	Units	Maximum Soil Concentration	Risk-based Remedial Levels Hazard Index				Remedial Level Based on MCL	Subsurface Soil Background
			0.1	0.5	1	3		
Cadmium	mg/kg	19.3	0.2	0.8	1.5	4.5	1.0	**5.36**

Bold indicates value is the recommended remedial level.

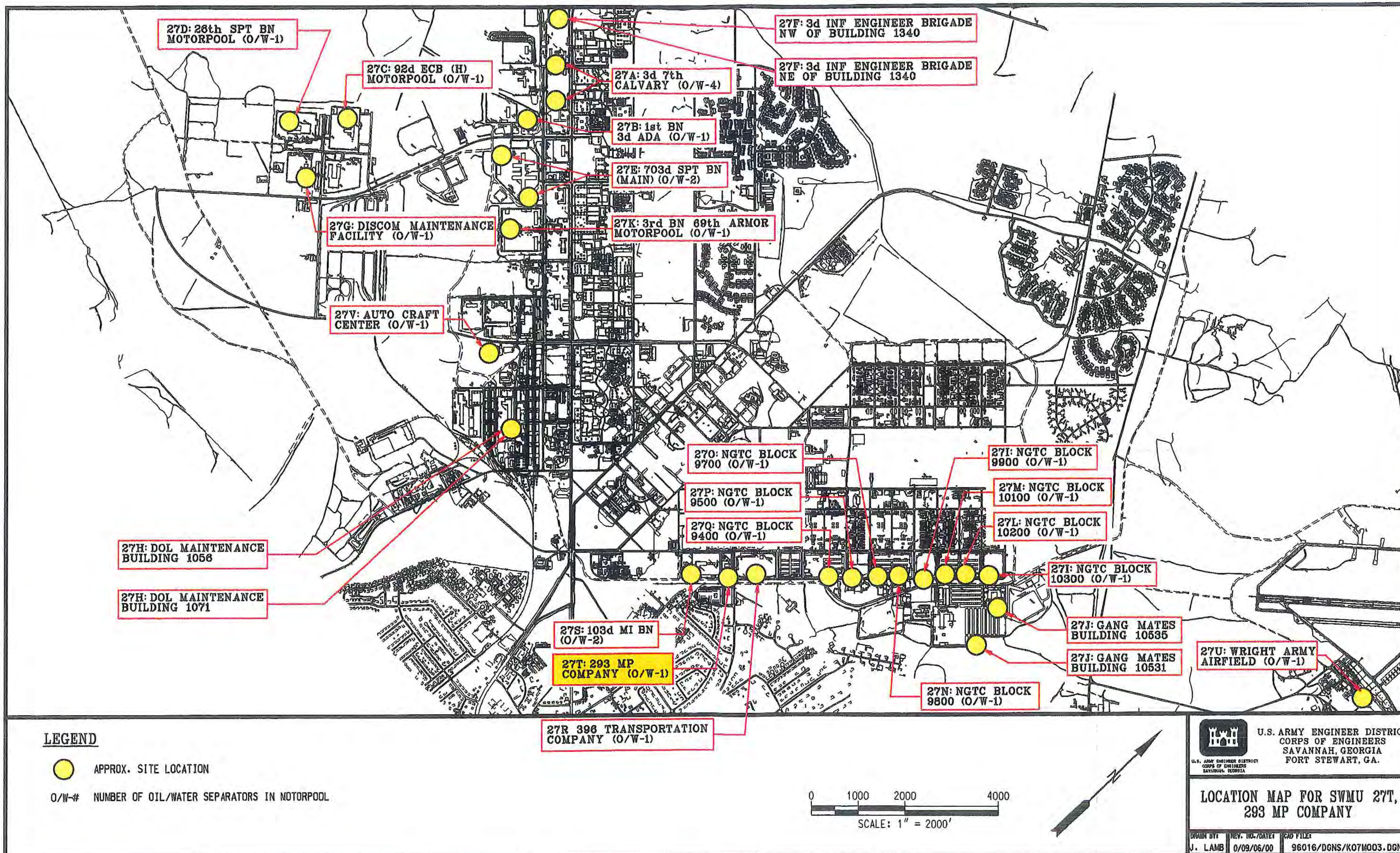

Figure 1. Location Map for SWMU 27T

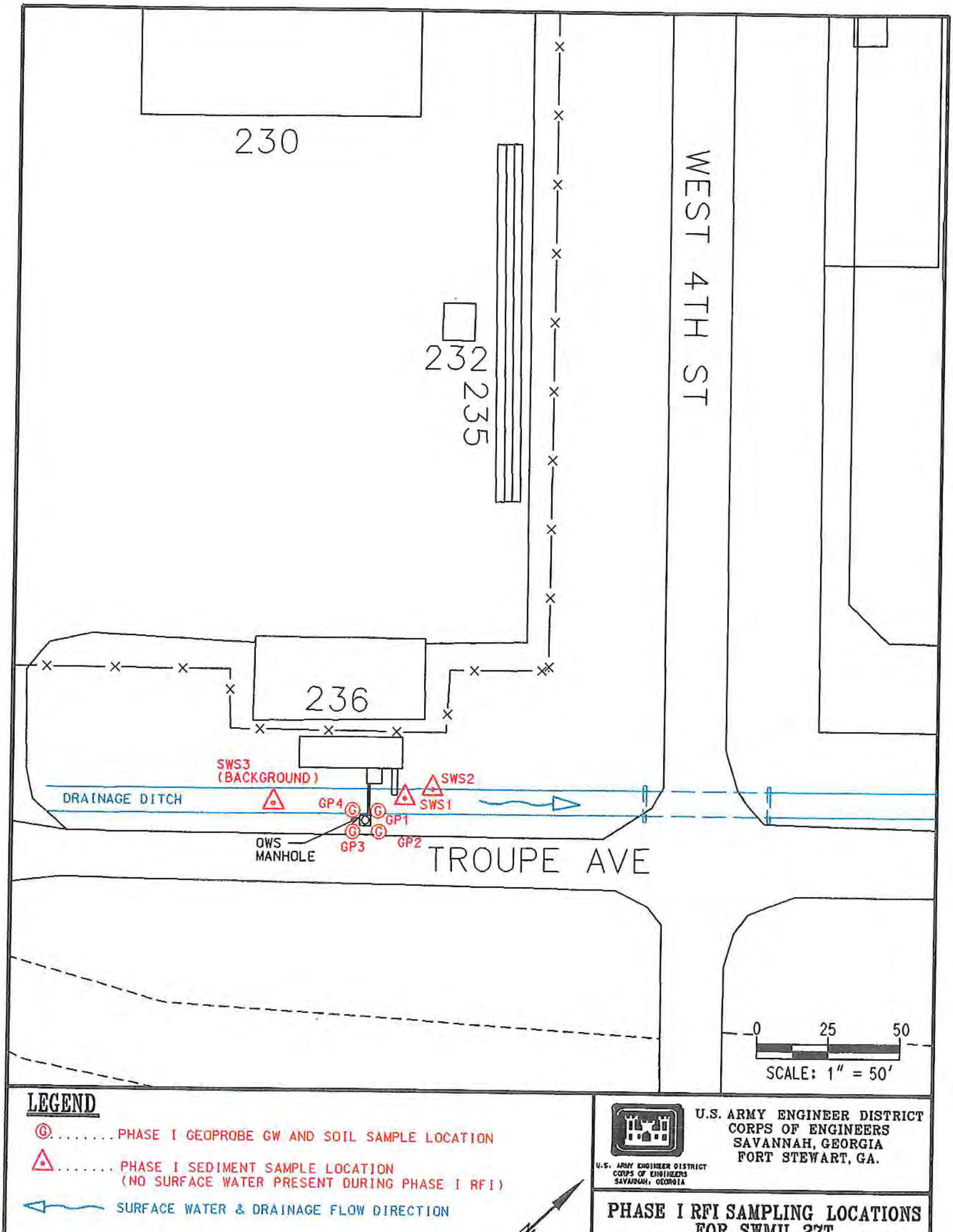

Figure 2. Phase I RFI Sampling Locations, SWMU 27T

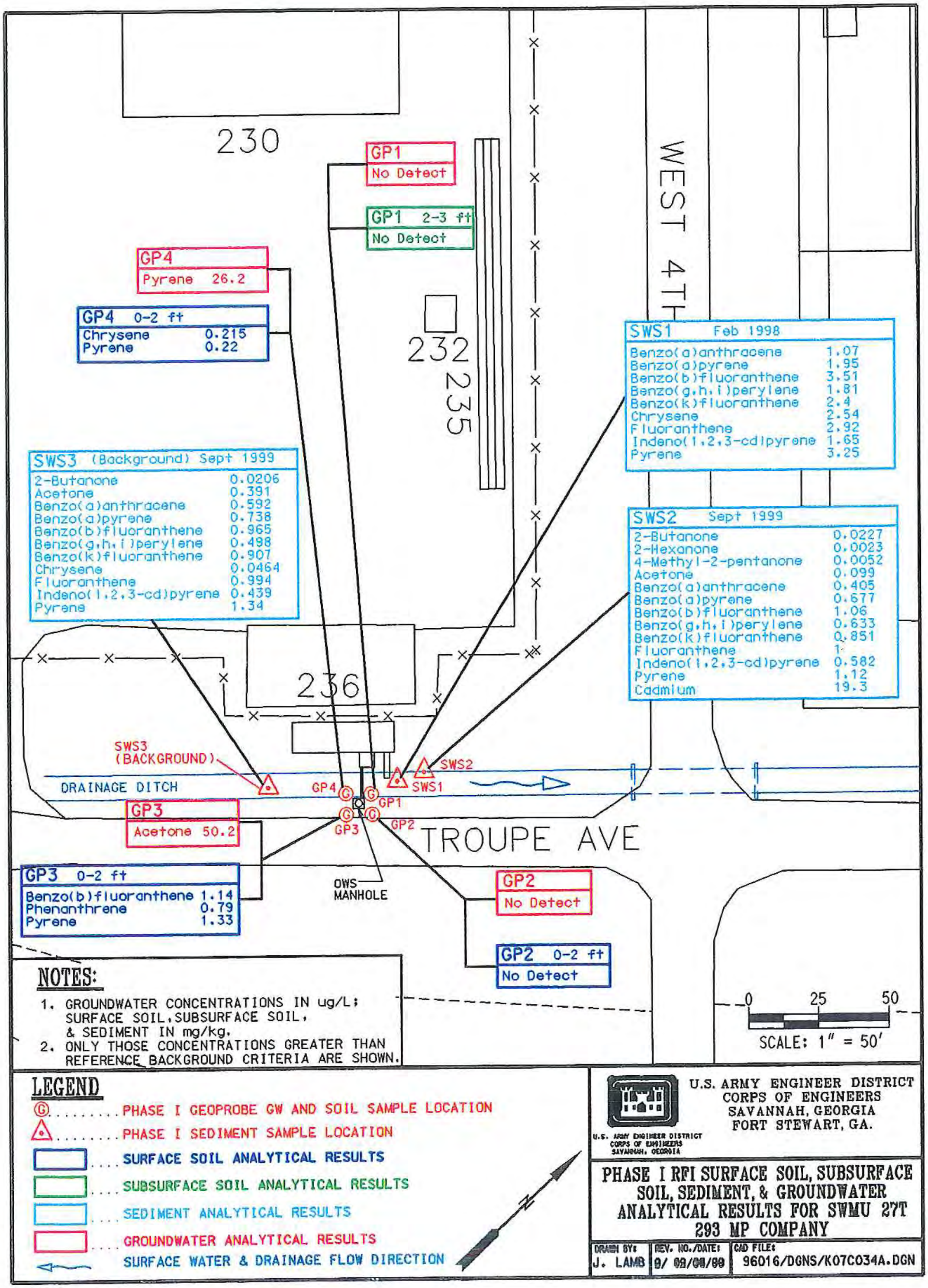

Figure 3. Summary of Phase I RFI Analytical Results in Surface Soil, Subsurface Soil, Groundwater, and Sediment, SWMU 27T

