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PHASE II
RCRA FACILITY INVESTIGATION REPORT
for the
SOUTH CENTRAL LANDFILL (SWMU 1)
at
Fort Stewart, Georgia

Prepared for

U.S. ARMY CORPS OF ENGINEERS
SAVANNAH DISTRICT

Contract No. DACA21-95-D-0022
Delivery Order 0012

March 1999

98-054P(PPT)/032599

DOCUMENT 8

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PHASE II RCRA FACILITY INVESTIGATION REPORT FOR THE SOUTH CENTRAL LANDFILL (SWMU 1) AT FORT STEWART, GEORGIA

<u>REGULATORY AUTHORITY</u>
RESOURCE CONSERVATION AND RECOVERY ACT
40 CFR 264, TITLE II, SUBPART C, SECTION 3004;
42 USC 6901 ET SEQ.

Prepared for:

U.S. Army Corps of Engineers
Savannah District
Under Contract DACA21-95-D-0022
Delivery Order Number 0012

Prepared by:

Science Applications International Corporation
800 Oak Ridge Turnpike
Oak Ridge, Tennessee 37831

March 1999

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 by a subordinate working under my direction.

22851
P.A. STOLL

Patricia Stoll, P.E.
Technical Manager
SAIC

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SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

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

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List of Abbreviations and Acronyms

ADD	average daily dose
amsl	above mean sea level
Army	U.S. Army
ASTM	American Society for Testing and Materials
AUF	area use factor
AWQC	Ambient Water Quality Criteria
bgs	below ground surface
BHHRA	baseline human health risk assessment
BOD	biochemical oxygen demand

CAP	Corrective Action Plan
CFR	Code of Federal Regulations
CMCOPC	contaminant migration constituent of potential concern
COC	chemical of concern
COD	chemical oxygen demand
COPC	contaminant of potential concern
CRDL	Client-Required Detection Limit
CSM	Conceptual Site Model
DAF	dilution attenuation factor
DOE	U.S. Department of Energy
DQO	data quality objective
Eh	oxidation-reduction potential
EPRE	ecological preliminary risk evaluation
ERA	ecological risk assessment
ESV	ecological screening value
FSMR	Fort Stewart Military Reservation
GEPD	Georgia Environmental Protection Division
GMP	Groundwater Monitoring Plan
GSSL	generic soil screening level
HAZWRAP	Hazardous Waste Remedial Actions Program
HHPRE	human health preliminary risk evaluation
HI	Hazard Index
HQ	Hazard Quotient
IAEA	International Atomic Energy Agency
IDW	investigation-derived waste
ILCR	incremental lifetime cancer risk
LOAEL	lowest-observed-adverse-effect level
MCL	maximum contaminant level
NOAEL	no-observed-adverse-effect level
NTU	nephelometric turbidity unit
PCB	polychlorinated biphenyl
PID	photoionization detector
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QST	QST Environmental, Inc.
RAGS	Risk Assessment Guidance for Superfund
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RL	Remedial Levels
RME	reasonable maximum exposure
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SESOIL	Seasonal Soil Compartment Model
SQB	sediment quality benchmark
SRC	site-related contaminant
SSL	soil screening level
SVOC	semivolatile organic compound
SWMU	solid waste management unit

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TDS	total dissolved solids
TOC	total organic carbon
TPS	Tanker Purging Station
TRV	toxicity reference value
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound
WQC	Water Quality Criteria

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EXECUTIVE SUMMARY

This report summarizes the results of the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for the South Central Landfill, Solid Waste Management Unit (SWMU) 1, at Fort Stewart, Georgia. 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. 0012. The RFI was conducted in accordance with USACE Guidance EM 200-1-3 and the approved Phase II RFI Sampling and Analysis Plan (SAP).

The South Central Landfill is located approximately 0.75 mile northwest of the Fort Stewart Main Cantonment area of the Fort Stewart Military Reservation (FSMR). Areas of SWMU 1 have been used for solid waste disposal since the 1940s, with landfill operations moving from east to west. Disposal practices at the landfill have ranged from burn-pit to trench-and-fill operations. The current (active), permitted landfill operations are being constructed on the clay cap of the former trench-and-fill portion of the landfill. The active, permitted landfill comprises two cells: the eastern cell covers approximately 35 acres, while the western cell, which is closed, covers about 30 acres. The active landfill is operated under Permit No. 089-010 D (SL), issued by the State of Georgia in 1982. The nonputrescible landfill is operated under Permit No. 089-020 D (L), issued by the State of Georgia in 1982. Since 1983 the South Central Landfill has been operated under the provisions of the Design and Operation Plan as an area fill landfill with appropriate groundwater monitoring. As a permitted facility, the South Central Landfill must meet closure and postclosure requirements in accordance with the requirements of 40 Code of Federal Regulations 258.60 and Chapter 391-3-4, Rules of the Georgia Environmental Protection Division (GEPD). The active landfill has a network of 13 groundwater compliance monitoring wells located around it as part of the Groundwater Monitoring Plan (GMP) for operation, closure, and postclosure approved by GEPD January 25, 1996.

Site interviews conducted during the Phase I RFI around the active landfill identified the existence of an older, inactive portion of SWMU 1 east of the active landfill. The old, inactive landfill is heavily forested and estimated to encompass approximately 80 acres. This area was investigated in December 1997.

Results of the Phase I RFI of SWMU 1 conducted in July and October 1993 indicated that metals, pesticides, and Radium 226/228 were elevated in the groundwater around the active portion of the landfill. Based on these findings and the discovery of the existence of the old, inactive landfill, GEPD instructed the Fort Stewart Directorate of Public Works to conduct a Phase II RFI. The Phase II RFI focuses primarily on the old, inactive portion of the landfill.

The objectives of the Phase II RFI for the South Central Landfill at Fort Stewart, Georgia, as defined in the Phase II RFI SAP approved by GEPD on October 10, 1997, are as follows:

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

The information provided in this report is based upon data collected previously during the Phase I RFI and data collected as part of the Phase II field sampling and analysis performed November 5 through December 5, 1997. The scope of the Phase II fieldwork included the following activities:

- Collecting direct-push soil samples using a push probe at ten locations within the boundary of the old, inactive landfill. Direct-push soil samples were analyzed for volatile organic compounds (VOCs).

- Collecting direct-push groundwater samples using a push probe at 25 locations, including 2 vertical-profile probes. The 25 locations included 11 locations (1 vertical-profile) within the estimated boundary of the old, inactive landfill and 14 (1 vertical-profile) around the perimeter of the old, inactive landfill. Direct-push groundwater samples were analyzed for VOCs.

- Installing nine permanent groundwater monitoring wells both upgradient and downgradient of the site. Soil samples from the well boreholes were analyzed for VOCs, semivolatile organic compounds (SVOCs), RCRA metals, pesticides/polychlorinated biphenyls (PCBs), and Radium 226/228.

- Groundwater sampling at the 13 existing monitoring wells around the active portion of the landfill and at the 9 newly installed monitoring wells around the old, inactive portion of the landfill. Groundwater samples were analyzed for VOCs, SVOCs, RCRA metals, pesticides/PCBs, and Radium 226/228.

- Collecting surface water and sediment samples at four locations (upstream and downstream of SWMU 1) within Taylors and Mill creeks, which border two sides of the site. Surface water and sediment samples were analyzed for VOCs, SVOCs, RCRA metals, pesticides/PCBs, and Radium 226/228.

PHYSICAL CHARACTERISTICS OF THE SITE

The South Central Landfill occupies a low-lying, flat region on the coastal plain of Georgia and is situated in the Penholoway terrace. The surface topography of the old, inactive landfill portion of the South Central Landfill ranges from approximately 70 feet above mean sea level (amsl) along the southern boundary to approximately 60 feet amsl along the northern boundary.

The South Central Landfill is bounded on the north by Taylors Creek, a tributary of Canoochee Creek, and on the south by Mill Creek, a tributary of Taylors Creek. Taylors Creek is approximately 1,200 feet from the northern boundary of the old, inactive landfill, while Mill Creek is approximately 4,000 feet southwest of the old, inactive landfill and along the western edge of the active landfill. A drainage swale (shallow ditch) that discharges into Taylors Creek is located between the active landfill and the old, inactive landfill. A drainage ditch that runs south to north is located in the eastern portion of the old, inactive landfill and discharges to wetlands adjacent to Taylors Creek. Wetland areas are located along Mill and Taylors Creeks, which are to the west and north, respectively, of the South Central Landfill.

The soils present across the SWMU 1 landfill are predominantly sand. In the lower-lying areas northeast of the old, inactive landfill, a 1-foot-thick highly-organic layer is present. The surficial materials are generally sands or silty sands from 7 to 10 feet thick. A sandy clay layer approximately 4 feet thick is present below the sands or silty sands. This sandy clay layer is underlain by a sand layer, which in turn is underlain by a clay layer that is up to 10 feet thick.

Geotechnical testing results indicate that tested soils are slightly silty sands with the proportion of fine-grained particles varying from 0 to 8% by weight. All the soils except those at SC-M11 were nonplastic. The soil from the screened interval in SC-M11 had a permeability of 5.66×10^{-5} cm/sec, while the permeability at VP-2 was determined to be 8.96×10^{-4} cm/sec, typical for slightly silty sands.

The uppermost hydrologic unit is the surficial aquifer and ranges from 55 to 150 feet in thickness. The groundwater contours from the monitoring wells indicate that there is a groundwater divide in the southern portion of the old, inactive landfill near SC-M10 and GP-10. North of the groundwater divide, the groundwater flows north toward Taylors Creek at an average of 0.0086 foot/foot. South of the groundwater divide, the groundwater flows southwest toward Mill Creek at an average of 0.003 foot/foot.

CONTAMINANT NATURE AND EXTENT

Results of the chemical analyses indicate that soils, groundwater, surface water, and sediment at the South Central Landfill contain organic and metal contaminants at concentrations greater than their reference background concentrations.

Isolated low levels of organic contamination (VOCs, SVOCs, and pesticides) and metals are present in soil; however, no clear distribution or trends of contaminants are evident. Acetone, methylene chloride, toluene, and 1,2,4-trichlorobenzene were detected in surface soil above reference surface soil background criteria. 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT were detected in two surface soil samples, SC-M13 and SC-M18. 1,2,4-Trichlorobenzene; pyrene; 2-butanone; acetone; methylene chloride; styrene; and toluene were detected in subsurface soil above subsurface soil reference background criteria.

Selenium was detected in surface soil above FSMR reference surface soil background concentration in a single soil sample. Selenium concentrations in surface soil were not above FSMR reference background concentrations for subsurface soil.

Low levels of VOCs, SVOCs, metals, and Radium 226/228 are present in the surficial aquifer; however, no clear distribution or trends of contaminants are evident. Trichloroethene was detected in a single groundwater sample above its respective maximum contaminant level (MCL) (direct-push sample GP-7). Bis(2-ethylhexyl)phthalate was detected in groundwater above its MCL (6 µg/L) at two locations (NMW-2A and SC-M9) at concentrations of 7.8 µg/L and 61.4 µg/L, respectively. Metals were detected in groundwater, with only one sample detected above MCLs. Lead was detected at 18.4 µg/L at monitoring well SC-M17 (MCL 15 µg/L). However, the filtered lead concentration at SC-M17 was nondetect, indicating that the lead may be associated with colloid particulates in the groundwater. Barium, cadmium, chromium, iron, and lead were detected above FSMR reference background concentrations. Low levels of Radium 226/228 were detected in the groundwater. The combined Radium 226/228 concentrations exceeded the MCL at two locations (SC-M5 and SC-M19). The groundwater field sampling data (dissolved oxygen, oxidation-reduction potential, pH) do not indicate that leachate is impacting the groundwater.

Low levels of organics, metals, and Radium 226/228 were detected in sediment and surface water. Chromium, lead, mercury, and Radium 228 were detected in sediment above site-specific background criteria. Two VOCs (acetone and 2-butanone) were detected in one sediment sample, and one SVOC (1,2,4-trichlorobenzene) was detected in two sediment samples above site-specific background criteria. Dimethyl phthalate and pyrene were detected in surface water above site-specific background criteria. Radium 228 was detected in surface water above the site-specific background criterion.

CONTAMINANT FATE AND TRANSPORT

Contaminant fate and transport analysis provided an assessment of the potential migration pathways and transport mechanisms affecting the chemicals at the sites. In particular, the leachability of contaminants from soil to groundwater and their natural attenuation in groundwater were evaluated.

Acetone and methylene chloride in the soil at the South Central landfill exceeded U.S. Environmental Protection Agency (EPA) Generic Soil Screening Levels (GSSLs). Therefore, these constituents may leach into groundwater at concentrations that exceed groundwater standards [i.e., concentrations that exceed the MCL, or in the absence of an MCL, the risk-based concentration (RBC) for drinking water]. The concentration of acetone exceeded the GSSL in only one out of nine detections in soil. This soil sample, SC-M16, was located outside of the boundary of the landfill or the area affected by the landfill operations. Therefore, the acetone present in this sample is not associated with the landfill operations. Acetone is not considered a contaminant migration contaminant of potential concern (COPC). Acetone was detected in groundwater above its RBC as established by EPA Region III and is considered to be a human health COPC in groundwater.

All of the detected methylene chloride concentrations (seven out of 25 soil samples) exceeded the GSSL. One of the detections of methylene chloride (SC-M15) was located outside the boundary of the landfill or the area affected by the landfill operations. The maximum concentration of methylene chloride (52.2 µg/kg) was detected at SC-M15. Methylene chloride was the only contaminant migration COPC in soil around the old, inactive portion of the landfill. Methylene chloride was not detected in groundwater.

Selenium exceeded its reference background criteria in soil; however, it did not exceed its GSSL based on leaching to groundwater. Therefore, selenium is not considered a contaminant migration COPC.

Chromium, lead, and Radium 226/228 exceeded the respective RBC/MCL in groundwater. The one elevated concentration of lead may be due to colloid particulates in the groundwater. Off-site migration of chromium, lead, and Radium 226/228 will be limited, however, because of their high retardation factors.

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Bis(2-ethylhexyl)phthalate and trichloroethene exceeded their MCLs, but were not found in soils. Therefore, bis(2-ethylhexyl)phthalate and trichloroethene were not screened as contaminant migration COPCs in soils. Maximum groundwater concentrations of bis(2-ethylhexyl)phthalate and trichloroethene were detected at 61.4 µg/L (MCL 6 µg/L) and 5.4 µg/L (MCL 5 µg/L), respectively. These two concentrations above MCLs represent only a single detection out of 51 groundwater samples (23 direct-push, 2 vertical profiles, and 22 groundwater monitoring wells). Bis(2-ethylhexyl)phthalate and trichloroethene were detected in the groundwater only and not in soils, indicating that these contaminants may have leached in the past or are potentially leaching directly from a very confined or small point source. Off-site migration of these organic contaminants will be limited due to retardation and degradation through various processes as well as the slow movement of groundwater (12.8 feet/year). At the velocity of 12.8 feet/year, site groundwater will take 94 years to reach Taylors Creek. In reality, contaminants will move slower than groundwater due to retardation, and the organic contaminants will gradually decay in nature.

HUMAN HEALTH PRELIMINARY RISK EVALUATION

The human health preliminary risk evaluation included a Step 1 risk evaluation to determine potential human health risks associated with the contaminants. Human health COPCs have been identified as those constituents present at concentrations higher than their reference background criteria and higher than their respective risk-based or applicable or relevant and appropriate requirement-based screening criteria. Based on the results of the screening and the weight-of-evidence analysis, potential human health COPCs have been identified for surface soil and groundwater. There are no human health COPCs for surface soil, subsurface soil, surface water, or sediment.

The initial human health COPCs for groundwater were identified because they present a potential threat to human health as a result of using groundwater as a source of drinking water. The initial human health COPCs for groundwater are iron; acetone; benzene; chromium; lead; Radium 226; Radium 228; bis(2-ethylhexyl)phthalate; 1,2-*cis*-dichloroethene; and trichloroethene. Iron, Radium 226, and Radium 228 are not hazardous constituents as defined by Section I.E of FSMR's Hazardous Waste Facility Permit #HW-045 (S&T) and are not subject to the corrective action requirements under the terms and conditions of the permit or under the Georgia Hazardous Waste Management Act, O.C.G.A ξ12-8-60, et seq., as amended, and the Rules for Hazardous Waste Management, Chapter 391-3-11, promulgated pursuant thereto, as amended. Therefore, iron, Radium 226, and Radium 228 are eliminated as human health COPCs in groundwater at SWMU 1.

A human health baseline risk assessment was performed to quantitatively assess the risks associated with exposure to human health COPCs in groundwater. In addition, the baseline risk assessment evaluated the risks associated with the leaching of the contaminant migration COPC (methylene chloride) to groundwater underlying the site and migrating off-site via groundwater.

ECOLOGICAL PRELIMINARY RISK EVALUATION

The Phase II RFI performed a Phase I ecological preliminary risk evaluation (EPRE) for potential terrestrial and aquatic receptors at the site. The EPRE for the South Central Landfill identified ecological COPCs in groundwater based on a comparison of their maximum site concentrations to EPA Region 4 ecological screening values. No ecological COPCs were identified in surface water on sediment. Preliminary risk calculations for identified ecological COPCs in surface soil and groundwater were based on a comparison of detected concentrations to toxicity reference values (TRVs) for surrogate species representing ecological receptors.

Selenium and the pesticide DDT and its metabolites were detected in surface soil at the South Central Landfill at concentrations that exceeded both reference background criteria and the TRVs for terrestrial receptors. Selenium was detected in only one of eight surface soil samples at SWMU 1, at only slightly above its background concentration (0.69 mg/kg versus 0.63 mg/kg). Selenium was not detected in the other seven soil samples. Therefore, selenium is not considered an ecological COPC in surface soil at SWMU. DDT and its metabolites in surface soil at SWMU 1 are ecological COPCs for birds with small home ranges ingesting soil-dwelling invertebrates. DDT and its metabolites are likely to be present in surface soil in most areas of Georgia and the southeast due to its past widespread use as an insecticide. Assuming the effects of DDT, DDE, and DDD are additive, the combined exposure at each of the two sampling locations where these constituents were detected does not exceed the lowest-observed-adverse-effect level (LOAEL) dose. The fact that maximum estimated doses lie between the no-observed-adverse-effect level (NOAEL) and the LOAEL suggests that the pesticides and their metabolites are not ecological COPCs in surface soil at SWMU 1.

Barium, iron, lead, bis(2-ethylhexyl)phthalate, and xylenes (total) are present in groundwater at the South Central Landfill at concentrations that exceed EPA Region IV ESVs for surface water. Bis(2-ethylhexyl)phthalate was detected in groundwater at concentrations above background criteria and that resulted in estimated exposures exceeding TRVs for terrestrial ecological receptors that ingest fish and other aquatic biota. The ecological COPCs in groundwater are barium, iron, lead, bis(2-ethylhexyl)phthalate, and xylenes for aquatic biota and bis(2-ethylhexyl)phthalate for birds ingesting fish exposed to groundwater potentially discharging to surface water. The concentrations of these constituents in numerous monitoring wells and direct-push groundwater samples exceeded background criteria and risk-based screening or reference values. However, none of these constituents is an ecological COPC in surface water and sediment at SWMU 1. This suggests that dilution, degradation, adsorption, or other processes are operating to reduce the low concentrations in groundwater discharging to Taylors and Mill creeks or that groundwater at SWMU 1 has not yet migrated to the creeks. Groundwater flow rates indicate that it takes approximately 94 years for groundwater to reach Mill and Taylors creeks. Therefore, groundwater constituents are not ecological COPCs at the present time because they have not been indicated as ecological COPCs in surface water and sediment. The groundwater constituents are not likely to be ecological COPCs in the future because of their low concentrations and associated small hazard quotients and the continued natural attenuation processes occurring in the subsurface soil (i.e., dilution, degradation, absorption, etc.).

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BASELINE HUMAN HEALTH RISK ASSESSMENT

A baseline human health risk assessment (BHHRA) was performed to assess groundwater around SWMU 1. The human health COPCs identified in groundwater include acetone, benzene, bis(2-ethylhexyl)phthalate, 1,2-cis-dichloroethene, trichloroethene, chromium, and lead. Methylene chloride was identified as a contaminant migration COPC based on its potential to leach into groundwater, resulting in potential exposure of receptors. Although, acetone was identified as a contaminant migration COPC, it was only detected above its GSSL in SC-M16, which was located in an area determined to be not impacted by SWMU 1; therefore, the potential for acetone to leach into groundwater from soil was not evaluated in the BHHRA. Potential future groundwater concentrations of methylene chloride were estimated using the Seasonal Soil Compartment Model. This concentration was included in the risk assessment in addition to the human health COPCs.

The potential current and future receptors evaluated included an on-site and off-site worker, a resident (adult and child), and a child playing in Taylors Creek, a point of groundwater discharge. The worker and resident were evaluated based on a potential drinking water scenario, where drinking water is obtained from the surficial aquifer. The Installation worker is the only likely receptor population. However, GEPD guidance states that resident populations must be evaluated as both an on-site and off-site receptor. Groundwater underlying SWMU 1 flows predominantly in the direction of Taylors Creek, where it is likely to discharge to surface waters. Therefore, the potential risk to a child playing in Taylors Creek was evaluated.

Constituents migrating off-site were modeled to determine groundwater concentrations at the points of exposure. The model assumed that the maximum measured concentration of a constituent was present in groundwater at the northern boundary of the old, inactive landfill. It was assumed that all off-site receptors come into contact with the groundwater at some point north of the site, which is the predominant direction of groundwater flow. The exposure point groundwater concentrations of COPCs for the off-site receptors were negligible. Therefore, potential risks resulting from exposure of off-site receptors would be well below target values.

Ingestion, dermal absorption, and inhalation were evaluated as the potential exposure pathways (i.e., routes of exposure of the constituent to the body). The risks associated with carcinogenic hazardous constituents were estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen [i.e., the incremental lifetime cancer risk (ILCR)]. The ILCRs for the individual carcinogens are summed to provide the total ILCR. A total ILCR of less than 1E-6 does not represent a significant carcinogenic risk. The risks associated with the systemic effects of noncarcinogenic toxicity were evaluated by comparing an estimated intake (mg/kg/day) to a reference dose. This ratio of estimated intake over the reference dose is termed the hazard quotient (HQ). The sum of all of the HQs for a given exposure route (i.e., oral, inhalation, or dermal) is called the hazard index (HI). HIs less than 1.0 indicate that the sum of exposures to all of the constituents present is not likely to result in adverse health effects. Lead does not have a reference dose, but it does have a maximum acceptable blood-lead concentration of 10 µg/dL in children, which represents the most sensitive receptor population. The blood-lead levels for children ages 1 to 7 were estimated to determine if there is an unacceptable risk associated with exposure to lead in groundwater.

Constituents present in groundwater at SWMU 1 do not present a significant noncarcinogenic risk to human health. The quantitative estimates of noncarcinogenic risks were below their target values for both on-site occupational and residential receptor populations. The carcinogenic risks for the occupational receptor population was below the target risk value of 1E-6; however, the carcinogenic risk for the on-site residential receptor exceeded the target value with an ILCR of 8.9E-6. This value includes an ILCR of 3.4E-6 resulting from exposure to methylene chloride that may leach into groundwater. The other risk drivers are benzene (ILCR = 2.5E-6) and bis(2-ethylhexyl)phthalate (ILCR = 2.1E-6).

The remedial levels for benzene and bis(2-ethylhexyl)phthalate were based on their respective MCLs (5 µg/L and 6 µg/L, respectively). The MCL for benzene (5 µg/L) was greater than the maximum detected value of 2.5 µg/L. Therefore, corrective action is not required to address the presence of benzene in groundwater. Groundwater concentrations of bis(2-ethylhexyl)phthalate exceeding the remedial level were detected only in the wells (NMW-2A and SC-M9) associated with the active landfill. Therefore, bis(2-ethylhexyl)phthalate is not associated with the old, inactive landfill.

The remedial soil level for methylene chloride was determined to be 3.3 mg/kg and represents a concentration of the constituent in soil that is not likely to leach into groundwater resulting in groundwater concentrations that exceed the MCL for methylene chloride (5 µg/L). Only four sampling locations indicated methylene chloride above the 3.3 mg/kg remedial level. SC-M11, SC-M12, SC-M14, and SC-M16 had methylene concentrations of 9.2 mg/kg, 13.7 mg/kg, 3.9 mg/kg, and 52.2 mg/kg respectively, and SC-M16 is not located within the boundaries of the SWMU 1.