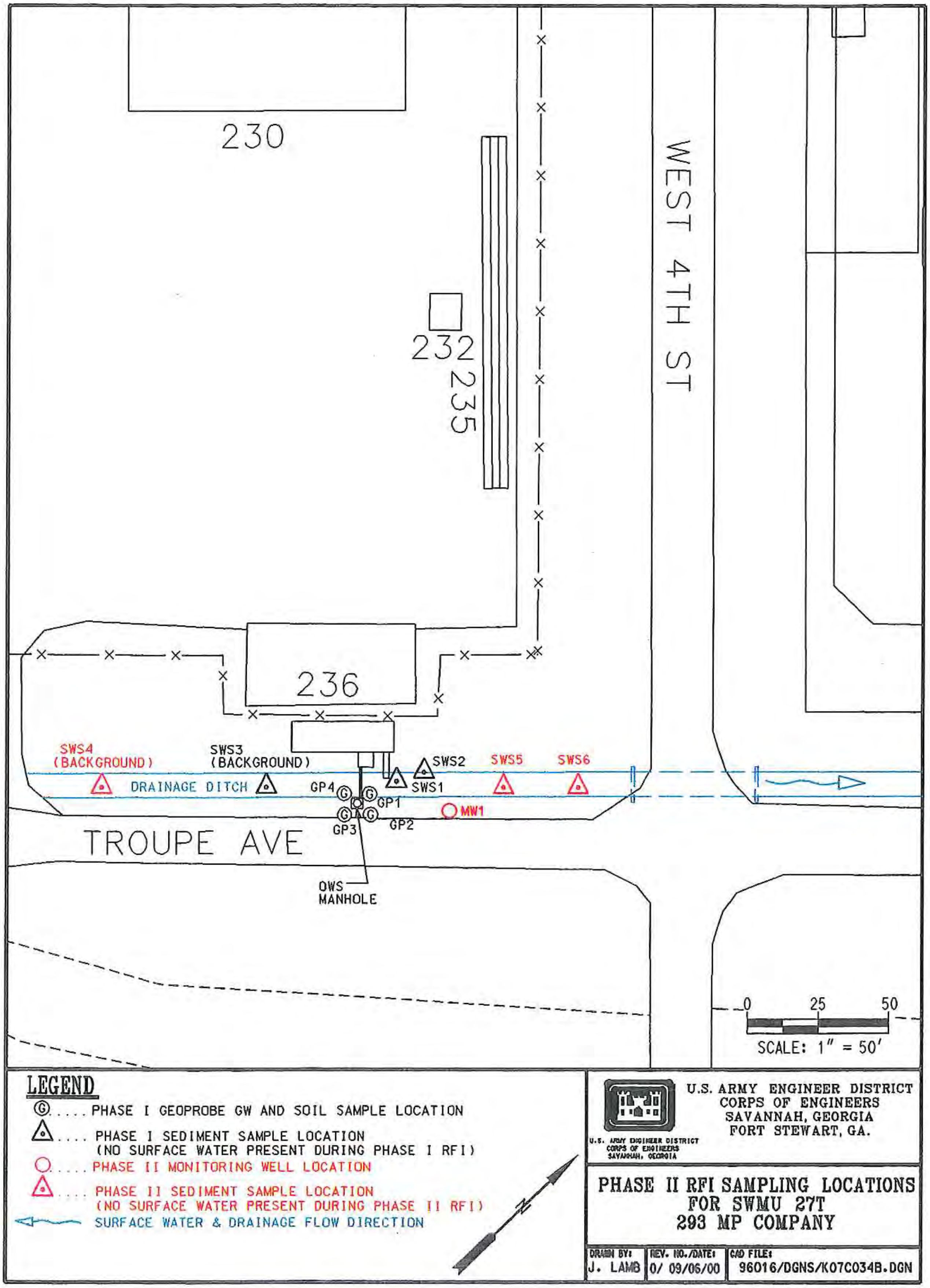

Figure 4. Phase II RFI Sampling Locations, SWMU 27T

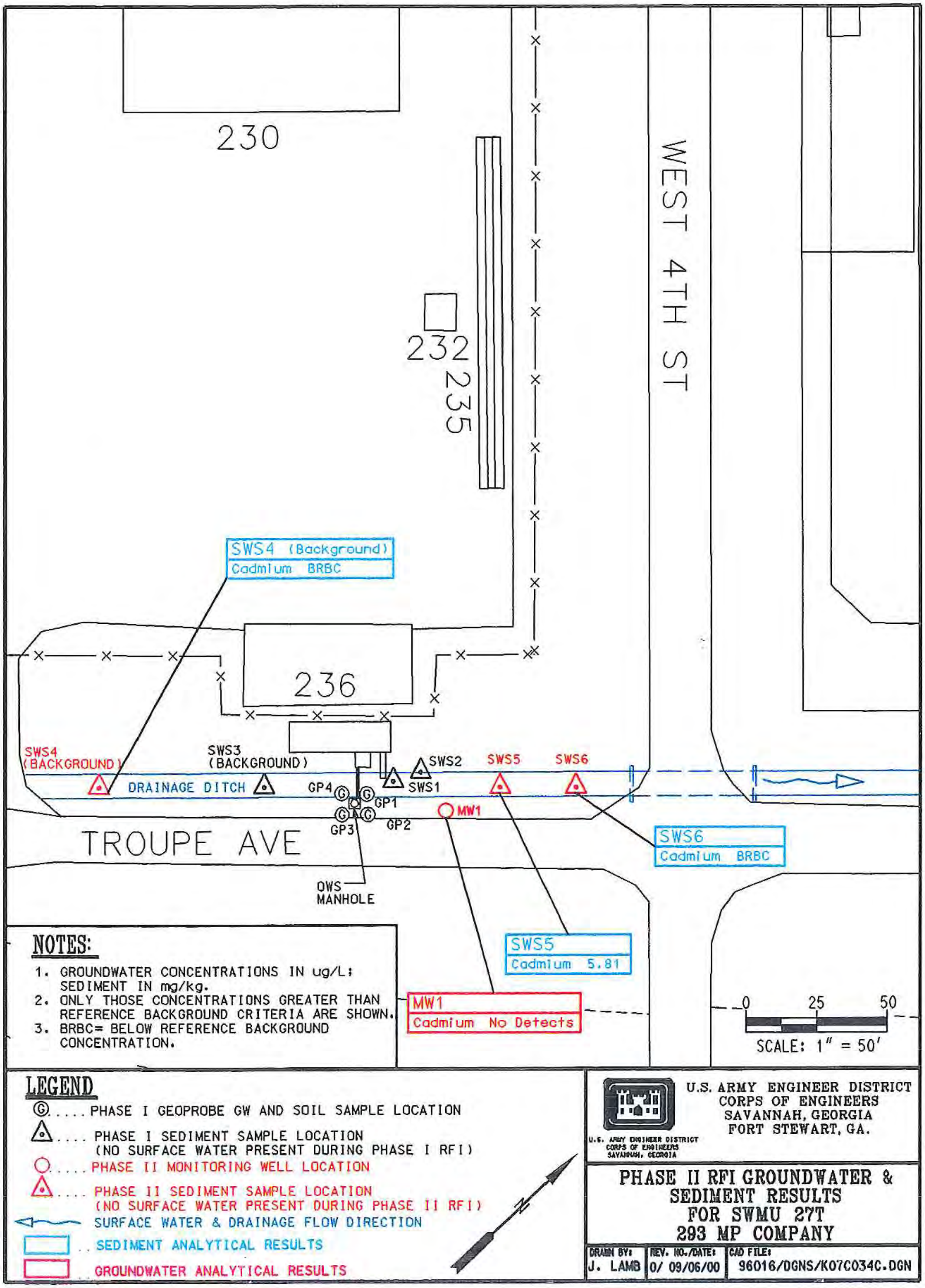

Figure 5. Summary of Phase II RFI Analytical Results in Groundwater and Sediment, SWMU 27T

❑ = Exposure pathway not complete.
* = Exposure pathway complete.
1 = Future exposure pathway only.
a = Future receptor only.

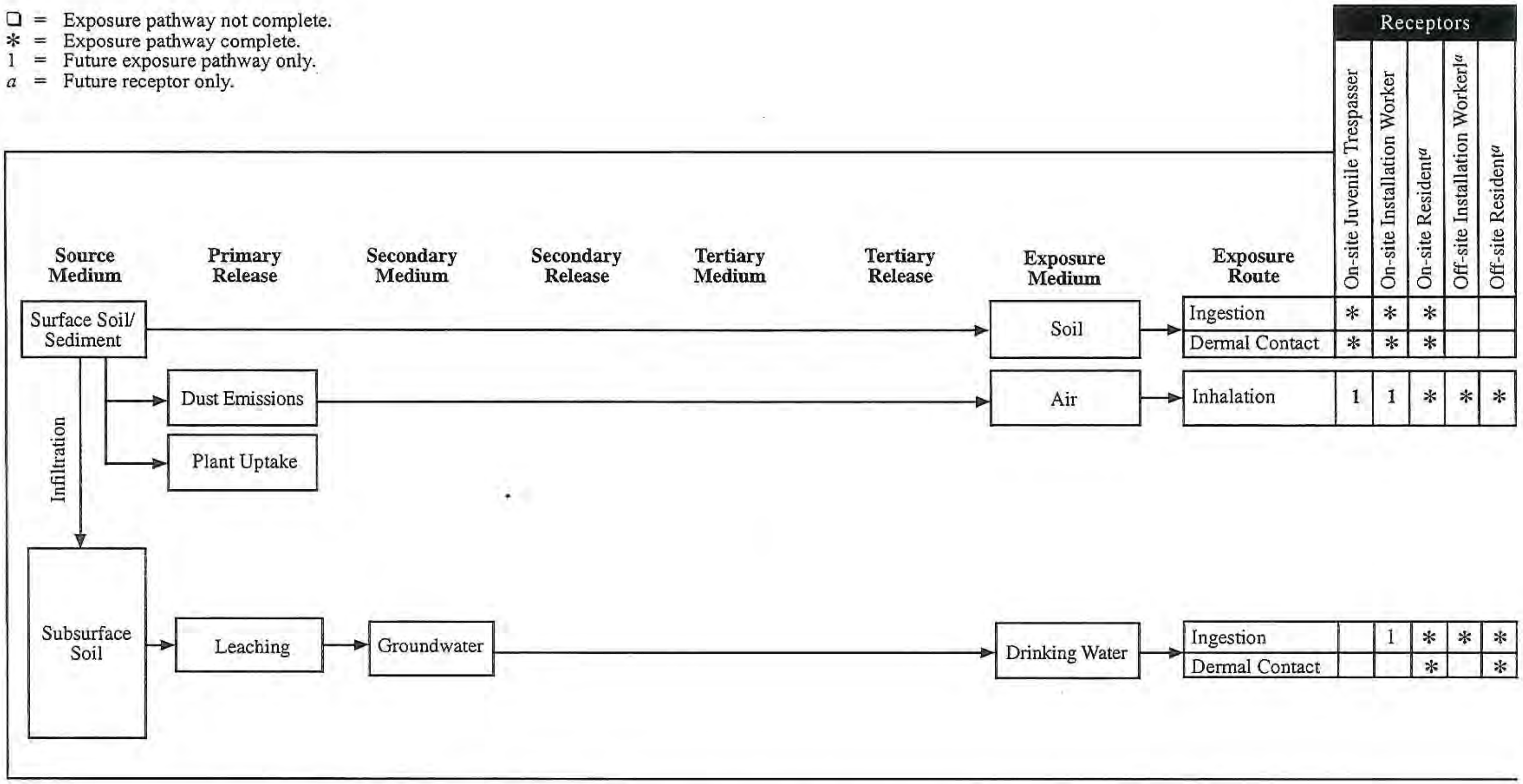

Figure 6. Phase II RFI Potential Migration and Exposure Pathways, SWMU 27T

ATTACHMENT A
TO SWMU 27T
TO THE
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FOR
16 SOLID WASTE MANAGEMENT UNITS
AT
FORT STEWART, GEORGIA

E-MAIL FROM REGULATOR

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Longaker, Jeff

From: Brent Rabon [brent_rabon@mail.dnr.state.ga.us]
Sent: Monday, July 17, 2000 10:12 AM
To: LittleDERA@aol.com
Subject: Re: Monitoring Well Installation at SWMU 27T (FSGA)

Melanie, GA EPD is in receipt of your facsimile and e-mail (Little to Rabon) dated 14 July 2000 which proposes a single permanent monitoring wells at the 293 MP Company Washrack and Oil/Water Separator (SWMU 27T). Based upon our review, GA EPD concurs with the permanent monitoring well location for SWMU 27T which is proposed by Fort Stewart in the referenced facsimile. Per your discretion, Fort Stewart may limit hazardous constituent analysis of the groundwater sample collected from the single permanent monitoring well at SWMU 27T to cadmium.

Should you have any questions concerning this e-mail, please do not hesitate to contact me.

Thank you,
Brent Rabon

>>> <LittleDERA@aol.com> 07/14/00 12:15PM >>>
Brent, based on the results of the fate and transport modeling at SWMU 27T, we actually need a groundwater sample (using low-flow sampling) to verify that cadmium
is not in the groundwater above background concentrations. Thus, instead of the three MWs we proposed in the revised final Phase II RFI Report (April 2000), Fort Stewart recommends only one permanent 2" monitoring well at this site (see faxed site map for proposed location).

For your information, we have conducted the "first round" of sediment sampling described in the SWMU 27T recommendations and conclusions section, and the Cd concentrations in sediment are: 3.16 mg/kg at SWS4(upgradient); 5.81 mg/kg at SWS5 (downgradient) and 3.85 mg/kg at SWS6 (downgradient). Only the 5.81 mg/kg is above reference background, and it will actually "pass" the modeling. However, the Phase I sampling result of ~19 mg/kg will not "pass" the modeling, hence the need to put in a well to confirm or deny the presence of cadmium above reference background in the site groundwater. This information will be used in the "justification" section of the SWMU 27T Addendum.

In addition, SAIC will model both the maximum and average concentration of cadmium in sediment/surface soil for this site.

If you have any questions, please call me at your convenience.

Sincerely, Melanie Little

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ATTACHMENT B
TO SWMU 27T
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16 SOLID WASTE MANAGEMENT UNITS
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FORT STEWART, GEORGIA

BORING LOG AND WELL CONSTRUCTION

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HTRW DRILLING LOG

HTRW DRILLING LOG	DISTRICT: USACE - Savannah	HOLE NUMBER MW-Ø1
1. COMPANY NAME: SAIC	2. DRILL SUBCONTRACTOR: Miller Drilling	SHEET 1 OF 3

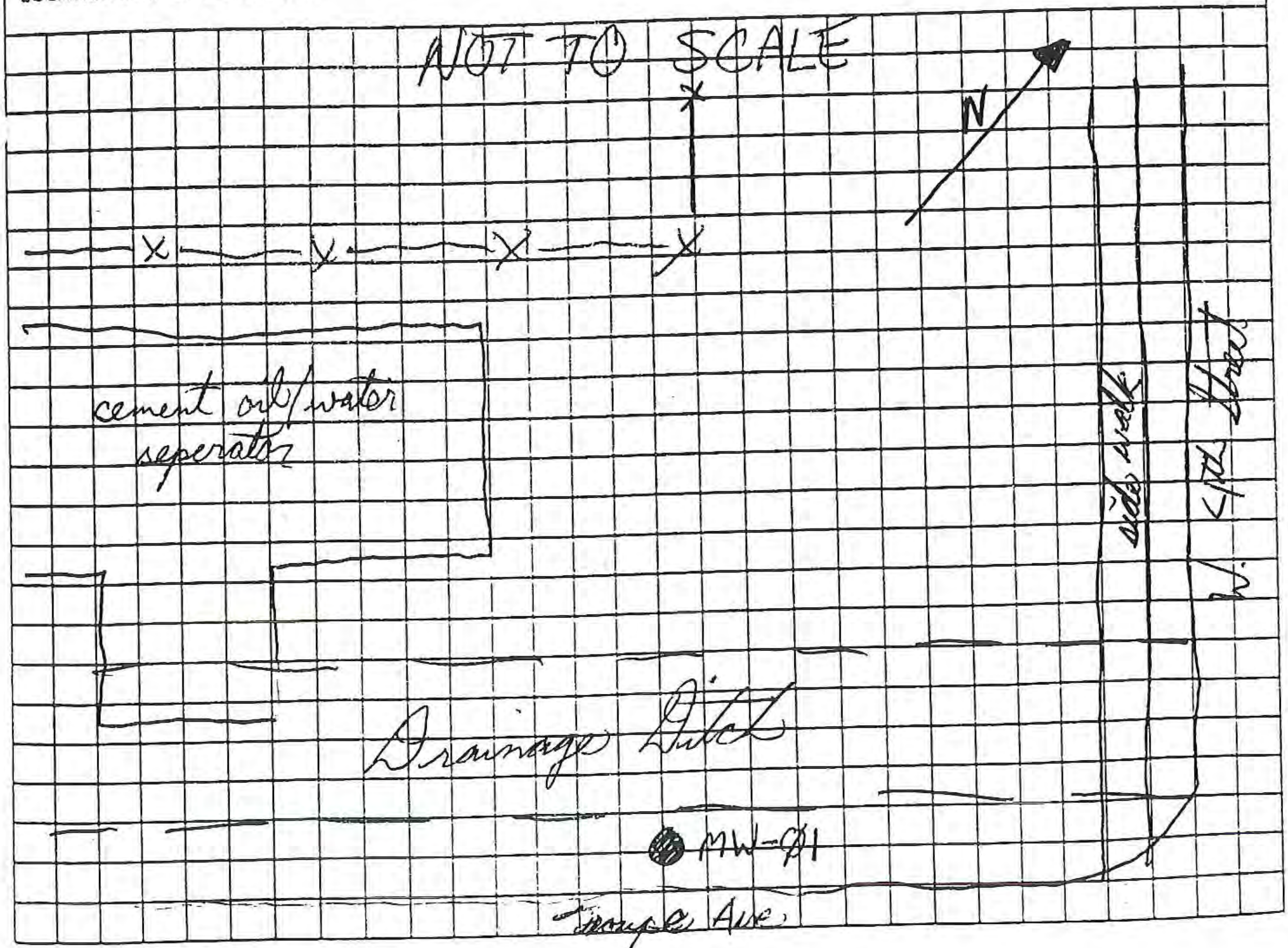
3

3. PROJECT: 16 SWMU'S	4. LOCATION: 16 SWMUS (29T)
5. NAME OF DRILLER: Steven Gautney	6. MANUFACTURERS DESIGNATION OF DRILL: Ingersoll-Rand A-300
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 8" hollow stem augers; 4" x 5' split spoon samplers	8. HOLE LOCATION: 17' east of the east corner of the oil water separator
	9. SURFACE ELEVATION: NA
	10. DATE STARTED: 7/22/00 — 11. DATE COMPLETED: 7/23/00
12. OVERBURDEN THICKNESS: NA	15. DEPTH GROUNDWATER ENCOUNTERED: 9.5'
13. DEPTH DRILLED INTO ROCK: NA	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: NA
14. TOTAL DEPTH OF HOLE: 15'	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): NA

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES N/A		
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC X	METALS	~~OTHER (SPECIFY)~~ LEAD X	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY 50%
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL X	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR Matt Root	

LOCATION SKETCH/COMMENTS

SCALE:



HOLE NUMBER MW-Ø1

4

SHEET 2 OF 3

HTRW DRILLING LOG

PROJECT: 16 SWMU'S

INSPECTOR Matt Root

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		SM-poorly graded fine silty sand, 10YR5/4, dry -color change to 10YR2/1	NA			Ø'-5' - 3' of recovery 5'-10' - 2' of recovery note: sample 8F1171 for lead+VOCs was taken over the entire borehole (Ø-~~30~~ MJR 7/23/10 15') -sample 8F1172 for geotech was taken from 10'-15' BGS.
	1					
		-color change to 10YR3/1				
	2					
	3					
	4					
	5	color change to 10YR6/3				
	6	gradually grades colors from 5-7'				
	7	color grades to 7.5YR2.5/1 (contains some organic matter-roots)				
	8					
	9					
	10					

5

HTRW DRILLING LOG						HOLE NUMBER MW-Ø1
PROJECT: 16 SWMU's		INSPECTOR Matt Root				SHEET 3 OF 3
ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	HEADSPACE SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX	ANALYTICAL SAMPLE NO.	REMARKS (G)
		SM-poorly graded fine silty sand, 5YR2.5/1, saturated	NA			1Ø-15' - 2' of recovery
		-organic material from 10.9'-11.Ø'				
	11	SP-SM-poorly graded sand w/little silt 5YR7/1				
		SM-poorly graded fine silty sand w/organic matter, 5YR2.5/1				
	12			8F1172		
	13					
	14					
	15	end augering @ 15' BGS				
	16					
	17	Matthew Root 7/23/ØØ				
	18					
	19					

MONITORING WELL INSTALLATION LOG

PROJECT: FORT STEWART - 16 SWMUs **DELIVERY ORDER: 0009**

MONITORING WELL ID: 27T-MW-01

INSTALLATION START: **DATE:** 7/23/00 **TIME:** 08:45

INSTALLATION FINISH: **DATE:** 7/23/00 **TIME:** 09:20

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK: **TYPE:** #1 Filter pack sand **QUANTITY:** 3 5-lb bags

BENTONITE SEAL: **TYPE:** 3/8" Bentonite pellets **QUANTITY:** 1 5-gal bucket

GROUT: **TYPE:** 97%/3% Bentonite/ Grout mixture **QUANTITY:** None used on shallow hole

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.008 **SLOT CONFIGURATION:** cut

TOTAL OPEN AREA PER FOOT OF SCREEN: N/A

OUTSIDE DIAMETER: 2 3/8" **NOMINAL INSIDE DIAMETER:** 2"

SCHEDULE/THICKNESS: Sch 40 **COMPOSITION:** PVC

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: PVC

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 2 3/8" **NOMINAL INSIDE DIAMETER:** 2"

SCHEDULE/THICKNESS: Sch 40 **COMPOSITION:** PVC

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Threaded PVC

CENTRALIZERS DESIGN AND COMPOSITION: N/A

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 8" **COMPOSITION:** drive over steel

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

Use ~ 20 gallons of water to stop heaving sands from coming up into augers

Was all well screen and casing material used for construction free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.)? **YES [X] NO [ ]**

Was all well screen and casing material used for construction free of unsecured couplings, ruptures, and other physical breakage and/or defects? **YES [X] NO [ ]**

Is deformation or bending of the installed well screen and casing minimized to the point of allowing the insertion and retrieval of a 1.0-inch bailer throughout the entire length of the completed well? **YES [X] NO [ ]**

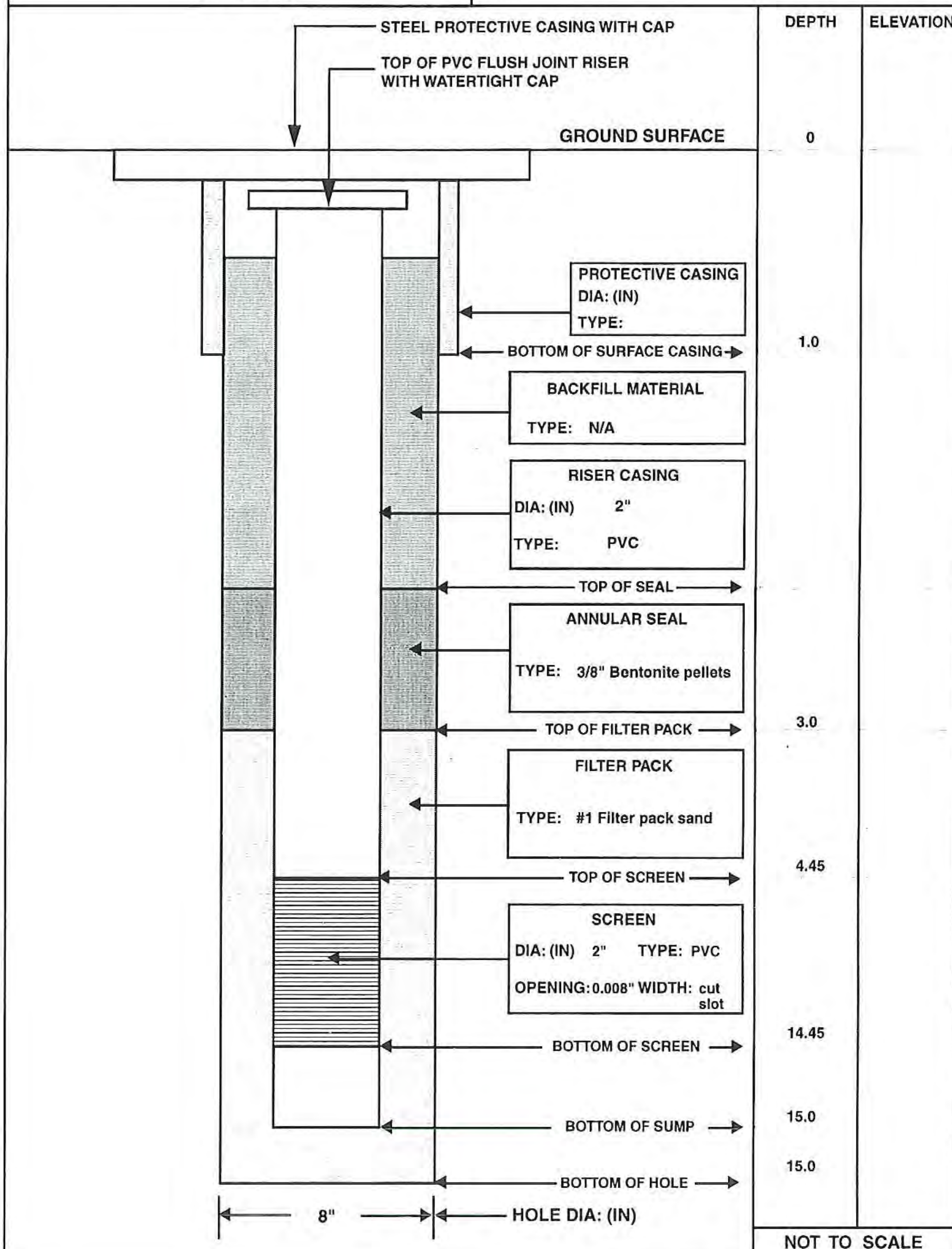
QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: ~ 20 gallons

RECORDED BY: Matthew Root 7/23/00 **QA CHECK BY:** Timothy Coffey 8/7/00

(Signature & Date) **(Signature & Date)**

MONITORING WELL

PROJECT: FORT STEWART - 16 SWMUs		DELIVERY ORDER: 0009
WELL NUMBER: 27T-MW-01	BEGIN: 7/23/00 08:45	END: 7/23/00 09:20
COORDINATES: N:678415.44 E:832498.92	REFERENCE POINT: MSL	ELEVATION: 85.57



00-150 (PM)08/28/00

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ATTACHMENT C
TO SWMU 27T
TO THE
REVISED FINAL PHASE II RCRA FACILITY INVESTIGATION REPORT
FOR
16 SOLID WASTE MANAGEMENT UNITS
AT
FORT STEWART, GEORGIA

CHAIN-OF-CUSTODY FORM AND ANALYTICAL DATA

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SAIC An Employee-Owned Company
Science Applications International Corporation
800 Oak Ridge Turnpike, Oak Ridge, TN 37831 (423) 481-4600

CHAIN OF CUSTODY RECORD

COC NO.: GZ7TØZ

20008 7223

PROJECT NAME: Ft. Stewart-SWMU 27T

PROJECT NUMBER: 01-1624-04-1041-200

PROJECT MANAGER: Jeff Longaker

Sampler (Signature) Laura Lumley (Printed Name) Laura Lumley

LABORATORY NAME: General Engineering Laboratory

LABORATORY ADDRESS: 2040 Savage Road, Charleston, SC 29417

PHONE NO: (843) 556-8171

REQUESTED PARAMETERS

Sample ID	Date Collected	Time Collected	Matrix	TCLP BTEX	TCLP Lead	Cadmium	Dissolved Cadmium	No. of Bottles/ Vials	OVA SCREENING	OBSERVATIONS, COMMENTS, SPECIAL INSTRUCTIONS
8F4171	8/23/00	1730	water			1	1	2		

8/24/00

RELINQUISHED BY: Laura Lumley	Date/Time 8/24/00 1111	RECEIVED BY:	Date/Time 8/24/00 1450	TOTAL NUMBER OF CONTAINERS: 2	Cooler Temperature: 4°C
COMPANY NAME: SAIC		COMPANY NAME: GEL		Cooler ID: #226	FEDEX NUMBER:
RECEIVED BY: Laura Keller	Date/Time 8/24/00 1111	RELINQUISHED BY:	Date/Time	#24 hr. Turn	
COMPANY NAME: GEL		COMPANY NAME:			
RELINQUISHED BY: S. Collins	Date/Time 8/24/00 1450	RECEIVED BY: Patricia Dauer	Date/Time 8/24/00 14:50		
COMPANY NAME: GEL		COMPANY NAME: GEL			

SAIC An Employee Owned Company
Science Applications International Corporation
800 Oak Ridge Turnpike, Oak Ridge, TN 37831 (423) 481-4600