RISK MANAGEMENT AND SITE RECOMMENDATIONS

The results of the RFI and conclusions regarding nature and extent of contamination, fate and transport, human health risk, and ecological risk indicate that the future additional actions listed below are warranted at the South Central Landfill site. Recommendations for further action are as follows:

- An ERA is not warranted because the EPRE at the South Central Landfill indicated there is no present ecological risk and the site is unlikely to pose an ecological risk in the future.

- The results of the BHHRA on groundwater indicate that bis(2-ethylhexyl)phthalate exceeds its remedial level (MCL) in two groundwater monitoring wells (NMW-2A and SC-M9) around the active portion of the landfill. In addition, methylene chloride present in soils at three locations around the old, inactive landfill (SC-M11, SC-M12, and SC-M14) may leach into groundwater, resulting in groundwater concentrations that exceed the MCL.

- Results of the SESOIL modeling have shown that three of the detected concentrations of methylene chloride in soils from the old, inactive landfill (SC-M11, SC-M12, and SC-M14), exceeded the soil remedial levels for protection of groundwater. Therefore, the methylene chloride at these locations may leach into groundwater at concentrations that present a carcinogenic risk above the target risk (>10E-6) to an on-site resident using the surficial groundwater as a source of drinking water. However, the potential of this type of exposure taking place is very small. The exposure scenario assumes that in the future a residence will be built on-site and that the household drinking water supply comes directly from the surficial aquifer. Current planning, which goes through the year 2020, does not include the

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construction of any facilities on the inactive portion of the landfill. Given that methylene chloride degrades rapidly in groundwater (half-life in groundwater equals 112 days), the methylene chloride leaching into groundwater would completely degrade before any structure would be built on the site. It should be noted that methylene chloride was not detected in any of the groundwater samples associated with the old, inactive landfill, including those located in the area of the methylene chloride soil contamination (SC-MW11, SC-M12, or SC-W14). Therefore, potential exposure of a residential receptor to methylene chloride is not a likely scenario. Given the unlikely possibility of exposure of an on-site resident to methylene chloride in the surficial groundwater, Fort Stewart respectively requests that the old, inactive portion of SWMU 1 be assigned a "No Further Action Required" status for investigative purposes.

- At the active portion of SWMU 1, which is operated under Permit No. 089-010D (SL) and 089-020D (L), the few constituents detected above MCLs [i.e., bis(2-ethylhexyl)phthalate at SC-M9 and NMW-2A] will continue to be monitored through the GMP, approved by the GEPD Land Protection Division, and corrective action to reduce the identified concentrations of bis(2-ethylhexyl)phthalate in these two wells is not required. The GMP will allow continued evaluation of potential contaminant migration of the groundwater and surface water and will identify if any contaminant levels become elevated and/or any trends develop in contaminant distribution across the active portion of the landfill. In addition, the present operational and design procedures are structured to prevent off-site migration of contaminants from the active landfills. Thus, it is recommended that the active portion of SWMU 1 continue to be monitored in association with the approved GMP. All analytical data will continue to be submitted to the GEPD Land Protection Division.

- Based on the information in this report, Fort Stewart recommends that a CAP proposing institutional controls (deed restrictions, land use restrictions, etc.) be prepared for the old, inactive portion of the landfill. FSMR recommends that the monitoring wells (SC-M11 through SC-M19) around the old, inactive portion of the landfill be abandoned by grouting the wells to the surface and removing the surface completion. The monitoring wells around the old, inactive portion of the landfill will be abandoned upon approval of the CAP by GEPD. It is anticipated that the CAP will be submitted to GEPD in the first fiscal quarter (October through December) 2000.

1.0 INTRODUCTION

This report summarizes the results of the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for the South Central Landfill, Solid Waste Management Unit (SWMU) 1, at Fort Stewart, Georgia. This report has been prepared by Science Applications International Corporation (SAIC) for the U.S. Army (Army) Corps of Engineers (USACE), Savannah District, under Contract DACA21-95-D-0022, Delivery Order No. 0012. The RFI was conducted in accordance with USACE Guidance EM 200-1-3.

SWMU 1 is located approximately 0.75 mile northwest of the Fort Stewart Main Cantonment area. Areas of SWMU 1 have been used for solid waste disposal since the 1940s, with landfill operations moving from east to west. Disposal practices at the landfill have ranged from burn-pit to trench-and-fill operations. The current (active), permitted landfill operations are being constructed on the clay cap of the former trench-and-fill portion of the landfill. The active, permitted landfill comprises two cells: the eastern cell covers approximately 35 acres, while the western cell, which is closed, covers about 30 acres. The old inactive portion of SWMU 1 east of the active landfill is heavily forested and estimated to be approximately 80 acres (refer to Figure 2-4). Results of the Phase I RFI of SWMU 1 conducted in July and October 1993 indicated that additional investigation, including investigation of the old, inactive landfill (east of the active landfill), was required to define the nature and extent of contamination. Based on these findings, Georgia Environmental Protection Division (GEPD) instructed the Fort Stewart Directorate of Public Works to conduct a Phase II RFI.

1.1 OBJECTIVES AND SCOPE OF THE INVESTIGATION

The specific objectives of the Phase II RFI for the South Central Landfill at Fort Stewart, Georgia, as defined in the Phase II RFI Sampling and Analysis Plan (SAP) (SAIC 1997) (approved by GEPD on October 10, 1997), are to

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

The information provided in this report is based upon data collected previously during the Phase I RFI and data collected as part of the Phase II field sampling and analysis. The Phase II sampling program incorporated an observational approach to sampling, as defined in the Phase II RFI SAP (SAIC 1997). This observational approach used field screening techniques to determine the horizontal and vertical extents of contamination at the old portion of SWMU 1 and to identify suitable locations for installation of permanent monitoring wells. The scope of the fieldwork included the following activities:

- Collection of direct-push soil samples using a push probe at ten locations within the boundary of the old, inactive landfill.

- Collection of direct-push groundwater samples using a push probe at 25 locations, including 2 vertical-profile probes. The 25 locations included 11 locations (1 vertical-profile) within the estimated boundary of the old, inactive landfill and 14 (1 vertical-profile) around the perimeter of the old, inactive landfill.

- Installation of nine permanent groundwater monitoring wells both upgradient and downgradient of the site.
- Groundwater sampling at the 13 existing monitoring wells around the active portion of the landfill and at the 9 newly installed monitoring wells around the old, inactive portion of the landfill.
- Collection of surface water and sediment samples at four locations within Taylors and Mill creeks, which border three sides of the site.
- Surveying of the positions of all sample locations.

1.2 REPORT ORGANIZATION

This Phase II RFI Report consists of ten chapters. Chapter 1.0 describes the purpose of this investigation and summarizes the scope of work performed. Chapter 2.0 discusses the specific site history and Conceptual Site Model (CSM) for the South Central Landfill. Chapter 3.0 summarizes the investigation activities and methodologies used in completing the Phase II RFI fieldwork. Chapter 4.0 presents the regional setting of the Fort Stewart Military Reservation (FSMR), including the demographics, topography, regional geology and hydrogeology, surface drainage, soils, and ecology. Chapter 5.0 describes the results of the investigation and presents an interpretation of the nature and extent of contamination. Chapter 6.0 identifies site-specific considerations affecting contaminant fate and transport. Chapter 7.0 presents the human health preliminary risk evaluation (HHPRE), and Chapter 8.0 presents the ecological preliminary risk evaluation (EPRE) for ecological receptors. Chapter 9.0 presents the results of the baseline risk assessment. Chapter 10.0 summarizes the report's conclusions and recommendations for subsequent monitoring at the site. The references are presented in Chapter 11.0.

2.0 SITE HISTORY AND CONTAMINANTS

2.1 INSTALLATION DESCRIPTION

Fort Stewart (then known as Camp Stewart) was established in June 1940 as an antiaircraft artillery training center. Between January and September 1945, the installation operated as a prisoner-of-war camp. The installation was deactivated in September 1945. In August 1950 Fort Stewart was reactivated to train antiaircraft artillery units for the Korean Conflict. The training mission was expanded to include armor training in 1953. Fort Stewart was designated a permanent Army installation in 1956 and became a flight training center in 1966. Aviation training at the Fort Stewart facilities was phased out in 1973. In January 1974 the 1st Battalion, 75th Infantry was activated at Fort Stewart. Fort Stewart then became a training and maneuver area, providing tank, field artillery, helicopter gunnery, and small arms training for regular Army and National Guard units. The 24th Infantry Division, which was reflagged as the 3rd Infantry Division in May 1996, was permanently stationed at Fort Stewart in 1975. These activities comprise the installation's primary mission today.

The FSMR is located in portions of Liberty, Bryan, Long, Tattnall, and Evans counties, Georgia, approximately 40 miles west-southwest of Savannah, Georgia (Figures 2-1 and 2-2). The cantonment, or garrison area, of the FSMR is located within the Liberty County portion of the FSMR, on the southern boundary of the reservation. Hinesville, Georgia, is the nearest city to the garrison area and is located immediately south of the reservation's boundary.

2.2 SITE LOCATION AND HISTORY

The South Central Landfill (SWMU 1) is located approximately 0.75 mile northwest of Fort Stewart Main Cantonment Area (Figure 2-3). The area now referred to as the South Central Landfill comprises 87 acres bounded on the north by Taylors Creek and on the west and south by Mill Creek, a tributary of Taylors Creek. The South Central Landfill is divided into two sections: the current, permitted landfill, which contains both closed and active sections, and the old, inactive landfill, which was identified during the Phase I RFI and ceased operation prior to 1966. Figure 2-4 shows the current, permitted landfill and the old, inactive landfill of SWMU 1.

The South Central Landfill is operated under Permit No. 089-010 D (SL), issued by the State of Georgia in 1982. The nonputrescible landfill is operated under Permit No. 089-020 D (L), issued by the State of Georgia in 1982. Since 1983 the South Central Landfill has been operated under the provisions of the Design and Operation Plan as an area fill landfill with appropriate groundwater monitoring. During the preparation of the SAP for this Phase II RFI (SAIC 1997), interviews were conducted with past and present South Central Landfill operators to confirm operational practices at the landfill and to gather information regarding the old, inactive portion of the landfill.

Active Landfill

From 1960 to 1970, the active landfill's eastern cell operated as a garbage, paper waste, and construction debris landfill. Other waste disposed of included sludge from wash racks, sludge from industrial and sanitary wastewater treatment plants, waste air filters from the paint booth in the Directorate of Logistics Allied Trades Shop, grease from mess halls, autoclaved infectious wastes

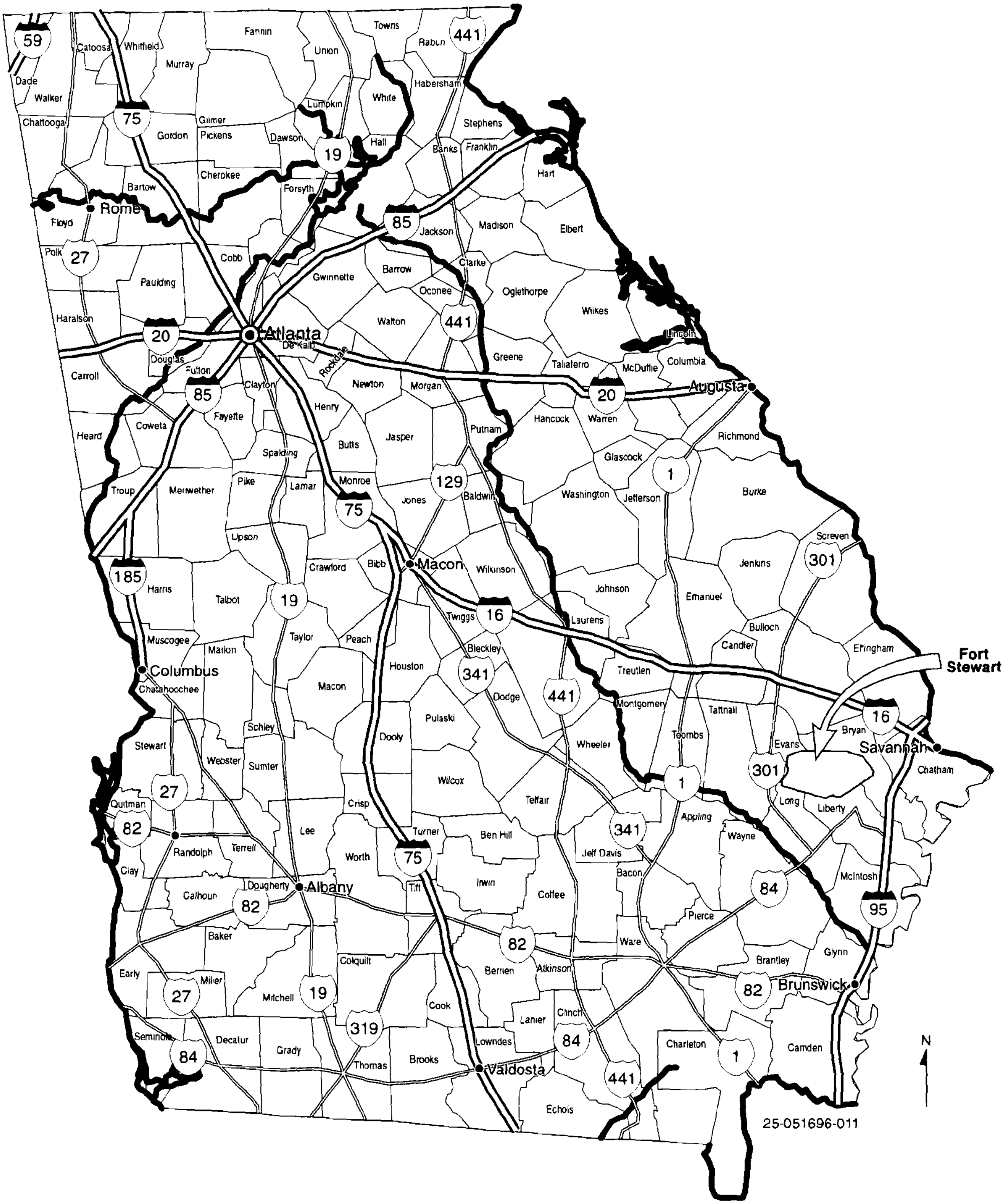

Figure 2-1. Regional Location Map for Fort Stewart Military Reservation, Georgia

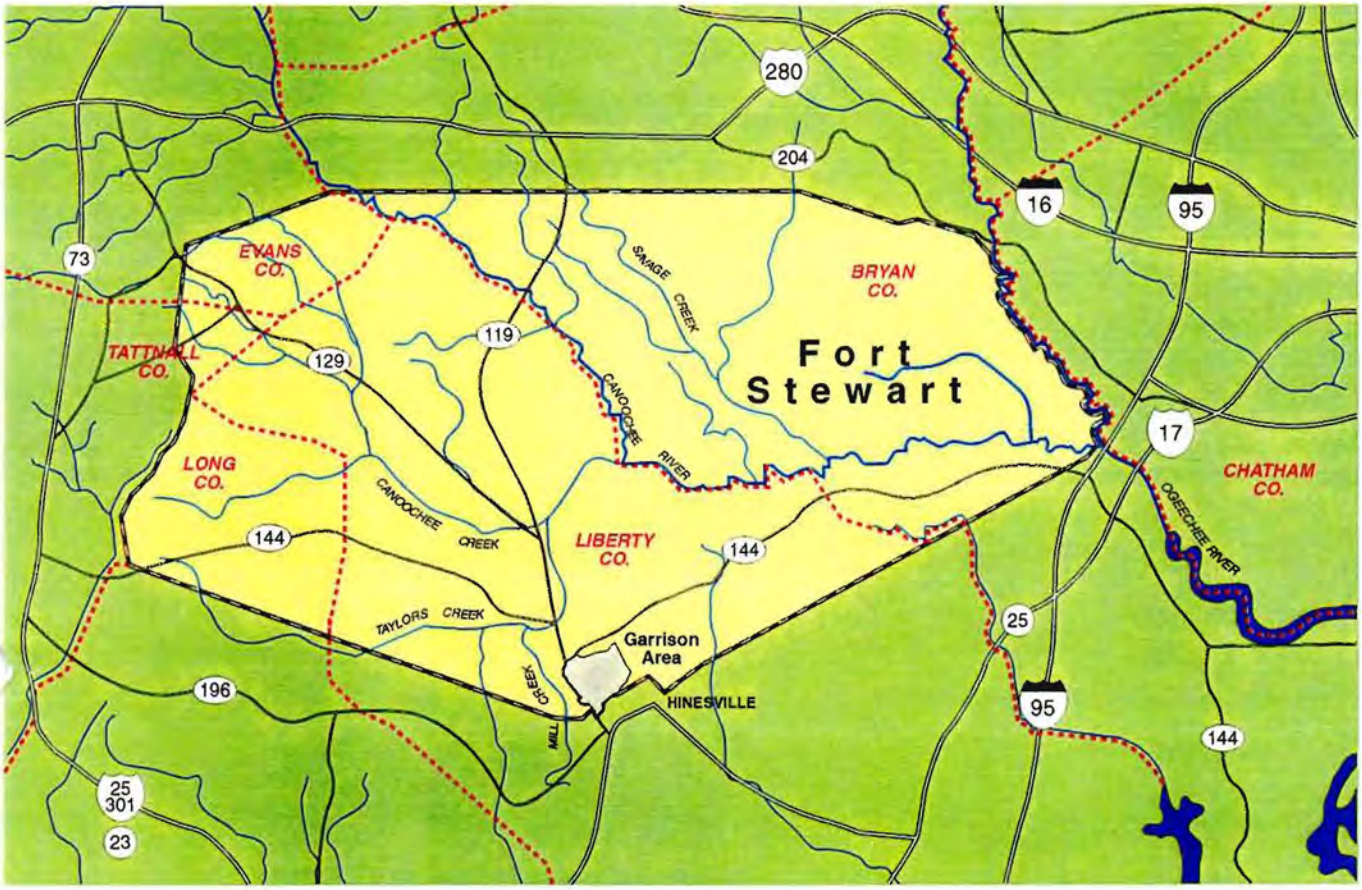

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Figure 2-2. Location Map for Fort Stewart Military Reservation, Georgia

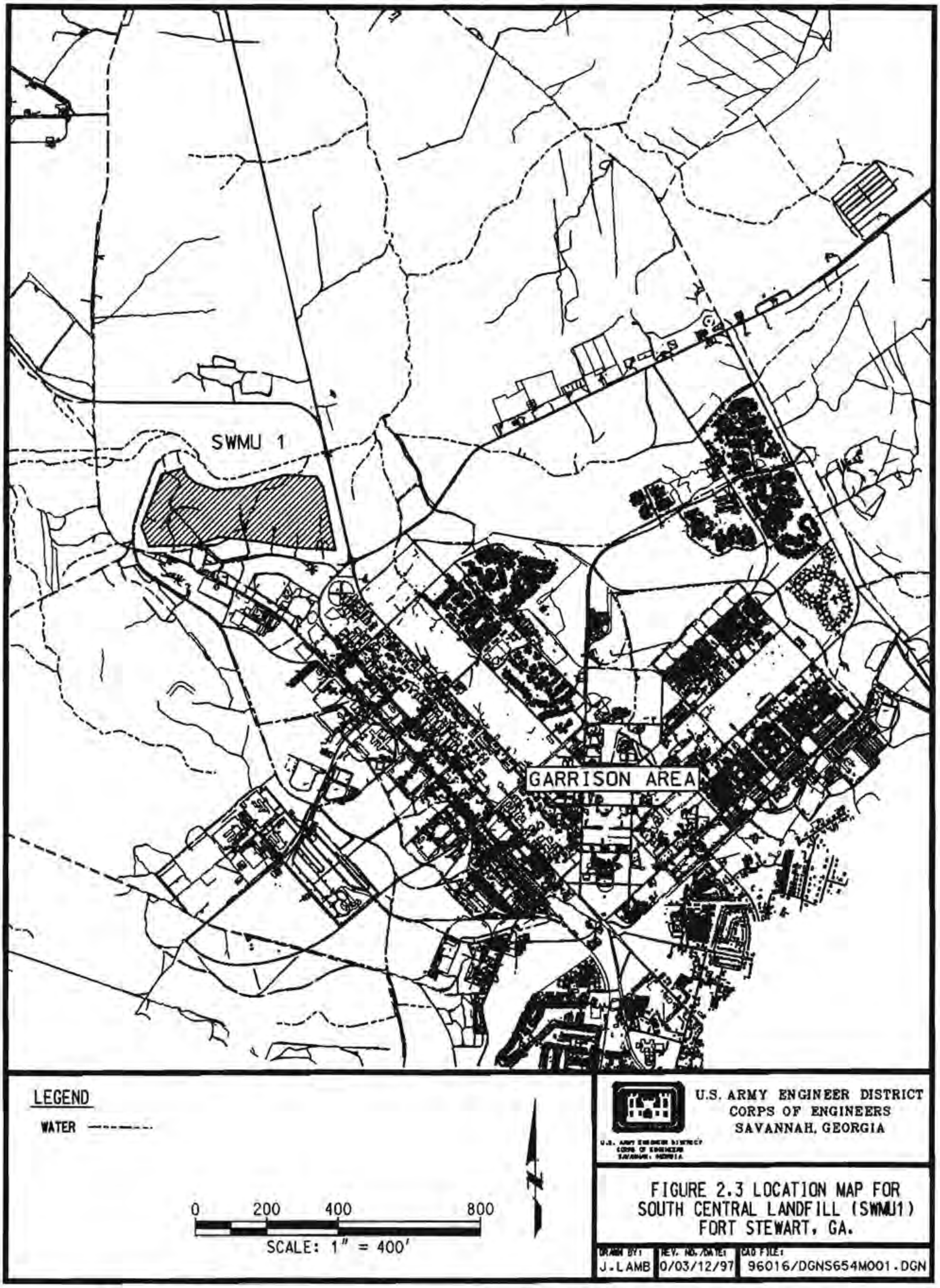
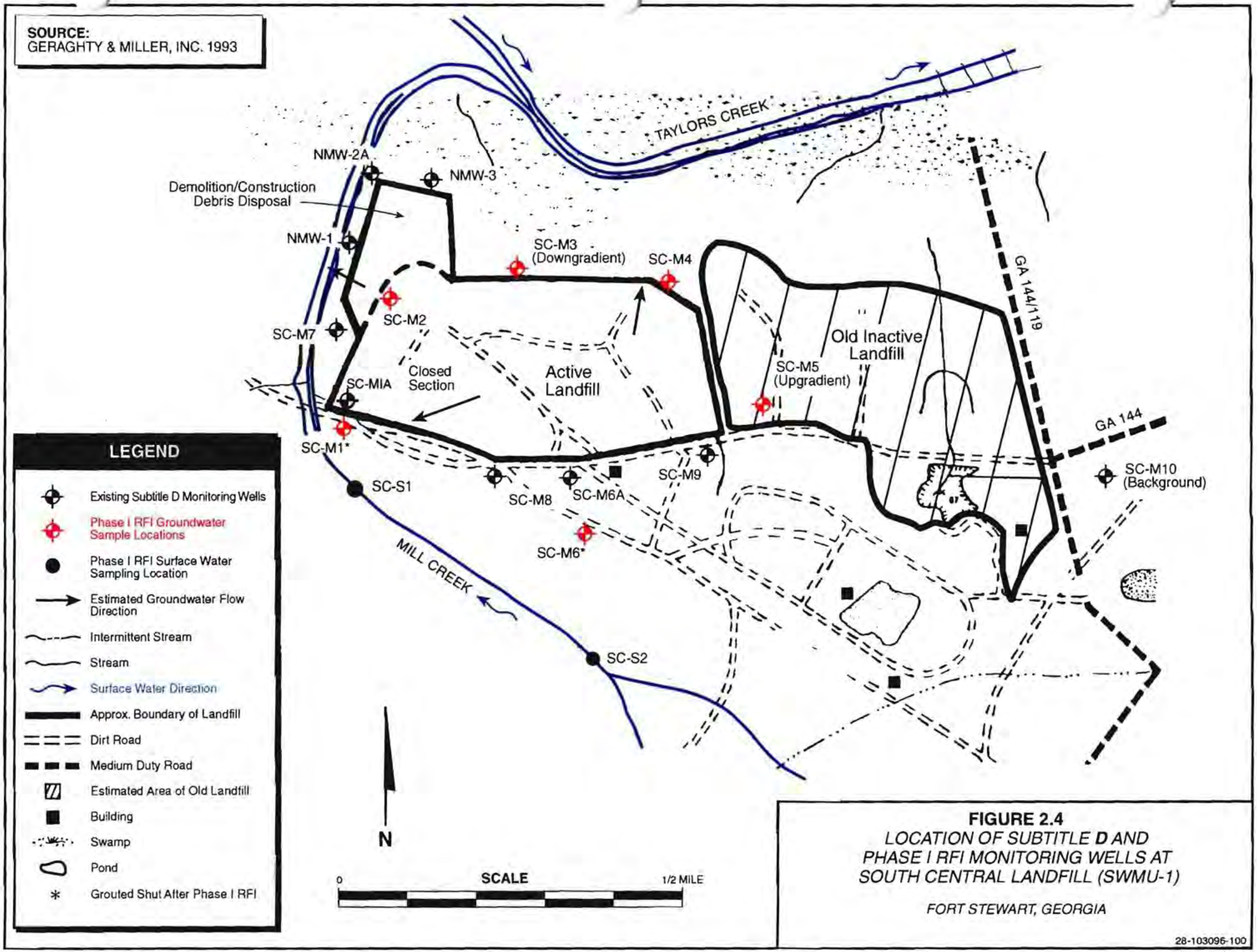


Figure 2-3. Location Map for South Central Landfill (SWMU 1), Fort Stewart, Georgia



SOURCE:
GERAGHTY & MILLER, INC. 1993

FIGURE 2.4
*LOCATION OF SUBTITLE **D** AND PHASE I RFI MONITORING WELLS AT SOUTH CENTRAL LANDFILL (SWMU-1)*

FORT STEWART, GEORGIA

28-103096-100

bagged in special containers, and ash from the energy plant. Operational practices have prohibited the disposal of ordnance at the landfill; however, some explosive ordnance has been discovered during routine operations. Upon such discoveries, FSMR explosive ordnance disposal teams have removed all devices. From 1970 to 1982, trench-and-fill operations were used in the active South Central Landfill's eastern cell. The trench-and-fill operation has moved from east to west, with previously filled land being restored to forest.

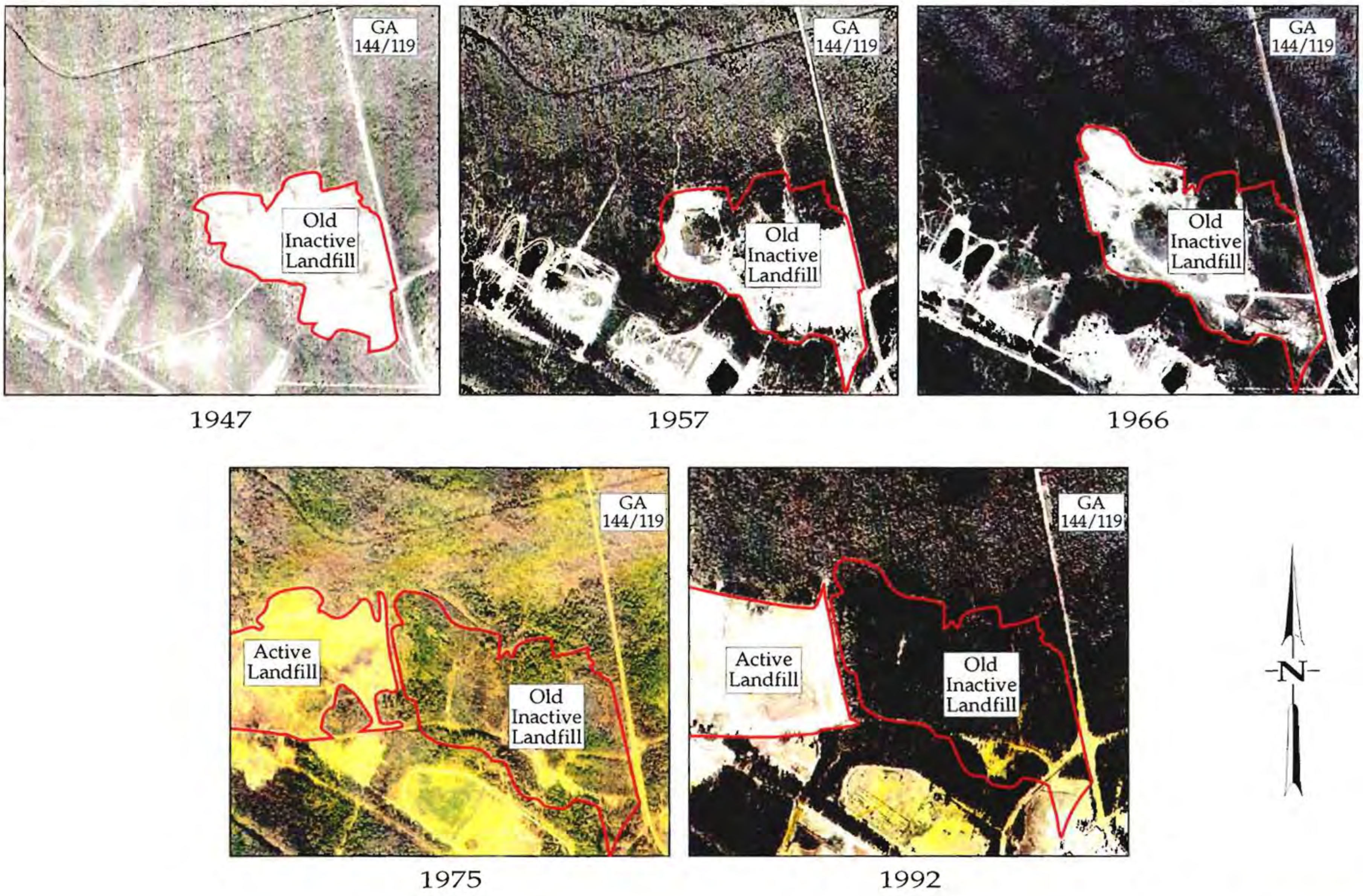
Beginning in the spring of 1982, tumulus refuse disposal operations began, representing the present day disposal practices at the landfill. This operation has been performed over the western portion of the trench-and-fill area of the landfill. The active portion of the South Central Landfill comprises two cells that are constructed on the clay cap of the former trench-and-fill landfill. The eastern cell covers approximately 35 acres and the western cell about 30 acres. Wastes disposed of at the active landfill include dry construction-type waste, putrescible garbage, and properly packaged asbestos.

The northwest portion of the South Central Landfill (Figure 2-4) was previously a borrow pit for the site and is presently being used for disposal of demolition/construction debris (non-putrescible waste).

Old, Inactive Landfill

During the Phase I RFI, it was discovered that an older portion of the landfill existed east of the active landfill and continued to Georgia state roads GA 144/119. The old, inactive landfill is estimated to encompass approximately 80 acres. Aerial photographs dated 1947 and 1957 indicate disposal was occurring at the old, inactive landfill. A 1966 aerial photograph shows approximately two-thirds of the old landfill immediately west of GA 144/119 with successional vegetation, indicating that by that time the landfill was no longer being used. Disposal at the current, active South Central Landfill site and complete vegetative cover of the old, inactive landfill area are evident in a 1975 aerial photograph; the conditions continue today. The aerial photographs of the SWMU 1 site from 1947 through 1992 are presented in Figure 2-5.

Interviews with previous operators indicated that waste disposal at the old, inactive portion of the landfill was limited to the areal extent identified by the aerial photographs (Figure 2-5).The old, inactive landfill received all waste generated at FSMR during its operation. According to previous operators, this waste included materials similar to those currently received at the active landfill, in addition to sludges from the sewage treatment plant, scrap metal, demolition/construction debris, sanitary/municipal waste, and drummed waste from the tear gas training facility. According to information provided by former landfill employees, operational practices at the old, inactive landfill involved excavation of a large pit to below the water table; stockpiling of the excavated soil; disposal and compaction of the solid waste; and covering with the stockpiled, excavated soil. In addition, intermittent burning was used to reduce the volume of the disposed waste in the large pits. Again, former employees have stated that this operational practice was discontinued because it was reducing air quality and there was concern regarding live rounds discharging during the burning. The disposal areas were covered with local soil that had been removed during excavation of the pits and the surrounding area. Some areas of the old, inactive landfill were planted with pines, whereas other areas were allowed to revegetate naturally with successional species. Site reconnaissance by SAIC in 1997, however, has indicated a few areas where debris is still observable at the surface.



1947

1957

1966

1975

1992

29-052297-024

Figure 2-5. Aerial Photographs of South Central Landfill (SWMU 1)

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2.3 PREVIOUS INVESTIGATIONS

2.3.1 Phase I RFI

A Phase I RFI was conducted in response to a RCRA Facility Assessment submitted to the GEPD in June 1990 that listed 24 SWMUs, including the South Central Landfill, for RFI action (Geraghty and Miller 1992). The objective of the Phase I RFI was to determine if a release to the environment had occurred from any of the 24 SWMUs. Site characterization at the South Central Landfill (SWMU 1) included surface water sampling from Mill Creek and groundwater sampling at six existing compliance wells (SC-M1 through SC-M6) located around the active portion of the landfill.

Two upgradient surface water samples were collected in Mill Creek, and groundwater samples were collected from six monitoring wells (SC-M1 through SC-M6) in July 1993. The waters were analyzed for volatile organic compounds (VOCs), RCRA total metals, pesticides/polychlorinated biphenyls (PCBs), and Radium 226/228. Because of an exceedance of holding times, the surface waters and groundwaters were resampled for VOCs in October 1993. Field parameters included pH and specific conductance. Phase I RFI locations of the surface water samples and monitoring wells are illustrated in Figure 2-4. A summary of the surface and groundwater sampling results showing those analytes detected in any sample is presented in Table 2-1.

Surface Water

No VOCs were detected above the detection limit in the surface water samples. Alpha benzene hexachloride (BHC), beta BHC, and gamma BHC were detected in the surface water above their respective GEPD guidelines. No PCBs were detected; however, matrix interferences resulted in detection limits in some of the water samples in excess of the maximum contaminant level (MCL). No Radium 226/228 concentrations were detected above the MCL.

Groundwater

Except for 2-butanone in monitoring well SC-M6, no VOC concentrations were reported above detection limits in groundwater. 2-Butanone is a common laboratory contaminant, and its detection in a single sample at a low concentration (11.2 μg/L) is consistent with that origin. Cadmium, chromium, and/or lead was detected in each of the six monitoring wells at levels exceeding the MCL or action level. In addition, arsenic, selenium, barium, and mercury were detected above site-specific background concentrations. Alpha BHC, delta BHC, gamma BHC, and heptachlor were detected in groundwater, but not above their respective MCLs. No PCBs were detected; however, matrix interferences resulted in detection limits in some of the groundwater samples in excess of the MCL. Radium 226/228 was detected at or above the MCL in two of the monitoring wells (SC-M2 and SC-M4).

2.4 GROUNDWATER MONITORING PROGRAM

As a permitted facility, the South Central Landfill must meet closure and postclosure requirements in accordance with the requirements of 40 Code of Federal Regulations (CFR) 258.60 and Chapter 391-3-4, Rules of GEPD. Fort Stewart submitted a Closure/Postclosure Plan to GEPD on October 5, 1993, with a revised submittal in September 1994. Final approval from GEPD was received on January 25, 1996.

Table 2-1. Summary of Phase I RFI Results for South Central Landfill, SWMU 1

		Groundwater Monitoring Well								Surface Water Sample Location		
Analyte (µg/L)	MCL or Action Level	SC-M1	SC-M2	SC-M2 Dup	SC-M3	SC-M4	SC-M5[a]	SC-M6	GEPD Standards	S1[a]	S1 Dup	S2
2-Butanone	NONE	BDL	BDL	BDL	BDL	BDL	BDL	1.2	NA	BDL	BDL	BDL
Arsenic	50	BDL	14	13	12	9	BDL	BDL	NA	BDL	BDL	BDL
Selenium	50	BDL	7.2	7.1	BDL	5.2	BDL	BDL	NA	BDL	BDL	BDL
Barium	2,000	90	390	290	180	370	100	60	NA	BDL	BDL	BDL
Cadmium	5	BDL	**20**	BDL	100	**30**	BDL	BDL	NA	BDL	BDL	BDL
Chromium	100	BDL	**220**	**150**	BDL	**120**	BDL	BDL	NA	BDL	BDL	BDL
Lead	15	**16**	**220**	**220**	**28**	**79**	**34**	**20**	NA	BDL	BDL	BDL
Mercury	2	BDL	0.2	0.26	BDL	BDL	BDL	BDL	NA	BDL	BDL	BDL
Aldrin	NONE	0. 04	BDL	BDL	BDL	0.04	0.1	BDL	NA	BDL	BDL	BDL
Alpha BHC	NONE	0. 07	0.5	0.06	BDL	0.06	BDL	BDL	0.0131	BDL	0.04	BDL
Beta BHC	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.046	BDL	0.05	BDL
Delta BHC	NONE	BDL	0.03	BDL	BDL	BDL	BDL	BDL	NONE	BDL	0.06	BDL
Gamma BHC	NONE	BDL	BDL	BDL	BDL	0.03	BDL	BDL	NA	BDL	BDL	BDL
Heptachlor	0.4	BDL	BDL	BDL	BDL	BDL	0.02	BDL	NA	BDL	BDL	BDL
Radium 226/228 (pCi/L)	5	3.8	**8.5**	**8.9**	3.2	5.0	2.8	1.6	NONE	0.6	1.3	0.34

[a] Site-specific background location.
BDL = Below detection level.
BHC = Benzene hexachloride.
GEPD = Georgia Environmental Protection Division.
MCL = Maximum contaminant level.
NA = Not applicable.
Bold indicates concentrations above MCLs.

In accordance with GEPD operational requirements, six monitoring wells (SC-M1 through SC-M6) were installed around the landfill in 1980. These wells were sampled for compliance on a quarterly basis until 1985, when the requirements were changed to require monitoring on an annual basis. Three shallow monitoring wells [NMW-1, NMW-2A, and NMW-3 (Figure 2-4)] were installed in July 1993 around the western periphery of the site for additional monitoring capability around the nonputrescible fill area.

As part of the Groundwater Monitoring Plan (GMP) (USACE 1995) for operation, closure, and postclosure approved by GEPD January 25, 1996, existing monitoring wells SC-M1 and SC-M6 were abandoned (grouted shut), and two new wells (SC-M1A and SC-M6A) were installed to replace the two poorly constructed wells. In addition, four new wells (SC-7 through SC-10) were installed. SC-7, SC-8, and SC-9 were installed to fill in gaps in the existing monitoring well network. SC-10 was installed upgradient of the active and the old, inactive portions of the South Central Landfill to provide a background groundwater monitoring well for the site. The locations of these new monitoring wells are presented in Figure 2-4.

As described in the GMP, monitoring and reporting are in accordance with closure and postclosure requirements of GEPD 391-3-4. These requirements include: (1) collection and analysis in groundwater for constituents listed in Appendix I, 40 CFR 258, a minimum of 4 independent samples from each monitoring well during the first 6-month period of closure or any partial closure; and (2) continuation of collection and analysis of one sample from each monitoring well every 6 months for the remainder of the 30-year postclosure period. Any deviation from these requirements must have prior approval by GEPD.

A summary of the monitoring well data collected under the GMP at South Central Landfill in 1997 and 1998 is presented in Appendix A. A discussion of the data is presented in the following sections.

Groundwater monitoring under the GMP was performed January 1997, September 1997, and January 1998 to support compliance with the permit. The analytical results for January 1997, September 1997, and January 1998 are presented in Appendix A, Tables A1, A2, and A3, respectively. Only data accumulated after January 1997 at the South Central Landfill under the GMP were evaluated and are discussed in the following sections.

VOCs. VOCs were analyzed during January 1997 sampling. Only two VOCs were detected: methylene chloride and 2-butanone. Methylene chloride was detected in SC-M5, SC-M7, NWM-1, NWM-2A, NWM-3, SC-M4, and SC-M3 duplicate above its MCL of 5 μg/L. The methylene chloride concentration ranged from 15 μg/L in SC-M4 to 22 μg/L in SC-M7. 2-Butanone was detected in SC-M4, SC-M8, and SC-M2 at concentrations of 12 μg/L, 12 μg/L, and 17 μg/L, respectively.

Metals. Metals were evaluated against site background and FSMR reference background. Site background consists of twice the average of the January 1997, September 1997, and January 1998 data collected at SC-M10. FSMR reference background is developed from data accumulated across FSMR during Phase I and Phase II investigations at various SWMUs (see Chapter 5.0). None of the metal concentrations across the three sampling events was above its respective MCL. However, numerous metals exceeded both the site and FSMR reference background concentrations.

Other Analytes. Miscellaneous constituents including hardness, total dissolved solids (TDS), total suspended solids, alkalinity, chloride, ammonia, total Kjeldahl nitrogen, ammonia, nitrate-nitrite, sulfate, biochemical oxygen demand (BOD), and chemical oxygen demand (COD) were measured during the September 1997 sampling event only. TDS, chloride, and sulfate concentrations were below the secondary drinking water standards. Nitrate-nitrite concentrations were below the MCL of 10 µg/L. The hardness of the water ranged from 7.1 mg/L to 170 mg/L, with only one measurement exceeding 140 mg/L; waters with hardness up to 150 mg/L are considered moderately hard. Suspended solids concentrations were elevated between 220 mg/L and 430 mg/L in three groundwater samples, indicating the presence of significant fines in these water samples. BOD and COD concentrations were less than 17 mg/L and 38 mg/L, respectively, after eliminating one high value from each data set. The high BOD and COD data were assumed to be erroneous because the associated COD or BOD value was not elevated.

2.5 PRELIMINARY CONCEPTUAL SITE MODEL

The preliminary CSM has been developed based upon a review of the history of operations at the South Central Landfill and the results of the Phase I RFI. Municipal/sanitary solid waste, construction and demolition debris, sludges, etc. (see Section 2.2) were disposed of at the South Central Landfill using both trench-and-fill (in the past) and tumulus (presently) landfill concentration techniques. The old, inactive portion of the landfill was covered with local native soil and portions were planted with either pines or allowed to vegetate naturally. Based on the results of the Phase I RFI at the active portion of the South Central Landfill, it is possible that a release occurred at this site. In addition, buried refuse at the site may cause leaching to surface water and/or groundwater in the area.

The potential sources of contaminants at the South Central Landfill include: (1) leachate from the infiltration/percolation of precipitation through buried material and its decomposition products, (2) fluctuating groundwater levels distributing contaminants from the buried material and its decomposition products, (3) contaminants from debris exposed at the surface migrating through surface runoff. Leachate migration represents the most likely pathway for contaminant migration at the South Central Landfill. Potential contaminant pathways include surface runoff, migration of leachate from seeps to surface water, and migration of leachate to groundwater.

The most likely pathways for contaminant migration at this site are (1) via overland flow to the wetlands located north of the facility and (2) via groundwater flow toward Taylors and Mill creeks, located adjacent to two sides of the facility.

Potential human receptors include recreational users of the wetlands or Taylors and Mill creeks who may come into contact with contaminated surface water or sediment, on-site workers or soldiers on maneuvers who may come into contact with contaminated soils or waters, and hypothetical future residents who may ingest groundwater. Because the surficial aquifer is not used as a source of potable water, any ingestion of groundwater by future residents would be accidental. Potential ecological receptors include terrestrial soil-dwelling animals and their predators that may ingest contaminated soil or waters at the site or within the swale west of the site, and aquatic biota in Taylors and Mill creeks that may ingest contaminated groundwater, surface water, or sediments.

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3.0 SUMMARY OF INVESTIGATION ACTIVITIES

3.1 SAMPLING METHODOLOGIES

This section describes the RFI field investigations conducted at the South Central Landfill from November 4 through December 18, 1997. The sampling methodologies and types of testing for physical and chemical characterization of the site are also described. Locations of the Phase II sampling stations are shown on Figure 3-1. The sampling strategy included soil and groundwater screening within the boundary of the old, inactive landfill, groundwater screening around the perimeter of the old, inactive landfill, installation and sampling of monitoring wells, groundwater sampling of existing monitoring wells, and surface water and sediment sampling in Taylors and Mill creeks.

3.1.1 Soil Sampling

Soil sampling was conducted using two methods: (1) direct-push methods and (2) hollow-stem augers during installation of monitoring wells.

3.1.1.1 Direct-Push Soil Sampling

Ten direct-push soil probes were completed within the estimated boundary of the old, inactive portion of the South Central Landfill. The locations of the direct-push soil probes are shown on Figure 3-1. The locations were distributed throughout the area within the boundary of the old, inactive landfill to evaluate the potential extent of contamination. The direct-push soil probes were selected for the following reasons:

- to determine the extent of VOC contamination in surface and subsurface soil within the boundary of the landfill and

- to minimize generation of investigation-derived waste (IDW).

The direct-push soil samples were taken using a 4-foot macro sampler by pushing the sampler from the ground surface down to the water table in continuous 4-foot intervals. Each 4-foot sample was split into two 2-foot samples. Total depth of sampling ranged from 8 to 12 feet. The headspace of the soil samples was field-tested for VOCs using a photoionization detector (PID). The sample from each boring having the highest detected organic vapor concentration in the headspace gas was then sent off-site for quantitative laboratory analysis for VOCs with rapid (24-hour) turnaround. If no VOCs were detected in the headspace gas, then the sample from the 2-foot interval directly above the water table was sent for analysis because chemicals of concern (COCs) from leachate produced from buried material would tend to be distributed at the water table interface. These samples served to confirm the presence or absence of contamination using quantitative data. Results of the laboratory VOC analyses are presented in Chapter 5.0. Boring logs for the direct-push soil probes showing headspace readings and depths sampled are included in Appendix B.

Samples designated for possible VOC laboratory analysis were collected first from each interval using a stainless steel spoon and placed into laboratory sample containers. A portion of the remaining sample was then placed into containers designated for headspace and grain-size analyses. The remaining portion of the sample was used for field lithologic description.

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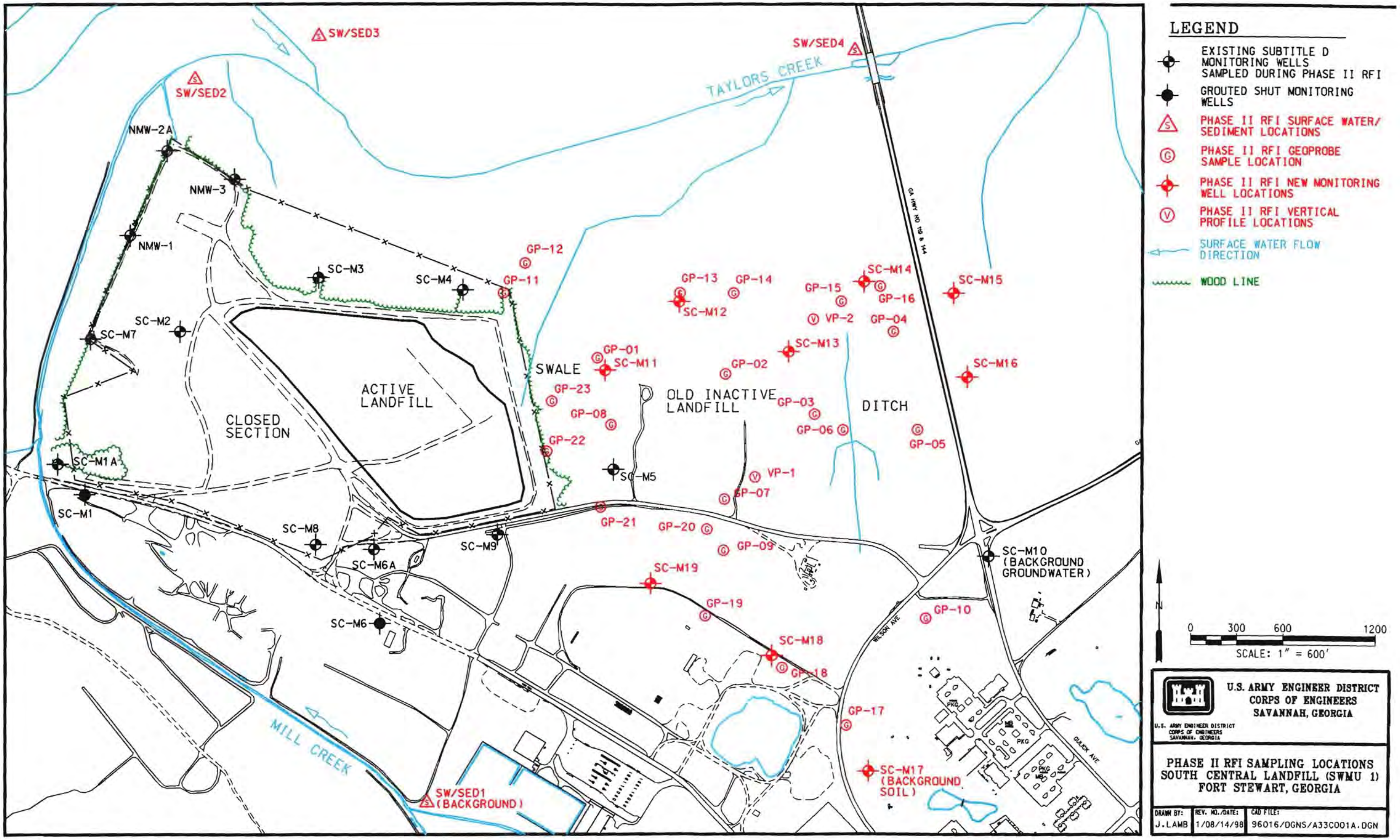

Figure 3-1. Phase II RFI Sampling Locations, SWMU 1

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3.1.1.2 Soil Sampling at Monitoring Wells

Soil samples were also taken during the drilling of boreholes for the installation of nine monitoring wells using the hollow-stem auger drilling method. The locations of the monitoring wells are shown on Figure 3-1. Auger-drilled soil boreholes were advanced using 4.25-inch inside diameter hollow-stem augers using either a CME-55 or Ingersoll-Rand A-300 drill rig. The total depth of the nine boreholes ranged from 6.0 to 15 feet. The borehole samples were collected to obtain

- relatively undisturbed samples for geotechnical testing,
- lithographic descriptions of the soil profile at each monitoring well,
- background surface and subsurface soil samples for characterization, and
- surface and subsurface soil samples for characterizing the nature and extent of contaminants.