CHAIN OF CUSTODY RECORD

COC NO.: G16Ø37

PROJECT NAME: ~~SWMU 12A~~ 16 SWMUs

PROJECT NUMBER: 01-1624-04-7328-~~710~~ 600

PROJECT MANAGER: Jeff Longaker

Sampler (Signature) (Printed Name) Laura

LABORATORY NAME: General Engineering Laboratory

LABORATORY ADDRESS: 2040 Savage Raod Charleston, SC 29417

PHONE NO: (803) 556-8171

REQUESTED PARAMETERS

Sample ID	Date Collected	Time Collected	Matrix	EXPLOSIVES	SVOC	RCRA METALS	BIS	Cadmium	No. of Bottles/ Vials:	OVA SCREENING	OBSERVATIONS, COMMENTS, SPECIAL INSTRUCTIONS
7U1412	6/23/00	1430	water				2		2	27506001	7 day TAT
7N1412	6/22/00	1550					2		2	27506002	
8FZ411	6/24/00	0820	Sediment Soil					1	1	27507 001	
8FZ511	6/24/00	0825						1	1	27507 002	
8FZ611	6/24/00	0835						1	1	27507 003	

SS 6/24/00

RELINQUISHED BY:	Date/Time 6/24/00 0920	RECEIVED BY:	Date/Time 6/24/00 1155
COMPANY NAME: SAIC		COMPANY NAME: GEL	
RECEIVED BY: Raymond Reed	Date/Time 6/24/00 0920	RELINQUISHED BY:	Date/Time
COMPANY NAME: GEL		COMPANY NAME:	
RELINQUISHED BY: Raymond Reed	Date/Time 6/24/00 1155	RECEIVED BY:	Date/Time
COMPANY NAME: GEL		COMPANY NAME:	

TOTAL NUMBER OF CONTAINERS: 7

Cooler ID: #406

Cooler Temperature: 3.7°C

FEDEX NUMBER:

Location: SWMU 27T, 293 MP COMPANY
Station : 27T-MW-01

8F4171 0.0 - 0.0 FT Field Sample Type: Grab Matrix: Groundwater Collected: 08/23/2000

Sample Type	Metals	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Cadmium	.69	UG/L	U	U	

Sample Type	Filtered Metals	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Cadmium	.69	UG/L	U	U	

Location: SWMU 27T, 293 MP COMPANY
Station : 8F-SWS-04

8F2411 0.0 - 0.0 FT Field Sample Type: Grab Matrix: Sediment Collected: 06/24/2000

Sample Type	Metals	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Cadmium	3160	UG/KG		=	

Location: SWMU 27T, 293 MP COMPANY
Station : 8F-SWS-05

8F2511 0.0 - 0.0 FT Field Sample Type: Grab Matrix: Sediment Collected: 06/24/2000

Sample Type	Metals	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Cadmium	5810	UG/KG		=	

Location: SWMU 27T, 293 MP COMPANY
Station : 8F-SWS-06

8F2611 0.0 - 0.0 FT Field Sample Type: Grab Matrix: Sediment Collected: 06/24/2000

Sample Type	Metals	Result	Units	Qualifiers Lab	Qualifiers Data	Validation Code
REG	Cadmium	3850	UG/KG		=	

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ATTACHMENT D
TO SWMU 27T
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16 SOLID WASTE MANAGEMENT UNITS
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FORT STEWART, GEORGIA

FATE AND TRANSPORT ANALYSIS

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Fate and transport modeling was performed for the only preliminary contaminant migration contaminant of potential concern (CMCOPC) in sediment (cadmium) (see Table 9 of this addendum) and the only ecological contaminant of potential concern (ECOPC) in groundwater (pyrene) (see Table 11 of this addendum). No preliminary CMCOPCs were identified in soil. The main purpose of the modeling was to estimate future groundwater concentrations from the leachate beneath Solid Waste Management Unit (SWMU) 27T and also to predict future surface water concentrations at the receptor locations. A tributary to Melvin Swamp is located approximately 1,320 feet southeast of the site.

Migration to Groundwater Beneath the Source

The estimated groundwater concentration resulting from the leaching of the preliminary CMCOPC, cadmium (see Table 21 of this addendum) from the sediment above the water table was estimated using the Seasonal Soil Compartment (SESOIL) Model. A detailed discussion of the SESOIL model is presented in Chapter 6.0 and Appendix K of the revised final Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for 16 SWMUs (SAIC 2000). The chemical and climatic parameters used in SESOIL modeling are presented in Table 6-2 and Appendix K, Table K-1, respectively, of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000). The hydrogeological parameters and application data used in SESOIL for SWMU 27T are presented in Tables D-1 and D-2, respectively. Among the hydrogeological parameters (Table D-1), bulk density, porosity, and organic carbon content were taken from the samples collected from the nearby Underground Storage Tank (UST) 207 site [see the Corrective Action Plan, Part A for UST 207, Facility ID #9-089038 (SAIC 1998)]. The SESOIL modeling results are presented in Table D-3 and Figure D-1. The estimated groundwater concentrations were calculated by dividing the SESOIL leachate concentration by a dilution factor (DF) of 1.6. The DF was developed by using the hydraulic analysis method (EPA 1996), which involves calculating the rate of flow through the aquifer system and the rate of rainwater percolation into the aquifer. The parameters used in the development of the DF are presented in Table D-1. The thickness of the zone of mixing in the groundwater aquifer was calculated to be 10.3 feet using the formula for depth of mixing presented in the U.S. Environmental Protection Agency Soil Screening Guidance (EPA 1996). The modeling results indicated that predicted maximum concentration (0.1 mg/L) of cadmium will exceed its maximum contaminant level (0.005 mg/L), and cadmium was identified as a CMCOPC for further evaluation in the baseline risk assessment. The SESOIL–predicted maximum concentration of cadmium was used as the groundwater exposure concentration in the baseline risk assessment.

Migration of Groundwater to Surface Water

The concentration of the only groundwater ECOPC (pyrene) and the predicted groundwater concentration of cadmium were modeled to estimate their potential concentrations at the tributary to Melvin Swamp, located approximately 1,320 feet from the site. One-dimensional Analytical Solute Transport (ODAST) and Analytical Transient 1-, 2-, and 3-Dimensional (AT123D) models were used to predict the surface water concentrations of cadmium and pyrene, respectively, due to migration of groundwater to surface water [see Chapter 6.0 and Appendix K of the revised final Phase II RFI Report for 16 SWMUs (SAIC 2000)].

The ODAST modeling parameters are presented in Table D-4. The ODAST modeling of cadmium assumed a constant concentration at the source for a period of 70 years. The ODAST Model for cadmium was simulated for a period of 1,000 years. The ODAST modeling result is presented in Table D-5. The result indicates that cadmium in groundwater will not migrate to the tributary to Melvin Swamp through the groundwater pathway.

The AT123D modeling parameters are presented in Table D-6. The biodegradation rate of pyrene used in the modeling is presented in Table 6-2 of the revised final Phase II RFI Report for 16 SWMUs (SAIC

2000). The AT123D Model for pyrene was calibrated to the maximum observed groundwater concentration (0.0262 mg/L). The AT123D modeling assumed a steady-state, constant concentration of pyrene at the source. The AT123D modeling result is presented in Table D-7. The result indicates that pyrene will not reach the receptor location through the groundwater pathway. An AT123D output file with input parameters for pyrene is presented at the back of this attachment. The predicted surface water exposure concentrations due to migration of the groundwater ECOPC, pyrene, are zero.

Therefore, the risks from pyrene and cadmium in groundwater migrating to the surface water were not assessed further in the risk assessment.

REFERENCES

EPA (U.S. Environmental Protection Agency) 1996. Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, Office of Solid Waste and Emergency Response, May.

Mills, W. B., D. B. Porcella, M. J. Ungs, S. A. Gherini, K. V. Summers, G. L. Rupp, and G. L. Bowie 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants: Parts 1, 2, and 3, EPA/600/6-85/002, EPA Environmental Research Laboratory, Office of Research and Development, Athens, Georgia.

SAIC (Science Applications International Corporation) 1998. Corrective Action Plan, Part A, Underground Storage Tank 207, Facility ID #9-089038, Building 232, Fort Stewart, Georgia, December.

SAIC 2000. Phase II RCRA Facility Investigation Report for 16 Solid Waste Management Units at Fort Stewart, Georgia (Revised Final), April.

Table D-1. Hydrogeological Parameters Used for SESOIL Modeling, SWMU 27T

Parameter Type	Parameter Value	Source
Soil type	Sandy silt	SWMU 27T specific
Bulk density (gm/cm^3)	1.82	Laboratory analysis of nearby UST 207 samples
Percolation rate (cm/year)	39.88	16 SWMUs average
Intrinsic permeability (cm^2)	9.40E-10	Calibrated
Disconnectedness index	10	Calibrated
Porosity (%)	0.3	Laboratory analysis of nearby UST Tank 207 samples
Depth to water table (feet)	4	Site specific
Organic carbon content (%)	0.547	Laboratory analysis of nearby UST Tank 207 samples
Frendlich equation exponent	1	SESOIL default value
DAF	1.6	Calculated
Area of source (m^2)	1.79E+02	Estimated contaminated area

DAF = Dilution attenuation factor.

Table D-2. SESOIL Application Data, SWMU 27T

Contaminants of Potential Concern	No. of Layers	Layer No.	Thickness of Layer (feet)	No. of Sublayers	Sublayer No.	Concentration (µg/g)
Cadmium	3	1	1	1	1	19.3
		2	2	3	1	0
					2	0
		3	1	10	1	0
					2	0
					3	0
					4	0
					5	0
					6	0
					7	0
					8	0
					9	0
					10	0

Table D-3. Summary of Leachate Modeling Results, SWMU 27T

Preliminary CMCOPCs[a]	Maximum Concentration (mg/kg)	Predicted $C_{leachate,max}$ beneath the Source (mg/L)	Predicted T_{max} (years)	Predicted $C_{gw,max}$ at the Source[b] (mg/L)	Maximum Observed Groundwater Concentration (mg/L)	Groundwater Target Concentration (mg/L)	Source[c]	CMCOPC?
INORGANICS								
Cadmium	19.3	0.160	266	0.10	NA	0.005	M	Yes

[a]These constituents were selected for SESOIL modeling from this site.
[b]The predicted maximum concentration in groundwater ($C_{gw,max}$) at the source was calculated by applying a dilution factor to the predicted maximum leachate concentration ($C_{leachate,max}$).
[c]M = Maximum contaminant level.
NA = Not analyzed.

Table D-4. Parameters Used for ODAST Modeling, SWMU 27T

Parameter Type	Parameter Value	Source
Bulk density (gm/cm^3)	1.82	Laboratory analysis of nearby UST 207 samples
Effective porosity (%)	0.2	Mills et al. (1985) for sandy silt
Hydraulic conductivity (cm/s)	6.64E-04	Laboratory analysis of nearby UST 207 samples
Hydraulic gradient	0.0059	UST 207 CAP–Part A Report
Groundwater velocity (feet/day)	0.055	Calculated
Dispersion coefficient ($feet^2$/day)	7.26	Calculated assuming dispersivity = 0.1 × distance to receptor
Distance to receptor (feet)	1,320	Approximate distance to a tributary to Mill Creek
Distribution coefficient for cadmium (L/kg)	35	Corresponding to pH = 5.9 (EPA 1996)

CAP = Corrective Action Plan.