During the drilling of each soil borehole, soil samples were collected with a split-barrel sampler continuously over 5-foot intervals from the ground surface to the water table. The 5-foot core was split into two 2.5-foot sections. A portion of each 2.5-foot section was field-tested for VOC headspace gas using a PID. As with the direct-push soil samples, the borehole sample having the highest detected organic vapor concentration in the headspace gas was then sent off-site for quantitative laboratory analysis for VOCs, semivolatile organic compounds (SVOCs), RCRA metals, pesticides/PCBs, and Radium 226/228. In addition, in accordance with the Phase II RFI SAP (SAIC 1997), two soil samples from two new monitoring wells (SC-M11 and VP-2) were selected for full geotechnical analysis. Based on the SAP, these samples were also programmed for analysis of total organic carbon (TOC), but these TOC samples were inadvertently not collected and the analysis was not performed due to an accounting error. If no VOCs were detected in the headspace gas, then the sample from the 2.5-foot interval directly above the water table was sent for analysis because leachate from buried material would tend to distribute contaminants at the water table interface. In addition, a surface soil sample was collected from a depth of 0 to 1 foot below ground surface (bgs) for use in the HHPRE and EPRE; therefore, two soil samples were collected from each borehole for chemical analysis (VOCs, SVOCs, RCRA metals, and pesticides/PCBs). Results of the chemical analyses are presented in Chapter 5.0. Boring logs for the drilling of monitoring wells are included in Appendix B.

Decontamination of drilling and downhole sampling equipment was accomplished in accordance with the procedures specified in the Phase II RFI SAP (SAIC 1997). These procedures included washing with water and phosphate-free detergent, rinsing alternately with water and isopropyl alcohol, and placing the equipment on clean plastic or wrapping it in plastic or aluminum foil to prevent cross-contamination.

One soil sample from the screened interval in each borehole was analyzed for geotechnical parameters to support contaminant transport evaluation. Bulk soil samples were taken from all monitoring well boreholes except SC-M13. The soil sample at SC-M13 was unable to be collected in a Shelby tube due to the high water table and the sandy nature of the soil. A soil sample at Station VP-2 was substituted for the SC-M13 sample. The soil was collected directly from the 5-foot split-barrel core and placed into containers. The samples were tested for moisture content, plasticity, and grain-size distribution. A relatively undisturbed sample was collected from SC-M11 and VP-2 for geotechnical analysis using a thin-walled (Shelby) tube sampler. The Shelby tube sampler was inserted into the hollow-stem auger string and hydraulically pushed approximately 2.0 feet. The ends of the Shelby tube sampler were sealed with wax to preserve moisture content in accordance with American Society for Testing and Materials (ASTM) K1587-83, and the tubes were shipped to an off-site laboratory for analysis. The Shelby tube sample was tested for moisture content, Atterberg limits, grain-size distribution, soil porosity, and permeability.

3.1.2 Groundwater Sampling

3.1.2.1 Direct-Push Groundwater Sampling

Twenty-five direct-push groundwater probes were installed at the old, inactive portion of the South Central Landfill (Figure 3-1). Twenty-three of the 25 direct-push probes were water-table-screening probes, while the remaining two were vertical-profile probes. Water-table probes were pushed from between 3 to 5 ft below where the level of the water table was encountered and a groundwater sample was collected. Ten water-table probes were installed within the estimated boundary of the old, inactive landfill to evaluate the presence of leachate. Thirteen water-table probes were installed around the perimeter of the old, inactive landfill to evaluate potential migration of contaminants from it. Two vertical profiles were installed, one inside the boundary of the old, inactive landfill and one downgradient and outside its perimeter. A single grab sample of groundwater was obtained at the water table from 23 of the direct-push locations. Multiple grab samples of groundwater at varying depth intervals were collected at the two vertical-profile stations (VP-1 and VP-2) to measure the vertical distribution of contamination. The locations of the direct-push groundwater probes are shown on Figure 3-1. The direct-push groundwater probes were taken for the following reasons:

- to delineate the extent of VOC contamination in groundwater,
- to determine the most appropriate locations for monitoring wells, and
- to estimate the approximate direction of groundwater flow to determine the most appropriate locations for downgradient monitoring wells.

The vertical extent of contamination was investigated by installing two vertical-profile direct-push probes at the South Central Landfill (VP-1 and VP-2). The total depths of the vertical-profile probes were 40 feet bgs.

The direct-push groundwater samples at the 23 water-table probe locations were taken using direct-push sampling techniques (Dietrich Power Punch devices mounted on a Mobil B-47 drilling rig). The sampling device, having a 7/8-inch inside-diameter screen/casing, was pushed down to the target depth, and a grab groundwater sample was retrieved at the water table using a peristaltic pump or stainless steel bailer. At the vertical profile locations (VP-1 and VP-2), separate sample holes were pushed for each sample depth. Groundwater samples were collected at 10-foot intervals to refusal. Refusal was encountered in both locations at a depth of 40 feet. The samples were then sent off-site for laboratory analysis for VOCs with rapid (24-hour) turnaround. Results of the VOC analyses are presented in Chapter 5.0.

The total depth of the 23 water-table-screening probes ranged from 3 to 20 feet bgs. To assist in estimating the direction of groundwater flow, water levels were measured in temporary piezometers that were set in the direct-push probe. Following installation of all temporary piezometers, each piezometer was surveyed for horizontal and vertical elevation. Field parameter measurements taken during groundwater screening sampling included pH, conductivity, temperature, turbidity, dissolved oxygen, and oxidation-reduction potential (Eh). The results of these measures are presented in Table 3-1.

Table 3-1. Field Parameter Measurements during Groundwater Screening Sampling (Direct-Push) for the South Central Landfill

Field Reading at Direct-Push Location						
Parameter	**pH**	**Conductivity**	**Temperature**	**Turbidity**	**DO**	**Eh**
Units	**su**	**mS/cm**	**°C**	**NTU**	**mg/L**	**mV**
GP-1	5.52	121	22.51	NA	2.04	176
GP-2	5.76	164.00	19.52	NA	3.82	-191
GP-3	4.71	70	19.16	NA	2.77	54.1
GP-4	NA	NA	NA	NA	NA	NA
GP-5	NA	NA	NA	NA	NA	NA
GP-6	NA	NA	NA	NA	NA	NA
GP-7	NA	NA	NA	NA	NA	NA
GP-8	5.9	259	18.86	NA	3.32	35
GP-9	5.31	169	22.45	NA	4.21	-111
GP-10	NA	NA	NA	NA	NA	NA
GP-11	NA	NA	NA	NA	NA	NA
GP-12	4.91	70	19.16	NA	2.77	240
GP-13	5.06	89	22.89	NA	0.88	267
GP-14	4.65	54	19.85	NA	3.96	331
GP-15	NA	NA	NA	NA	NA	NA
GP-16	NA	NA	NA	NA	NA	NA
GP-17	NA	NA	NA	NA	NA	NA
GP-18	NA	NA	NA	NA	NA	NA
GP-19	NA	NA	NA	NA	NA	NA
GP-20	5.68	124	19.79	NA	6.80	-86.5
GP-21	NA	NA	NA	NA	NA	NA
GP-22	4.5	92	19.39	NA	1.92	160
GP-23	3.58	530	20.72	NA	4.90	320.6
VP-1						
5–10 feet	6.75	1205.0	16.85	>440	8.10	294.7
15–20 feet	5.35	960	18.25	>440	5.25	316.2
25–30 feet[a]						
35–40 feet	6.31	967.0	18.27	127	9.16	355.2
VP-2						
5–10 feet	5.05	322	15.7	12.7	1.77	-20.4
15–20 feet	5.48	83	18.34	>440	9.71	82.5
25–30 feet	6.71	244	18.41	225	4.77	194.1
35–40 feet[b]						

Note: Sampling event occurred November 5–18, 1997.

[a] Twenty-five to thirty-foot interval lost due to auger malfunction.

[b] Refusal was encountered in the 35–40 foot interval; no water sample could be collected.

DO = Dissolved oxygen.

Eh = Oxidation-reduction potential.

NA = Not analyzed.

NTU = Nephelometric turbidity unit.

3.1.2.2 Monitoring Well Installation and Development

Monitoring wells were installed at the nine locations (SC-M11 through SC-M19) shown on Figure 3-1 between November 15 and 16, 1997. The wells were constructed of 2.0-inch-diameter Schedule 40 polyvinyl chloride with flush-threaded couplings. Well screens were constructed of factory-slotted pipe in 10-foot-long sections. Slot size, determined from the sieve analysis results from the direct-push soil probes and field sieve analyses, was 0.008 inches (No. 8 slot). Filter pack materials consisted of DSI Extra-Fine Sand. In seven of the nine newly installed wells, the water table was within 3 to 4 feet of the ground surface, so the top of the screen was set at 1 to 2 feet bgs and 0.25 to 1.0 number filter pack was placed above the top of the screen, followed by a bentonite seal to ground surface. A concrete pad was placed above the bentonite seal. Well construction diagrams are presented in Appendix C. Well construction details are summarized in Table 3-2.

The nine wells were installed at the water table to depths of 10 to 15 feet. These wells were installed such that the screened interval bisected the water table so that any nonaqueous-phase liquid floating on the water table surface could be detected in the well.

The wells were developed on November 19 and 20, 1997. Well development was accomplished using a downhole positive-displacement pump. A surge block was used to agitate and mobilize particulates around the well screen by rapidly surging the bailer up and down. Well development continued until the well water was clear to the eye, sediment within the well was less than 0.1 foot, a minimum of five times the standing water volume in the well had been removed, and five times the volume of any water added during completion had been removed. In addition, water quality parameters (pH, conductivity, temperature, dissolved oxygen, Eh, and turbidity) were measured during well development to verify that all field parameters had reached equilibrium, and development continued until turbidity measured less than 10 nephelometric turbidity units (NTUs). Turbidity remained higher than 10 NTUs in SC-M12, SC-M14, SC-M17, SC-M18, and SC-M19 following well development. Well development is summarized in Table 3-3.

3.1.2.3 Monitoring Well Sampling

Groundwater sampling was conducted between December 10 and 15, 1997, at least 14 days after well development. Monitoring wells were sampled using low-flow micropurging techniques to minimize the volume of purge water, the disturbance of the aquifer, and, thereby, the turbidity in the sample. Field parameters (pH, conductivity, temperature, dissolved oxygen, Eh, and turbidity) were monitored during micropurging. The purge rate was adjusted, as necessary, to avoid purging any well to dryness and to equal the recharge of the aquifer. Purging was considered complete when the field parameters stabilized within plus or minus 10% after a minimum of three readings at 5-minute intervals. Purging times varied, requiring from 8 to 12 hours to attain a turbidity less than 10 NTUs. At some wells turbidity did not reduce to below 10 NTUs after 6 consecutive hours of purging. In such cases a field decision was made to increase the target turbidity to 25 NTUs, and up to 4 additional hours of purging were performed to achieve 25 NTUs. After a total of 10 hours of purging, if the turbidity still had not dropped below 25 NTUs, filtered and unfiltered metal samples were taken. Five of the 22 wells did not achieve 25 NTUs even after 10 hours of purging. The results of field parameter measurements recorded at the end of purging in each well are listed in Table 3-4.

Table 3-2. Monitoring Well Construction Summary for the South Central Landfill

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 msl)
SC-M11	11/16/97	2 inches/ PVC	N687128.3 E820149.1	15.0	2.0–15.0	1.0	71.56
SC-M12	11/16/97	2 inches/ PVC	N688152.7 E820612.0	12.0	2.0–12.0	1.0	59.13
SC-M13	11/16/97	2 inches/ PVC	N687813.1 E821316.4	15.0	5.0–15.0	3.0	65.78
SC-M14	11/16/97	2 inches/ PVC	N688259.9 E821811.5	10.0	1.0–11.0	0.75	57.67
SC-M15	11/15/97	2 inches/ PVC	N688173.7 E822390.6	16.0	1.0–6.0	0.5	56.60
SC-M16	11/15/97	2 inches/ PVC	N687627.9 E822469.6	11.0	1.0–11.0	0.75	63.33
SC-M17	11/16/97	2 inches/ PVC	N685063.8 E821789.4	15.0	5.0–15.0	3.0	70.88
SC-M18	11/15/97	2 inches/ PVC	N685834.1 E821176.9	15.0	2.0–15.0	1.0	72.03
SC-M19	11/16/97	2 inches/ PVC	N686318.7 E820398.1	15.0	2.0–15.0	1.0	70.12

Note: All elevations are National Geodetic Vertical Datum 1929.
bgs = Below ground surface.
msl = Mean sea level.
PVC = Polyvinyl chloride.

Table 3-3. Well Development Summary for the South Central Landfill

Well No.	Date	Total Development Time (hours)	Total Volume Removed (gallons)	Final Turbidity Reading (NTUs)
SC-M11	11/19/97	3.05	105	3.3
SC-M12	11/19–20/97	14.0	220	>400
SC-M13	11/19/97	1.95	100	2.3
SC-M14	11/19–20/97	8.43	138	110
SC-M15	11/18/97	3.71	100	3.5
SC-M16	11/19–20/97	5.0	170	7.4
SC-M17	11/20/97	7.86	88	25.8
SC-M18	11/19–20/97	11.0	270	21.7
SC-M19	11/19–20/97	12.75	440	61.2

NTU = Nephelometric turbidity unit.

Table 3-4. Field Parameter Measurements during Groundwater Sampling for the South Central Landfill

Field Reading at Monitoring Well							
Parameter	**pH**	**Conductivity**	**Temperature**	**Turbidity**	**DO**	**Eh**	**Ferric Iron**
Units	**su**	**mS/cm**	**°C**	**NTU**	**mg/L**	**mV**	**mg/L**
SC-M1A	4.96	287	19.20	21.1	0.08	33.9	NA
SC-M2	6.18	196	22.95	5.7	NA	160.3	0.0
SC-M3	6.91	134	19.1	8.2	0.55	-48.5	0.2
SC-M4	5.52	320	21.10	5.3	NA	51.2	3.2
SC-M5	3.97	422	18.41	3.8	2.38	1.5	1.9
SC-M6A	4.73	39	19.5	77.5	1.14	121.1	NA
SC-M7	6.75	264	19.26	5.6	1.25	-18.5	NA
SC-M8	4.30	83	18.65	1.9	3.65	458.9	NA
SC-M9	4.47	40	18.85	0.1	0.73	44.0	NA
SC-M10	4.95	37	18.06	136	1.21	154.8	2.9
SC-M11	5.07	190	19.71	5.5	3.10	383.3	NA
SC-M12	4.93	125	13.58	72.7	1.05	64.2	NA
SC-M13	4.85	60	19.22	1.6	1.37	400.5	NA
SC-M14	6.20	182	14.15	18.3	0.86	237	NA
SC-M15	7.32	182	18.53	9.7	1.09	-54.9	1.0
SC-M16	4.34	88	17.85	9.7	0.63	161.4	1.9
SC-M17	4.72	53	17.39	102	0.66	64.3	1.3
SC-M18	4.36	47	18.81	11.2	0.56	167.8	NA
SC-M19	4.68	23	20.27	231	0.49	-7.4	0.9
NWM-1	4.84	53	17.79	10.2	0.68	-39.6	1.9
NWM-2A	6.76	291	19.78	7.4	1.78	-49.6	1.8
NWM-3	6.93	280	17.17	2.3	1.54	61.8	0.4

Note: Sampling event occurred December 10–15, 1997.
DO = Dissolved oxygen.
Eh = Oxidation-reduction potential.
NA = Not analyzed.
NTU = Nephelometric turbidity unit.

Sampling of each monitoring well began immediately after completion of purging, using the same micropurging pump. Groundwater samples were transferred directly into laboratory sample containers, with the portion designated for volatile organic analysis taken first. Filtered groundwater samples were collected by attaching a 0.45-micron filter to the end of the low-flow pump sampling line. A field test kit was used to measure ferric iron at 13 of the 22 monitoring wells, including three newly installed wells. Ferric iron analyses were randomly distributed across existing and new wells (Table 3-4). Groundwater samples were then sent off-site for laboratory analysis for VOCs, SVOCs, RCRA metals, iron, sulfate, pesticides/PCBs, and Radium 226/228. Total iron, ferric iron, and sulfate analyses were performed to support contaminant fate and transport modeling and potential remedial alternative development. Total iron and sulfate analysis were performed at all monitoring wells.

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3.1.3 Surface Water and Sediment Sampling

Surface water and sediment samples were collected on November 14 and 15, 1997, at four stations, as shown on Figure 3-1. Station SW/SED-1 is an upstream (background) sample location in Mill Creek, approximately 0.5 mile upstream and south of the site (Figure 3-1). Station SW/SED-2 is also located in Mill Creek, approximately 300 feet northwest (downstream of the active landfill) of the site. Station SW/SED-3 is located in Taylors Creek, upstream of where Mill Creek enters Taylors Creek. SW/SED-4 is located in Taylors Creek (downstream of active and old inactive landfill) at the GA 144/119 bridge. Both surface water and sediment samples were taken at each station. Surface water samples were collected first, and then field measurements were taken for pH, specific conductance, temperature, dissolved oxygen, and turbidity. Sediment samples were collected using stainless steel scoops. Samples were then sent off-site for laboratory analysis for VOCs, SVOCs, RCRA metals, pesticides/PCBs, and Radium 226/228.

3.1.4 Investigation-Derived Waste Management

IDW was managed in accordance with the procedures specified in the Phase II RFI SAP (SAIC 1997). All IDWs were determined to be nonhazardous materials. Solid wastes were disposed of by transporting the material to the Fort Stewart Sanitary Landfill for use as daily cover. Liquid wastes were disposed of at the Fort Stewart Industrial Wastewater Treatment Plant.

3.2 DATA QUALITY ASSESSMENT

Multiple activities were performed to achieve the desired data quality in this project. Data quality objectives (DQOs) were established to guide the implementation of the field sampling and laboratory analysis. A quality assurance (QA) program was established to standardize procedures and to document activities. Upon receipt by the project team, data were subjected to verification and validation reviews that identified and qualified problems related to the analysis. These review steps contributed to the final Quality Control Summary Report (Appendix D), which states that data used in the investigation met the project quality criteria and the review steps were appropriately employed.

The QA program established requirements for both field and laboratory quality control (QC) procedures. In general, field QC duplicates and QA split samples were required for each environmental sample matrix collected at sites being investigated at a frequency of 10%; VOC trip blanks were to accompany each cooler containing water samples for VOC determinations; and analytical laboratory QC duplicates, matrix spikes, laboratory control samples, and method blanks were required for every 20 samples or fewer of each matrix and analyte. The primary goal of the QA program was to ensure that the quality of results for all environmental measurements was appropriate for their intended uses. To this end a Quality Assurance Project Plan (QAPP) and standardized field procedures were compiled to guide the investigation. Through the process of readiness review, training, equipment calibration, QC implementation, and detailed documentation, the project successfully accomplished the goals set by the QA program.

Project data quality determines its usability. The evaluation is based on the interpretation of laboratory QC measures, field QC measures, and the project DQOs. Data Quality Control Reports and other field-generated documents, such as sampling logs, boring logs, daily health and safety summarizes, daily safety inspections, equipment calibration and maintenance logs, and sample management logs, were peer-reviewed on-site. Analytical data generated for this project were subjected to a process of data verification, validation, and review. The project implemented the use of data validation checklists to facilitate laboratory data validation. These checklists were completed by the project-designated validation staff and were reviewed by the Project Laboratory Coordinator.

A total of 118 environmental soil, groundwater, and field QC samples were collected, with approximately 8600 discrete analyses (i.e., analytes) being obtained, reviewed, and integrated into the assessment. These totals do not include field measurements and field descriptions. In addition, they do not include three TOC soil samples that were inadvertently not collected. The project produced acceptable results for more than 99% of the sample analyses performed and successfully collected the required investigation samples, with the exception of three soil samples.

The overall quality of South Central Landfill information met or exceeded the established project objectives. Through proper implementation of the project data verification, validation, and assessment process, project information was determined to be acceptable for use. Data, as presented, have been qualified as usable, but estimated, when necessary. Data produced for this study demonstrated that they can withstand scientific scrutiny; are appropriate for their intended purposes; are technically defensible; and are of known and acceptable sensitivity, precision, and accuracy. A more detailed data quality assessment may be found in Appendix D.

Filtered versus Unfiltered Analyses. RCRA metals analyses were conducted on both filtered and unfiltered groundwater samples from five wells at South Central Landfill using low-flow sampling techniques (SAIC 1997). Results for detected analytes are listed in Table 3-5.

As discussed in Appendix D, the results indicated no significant relative percent difference for any of the analytes. Filtered results were somewhat less than the corresponding unfiltered results in most cases, but the differences were not significant relative to the analytical precision. With few exceptions the results were less than five times the quantitation limit for the analyte. At these low concentrations, the absolute differences between analytical results are not considered significant if the difference is less than three times the quantitation limit; therefore, filtered and unfiltered results were comparable, indicating good correlation in results. These results demonstrated that efforts to reduce the effects of turbidity in groundwater samples were successful and that any residual turbidity did not adversely affect the groundwater sampling results.

The exception was lead from well SC-M17. The unfiltered concentration was approximately 36 times the filtered value and well above 5 times the quantification limit. The unfiltered result was, therefore, questionable and might reflect lead in colloid particulates rather than in the groundwater.

Table 3-5. Filtered versus Unfiltered Groundwater Sample Comparison for Detected Analytes

Station	Sample ID	Parameter	Reporting Limit (µg/L)	Unfiltered Result (µg/L)	Filtered Result (µg/L)
SC-M6A	012M11	Barium	200	35.4 J	23 J
SC-M10	012T11	Barium	200	38 J	37 J
SC-M12	012211	Barium	200	23.4 J	17.3 J
SC-M17	012711	Barium	200	43.3 J	32.7 J
SC-M19	012911	Barium	200	101 J	6.6 J
SC-M6A	012M11	Chromium	10	7.9 J	1.3 J
SC-M10	012T11	Chromium	10	7.3 J	1.3 J
SC-M12	012211	Chromium	10	11.6 J	7.1 U
SC-M19	012911	Chromium	10	10.9 J	0.6 U
SC-M6A	012M11	Lead	1	3.6	0.07 J
SC-M10	012T11	Lead	1	3.9	0.11 J
SC-M12	012211	Lead	1	2.4	0.36 U
SC-M17	012711	Lead	1	18.4	0.47 U
SC-M19	012911	Lead	1	11.3 J	6 J
SC-M12	012211	Mercury	0.05	0.04 J	0.03 U
SC-M19	012911	Mercury	0.05	0.07 J	0.03 U
SC-M6A	012M11	Selenium	5	1.4 J	0.82 J
SC-M12	012211	Arsenic	5	1.5 J	0.6 U
SC-M17	012711	Arsenic	5	0.89 J	1.1 J
SC-M19	012911	Arsenic	5	0.70 J	0.6 U

J = Estimated value.
U = Undetected.

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4.0 PHYSICAL CHARACTERISTICS OF THE SITE

4.1 DEMOGRAPHICS

The cantonment, or garrison area, of the FSMR is located within Liberty County, Georgia (Figure 2-2). Liberty County occupies 328,768 acres and had a total population of 52,745 in 1990. Forty-one percent of the county population lives in Hinesville, the largest city in Liberty County. The total population of Fort Stewart in 1990 was 13,774, 55 percent of which were employed by the Armed Forces. Forty-one percent of the Fort Stewart population lived in group quarters, while the remaining population lived in households (U.S. Department of Commerce 1990).

4.2 TOPOGRAPHY

The FSMR occupies a low-lying, flat region on the coastal plain of Georgia. Surface elevations range from approximately 20 to 100 feet above mean sea level (amsl) within the FSMR and generally decrease from northwest to southeast across the reservation. The topography is dominated by terraces dissected by surface water drainages. The terraces are remnants of sea level fluctuations. The four terraces present within the FSMR are the Wicomico, Penholoway, Talbot, and Pamlico (Metcalf and Eddy 1996). The South Central Landfill is situated in the Peholoway terrace.

The surface topography of the old, inactive landfill portion of the South Central Landfill ranges from approximately 70 feet amsl along the southern boundary to approximately 60 feet amsl along the northern boundary.

4.3 SURFACE DRAINAGE

The principal surface water body accepting drainage from the FSMR is the Canoochee River, which joins the Ogeechee River (part of the northwestern boundary of the reservation). Canoochee Creek is a tributary of the Canoochee River that drains much of the western portion of the FSMR. The South Central Landfill is bounded on the north by Taylors Creek, a tributary of Canoochee Creek, and on the south by Mill Creek, a tributary of Taylors Creek. Taylors Creek is approximately 1100 feet from the northern boundary of the old, inactive landfill, while Mill Creek is approximately 4000 feet southwest of the old, inactive landfill (Figure 3-1). A drainage swale is located between the active landfill and the old, inactive landfill (Figure 3-1). In addition, a drainage ditch that runs south to north is located approximately 700 feet west of GA 144/119 in the old, inactive landfill. The drainage ditch discharges to the wetlands adjacent to Taylors Creek. Wetland areas are located along Mill and Taylors creeks, which are to the west and north, respectively, of the South Central Landfill. In addition, a small wetlands area is located approximately between the active landfill and the old, inactive landfill. Figure 4-1 identifies the wetlands areas around the South Central Landfill.

4.4 REGIONAL GEOLOGY

The FSMR is located within the coastal plain physiographic province. This province is typified by southeastward-dipping strata that increase in thickness from 0 feet at the fall line (located approximately 350 miles inland from the Atlantic coast) to approximately 4200 feet at the coast. State

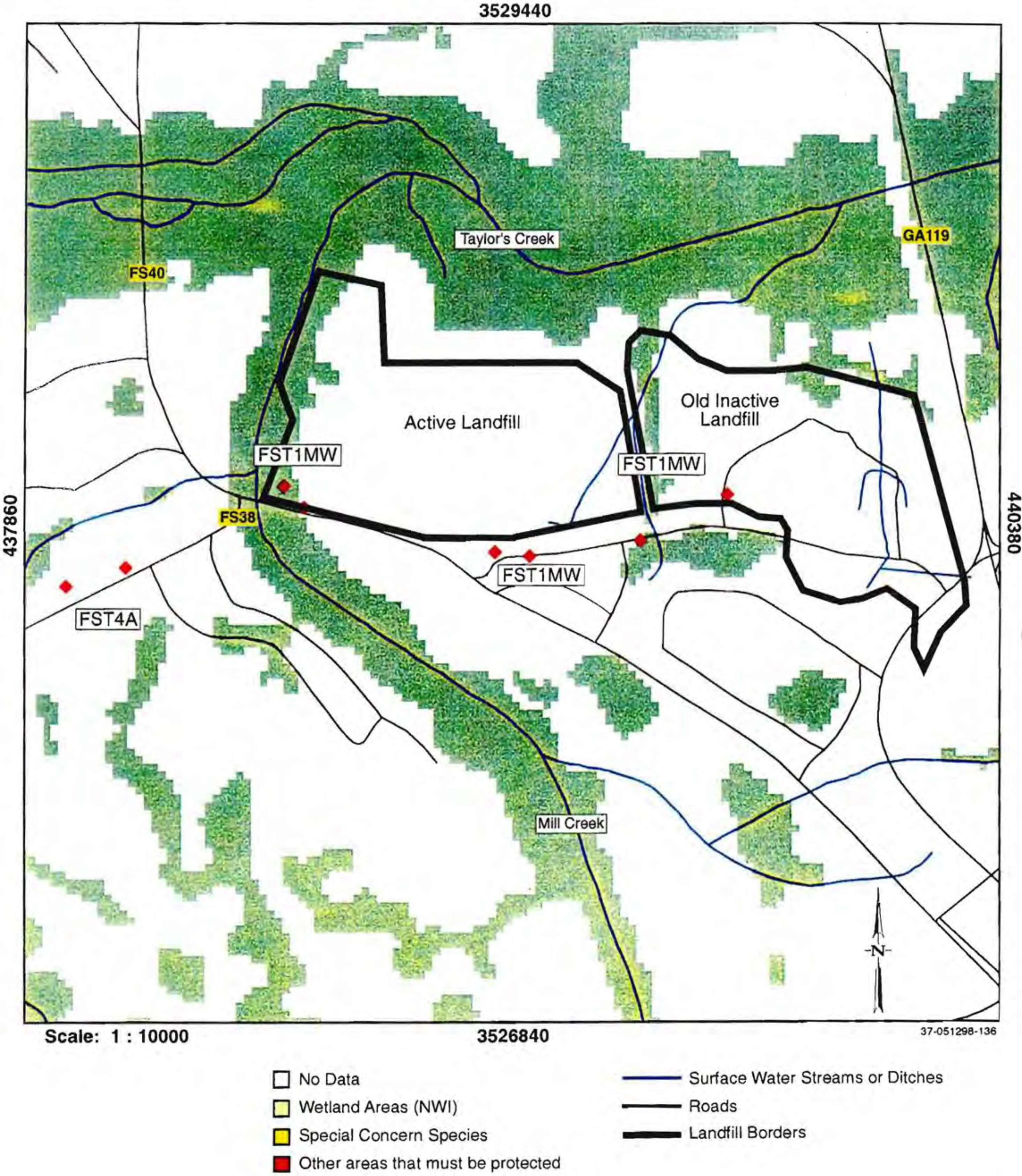

Figure 4-1. Wetlands at South Central Landfill

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geologic records describe a probable petroleum exploration well (the No. 1 Jelks-Rogers) located in the region as having encountered crystalline basement rocks at a depth of 4254 feet bgs. This well provided the most complete record for Cretaceous, Tertiary, and Quaternary sedimentary strata. Figure 4-2 presents a geologic column for the Tertiary and Quaternary sections in the Fort Stewart area.

The Cretaceous section is approximately 1970 feet in thickness and dominated by clastics. The Tertiary section is approximately 2170 feet in thickness and dominated by limestone, with a 175-foot-thick cap of dark green phosphatic clay. This clay is regionally extensive and is known as the Hawthorn Group. The interval from approximately 110 feet to the surface is Quaternary in age and composed primarily of sand with interbeds of clay or silt. This section is undifferentiated (Metcalf and Eddy 1996).

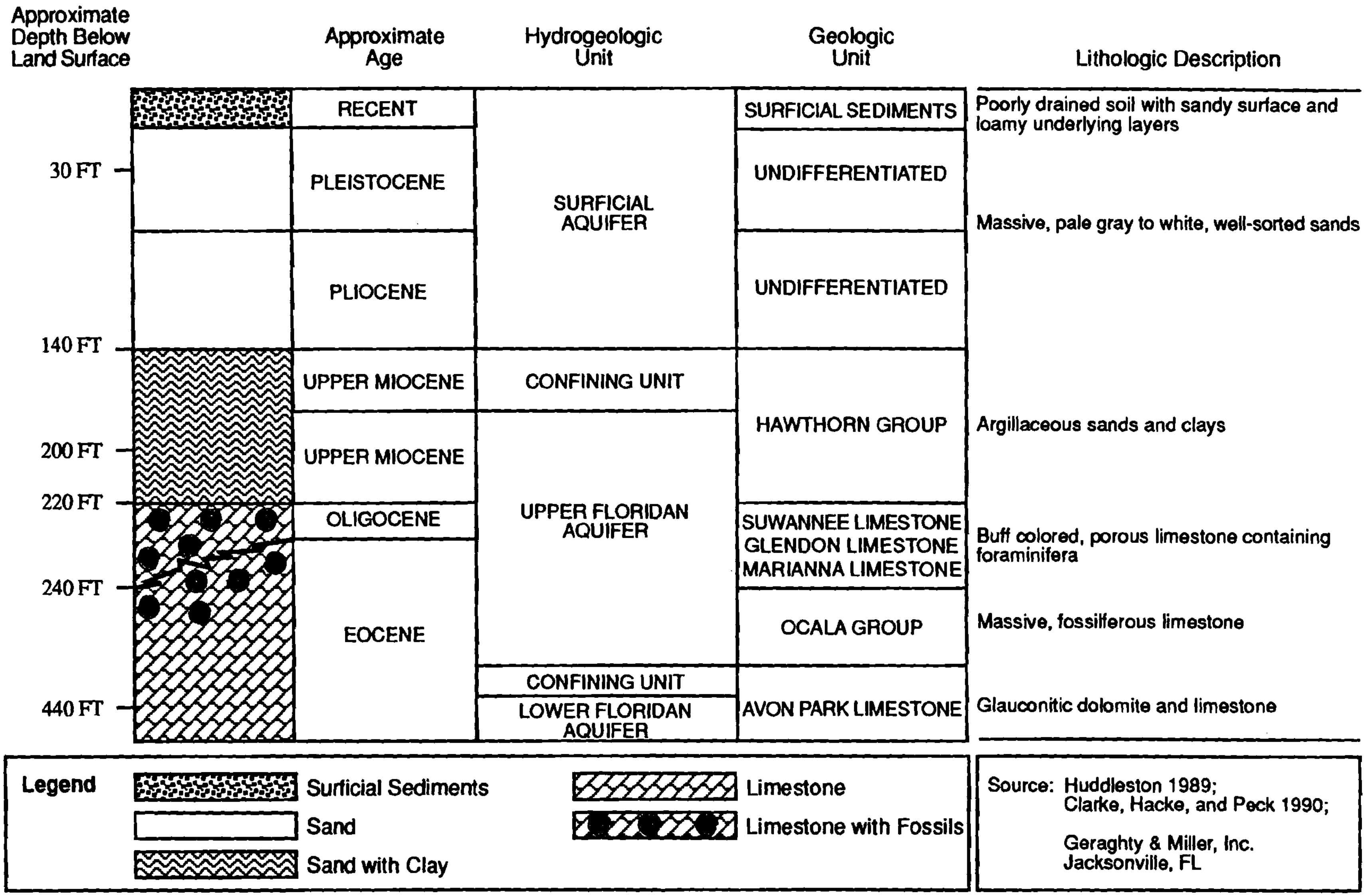
State geologic records contain information regarding a well drilled in October 1942, 1.8 miles north of Flemington at Liberty Field of Camp Stewart (now known as Fort Stewart). This well is believed to have been an artesian well located approximately 0.25 mile north of the runway at Wright Army Airfield within the FSMR. The log for this well describes a 410-foot section, the lowermost 110 feet of which consisted predominantly of limestone above which 245 feet of dark green phosphatic clay typical of the Hawthorn Group was encountered. The uppermost 55-foot interval was Quaternary-age interbedded sands and clays. The top 15 feet of these sediments were described as sandy clay (Metcalf and Eddy 1996).

4.5 SOILS

Boring logs showing the types of soils encountered during the Phase II RFI at the South Central Landfill in soil screening probes, groundwater screening probes, and monitoring well boreholes are given in Appendix B. Geological cross sections of the site are shown on Figures 4-3 and 4-4 depicting the lithology and stratigraphy of the unconsolidated soil deposits beneath the site, as inferred from the soil boring logs.

The cross sections indicate that the soils present across the SWMU 1 landfill are predominantly sand. In the lower-lying areas northeast of the old, inactive landfill, a 1-foot-thick highly organic layer is present at ground surface. The surficial materials are generally sands or silty sands from 7 to 10 feet thick. In the wells that transect the landfill (SC-M4, SC-M11, SC-M5, SC-M19, and SC-M18), a sandy clay layer (7 to 10 ft bgs) approximately 4 feet thick is present below the sands or silty sands. This sandy clay layer is underlain by a sand layer at 11 to 14 ft bgs. In the wells across the northern edge of the landfill (SC-M4, SC-M12, SC-M14, and SC-M15), the sands are underlain by a clay layer (7 to 10 ft bgs) that is up to 10 feet thick.

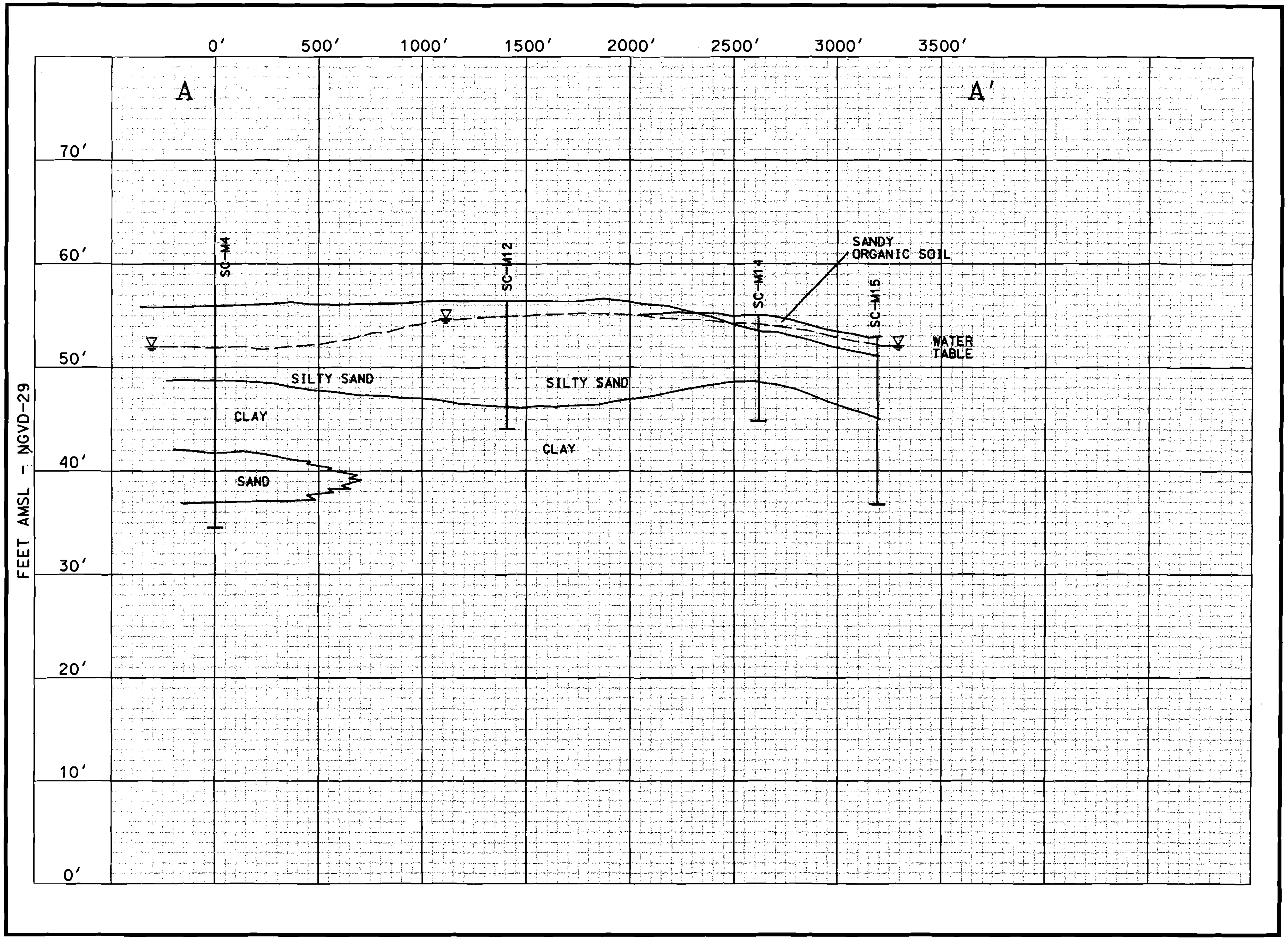
Geotechnical analyses were conducted on one bulk sample and one Shelby tube sample taken from the vertical-profile groundwater screening probe (VP-2), and eight bulk samples plus one Shelby tube sample were taken from the monitoring well boreholes (SC-M11 through SC-M19). The bulk samples were analyzed for grain-size distribution (in accordance with ASTM D422), moisture content (ASTM D2216), and Atterberg limits (ASTM D4318). In addition, the Shelby tube samples from VP-2 (sample 261513) and MW-11 (sample 265211) were analyzed for specific gravity (ASTM D854), porosity (EM1110-2-1906), and permeability (ASTM D5084). Results of the geotechnical analyses are summarized in Table 4-1. The geotechnical laboratory data sheets are included in Appendix E.



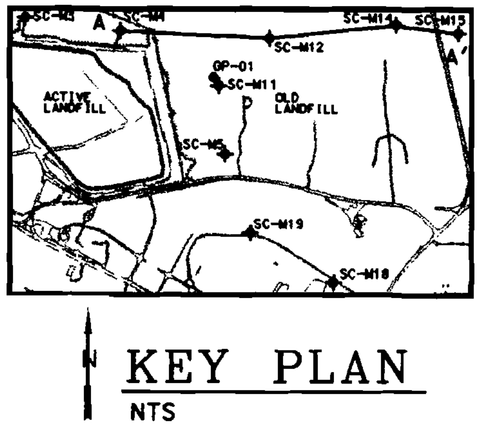
Source: Huddleston 1989;
Clarke, Hacke, and Peck 1990;

Geraghty & Miller, Inc.
Jacksonville, FL

Figure. 4-2. Approximate Geological Column for the FSMR Showing the Principal Hydrostratigraphy



LEGEND



KEY PLAN

NTS

0 250 500 1000

HORIZONTAL SCALE: 1" = 500'

0 2 4 6 8 10 20

VERTICAL SCALE: 1" = 10'

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CROSS-SECTION A
SOUTH CENTRAL LANDFILL (SWMU-1)
FORT STEWART, GA

DRAWN BY:	REV. NO./DATE:	CAD FILE:
J. LAMB	1/ 08/14/98	96016/DGNS/A33C005.DGN

Figure 4-3. Geologic Cross Section A-A', SWMU 1

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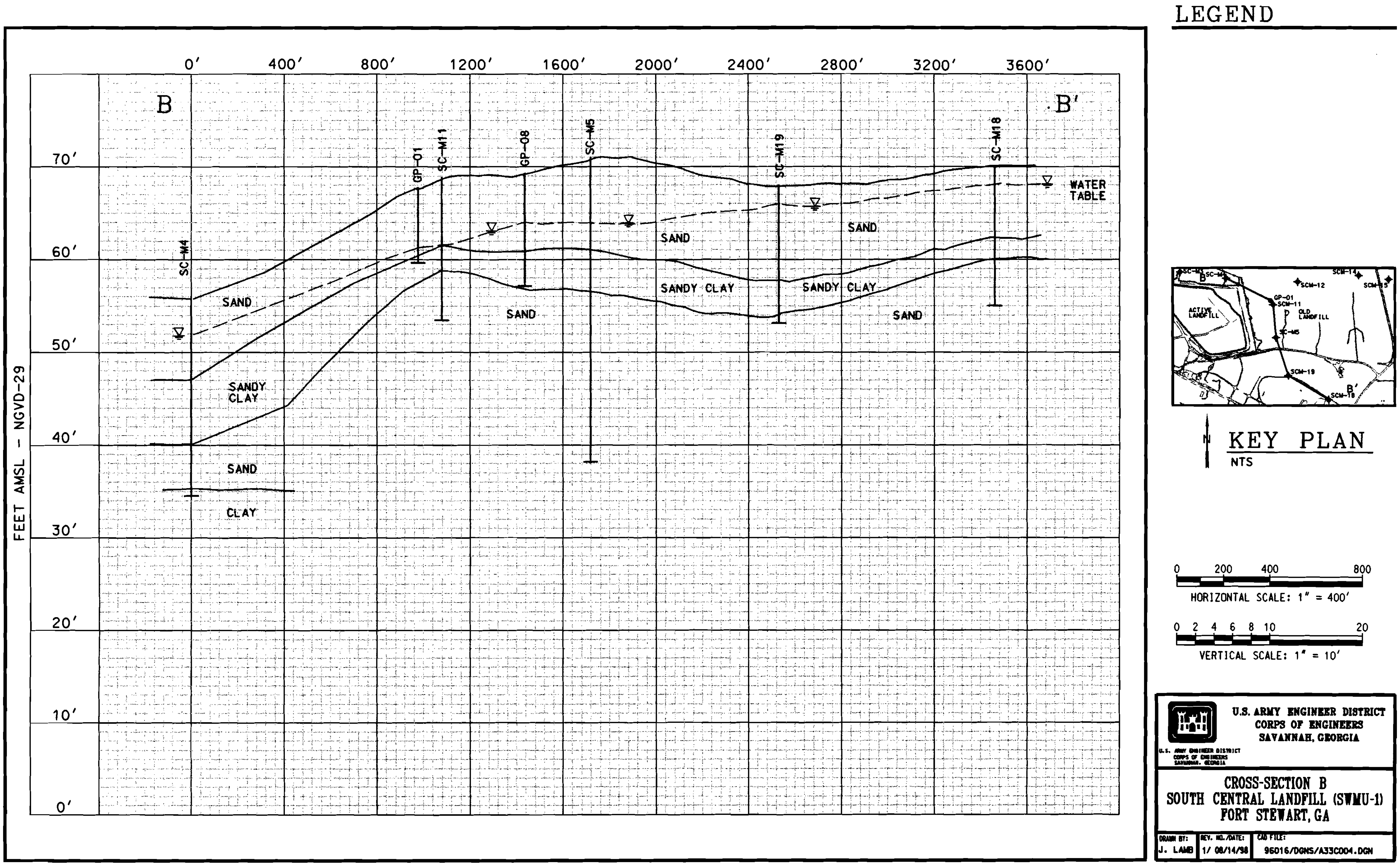

Figure 4-4. Geologic Cross Section B-B′, SWMU 1

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Table 4-1. Summary of Geotechnical Analyses, South Central Landfill

Station	Depth (feet)	Sample No.	Moisture Content (%)	Atterberg Limits: Liquid Limit (%)	Atterberg Limits: Plastic Limit (%)	Atterberg Limits: Plasticity Index (%)	Grain-Size Distribution: Gravel (%)	Grain-Size Distribution: Sand (%)	Grain-Size Distribution: Fines (%)	Specific Gravity	Soil Porosity	Permeability (cm/sec)
MW-11	5–7	011113[a]	14.8	25.7	17.0	8.7	0	96.6	3.4	2.64	0.27	5.66E-05
MW-12	2.5–5	011213	13.3	NP	NP	NP	0	97.9	2.1	NA	NA	NA
MW-14	5–7.5	011413	15.4	NP	NP	NP	0	91.8	8.2	NA	NA	NA
MW-15	5–7.5	011513	16.5	NP	NP	NP	0	93.8	6.2	NA	NA	NA
MW-16	7.5–10	011613	20.7	NP	NP	NP	0	97.4	2.6	NA	NA	NA
MW-17	10–12.5	011713	21.6	NP	NP	NP	0	99.6	0.4	NA	NA	NA
MW-18	7.5–10	011813	20.9	NP	NP	NP	0	97.4	2.6	NA	NA	NA
MW-19	7.5–10	011913	15.3	NP	NP	NP	0	97.9	2.1	NA	NA	NA
VP-2	0–2	01V213[a]	17.7	NP	NP	NP	0	94.0	6.0	2.69	0.38	8.96E-04

[a] Indicates Shelby tube sample.

NA= Not analyzed.

NP = Nonplastic.

These results indicate that tested soils are silty sands with the proportion of fine-grained particles varying from 0 to 8 percent by weight. All the soils except those at MW-11 were nonplastic. The soil from the screened interval in MW-1 had a permeability of 5.66×10^{-5} cm/sec, while the permeability at VP-2 was determined to be 8.96×10^{-4} cm/sec, typical for slightly silty sands.

4.6 HYDROGEOLOGY

The hydrogeology in the vicinity of the FSMR is dominated by two aquifers referred to as the Principal Artesian and the surficial aquifer that are separated by a confining unit (Figure 4-2).