Table D-5. ODAST Modeling Results, SWMU 27T

Contaminant of Potential Concern[a]	Source Concentration[b] (mg/L)	Dilution Factor[c]	Receptor	Receptor Point Groundwater Concentration (mg/L)
Cadmium	0.1	Infinite	Tributary to Melvin Swamp (1,320 feet)	0

[a]CMCOPC in sediment modeled to groundwater.

[b]SESOIL–predicted groundwater concentration.

[c]DF represents (maximum concentration at the source) ÷ (maximum predicted concentration at the receptor in 1,000 year simulation).

Table D-6. Key Hydrogeological Parameters Used for AT123D Modeling, SWMU 27T

Parameter Type	Parameter Value	Source
Bulk density (kg/m^3)	1,820	Laboratory analysis of nearby UST 207 samples
Effective porosity (%)	0.2	Mills et al. (1985) for sandy silt type
Hydraulic conductivity (minutes/hour)	2.39E-02	Laboratory analysis of nearby UST 207 samples
Hydraulic gradient	0.0059	UST 207 CAP–Part A Report
Longitudinal dispersivity (m)	40.2	Calculated assuming dispersivity = 0.1 × distance to receptor
Density of water (kg/m^3)	1,000	Assumed
Fraction of organic carbon (unitless)	0.0055	Laboratory analysis of nearby UST 207 samples
Distance to receptor (feet)	1320	Approximate distance to the Canoochee Creek
Source area length (m)	13.5	Conservative estimate
Source area width (m)	13.5	Conservative estimate

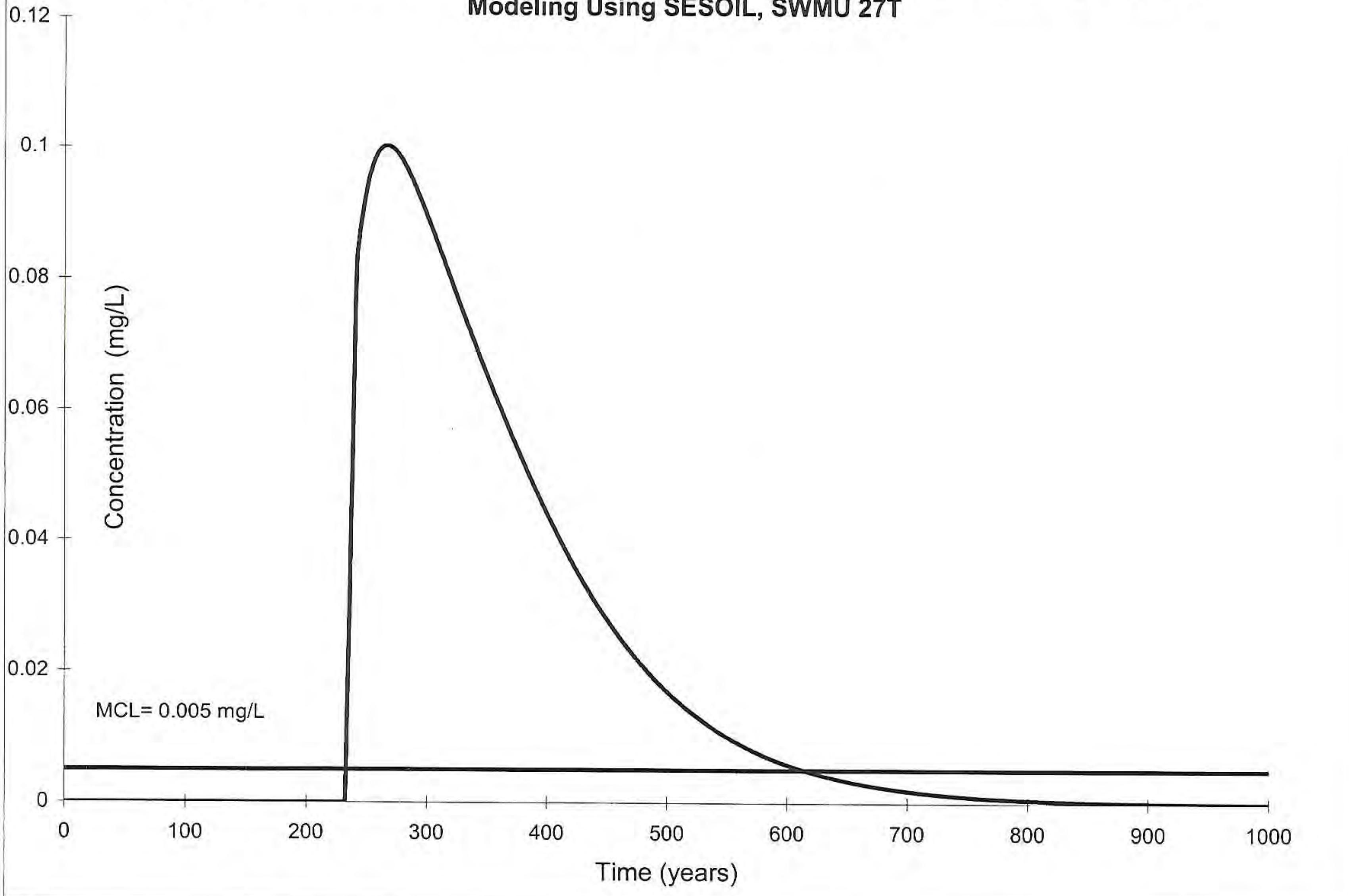
CAP = Corrective Action Plan.

Table D-7. AT123D Modeling Result, SWMU 27T

Contaminant of Potential Concern[a]	Source Concentration[b] (mg/L)	Dilution Factor[c]	Receptor	Receptor Point Groundwater Concentration (mg/L)
Pyrene	0.0262	Infinite	Tributary to Melvin Swamp (1,320 feet)	0.00E+00

[a]ECOPC in deep groundwater.
[b]Maximum observed groundwater concentrations in deep wells.
[c]DF represents (maximum concentration at the source) ÷ (maximum predicted concentration at the receptor).

Figure D-1. Predicted Concentration of Cadmium in Groundwater Based on Leachate Modeling Using SESOIL, SWMU 27T



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AT123D OUTPUT FILE FOR SWMU 27T

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SWMU 27T Pyrene

NO. OF POINTS IN X-DIRECTION 8
NO. OF POINTS IN Y-DIRECTION 1
NO. OF POINTS IN Z-DIRECTION 1
NO. OF ROOTS: NO. OF SERIES TERMS 400
NO. OF BEGINNING TIME STEP 900
NO. OF ENDING TIME STEP 1198
NO. OF TIME INTERVALS FOR PRINTED OUT SOLUTION 16
INSTANTANEOUS SOURCE CONTROL = 0 FOR INSTANT SOURCE 1
SOURCE CONDITION CONTROL = 0 FOR STEADY SOURCE 0
INTERMITTENT OUTPUT CONTROL = 0 NO SUCH OUTPUT 1
CASE CONTROL =1 THERMAL, = 2 FOR CHEMICAL, = 3 RAD 2

AQUIFER DEPTH, = 0.0 FOR INFINITE DEEP (METERS) .... 0.1524E+02
AQUIFER WIDTH, = 0.0 FOR INFINITE WIDE (METERS) .... 0.0000E+00
BEGIN POINT OF X-SOURCE LOCATION (METERS) .... -0.1350E+02
END POINT OF X-SOURCE LOCATION (METERS) .... 0.0000E+00
BEGIN POINT OF Y-SOURCE LOCATION (METERS) .... -0.6750E+01
END POINT OF Y-SOURCE LOCATION (METERS) .... 0.6750E+01
BEGIN POINT OF Z-SOURCE LOCATION (METERS) .... -0.1000E+01
END POINT OF Z-SOURCE LOCATION (METERS) .... 0.0000E+00

POROSITY .... 0.2000E+00
HYDRAULIC CONDUCTIVITY (METER/HOUR) 0.2390E-01
HYDRAULIC GRADIENT 0.5900E-02
LONGITUDINAL DISPERSIVITY (METER) .... 0.4020E+02
LATERAL DISPERSIVITY (METER) .... 0.4020E+01
VERTICAL DISPERSIVITY (METER) .... 0.1000E+01
DISTRIBUTION COEFFICIENT, KD (M**3/KG) .... 0.3720E+00
HEAT EXCHANGE COEFFICIENT (KCAL/HR-M**2-DEGREE C)...... 0.0000E+00

MOLECULAR DIFFUSION MULTIPLY BY POROSITY (M**2/HR) 0.2610E-05
DECAY CONSTANT (PER HOUR) 0.3800E-05
BULK DENSITY OF THE SOIL (KG/M**3) .... 0.1820E+04
ACCURACY TOLERANCE FOR REACHING STEADY STATE 0.1000E-02
DENSITY OF WATER (KG/M**3) .... 0.1000E+04
TIME INTERVAL SIZE FOR THE DESIRED SOLUTION (HR) .... 0.7300E+03
DISCHARGE TIME (HR) .... 0.8760E+06
WASTE RELEASE RATE (KCAL/HR), (KG/HR), OR (CI/HR) 0.2551E-04

RETARDATION FACTOR .... 0.3386E+04
RETARDED DARCY VELOCITY (M/HR) 0.2082E-06
RETARDED LONGITUDINAL DISPERSION COEFF. (M**2/HR) 0.8375E-05
RETARDED LATERAL DISPERSION COEFFICIENT (M**2/HR) 0.8410E-06
RETARDED VERTICAL DISPERSION COEFFICIENT (M**2/HR).... 0.2121E-06
WARNING: SERIES Z AT Z = 0.00 TIMED= 730.00NEEDS MORE TERMS
WARNING: SERIES Z AT Z = 0.00 TIMED= 1460.00NEEDS MORE TERMS

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.0000E+00 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CONTINUE X						
Y	200.	402.				
0.	0.000E+00	0.000E+00				

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.6563E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.252E-01	0.329E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CONTINUE X						
Y	200.	402.				
0.	0.000E+00	0.000E+00				

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.6680E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.253E-01	0.357E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CONTINUE X						
Y	200.	402.				
0.	0.000E+00	0.000E+00				

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.6796E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.254E-01	0.386E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CONTINUE X						
Y	200.	402.				
0.	0.000E+00	0.000E+00				