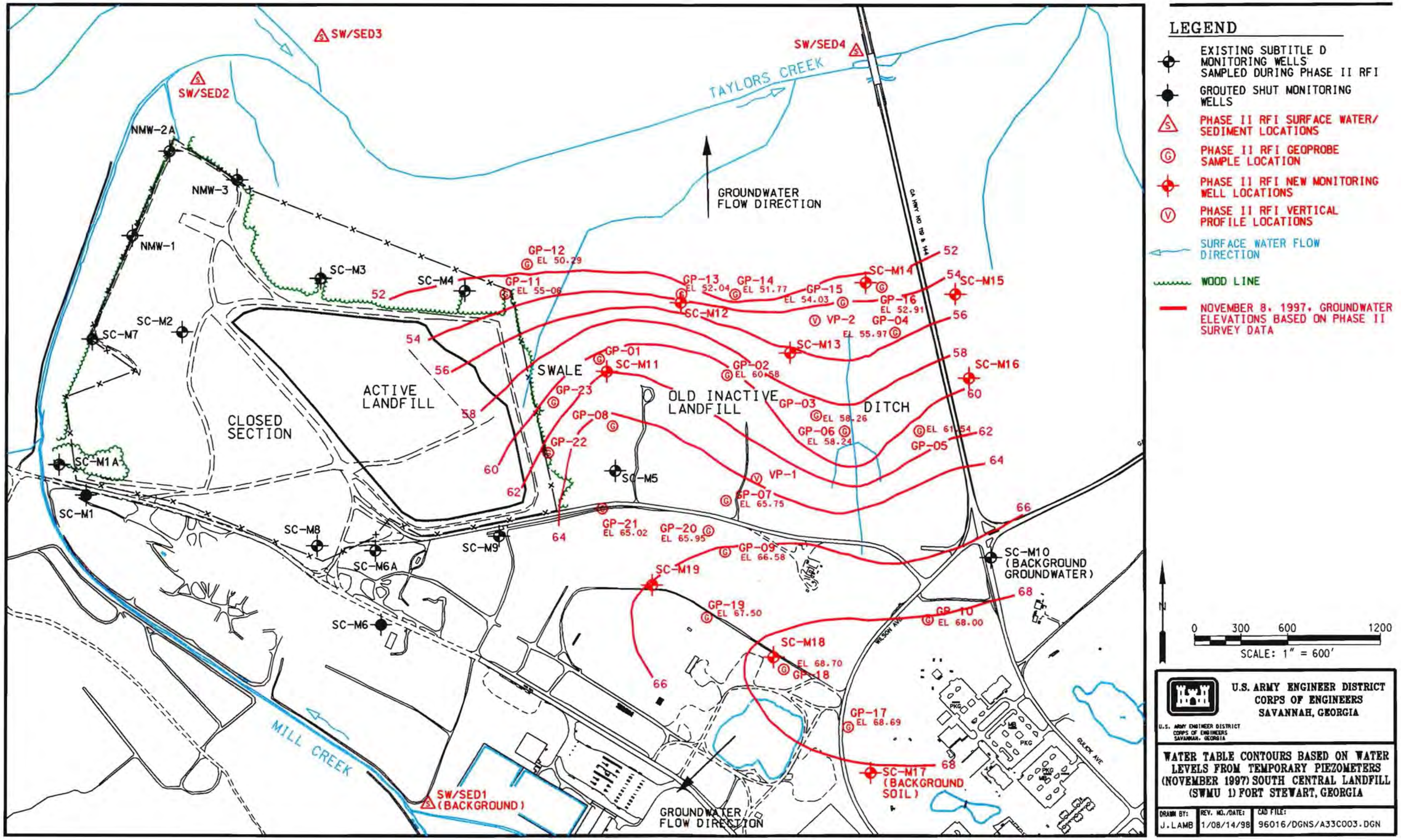
The Principal Artesian aquifer is the lowermost hydrologic unit, is regionally extensive from South Carolina through Georgia, Alabama, and most of Florida, and is regionally known as the Floridan Aquifer. This aquifer is subdivided into upper and lower hydrogeologic units. The upper hydrogeologic unit is composed primarily of Miocene-age argillaceous sands and clays and Oligocene- to Eocene-age limestones (including the Ocala Group and the Suwannee Limestone, where present) at the top. The upper hydrogeologic unit ranges in thickness from 200 to 260 feet and is most productive where it is thickest and where secondary permeability is most developed. The lower hydrologic unit is comprised of the Eocene-age Avon Park Limestone at the base. The transmissivity of the aquifer in the Savannah area ranges from about 28,000 to 33,000 square feet/day (Krause and Randolph 1989). Groundwater from this aquifer is primarily used for drinking water (Arora 1984). Thirteen groundwater production wells are used for potable water supply on the FSMR, and one additional production well is available for use in fire protection.

The confining layer for the Principal Artesian aquifer is the phosphatic clays of the upper Hawthorn Group. These sediments are regionally extensive and range from 60 to 80 feet in thickness at the FSMR. There are minor occurrences of aquifer material within the Hawthorn Group; however, they have limited utilization (Miller 1990).

The uppermost hydrologic unit is the surficial aquifer, which consists of varying amounts of sand, silt, and clay ranging from 55 to 150 feet in thickness. This aquifer is primarily used for domestic lawn and agricultural irrigation, with wells typically yielding 2 to 180 gallons per minute.

Water levels were measured on November 8, 1997, in the 23 temporary piezometers at the South Central Landfill. Elevation of the water table varied from 50.29 feet (GP-12) to 68.7 feet (GP-18) amsl. Figure 4-5 presents a map of the potentiometric surface based on the water levels in the temporary piezometers. These data were used to determine the placement of permanent monitoring wells around the old, inactive landfill. Based on the groundwater contours obtained from the Geoprobe locations, the groundwater is flowing north toward Taylors Creek at an average of 0.0086 foot/foot.

Water levels were also measured in the 22 (existing and new) monitoring wells around the South Central Landfill on April 19, 1998. Figure 4-6 presents the potentiometric surface based on the water levels in the monitoring wells. There is a discrepancy between the historical survey data and the Phase II RFI survey data for the top-of-casing elevations for existing wells SC-M4, SC-M5, SC-M9, and SC-M10. The four existing wells were surveyed during the Phase II RFI to locate the existing wells with respect to the new wells. As a result of the current survey data, top-of-casing elevations for these wells may vary by as much as 3.5 feet between the historical survey data and the current Phase II RFI survey data, and the source of this discrepancy could not be discerned. The difference in elevation data disallows meaningful interpretations of groundwater contours between the existing and newly installed



LEGEND

- EXISTING SUBTITLE D MONITORING WELLS SAMPLED DURING PHASE II RFI
- GROUTED SHUT MONITORING WELLS
- PHASE II RFI SURFACE WATER/ SEDIMENT LOCATIONS
- PHASE II RFI GEOPROBE SAMPLE LOCATION
- PHASE II RFI NEW MONITORING WELL LOCATIONS
- PHASE II RFI VERTICAL PROFILE LOCATIONS
- SURFACE WATER FLOW DIRECTION
- WOOD LINE
- NOVEMBER 8, 1997, GROUNDWATER ELEVATIONS BASED ON PHASE II SURVEY DATA

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WATER TABLE CONTOURS BASED ON WATER LEVELS FROM TEMPORARY PIEZOMETERS (NOVEMBER 1997) SOUTH CENTRAL LANDFILL (SWMU 1) FORT STEWART, GEORGIA

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J.LAMB	1/08/14/98	96016/DGNS/A33C003.DGN

Figure 4-5. Water Table Contours Based on Water Levels from Temporary Piezometers (November 1977)

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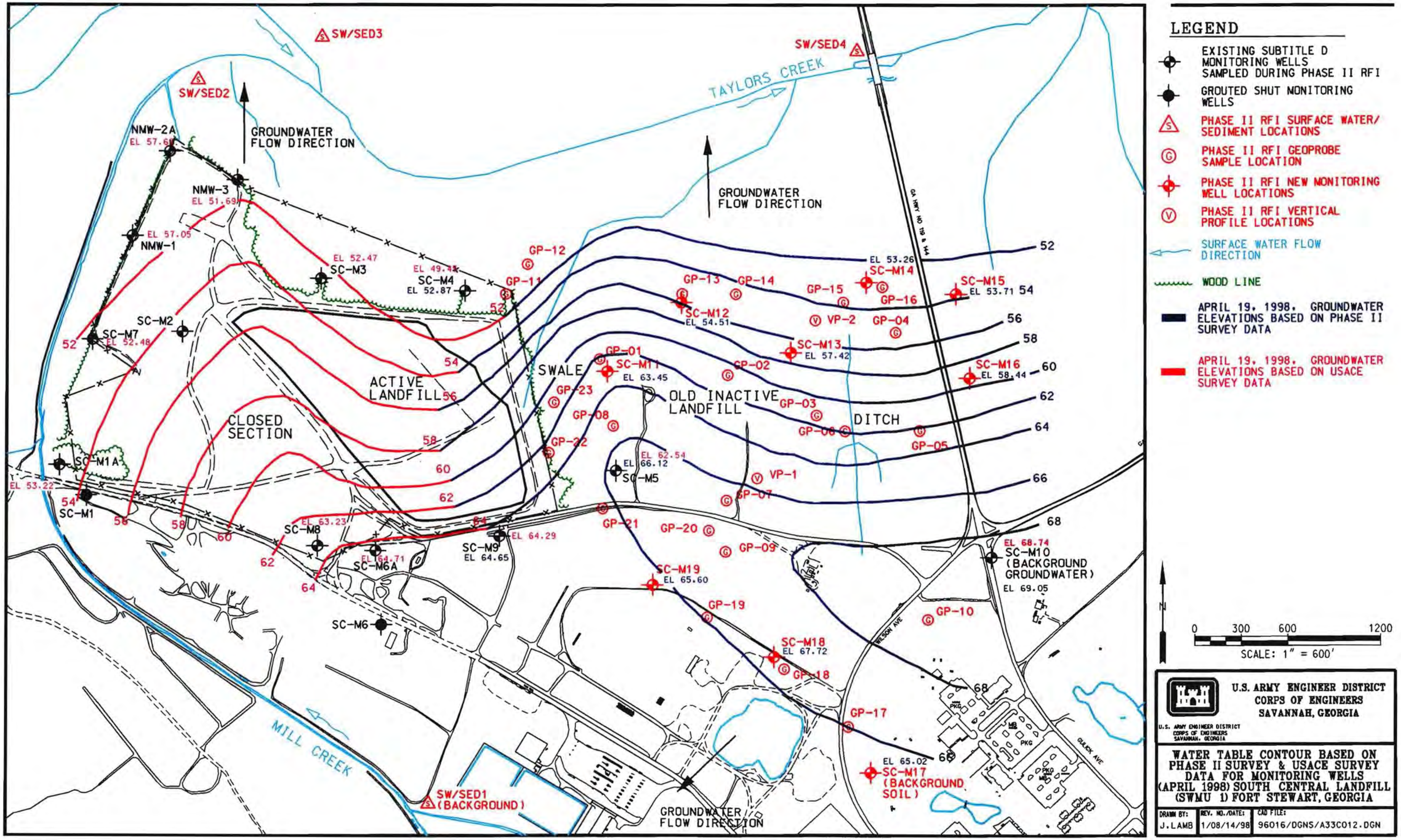

Figure 4-6. Water Table Contour Based on Phase II Survey and USACE Survey Data for Monitoring Wells (April 1998)

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wells. However, interpretation of the groundwater flow may be performed if the active landfill and the old, inactive landfill are evaluated individually against the water level measurements and their respective surveyed data sets. The historical monitoring well elevations were used to develop the groundwater contours around the active portion of the landfill, whereas the new survey data were used to assess the groundwater flow around the old, inactive landfill (Figure 4-6). The groundwater contours from the monitoring wells indicate that there is a groundwater divide in the southern portion of the old, inactive landfill near SC-M10 and GP-10. North of the groundwater divide, the groundwater flows north toward Taylors Creek at an average of 0.0086 foot/foot. South of the groundwater divide, the groundwater flows southwest toward Mill Creek at an average of 0.003 foot/foot.

4.7 ECOLOGY

Approximately 7.8 square miles of the 436.8 square miles at FSMR comprise the garrison area. The remainder is used for ranges and training areas (approximately 11 percent) or held as non-use areas.

Eighty-four percent of the land is forested (approximately 367.2 square miles). Sixty-six percent of the forest area is pine, with the major species including the slash, loblolly, and longleaf pines. Thirty-four percent of the forest is composed of river bottomlands and swamps whose major species include the tupelo, other gum trees, water oak, and bald cypress trees. The open range and training areas comprise 11 percent of the Installation and consist of grasses, shrubs, and scrub tree (oak) growth.

Aquatic habitats on FSMR include a number of natural or man-made ponds and lakes, the Canoochee River, Canoochee Creek and its tributaries, and a number of bottomland swamps and pools. The Ogeechee River borders the installation along its northeast boundary. Organic detritus content is high, and dark coloring of the water is not unusual. Dense growths of aquatic vegetation are also typical, especially during the summer months.

Both terrestrial and aquatic fauna are abundant in the unimproved areas of FSMR. Major game species found on the installation include white-tailed deer, feral hog, wild turkey, rabbit, squirrel, and bobwhite in addition to numerous other mammal, bird, reptile, and amphibian species (Environmental Science and Engineering 1982). Dominant fish include bluegill, largemouth bass, crappie, sunfish, channel catfish, minnows, and shiners. Three federally listed threatened or endangered species reside at FSMR: the American bald eagle, Eastern indigo snake, and red-cockaded woodpecker.

4.8 METEOROLOGY

Fort Stewart has a humid, subtropical climate with long, hot summers. Average temperatures range from 50°F in the winter to 80°F in the summer. Average annual precipitation is 48 inches, with slightly over half falling from June through September. Prolonged drought is rare in the area, but severe local storms (tornadoes and hurricanes) do occur. Under normal conditions, wind speeds rarely exceed 5 knots, but gusty winds of more than 25 knots may occur during summer thunderstorms (Geraghty and Miller 1992).

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5.0 CONTAMINANT NATURE AND EXTENT

This section summarizes the results of the chemical laboratory analyses of the soil, groundwater, surface water, and sediment samples collected at the South Central Landfill site. Complete analytical results for the Phase II chemical data are included in Appendix F of this report. Analytical results for the Phase I chemical data were presented in Appendix U of the Phase I RFI Report (Rust 1996) and are summarized in Section 2.3.1 of this report.

5.1 BACKGROUND DATA ANALYSIS AND SCREENING

The reference background criteria for the South Central Landfill have been developed, based on data from background samples collected, across the FSMR for SWMUs under Phase II RFI. In general, reference background samples were collected in each medium at locations upgradient or upstream of each site so as to be representative of naturally occurring conditions at SWMUs under investigation. In addition, soil collected during the Phase I [i.e., Burn Pits (SMWUs 4A-4F), Active EOD Area (SWMU 12A), etc.] was included in the background data set if it was determined to be upgradient of the site and of sufficient quality to be representative of natural background conditions at the FSMR. A summary of the sample locations by media at each SWMU and the source of the data (Phase I or II RFI is presented in Table 5-1).

EPA Region IV methodology (EPA 1996b) was used as guidance for the development of the background data set for screening metals data. In cases where enough samples (e.g., more than 20) are collected to define background, a background upper tolerance level can be calculated. In cases where fewer samples (e.g., less than 20) are collected to define background, background can be calculated as 2 times the mean background concentration (EPA 1996b). Given that fewer than 20 background samples were collected for the FSMR, the latter method was used for calculating reference background concentrations.

Appendix G presents the summary of background data and presents the two-times-mean background concentrations. Given the limited background data, the mean concentration for soils in the eastern United States is also presented for comparative purposes. Because of the limited number of background samples, the screening value for background may be heavily skewed as a result of an outlier in the sampling data. The following sections discuss the background used for each medium.

5.1.1. Surface Soil

Surface soil samples were taken from the ground surface to a depth of 1 or 2 feet depending on the amount of recovery from the sampling device. Thirteen surface soil samples were used in the development of the surface soil background data set (Table 5-1). The reference background surface soil concentration was calculated as 2 times the average concentration of these thirteen locations. Phase I data from SWMU 12A and SWMU 35 were determined to be of sufficient quality to include in the background data set. If a chemical was not detected at a site, then 1/2 the detection limit was used as the concentration used in calculating the mean background concentration. The sample results included in the data set are presented in Table G-1, Appendix G. The reference background concentration for organics is also presented in Table G-1, however, all detected organic compounds are considered site-related contaminants (SRCs) because organic constituents are considered

Table 5-1. Background Media Summary

SWMU Number	SWMU Name on Hazardous Waste Permit HW-045	Station				
		Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
1	South Central Landfill	SC-M17	SC-M17	MW10	SW/SED1	SW/SED1
2	Camp Oliver Landfill	MW5	MW5	MW5	NA	NA
3	TAC-X Landfill	MW5	MW5	MW5	NA	NA
4A	Burn Pit A		MW1 (Phase I)	MW1	NA	NA
4B	Burn Pit B		MW3 (Phase I)	MW3	NA	NA
4C	Burn Pit C	MW7	MW7	MW7	NA	NA
4D	Burn Pit D		MW2 (Phase I)	MW2	NA	NA
4E	Burn Pit E		MW3 (Phase I)	MW3	NA	NA
4F	Burn Pit F		MW1 (Phase I)	MW1	NA	NA
10	Inactive EOD Area				NA	NA
12A	Active EOD containing Open Detonation Unit and Open Burn Pit	MW1 (Phase I)	MW1 (Phase I)	MW1	NA	NA
14	Old Fire Training Area			MW8	NA	NA
17	DRMO Hazardous Waste Storage Area	MW1	MW1	MW1	NA	NA
18	Industrial Wastewater Treatment Plant	MW1	MW1	MW1	NA	NA
26	Former 724th Tanker Purging Station	MW1	MW1	MW1	NA	NA
29	Evans Army Heliport POL Storage Facility	MW5	MW5	MW5	NA	NA
31	DEH Asphalt Tanks	MW1	MW1	MW1	NA	NA
32	Supply Diesel Tank	MW1	MW1	MW1	NA	NA
34	DEH Equipment Wash Rack	MW1	MW1	MW1	NA	NA
35	Wright Army Airfield Bulk Fuel System	HA-05 (Phase I)	HA-05 (Phase I)	MW9 (Phase I)	NA	NA

NA = Not applicable, surface water and sediment background are site-specific.

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potentially man-made. Inorganics were considered SRCs if their concentrations were above the calculated reference background concentration, and organics were considered SRCs if they were detected. SRCs determined from the nature and extent are carried through to the human health and ecological preliminary risk evaluations.

5.1.2 Subsurface Soil

Subsurface soil samples were taken from the interval between a depth of 2 feet and the water table. Nineteen subsurface soil samples were used in the development of the subsurface soil background data set (Table 5-1). Phase I data from the SWMU 4A-F, SWMU 12A, and SWMU 35 were determined to be of sufficient quality to include in the subsurface soil background set. The reference background subsurface soil concentration was calculated as 2 times the average of the chemical detected at the nineteen locations. If a chemical was not detected in a sample, then 1/2 the detection limit was used in calculating the mean background concentration. The sample results included in the background data set are presented in Table G-2, Appendix G. Inorganics are considered SRCs if their concentrations were above the calculated reference background concentration, and organics are considered SRCs if they were detected because organic constituents are considered potentially man-made. SRCs determined from the nature and extent are carried through to the HHPRE and EPRE.

5.1.3 Groundwater

Only groundwater samples collected using low flow techniques (Phase II RFI) were used in the development of the groundwater background data set. Groundwater samples from 18 SWMUs were used to develop the groundwater background composite (Table 5-1). The reference background groundwater concentration was calculated as 2 times the average of these eighteen samples. If a chemical was not detected at a site, then 1/2 the detection limit was used in calculating the mean background concentration. The sample results included in background data set are presented in Table G-3, Appendix G. Inorganics in groundwater were considered SRCs if their concentrations were above the calculated reference background concentration, and organics are considered SRCs if they were detected because organic constituents are considered potentially man-made. SRCs determined from the nature and extent are carried through to the HHPRE and EPRE.

5.1.4 Surface Water/Sediment

Surface water and sediment background samples were collected during the Phase II RFI for South Central Landfill and are site-specific. The reference background surface water concentration was calculated as 2 times the average of the data taken at the site-specific background location. If a chemical was not detected at a site, then 1/2 the detection limit was used as the average background concentration. The sample results comprising the site-specific background data for surface water and sediment are presented in Table G-4, Appendix G. Inorganics were considered SRCs if their concentrations were above site-specific reference background concentration, and organics were considered SRCs if they were detected because organic constituents are considered potentially man-made. SRCs determined from the nature and extent are carried through to the HHPRE and EPRE.

5.1.5 Site-Related Contaminants

Inorganics for surface soil, subsurface soil, and groundwater were screened against the reference background criteria. Inorganics for surface water and sediment were screened against site-specific background values. As discussed in the preceding sections, all organics that are detected are considered potential SRCs because organic constituents are considered potentially man-made. Organic analytes that were detected at least once and those inorganic analytes where at least one sample result exceeded background are considered SRCs. Only the SRCs are carried through for evaluation under fate and transport (Chapter 6.0), HHPRE (Chapter 7.0), and EPRE (Chapter 8.0).

5.2 SURFACE SOIL CONTAMINATION

The nature and extent of surface soil contamination were evaluated using the results from surface soil samples taken from nine monitoring well boreholes (SC-M11 through SC-M19) and two direct-push samples (GP-2 and GP-7) at the site. The monitoring wells were installed along the perimeter of the old, inactive portion of the landfill (Figure 4-5). Two of the monitoring well boreholes (SC-MW15 and SC-MW16) are located outside the area previously used for landfill operations. Aerial photographs and historical information have never indicated that solid waste was disposed of east of GA 119/144. These sampling sites are separated from SWMU 1 by a major road (GA 119/144) and are cross gradient to the surface water flow direction (toward Taylors Creek) from the old, inactive portion of SWMU 1; therefore, it is unlikely that potential contaminants in surface soil from SWMU 1 would migrate to these boreholes locations. Therefore, contaminants detected in these surface soil samples are probably not the result of potential contamination from SWMU 1. The two direct-push samples were collected within the boundary of the old, inactive landfill and were selected because the 0-to-2-foot interval indicated the highest organic concentration during field screening. The samples from the monitoring wells were analyzed for VOCs, SVOCs, RCRA metals, pesticides/PCBs, and Radium 226/228. The direct-push samples were analyzed for only VOCs. Table 5-2 summarizes the analytical results for surface soil samples from the monitoring well boreholes and two direct-push samples. Figure 5-1 shows the distribution of VOCs, SVOCs, pesticides, and Radium 226/228 analytes detected as well as RCRA metal analytes detected above background. This assessment presents Phase II contaminant data only.

VOCs. Acetone, methylene chloride, and toluene were detected in the surface soil at SWMU 1. The acetone concentration ranged from 6.5 µg/kg at GP-2 to 44,100 µg/kg at SC-M16. Methylene chloride ranged from 1.4 µg/kg at SC-M13 to 52.2 µg/kg at SC-M16. The concentrations of acetone (44,100 µg/kg) and methylene chloride (52.2 µg/kg) detected in SC-M16 may be the result of laboratory contamination, given that these constituents are common laboratory contaminants. As previously discussed, SC-M16 is located off-site, and contaminants detected in these surface soil samples are outside the influence of potential SWMU 1 contaminants. The toluene concentration ranged from 0.51 µg/kg at SC-M18 to 59.4 µg/kg at SC-M19. Acetone, methylene chloride, and toluene are considered SRCs in surface soil.

SVOCs. 1,2,4-Tricholorobenzene was detected at 3.2 µg/kg at SC-M15 and SC-M18. No other SVOCs were detected in any surface soil samples. The concentration of 1,2,4-trichlorobenzene (3.2 µg/kg) detected in SC-M15 is likely to come from a source other than the landfill. As discussed previously, this sample location is off-site; therefore, constituents detected in this sample are not considered to be site-related.1,2,4-Trichlorobenzene is considered an SRC in surface soil.

Pesticides/PCBs. 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT were detected in two surface soil samples (SC-M13 and SC-M18). 4,4'-DDE and 4,4'-DDT were detected in SC-M18 at concentrations of 3.3 µg/kg and 1.4 µg/kg, respectively. 4,4'DDD and 4,4'-DDT were detected in SC-M13 at concentrations of 3.8 µg/kg and 2.1 µg/kg, respectively. No PCBs were detected in any of the surface soil samples. 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT are considered SRCs in surface soil.

Table 5-2. Summary of Analytical Results for Surface Soil from Monitoring Wells and Direct-Push Samples, SWMU 1

Station	Reference Background Criteria	SC-M11	SC-M12	SC-M13	SC-M14	SC-M15	SC-M16	SC-M17[a]	SC-M18	SC-M19	GP-2	GP-7
Sample ID		011111	011211	011311	011411	011511	011611	011711	011811	011911	011251	011751
Depth (feet)		0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Date Sampled		11/16/97	11/16/97	11/16/97	11/16/97	11/15/97	11/15/97	11/16/97	11/16/97	11/16/97	11/07/97	11/05/97
RCRA Metals (mg/kg)												
Arsenic	2.10	0.17						1.8		0.37	NA	NA
Barium	14.70	7.1	0.3	0.58	4.9	10.2	0.98	9.3	1.6	3.7	NA	NA
Cadmium	0.18				0.01						NA	NA
Chromium	6.21	2			0.62			**9.4**	0.79	2.1	NA	NA
Lead	8.81	2	0.38	0.45	1.9	2.4	0.3	3.3	1.3	4.7	NA	NA
Mercury	0.03	0.01			0.01	0.02		0.01		0.03	NA	NA
Selenium	0.41									**0.69**	NA	NA
Silver	0.15							0.06			NA	NA
Pesticides (µg/kg)												
4,4'-DDD	0			**3.8**							NA	NA
4,4'-DDE	0								**3.3**		NA	NA
4,4'-DDT	0			**2.1**					**1.4**		NA	NA
Radionuclides (pCi/g)												
Radium 226	0.86	0.334	0.216	0.295	0.407	0.626	0.257	0.428	0.295	0.464	NA	NA
Radium 228	1.70		0.212			0.561	0.186	0.851	0.365		NA	NA
Volatile Organic Compounds (µg/kg)												
Acetone	0						**44,100**			**72.3**	**6.5**	
Methylene Chloride	0	**9.2**	**13.7**	**1.4**	**3.9**		**52.2**					
Toluene	0								**0.51**	**59.4**		
Semivolatile Organic Compounds (µg/kg)												
1,2,4-Trichlorobenzene	0					**3.2**			**3.2**			

[a]Site Background Station.
Blank = Not detected.
NA = Not analyzed.
RCRA = Resource Conservation and Recovery Act.
Bold indicates concentration detected above FSMR reference background criteria.

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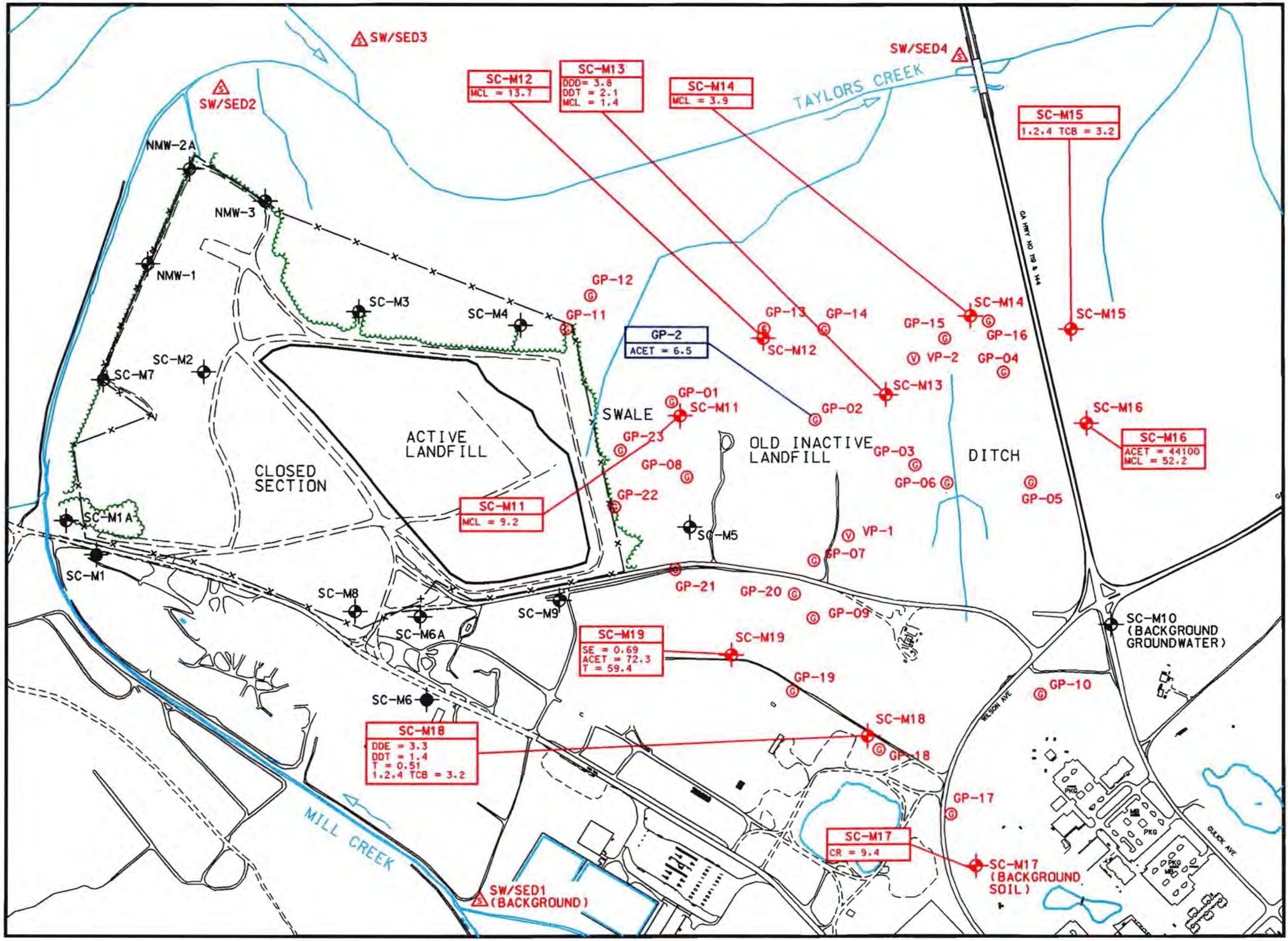

LEGEND

⌖ EXISTING SUBTITLE D MONITORING WELLS SAMPLED DURING PHASE II RFI

● GROUTED SHUT MONITORING WELLS

△ PHASE II RFI SURFACE WATER/ SEDIMENT LOCATIONS

Ⓖ PHASE II RFI GEOPROBE SAMPLE LOCATION

⌖ PHASE II RFI NEW MONITORING WELL LOCATIONS

Ⓥ PHASE II RFI VERTICAL PROFILE LOCATIONS

← SURFACE WATER FLOW DIRECTION

〰 WOOD LINE

CR = CHROMIUM
SE = SELENIUM
DDD = 4,4'-DDD
DDE = 4,4'-DDE
DDT = 4,4'-DDT
ACET = ACETONE
MCL = METHYLENE CHLORIDE
T = TOLUENE
1,2,4 TCB = 1,2,4-TRICHLOROBENZENE'

NOTE:

1. METALS IN mg/kg, ONLY THOSE ANALYTES PRESENT AT CONCENTRATIONS ABOVE REFERENCE BACKGROUND CRITERIA ARE SHOWN.
2. ORGANICS IN µg/kg, ANALYTES ABOVE DETECTION ARE SHOWN.
3. PESTICIDES IN µg/kg, ANALYTES ABOVE DETECTION ARE SHOWN.

N

0 300 600 1200

SCALE: 1" = 600'

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RESULTS OF SURFACE SOIL (0-1FT) ANALYSES SOUTH CENTRAL LANDFILL (SWMU 1) FORT STEWART, GEORGIA

DRAWN BY:	REV. NO./DATE:	CAD FILE:
J.LAMB	2/08/27/98	96016/DGNS/A33C006.DGN

Figure 5-1. Results of Surface Soil Analyses (0 to 1 foot)

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RCRA Metals. Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver were detected in surface soils. The distribution of the metals above reference background is presented in Figure 5-1.

- Arsenic was detected in three samples at a concentrations ranging from 0.17 mg/kg in SC-M11 to 1.8 mg/kg in SC-M17 (site background). The FSMR reference arsenic background concentration is 2.10 mg/kg. Because arsenic was not detected at levels greater than FSMR reference background, arsenic is not an SRC.

- Barium was detected in all samples, and the concentrations ranged from 0.3 mg/kg in SC-M12 to 10.2 mg/kg in SC-M15. Barium is not an SRC because its concentration did not exceed FSMR reference background in any of the surface soil samples collected in and around SWMU 1.

- Cadmium was detected in SC-M14 at a concentration of 0.01 mg/kg but is not an SRC because its concentration did not exceed FSMR reference background.

- Chromium was detected in five samples (SC-M11, SC-M14, SC-M17, SC-M18, and SC-M19), and the concentrations ranged from 2.0 mg/kg in SC-M11 to 9.4 mg/kg in SC-M17 (site background). Chromium is not an SRC because it was detected in SC-M17, the site background location, and not in any other station at levels greater than FSMR reference background.

- Lead was detected in all soil samples, but at levels below the FSMR reference background concentration. The lead concentrations ranged from 0.3 mg/kg in SC-M16 to 4.7 mg/kg in SC-M19.

- Mercury was detected in five soil samples (SC-M11, SC-M14, SC-M15, SC-M17, and SC-M19) at concentrations ranging from 0.01 mg/kg at SC-M11, SC-M14, and SC-M17 to 0.03 mg/kg in SC-M19, which is equal to the FSMR reference background (0.03 mg/kg). Therefore, mercury is not an SRC.

- Selenium was detected in SC-M19 at a concentration of 0.69 mg/kg, a concentration slightly higher than the FSMR reference background concentration of 0.63 mg/kg and is considered an SRC in surface soil.

- Silver was detected in SC-M17 at a concentration of 0.06 mg/kg, below the FSMR reference background concentration.

Only one surface soil sample (SC-M19) had concentrations of one metal, selenium, slightly greater than its respective FSMR reference background concentration and is considered an SRC in surface soil. The one elevated selenium surface soil concentration was not greater than the respective subsurface reference background concentration of 1.12 mg/kg (Table G-2, Appendix G); therefore, selenium is questionable as an SRC in surface soil.

Radium 226/228. Radium 226 was detected in all the surface soil samples at SWMU 1. The concentrations of Radium 226 ranged from 0.216 pCi/g at SC-M12 to 0.626 pCi/g at SC-M15. Radium 228 was detected in five (SC-M12, SC-M15, SCM-16, SC-M17, and SC-M18) out of eight of the surface soil samples. The concentrations ranged from 0.186 pCi/g at SC-M16 to 0.561 pCi/g at SC-M15. All the samples had concentrations below FSMR reference background; therefore, Radium 226/228 are not SRCs in surface soil.

5.3 SUBSURFACE SOIL CONTAMINATION

The nature and extent of subsurface soil contamination were evaluated using the results from both direct-push soil samples and discrete soil samples taken from monitoring well boreholes.

5.3.1 Direct-Push Soil Sampling Results

The direct-push soil samples were collected from ten direct-push stations located within the boundary of the old, inactive landfill. The samples were analyzed for VOCs only. Table 5-3 summarizes the VOC analytical results for direct-push soil samples, and Figure 5-2 shows the distribution of VOCs in subsurface soils. GP-2 and GP-7 data are included under the surface soil discussion in Section 5.2 because the soil was collected from the 0-to-1-foot interval based on field headspace readings.

VOCs. VOCs were detected in five of the seven direct-push probe stations within the boundary of the old, inactive landfill (GP-1, GP-5, GP-6, GP-8, and GP-10). Acetone was detected at GP-5, GP-6, GP-8, and GP-10. The acetone concentration ranged from 6.1 µg/kg at GP-6 to 133 µg/kg at GP-10. Toluene was detected at 0.32 µg/kg and 2.2 µg/kg at GP-1 and GP-10, respectively. Methylene chloride was detected in GP-1 at a concentration of 1.6 µg/kg. 2-Butanone was detected in GP-10 at a concentration of 14.1 µg/kg. The distribution of the VOCs is presented in Figure 5-2. No specific distribution trends or areas of contamination were evident. Acetone, toluene, methylene chloride, and 2-butanone are SRCs in subsurface soil.

5.3.2 Soil Boring Sampling

Discrete subsurface soil samples were collected from nine monitoring well boreholes (SC-MII–SC-M19). The monitoring wells were installed along the perimeter of the old, inactive portion of the landfill (Figure 4-5). Two of the monitoring well boreholes (SC-MW15 and SC-MW16) are located outside the area previously used for landfill operations. Aerial photographs and historical information have never indicated that solid waste was disposed of east of GA 119/144. These sampling sites are separated from SWMU 1 by a major road (GA119/144) and are cross gradient to the groundwater flow direction of the old, inactive portion of SWMU 1 (Figures 4-5 and 4-6); therefore, it is unlikely that potential contaminants in groundwater from the old, inactive portion of SWMU 1 would migrate to these boreholes to potentially impact subsurface soil. Therefore, contaminants detected in these subsurface soil samples are probably not the result of potential contamination from SWMU 1.The samples were analyzed for VOCs, SVOCs, RCRA metals, pesticides/PCBs, and Radium 226/228. Table 5-4 summarizes analytical results for the discrete soil samples, and Figure 5-2 shows the distribution of VOCs, SVOCs, pesticides, and Radium 226/228 detected as well as RCRA metals detected above background.

VOCs. VOCs were detected in eight of the nine subsurface soil samples (SC-M11, SC-M12, SC-M13, SC-M14, SC-M15, SC-M16, SC-M17, and SC-M18). Acetone was detected in SC-M14, SC-M16, and SC-M17 at concentrations of 22 µg/kg, 638 µg/kg, and 25.4 µg/kg, respectively. Methylene chloride was detected at a concentration of 2.8 µg/kg at SC-M14. Styrene was detected at a concentration of 0.67 µg/kg in SC-M13. Toluene was detected at SC-M11, SC-M13, SC-M15, and SC-M19 at concentrations of 6.1 µg/kg , 0.39 µg/kg, and 0.36 µg/kg, respectively. The concentrations of acetone (638 µg/kg) and toluene (0.36 µg/kg) detected in SC-M16 and SC-M15, respectively, are not representative of constituent concentrations within the landfill. As discussed

Table 5-3. Summary of Analytical Results for Subsurface Soil from Geoprobe Samples, SWMU 1

Station	**Subsurface Soil Background Criteria**	**GP-1**	**GP-3**	**GP-5**	**GP-6**	**GP-8**	**GP-9**	**GP-10**
Sample ID		**011151**	**011351**	**011551**	**011651**	**011851**	**011951**	**011A51**
Date		**11/06/97**	**11/07/97**	**11/07/97**	**11/07/97**	**11/06/97**	**11/05/97**	**11/07/97**
Depth (feet)		**4–6**	**4–8**	**4–6**	**4–8**	**4–6**	**2–4**	**2–4**
Sample Type		**Grab**	**Grab**	**Grab**	**Grab**	**Grab**	**Grab**	**Grab**
Volatile Organic Compounds (mg/kg)								
2-Butanone	0.00							**14.1**
Acetone	0.00			**9.9**	**6.1**	**37.4**		**133**
Methylene Chloride	0.00	**1.6**						
Toluene	0.00	**0.32**						**2.2**

Blank = Not detected.

Bold indicates concentrations above FSMR reference background criteria.

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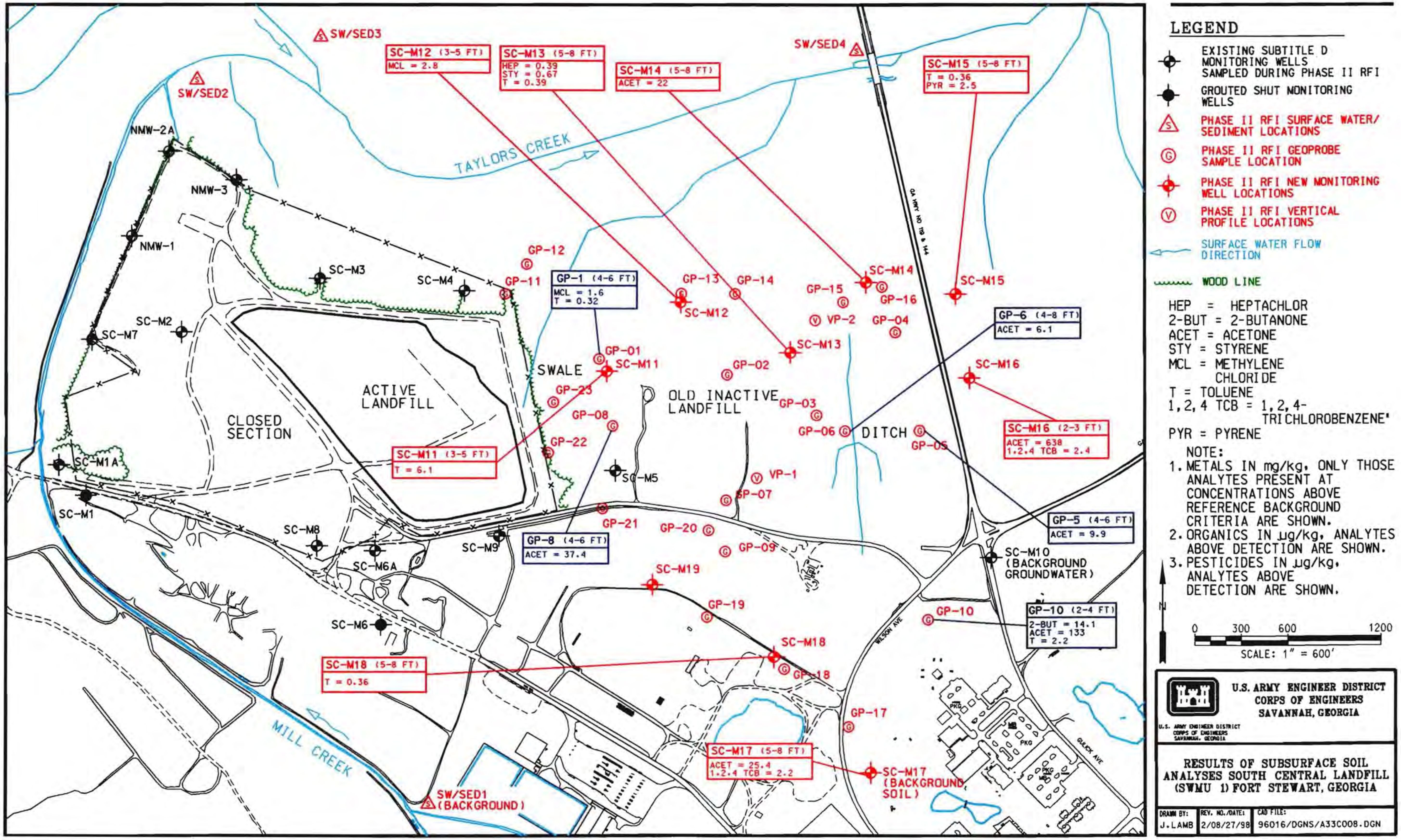

Figure 5-2. Results of Subsurface Soil Analyses

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Table 5-4. Summary of Analytical Results for Subsurface Soil from Monitoring Wells, SWMU 1

Station	Reference Background Criteria	SC-M11	SC-M12	SC-M13	SC-M14	SC-M15	SC-M16	SC-M17[a]	SC-M18	SC-M19
Sample ID		**011112**	**011212**	**011312**	**011412**	**011512**	**011612**	**011712**	**011812**	**011912**
Depth (feet)		**3–5**	**3–5**	**5–8**	**5–8**	**5–8**	**2–3**	**5–8**	**5–8**	**5–8**
Date Sampled		**11/16/97**	**11/15/97**	**11/16/97**	**11/16/97**	**11/15/97**	**11/15/97**	**11/16/97**	**11/16/97**	**11/16/97**
RCRA Metals (mg/kg)										
Barium	17.00	6.4	2.6	8	14.3	6.4	1.8	7.1	4.8	6.2
Cadmium	0.24				0.02					
Chromium	11.60		0.52	3.8	3.4	0.81		2.8	3.7	3.7
Lead	11.10	0.79	1.2	3.8	2.7	2.7	0.83	3.2	3	3.3
Mercury	0.05	0.01	0.02	0.03	0.01			0.01	0.01	0.03
Pesticides (µg/kg)										
Heptachlor	0.00			**0.39**						
Radionuclides (pCi/g)										
Radium 226	1.09	0.322			0.491	0.548		0.547	0.369	0.480
Radium 228	0.89	0.222			0.782	0.826		0.445	0.627	0.556
Volatile Organic Compounds (µg/kg)										
Acetone	0				**22**		**638**	**25.4**		
Methylene Chloride	0		**2.8**							
Styrene	0			**0.67**						
Toluene	0	**6.1**		**0.39**		**0.36**			**0.36**	
Semivolatile Organic Compounds (µg/kg)										
1,2,4-Trichlorobenzene	0						**2.4**	**2.2**		
Pyrene	0					**2.5**				

[a]Site Background Station.

Bold font indicates concentrations above FSMR reference background concentrations.

previously, these sampling locations are outside of SWMU 1. The presence of acetone in the sample may be the result of laboratory contamination, given that acetone is a common laboratory contaminant. Toluene is likely to come from a source other than SWMU 1 or to be a laboratory contaminant. Acetone, methylene chloride, styrene, and toluene are SRCs in subsurface soils.

SVOCs. 1,2,4-Trichlorobenzene and pyrene were detected in three subsurface soil samples. 1,2,4-Trichlorobenzene was detected in SC-M16 and SC-M17 at concentrations of 2.4 µg/kg and 2.2 µg/kg, respectively. Pyrene was detected at SC-M15 at a concentration of 2.5 µg/kg. The single detection of pyrene (2.5 µg/kg) at SC-M15 and the concentration of 1,2,4-trichlorobenzene (2.4 µg/kg) at SC-M16 are not likely to be the result of landfill operations at SWMU 1. Both of these locations are located east of GA119/144, which is outside the influence of potential SWMU 1 contaminants. Monitoring wells SC-M15 and SC-M16 are located side gradient to the old, inactive portion of SWMU 1 (Figures 4-5 and 4-6). 1,2,4-Trichlorobenzene and pyrene are considered SRCs in subsurface soil.

Pesticides/PCBs. Heptachlor was detected in one subsurface soil sample, SC-M12, at a concentration of 0.39 µg/kg and is an SRC in subsurface soil. No PCBs were detected in subsurface soil.

RCRA Metals. Barium, cadmium, chromium, lead, and mercury were detected in subsurface soil but below FSMR reference background criteria. Barium and lead were detected in all subsurface samples. Barium concentrations ranged from 1.8 mg/kg at SC-M16 to 14.3 mg/kg at SC-M14. Chromium was detected in seven of the nine samples. Chromium concentrations ranged from 0.35 mg/kg at SC-M16 to 3.8 mg/kg at SC-M13. Lead concentrations ranged from 0.83 mg/kg at SC-M16 to 3.8 mg/kg at SC-M13. Cadmium was detected at SC-M14 at a concentration of 0.04 mg/kg. Mercury was detected in seven of the nine samples. The mercury concentrations ranged from 0.01 mg/kg to 0.03 mg/kg. Barium, cadmium, chromium, lead and mercury were not detected above FSMR reference background criteria; therefore, they are not SRCs in subsurface soil.

Radium 226/228. Radium 226/228 were detected in six of the nine subsurface soil samples (SC M11, SC-M14, SC-M15, SC-M17, SC-M18, and SC-M19). Radium 226 concentrations ranged from 0.322 pCi/g in SC-M11 to 0.548 pCi/g in SC-M15. Radium 228 concentrations ranged from 0.222 mg/kg at SC-M11 to 0.826 at SC-M15. The Radium 226/228 concentrations were below the FSMR reference background concentrations in all samples; therefore, Radium 226/228 are not SRCs in subsurface soil.

5.4 GROUNDWATER CONTAMINATION

A total of 25 direct-push groundwater samples and 22 groundwater monitoring well samples (13 existing wells and 9 new wells) were collected. Direct-push groundwater samples were used to establish groundwater flow direction and extent of contamination for use in locating nine new permanent monitoring wells around the old, inactive landfill. The remaining 13 existing monitoring wells were installed under either the Phase I RFI or as part of the GMP at the South Central Landfill. Monitoring well samples are used to confirm the types and concentrations of contaminants present in groundwater and to assess risk to human health and the environment. The results of the groundwater analyses from both the direct-push probes and the Phase II monitoring wells are shown in Tables 5-5 and 5-6, respectively. Figures 5-3, 5-4, and 5-5 provide a comprehensive picture of contamination in groundwater at the site. This assessment presents Phase II contaminant data only.