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.6913E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.254E-01	0.416E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.7030E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.255E-01	0.448E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.7147E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.256E-01	0.480E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.7264E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.257E-01	0.513E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.7380E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.257E-01	0.547E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.7497E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.258E-01	0.582E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.7614E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.259E-01	0.618E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.7731E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.259E-01	0.654E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.7848E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.260E-01	0.692E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

CONTINUE X	
Y 200.	402.
0. 0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.7964E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.261E-01	0.729E-05	0.000E+00	0.000E+00	0.000E+00	0.000E+00

CONTINUE X	
Y 200.	402.
0. 0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.8081E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.261E-01	0.767E-05	0.122E-11	0.000E+00	0.000E+00	0.000E+00

CONTINUE X	
Y 200.	402.
0. 0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.8198E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00

X						
Y	0.	10.	20.	50.	75.	100.
0.	0.262E-01	0.806E-05	0.419E-11	0.000E+00	0.000E+00	0.000E+00

CONTINUE X	
Y 200.	402.
0. 0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.8315E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00
X

Y	0.	10.	20.	50.	75.	100.
0.	0.262E-01	0.845E-05	0.703E-11	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.8432E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00
X

Y	0.	10.	20.	50.	75.	100.
0.	0.263E-01	0.885E-05	0.107E-10	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.8548E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00
X

Y	0.	10.	20.	50.	75.	100.
0.	0.263E-01	0.925E-05	0.159E-10	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

STEADY STATE SOLUTION HAS NOT BEEN REACHED BEFORE FINAL SIMULATING TIME

DISTRIBUTION OF DISSOLVED CHEMICALS IN PPM AT 0.8665E+06 HRS
(ADSORBED CHEMICAL CONC. = 0.3720E+03 * DISSOLVED CHEMICAL CONC.)

Z = 0.00
X

Y	0.	10.	20.	50.	75.	100.
0.	0.264E-01	0.965E-05	0.216E-10	0.000E+00	0.000E+00	0.000E+00

CONTINUE X

Y	200.	402.
0.	0.000E+00	0.000E+00

ATTACHMENT E
TO SWMU 27T
TO THE
REVISED FINAL PHASE II RCRA FACILITY INVESTIGATION REPORT
FOR
16 SOLID WASTE MANAGEMENT UNITS
AT
FORT STEWART, GEORGIA

TOXICITY PROFILES FOR CONTAMINANTS OF POTENTIAL CONCERN

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This appendix contains the toxicity profiles for human health contaminants of potential concern (HHCOPCs). The toxicity profiles provide pertinent information concerning the uptake, mechanisms of toxicity, and toxicity values for the HHCOPCs. In addition to the toxicity profiles, a toxicity summary (Table E-1) is given for each of the site-related contaminants. The toxicity summary consists of the essential data used to derive toxicity values [reference doses (RfDs) and cancer slope factors] obtained from U.S. Environmental Protection Agency (EPA) toxicity databases [Integrated Risk Information System (IRIS; EPA 2000) and Health Effects Assessment Summary Tables (HEAST; EPA 1997)].

Benzo(*a*)anthracene. Benzo(*a*)anthracene is a polycyclic aromatic hydrocarbon (PAH) with four aromatic rings, two of which share carbons with only one other ring. No commercial production or use of this compound is known. Benzo(*a*)anthracene is found in fossil fuels and occurs ubiquitously in products of incomplete combustion. It is found in various kinds of smoke and flue gases; tobacco smoke; automobile exhaust; roasted coffee; and charcoal-broiled, barbecued, or smoked meats. It is also found in creosote, coal tar, petroleum asphalt, and a variety of foods including vegetable oils and baker's yeast (Francis 1992).

No absorption data for benzo(*a*)anthracene were available; however, analogy to structurally related PAHs, primarily benzo(*a*)pyrene, suggests that it would be absorbed from the gastrointestinal tract, lungs, and skin (Francis 1992).

Benzo(*a*)anthracene is considered to be a carcinogenic PAH, but little is know about the systemic toxicity of this chemical. The toxic effects of benzo(*a*)anthracene and similar PAHs are primarily directed toward tissues that contain proliferating cells such as the hematopoietic system, lymphoid system, and reproductive tissues (Francis 1992). Neither an oral RfD nor an inhalation reference concentration (RfC) has been derived for benzo(*a*)anthracene in either IRIS or HEAST (EPA 2000; EPA 1997). Benzo(*a*)anthracene is classified by EPA in weight-of-evidence Group B2, probable human carcinogen (EPA 2000).

See also toxicity profile for PAHs.

Benzo(*b*)fluoranthene. Benzo(*b*)fluoranthene, a crystalline solid, is a PAH with one five-membered ring and four six-membered rings. No commercial production or use of this compound is known. Benzo(*b*)fluoranthene is found in fossil fuels and occurs ubiquitously in products of incomplete combustion. It has been detected in cigarette smoke, urban air, gasoline engine exhaust, emissions from burning coal and from oil-fired heating, broiled and smoked food, oils, and margarine (Faust 1994a).

No absorption data are available for benzo(*b*)fluoranthene; however, by analogy to structurally related PAHs, primarily benzo(*a*)pyrene, it would be expected to be absorbed from the gastrointestinal tract, lungs, and skin. Major metabolites of benzo(*b*)fluoranthene formed *in vitro* in the livers of rats include dihydrodiols and monohydroxy derivatives and monohydroxy derivatives in mouse epidermis (Faust 1994a).

Benzo(*b*)fluoranthene is considered to be a carcinogenic PAH, but little is know about the systemic toxicity of this chemical. Neither an oral RfD nor an inhalation RfC has been derived for benzo(*b*)fluoranthene in either IRIS or HEAST (EPA 2000; EPA 1997). Benzo(*b*)fluoranthene is classified by EPA in weight-of-evidence Group B2, probable human carcinogen (EPA 2000).

See also toxicity profile for PAHs.

Benzo(*a*)pyrene. Benzo(*a*)pyrene is a PAH that can be derived from coal tar. It occurs ubiquitously in products of incomplete combustion of fossil fuels and has been identified in ambient air, surface water, drinking water, wastewater, and charbroiled foods. Benzo(*a*)pyrene is primarily released to the air and removed from the atmosphere by photochemical oxidation and dry deposition to land or water. Biodegradation is the most important transformation process in soil or sediment (Faust 1994b).

Benzo(*a*)pyrene is readily absorbed after inhalation, ingestion, and dermal contact. After inhalation exposure, benzo(*a*)pyrene is rapidly distributed to several tissues in rats. The metabolism of the compound is complex and includes the formation of a proposed ultimate carcinogen, benzo(*a*)pyrene 7,8 diol-9,10-epoxide. The major route of excretion is hepatobiliary, followed by elimination in the feces (Faust 1994b).

Numerous epidemiologic studies have shown a clear association between exposure to various mixtures of PAHs containing benzo(*a*)pyrene (e.g., coke oven emissions, roofing tar emissions, and cigarette smoke) and increased risk of lung cancer and other tumors. However, each of the mixtures also contained other potentially carcinogenic PAHs; therefore, distinguishing the contribution of benzo(*a*)pyrene to the carcinogenicity of these mixtures is not possible. An extensive database is available for the carcinogenicity of benzo(*a*)pyrene in experimental animals. Dietary administration of the compound has produced papillomas and carcinomas of the forestomach in mice, and treatment by gavage has produced mammary tumors in rats and pulmonary adenomas in mice. Exposure by inhalation and intratracheal instillation has resulted in benign and malignant tumors of the respiratory and upper digestive tracts of hamsters. Numerous topical application studies have shown that benzo(*a*)pyrene induces skin tumors in several species, although mice appear to be the most sensitive species. Benzo(*a*)pyrene is a complete carcinogen and also an initiator of skin tumors. It has been reported to induce tumors in animals when administered by other routes, such as intravenous, intraperitoneal, subcutaneous, intrapulmonary, and transplacental (Faust 1994b).

No oral RfD or inhalation RfC has been calculated for this chemical (EPA 1997; EPA 2000). Benzo(*a*)pyrene is classified as a Group B2 carcinogen, probable human carcinogen, with an oral slope factor of 7.30/(mg/kg-day) (EPA 2000).

See also toxicity profile for PAHs.

Cadmium. Cadmium is a naturally occurring element found worldwide in soil and rocks. The primary sources of environmental cadmium contamination are smelters and the burning of fossil fuels in power plants.

Cadmium is absorbed more efficiently through the lungs than by the gastrointestinal tract. Acute oral exposures to cadmium can cause vomiting, diarrhea, and abdominal pain, while longer-term oral exposure to cadmium affects the kidneys and possibly the skeletal system (Young 1991). Inhalation exposure to cadmium may cause headache, chest pains, muscular weakness, pulmonary edema, and death (Young 1991), while longer-term inhalation exposure also results in kidney damage (ATSDR 1989a; EPA 1980; EPA 1984).

Limited evidence shows possible adverse spermatogenic effects of cadmium in occupationally exposed workers (Barlow and Sullivan 1982). The results of genotoxicity and mutagenicity tests with cadmium are inconclusive. Some assays show positive results (certain mammalian cell culture assay systems), while other assays report negative findings (mouse bone marrow and mouse micronucleus assays) (ATSDR 1989a).

EPA's IRIS database (EPA 2000) lists oral RfDs of 0.0005 mg/kg/day and 0.001 mg/kg/day for cadmium in water and in food, respectively. These RfDs were based on respective human no observed adverse effect levels (NOAELs) of 0.005 mg/kg/day and 0.01 mg/kg/day in water and food and uncertainty factors of 10 to account for human variability. The NOAELs were calculated with a toxicokinetic model using a human renal cortex concentration of 200 μg cadmium per gram wet weight, the highest human renal cadmium concentration not associated with significant proteinuria in EPA's Drinking Water Criteria Document on Cadmium (EPA 1985). The model assumes that 0.01 percent of the cadmium body burden is eliminated daily, and that 5 percent and 2.5 percent of ingested cadmium are absorbed from water and food, respectively. A new RfD has been proposed in EPA's recent Toxicological Review: Cadmium and Compounds (EPA 1999), which is undergoing external review. The proposed RfD of 0.0007 mg/kg/day is an estimate of a daily oral intake (in excess of estimated dietary cadmium intake) that would be associated with a 10-percent occurrence of minimal proteinuria/enzymuria in an exposed population at the age of 70. The estimate is based on a toxicokinetic model and data for renal dysfunction in cross-sectional studies of human populations exposed to excess cadmium.

An RfC assessment is not available in IRIS or HEAST, but an inhalation RfC has been proposed in EPA's recent Toxicological Review: Cadmium and Compounds (EPA 1999), which is undergoing external review. The proposed RfC of 0.00065 mg/m^3 is an estimate of an air concentration producing an inhaled intake (in excess of estimated dietary cadmium intake) that would be associated with a 10-percent occurrence of minimal proteinuria/enzymuria in an exposed population at the age of 70. The estimate is based on a toxicokinetic model and data for renal dysfunction in cross-sectional studies of human populations exposed to excess cadmium (EPA 1999).

EPA has placed cadmium in weight-of-evidence class B1, probable human carcinogen (EPA 2000). An inhalation unit risk of $1.8 \times 10^{-3}/(\mu g/m^3)$ was derived based on excess deaths from lung, trachea, and bronchus cancers in male workers exposed to airborne cadmium in the workplace (EPA 2000).

Indeno(*1,2,3-cd*)pyrene. Indeno(*1,2,3-cd*)pyrene is a crystalline solid. No commercial production or use of this compound is known. It is found in fossil fuels; occurs ubiquitously in products of incomplete combustion; and has been identified in soil, groundwater, and surface water at hazardous waste sites. No commercial production or use of this compound is known (Faust 1994c).

No absorption data for indeno(*1,2,3-cd*)pyrene are available; however, analogy to structurally related PAHs, primarily benzo(*a*)pyrene, suggests that it would be absorbed from the gastrointestinal tract, lungs, and skin. *In vivo* metabolites identified in mouse skin include the *trans*-1,2-dihydrodiol and 8- and 9-hydroxy forms of indeno(*1,2,3-cd*)pyrene. Similar metabolites were formed *in vitro* in rat liver microsomes (Faust 1994c).

Indeno(*1,2,3-cd*)pyrene is considered to be a carcinogenic PAH, but little is know about the systemic toxicity of this chemical. Neither an oral RfD nor an inhalation RfC has been derived for indeno(*1,2,3-cd*)pyrene in either IRIS or HEAST (EPA 2000; EPA 1997). Indeno(*1,2,3-cd*)pyrene is classified by EPA in weight-of-evidence Group B2, probable human carcinogen (EPA 2000).

See also toxicity profile for PAHs.

Polycyclic Aromatic Hydrocarbons. The PAHs are a group of chemicals that are formed during the incomplete burning of wood and fuel, including coal, oil, gas, and other organic substances (ATSDR 1989b). Exposure to PAHs may occur via inhalation, ingestion, and dermal contact. In any medium, PAHs most often exist as complex mixtures of compounds, and these compounds have been divided into (1) carcinogenic PAHs and (2) noncarcinogenic PAHs.

Carcinogenic Polycyclic Aromatic Hydrocarbons. Available data indicate that benzo(*a*)pyrene is one of the most potent of the carcinogenic PAHs. Other PAHs considered to be carcinogenic are benzo(*a*)anthracene, benzo(*b*)fluoranthene, benzo(*k*)fluoranthene, chrysene, dibenzo(*a,h*)anthracene, and indeno(*1,2,3-cd*)pyrene.

The arrangement of aromatic rings in the benzo(*a*)pyrene molecule and other PAHs gives it a "bay-region" that is often correlated with carcinogenic properties. In general, bay-region PAHs and some of their metabolites are known to react with cellular macromolecules, including DNA, which may account for the toxicity and carcinogenicity of these compounds (Francis 1992). The primary toxicological concern about exposure to this group of PAHs is carcinogenicity. No case reports or epidemiological studies on the significance of human exposure to individual PAHs are available. Coal tar and other materials known to be carcinogenic to humans, however, contain PAHs (Francis 1992). Lung and skin cancers in humans have been associated with chronic exposure by inhalation and dermal contact, respectively, to mixtures of compounds that include carcinogenic PAHs (ATSDR 1989b). Several individual PAHs administered to different animal species by various routes have been found to be carcinogenic at both local and systemic sites. Long-term experimental studies resulted in tumors in the liver, mammary gland, respiratory and gastrointestinal tracts, and skin (ATSDR 1989b). Carcinogenic PAHs are also reported to be mutagenic in a variety of test systems.

Although reproductive effects in mice fed benzo(*a*)pyrene and adverse effects in their offspring, including birth defects and decreased body weight, have been reported, no reproductive toxicity from PAH exposure has been demonstrated in humans (ATSDR 1989b). Toxic effects have also been observed in rapidly dividing cells of the intestinal epithelium, testes, and ovaries (oocytes). Animal studies also indicate that exposure to bay-region PAHs can damage the hematopoietic system, leading to progressive anemia as well as agranulocytosis. The lymphoid system can also be affected, resulting in lymphopenia.

Not all of the carcinogenic PAHs appear to be as potent as benzo(*a*)pyrene (ICF-Clement 1988; EPA 1993). Recent guidance published by EPA (1993) recommends that a series of relative potency values (orders of magnitude) be used for the risk assessment of oral exposure to PAHs, with carcinogenic potency being compared to that of benzo(*a*)pyrene.

Noncarcinogenic Polycyclic Aromatic Hydrocarbons. PAHs not considered to be carcinogenic include acenaphthene, benzo(*g,h,i*)perylene, naphthalene, and phenanthrene.

PAHs are toxic to the skin. For example, naphthalene is a primary skin irritant and causes erythema and dermatitis on repeated contact (Sittig 1981), and acenaphthene is irritating to the skin and mucous membranes of humans and animals (Faust 1994d). Other noncarcinogenic effects of PAHs have been observed in animals; however, of these, only effects of the blood and blood-forming system and of the skin have also been reported in humans (ATSDR 1989b). Animal studies indicate that PAHs may adversely affect the gastrointestinal tract, liver, kidneys, lungs, and hematopoietic system and may suppress the immune system after both short- and long-term exposure. Oral exposure of animals to acenaphthene caused reproductive effects, including decreased ovary weights, decreased ovarian and uterine activity, and fewer and smaller corpora lutea (Faust 1991; Faust 1994d). No mutagenic or carcinogenic effects of the noncarcinogenic PAHs have been reported.

REFERENCES

ATSDR (Agency for Toxic Substances and Disease Registry) 1989a. Toxicological Profile for Cadmium, U.S. Department of Health and Human Services, Public Health Service, Atlanta.

ATSDR 1989b. Toxicological Profile for Polycyclic Aromatic Hydrocarbons, U.S. Department of Health and Human Services, Public Health Service, Atlanta.

Barlow, S.M., and F.M. Sullivan 1982. Reproductive Hazards of Industrial Chemicals: An Evaluation of Animal and Human Data, Academic Press, New York.

EPA (U.S. Environmental Protection Agency) 1980. Ambient Water Quality Criteria for Cadmium, EPA 440/5-80-025, Office of Water Regulations and Standards, Criteria and Standards Division, Washington, D.C.

EPA 1984. Health Effects Assessment for Cadmium, EPA 540/1-86/038, Office of Research and Development, Washington, D.C.

EPA 1985. Drinking Water Criteria Document on Cadmium, Office of Drinking Water, Washington, D.C.

EPA 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons, EPA/600/R-93/089, Office of Research and Development, Washington, D.C.

EPA 1997. Health Effects Assessment Summary Tables, FY 1997 Update, EPA 540/R-97-036, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA 1999. Toxicological Review: Cadmium and Compounds in Support of Summary Information on Integrated Risk Information System (IRIS) (external review draft), National Center for Environmental Assessment, Office of Research and Development, Washington, D.C.

EPA 2000. Integrated Risk Information System, on-line database, Office of Environmental Criteria and Assessment Office, Cincinnati, available at <http://www.epa.gov/iris>.

Faust, R.A., 1991. Toxicity Summary for Anthracene, Biomedical and Environmental Information Analysis Section, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Faust, R.A., 1992. Toxicity Summary for Benzo(*a*)anthracene, Biomedical and Environmental Information Analysis Section, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Faust, R.A., 1994a. Toxicity Summary for Benzo(*b*)fluoranthene, Biomedical and Environmental Information Analysis Section, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Faust, R.A., 1994b. Toxicity Summary for Benzo(*a*)pyrene, Biomedical and Environmental Information Analysis Section, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Faust, R.A., 1994c. Toxicity Summary for Indeno(*1,2,3-cd*)pyrene, Biomedical and Environmental Information Analysis Section, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Faust, R.A., 1994d. Toxicity Summary for Acenaphthene, Biomedical and Environmental Information Analysis Section, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Francis, A., 1992. Toxicity Summary for Benzo(*a*)anthracene, Biomedical and Environmental Information Analysis Section, Health and Safety Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

ICF-Clement Associates 1988. Comparative Potency Approach for Estimating the Cancer Risk Associated with Exposure to Mixtures of Polycyclic Aromatic Hydrocarbons, interim final report.

Sittig, M., 1981. Handbook of Toxic and Hazardous Chemicals and Carcinogens, Noyes Publications, Park Ridge, New Jersey.

Young, R.A., 1991. Toxicity Summary for Cadmium, Biomedical and Environmental Information Analysis Section, Health and Safety Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, available at <http://risk.lsd.ornl.gov/tox/profiles/cadmiu_c.htm>.

Table E-1. Summary of Toxicity Data for Chemicals of Potential Concern

Chemical	CSF_o (1/mg/kg/day)	Ref	CSF_i (1/mg/kg/day)	Ref	WOE	RfD_o (mg/kg/day)	Ref	UF-MF	Target Organs	RfD_i (mg/kg/day)	Ref	UF-MF	Target Organs
Benzo(*a*)anthracene	7.30E-01	E	3.10E-01	E	B2								
Benzo(*a*)pyrene	7.30E+00	I	3.10E+00	E	B2								
Benzo(*b*)fluoranthene	7.30E-01	E	3.10E-01	E	B2								
Cadmium–food			6.30E+00	I		1.00E-03	I	10	Kidney				
Cadmium–water			6.30E+00	I		5.00E-04	I	10	Develop				
Indeno(*1,2,3-c,d*)pyrene	7.30E-01	E	3.10E-01	E	B2								

CSF_i = Inhalation cancer slope factor.
CSF_o = Oral cancer slope factor.
Ref = Source of information: E = EPA's National Center for Environmental Assessment; I = Integrated Risk Information System, on-line database, <www.epa.gov/IRIS>.
RfD_i = Inhalation reference dose.
RfD_o = Oral reference dose.
UF-MF = Product of the uncertainty and modifying factors.
Target Organs = Primary organ systems affected by noncarcinogenic chemicals.
Develop = Developmental toxicity.
WOE = Cancer weight-of-evidence classification.