Table 5-5. Summary of Analytical Results, VOCs in Groundwater in Geoprobe Samples, SWMU 1

Station			GP-1	GP-2	GP-3	GP-4	GP-5	GP-6	GP-7	GP-8	GP-9	GP-10
Sample ID			012151	012251	012351	012451	012551	012651	012751	012851	012951	012A51
Date	Reference		11/06/97	11/07/97	11/07/97	11/07/97	11/07/97	11/07/97	11/05/97	11/06/97	11/05/97	11/07/97
Depth (feet)	Background		7 to 12	7 to 12	8 to 13	1 to 6	7 to 12	8 to 13	7 to 12	7 to 12	3 to 8	0 to 0
Sample Type (µg/L)	Criteria	MCL	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
Volatile Organics Compounds µg/L												
1,2-*cis* -Dichloroethene	0	70		2.3					21			
1,2-*trans* -Dichloroethene	0	100							1.6			
Acetone	0	None			584							139
Benzene	0	5										0.23
Chlorobenzene	0	100										9.8
Chloroform	0	100[a]			0.51							
Ethylbenzene	0	700	0.22	26.9		2.1	2.5	6.9				1.3
Styrene	0	100										
Tetrachloroethene	0	5										
Toluene	0	1000	6.5						1.9		6.5	
Trichloroethene	0	5							*5.4*			
Xylenes, Total	0	10,000	0.85	212	1.9	17	24.2	66.6			0.95	11.9

Footnotes appear on page 5-19.

Table 5-5. Summary of Analytical Results, VOCs in Groundwater in Geoprobe Samples, SWMU 1 (continued)

Station			GP-11	GP-11	GP-12	GP-13	GP-14	GP-15	GP-16	GP-17	GP-18	GP-19	GP-20
Sample ID			012B51	012B61	012C51	012D51	012E51	012F51	012G51	012H51	012J51	012K51	012M51
Date	Reference		11/07/97	11/07/97	11/07/97	11/06/97	11/06/97	11/08/97	11/08/97	11/07/97	11/07/97	11/07/97	11/05/97
Depth (feet)	Background		1 to 6	1 to 6	1 to 6	1 to 6	2 to 7	1 to 2	1 to 3	0 to 0	0 to 0	0 to 0	0 to 0
Sample Type (µg/L)	Criteria	MCL	Grab	Field Dup	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
Volatile Organics Compounds µg/L													
1,2-*cis*-Dichloroethene	0	70											
1,2-*trans*-Dichloroethene	0	100											
Acetone	0	None		15.6					73.1		1140		
Benzene	0	5											
Chlorobenzene	0	100											
Chloroform	0	100[a]						22					
Ethylbenzene	0	700	1.3	2.3	0.4			0.41		1.6	15.2		
Styrene	0	100						0.29					
Tetrachloroethene	0	5											
Toluene	0	1000		0.19		17.8	1.5	3					2.2
Trichloroethene	0	5											
Xylenes, Total	0	10,000	12.8	22.1	3.8	0.43		2.7	1.2	12.5	115		

Footnotes appear on page 5-19.

Table 5-5. Summary of Analytical Results, VOCs in Groundwater in Geoprobe Samples, SWMU 1 (continued)

Station			**GP-21**	**GP-21**	**GP-22**	**GP-23**	**VP-1**	**VP-1**	**VP-1**	**VP-2**	**VP-2**	**VP-2**
Sample ID			**012N51**	**012N61**	**012P51**	**012S51**	**012T51**	**012T52**	**012T54**	**012U51**	**012U52**	**012U53**
Date	**Reference**		**11/06/97**	**11/06/97**	**11/06/97**	**11/06/97**	**11/18/97**	**11/18/97**	**11/13/97**	**11/17/97**	**11/17/97**	**11/18/97**
Depth (feet)	**Background**		**9 to 12**	**9 to 12**	**3 to 8**	**1 to 6**	**5 to 10**	**15 to 20**	**35 to 40**	**5 to 10**	**15 to 20**	**25 to 30**
Sample Type (µg/L)	**Criteria**	**MCL**	**Grab**	**Field Dup**	**Grab**	**Grab**	**Grab**	**Grab**	**Grab**	**Grab**	**Grab**	**Grab**
Volatile Organics Compounds µg/L												
1,2-*cis* -Dichloroethene	0	70						**3.2**	**1.4**			
1,2-*trans* -Dichloroethene	0	100										
Acetone	0	None					**16.2**			**24.5**	**37.5**	**31.3**
Benzene	0	5										
Chlorobenzene	0	100										
Chloroform	0	100[a]										
Ethylbenzene	0	700							**0.32**			
Styrene	0	100										
Tetrachloroethene	0	5									**0.36**	
Toluene	0	1000			**0.36**	**1.2**				**0.77**		
Trichloroethene	0	5						**0.55**			**0.35**	
Xylenes, Total	0	10,000										

[a] MCL is for total halogenated methanes.

Bold indicates concentrations above FSMR reference background criteria.

Bold outlined box with ***italized*** text indicates concentration above MCL.

Table 5-6. Summary of Analytical Results from Monitoring Well Groundwater Samples, SWMU 1

Station Sample ID Date Sample Type	Reference Background Criteria	MCL	NMW-1 012C11 12/14/97 Grab	NMW-2A 012D11 12/15/97 Grab	NMW-3 012E11 12/15/97 Grab	SC-M1A 012F11 12/11/97 Grab	SC-M2 012G11 12/10/97 Grab	SC-M3 012H11 12/14/97 Grab	SC-M4 012J11 12/10/97 Grab	SC-M5 012K11 12/14/97 Grab	SC-M6A 012M11 12/10/97 Grab	SC-M7 012N11 12/14/97 Grab	SC-M8 012P11 12/14/97 Grab
Volatile Organic Compounds (µg/L)													
1,1,2,2-Tetrachloroethane	ND	None				0.69							
1,1-Dichloroethane	ND	None										0.56	
1,2-Dichloropropane	ND	5										0.24	
1,2-*cis*-Dichloroethene	ND	70				0.84	0.46		1.1				
2-Butanone	ND	None											
Acetone	ND	None	97.5		151	15.1							
Benzene	ND	5							2.5				
Ethylbenzene	ND	700				0.3							
Toluene	ND	1000				0.27							
Xylenes, Total	ND	10,000				0.74							
Semivolatile Organic Compounds (µg/L)													
4-Methylphenol	ND	None											
Bis(2-ethylhexyl)phthalate	ND	6	0.53	*7.8*	4			3.7		4.3			
Diethyl Phthalate	ND	None				0.66	0.93	0.64	5.2	0.56			
Pesticides (µg/L)													
Delta-BHC	ND	None	0.04										
Dieldrin	ND	None			0.025								

Footnotes appear on page 5-23.

Table 5-6. Summary of Analytical Results from Monitoring Well Groundwater Samples, SWMU 1 (continued)

Station Sample ID Date Sample Type	Reference Background Criteria	MCL	SC-M9 012S11 12/10/97 Grab	SC-M10[a] 012T11 12/11/97 Grab	SC-M11 012111 12/13/97 Grab	SC-M12 012211 12/12/97 Grab	SC-M13 012311 12/13/97 Grab	SC-M14 012411 12/15/97 Grab	SC-M15 012511 12/31/97 Grab	SC-M16 012611 12/13/97 Grab	SC-M17 012711 12/14/97 Grab	SC-M18 012811 12/12/97 Grab	SC-M19 012911 12/12/97 Grab
Volatile Organic Compounds (µg/L)													
1,1,2,2-Tetrachloroethane	ND	None											
1,1-Dichloroethane	ND	None											
1,2-Dichloropropane	ND	5											
1,2-*cis*-Dichloroethene	ND	70				0.4	0.8						
2-Butanone	ND	None			8.6								
Acetone	ND	None											
Benzene	ND	5				0.32							
Ethylbenzene	ND	700											
Toluene	ND	1000											
Xylenes, Total	ND	10,000											
Semivolatile Organic Compounds (µg/L)													
4-Methylphenol	ND	None								1.1			
Bis(2-ethylhexyl)phthalate	ND	6	***61.4***			0.78		2.4					
Diethyl Phthalate	ND	None									0.56		
Pesticides (µg/L)													
Delta-BHC	ND	None											
Dieldrin	ND	None											

Footnotes appear on page 5-23.

Table 5-6. Summary of Analytical Results from Monitoring Well Groundwater Samples, SWMU 1 (continued)

Station			NMW-1	NMW-2A	NMW-3	SC-M1A	SC-M2	SC-M3	SC-M4	SC-M5	SC-M6A	SC-M7	SC-M8
Sample ID	Reference		012C11	012D11	012E11	012F11	012G11	012H11	012J11	012K11	012M11	012N11	012P11
Date	Background		12/14/97	12/15/97	12/15/97	12/11/97	12/10/97	12/14/97	12/10/97	12/14/97	12/10/97	12/14/97	12/14/97
Sample Type	Criteria	MCL	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
Metals and Inorganic Compounds (µg/L)													
Sulfate	5070	None	174	133	279	313	1850	2680	2910	**187,000**	**6600**	915	**15,200**
Arsenic	3.02	50		1.3	0.76			1.7					
Barium	71.72	2000	23.3	68.5	**101**	29.9	27	38.2	**114**	63.2	35.4	49.7	**73.8**
Cadmium	0.43	5								0.25			
Chromium	3.56	100				3	0.8		0.71		**7.9**		
Iron	4378	None	956	1250	1070	**10,700**	888	1110	3950	**22,000**	1080	1520	140
Lead	4.69	15	1.1		3.1	0.47	0.52	**4.9**	0.16	2.3	3.6		
Mercury	0.14	2											
Selenium	1.9	50				0.53					1.4		
Radionuclides (pCi/L)													
Radium 226	1.16	5[b]		0.501		0.823	**1.32**		**1.22**	***1.58***	0.830		0.786
Radium 228	3.42		**3.85**	2.21	2.44	2.69	2.31	2.68	1.42	***6.9***	1.78	2.69	1.78

Footnotes appear on page 5-23.

Table 5-6. Summary of Analytical Results from Monitoring Well Groundwater Samples, SWMU 1 (continued)

Station Sample ID Date Sample Type	Reference Background Criteria	MCL	SC-M9 012S11 12/10/97 Grab	SC-M10[a] 012T11 12/11/97 Grab	SC-M11 012111 12/13/97 Grab	SC-M12 012211 12/12/97 Grab	SC-M13 012311 12/13/97 Grab	SC-M14 012411 12/15/97 Grab	SC-M15 012511 12/31/97 Grab	SC-M16 012611 12/13/97 Grab	SC-M17 012711 12/14/97 Grab	SC-M18 012811 12/12/97 Grab	SC-M19 012911 12/12/97 Grab
Metals and Inorganic Compounds (μg/L)													
Sulfate	5070	None	**5670**	2000	**45,700**	**13,000**	**5480**	**16,200**	2750	**16,200**	684	1840	255
Arsenic	3.02	50				1.5		0.72			0.89		0.70
Barium	71.72	2000	23.4	38	**134**	23.4	45.5	32.6	38.5	51.9	43.3	20.9	**101**
Cadmium	0.43	5			**0.59**								
Chromium	3.56	100	1.2	**7.3**		**11.6**							**10.9**
Iron	4378	None	1240	3780	1680	**4650**	76.5	1400	1630	1920	**6200**	2490	1890
Lead	4.69	15	0.12	3.9	0.91	2.4		0.82	1.1	3	***18.4***	4.5	**11.3**
Mercury	0.14	2				0.04							0.07
Selenium	1.9	50											
Radionuclides (pCi/L)													
Radium 226	1.16	5[b]		0.581			0.631				**1.34**		***1.63***
Radium 228	3.42		1.85	1.71	**3.74**	3.17	2.77	2.96	1.33	**3.62**	2.5	3.35	***4.15***

[a] Site-specific background location.

[b] MCL is for the total Radium 226 and Radium 228 concentration.

Blank = Nondetect.

MCL = Maximum contaminant level.

NA = Not analyzed.

Bold indicates concentration detected above FSMR reference background.

Bold outlined box with ***italized*** text indicates concentration above MCL.

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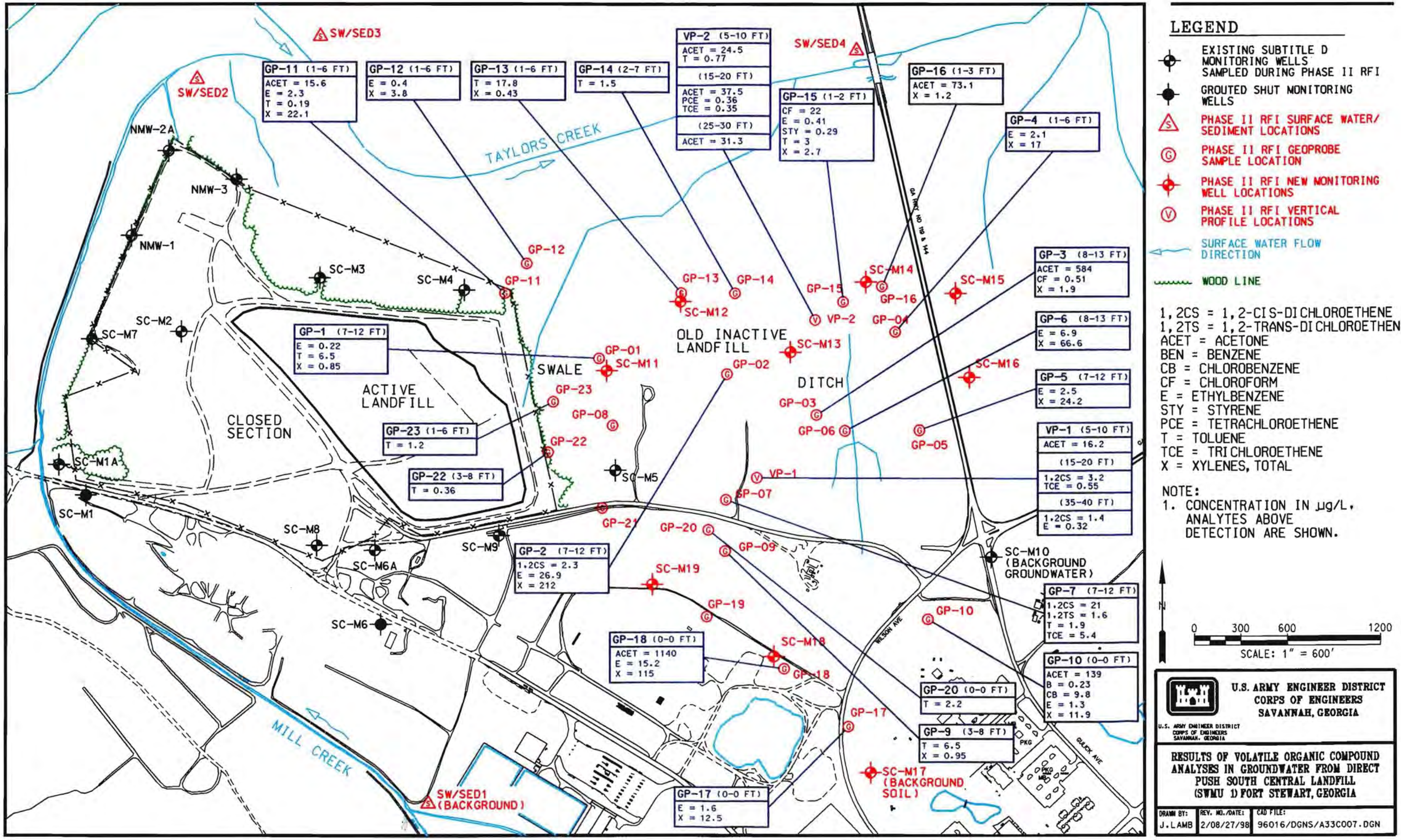

Figure 5-3. Results of VOC Analyses in Groundwater from Direct Push

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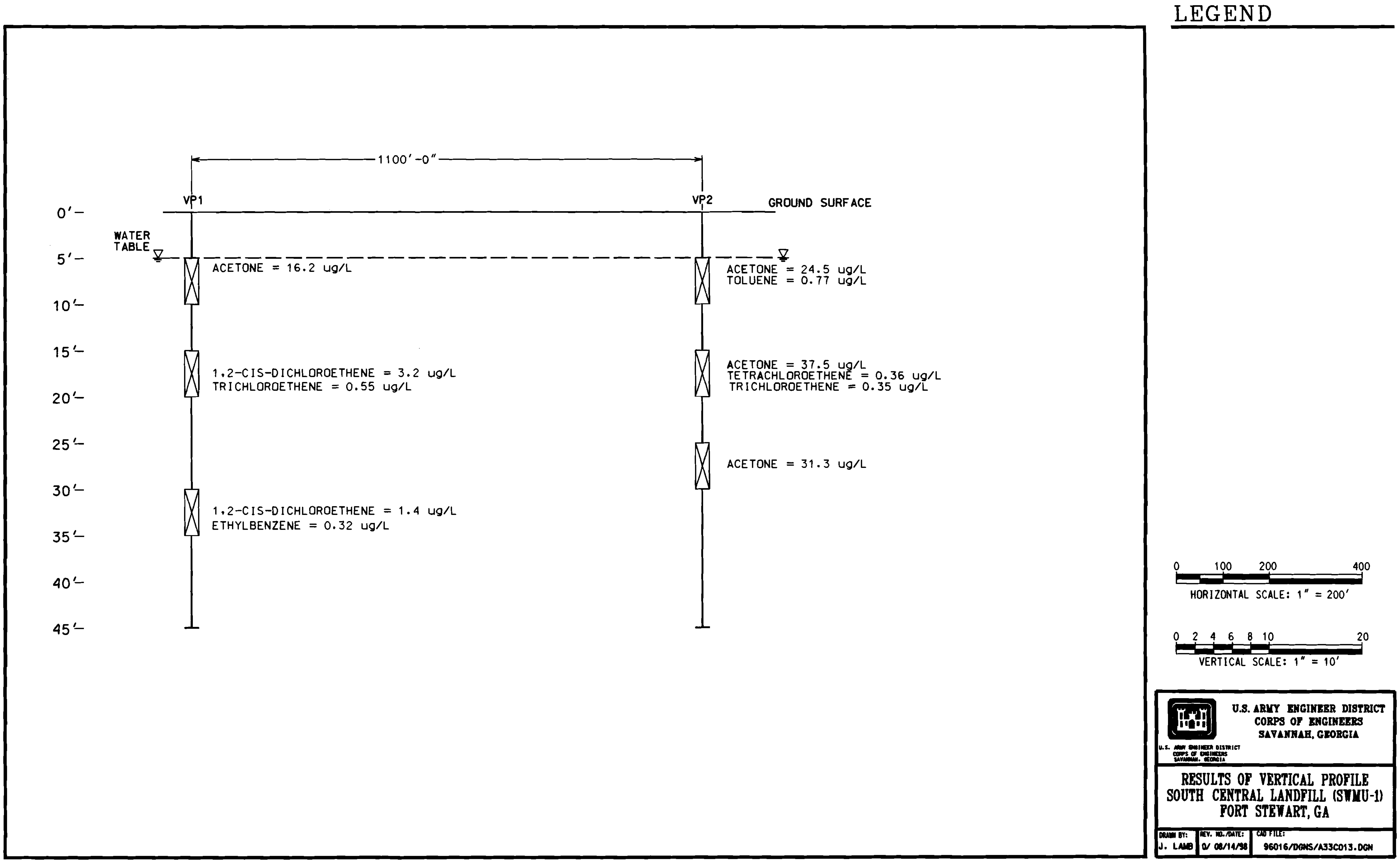

Figure 5-4. Results of Vertical Profile of Detected VOC Contaminants in Groundwater

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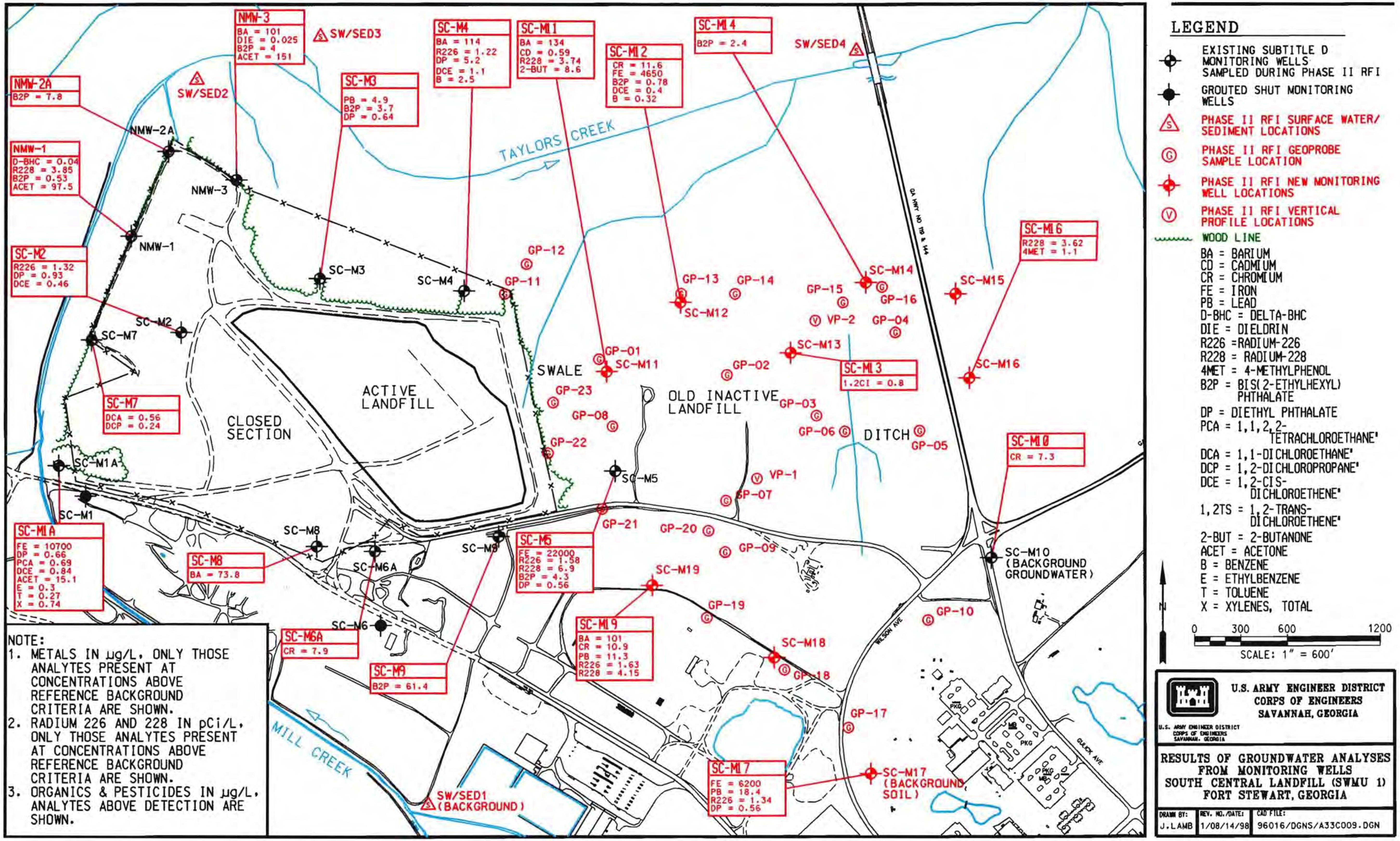

NOTE:
1. METALS IN µg/L, ONLY THOSE ANALYTES PRESENT AT CONCENTRATIONS ABOVE REFERENCE BACKGROUND CRITERIA ARE SHOWN.
2. RADIUM 226 AND 228 IN pCi/L, ONLY THOSE ANALYTES PRESENT AT CONCENTRATIONS ABOVE REFERENCE BACKGROUND CRITERIA ARE SHOWN.
3. ORGANICS & PESTICIDES IN µg/L, ANALYTES ABOVE DETECTION ARE SHOWN.

LEGEND

⊕ EXISTING SUBTITLE D MONITORING WELLS SAMPLED DURING PHASE II RFI
● GROUTED SHUT MONITORING WELLS
△ PHASE II RFI SURFACE WATER/ SEDIMENT LOCATIONS
Ⓖ PHASE II RFI GEOPROBE SAMPLE LOCATION
⊕ PHASE II RFI NEW MONITORING WELL LOCATIONS
Ⓥ PHASE II RFI VERTICAL PROFILE LOCATIONS
〰 WOOD LINE

BA = BARIUM
CD = CADMIUM
CR = CHROMIUM
FE = IRON
PB = LEAD
D-BHC = DELTA-BHC
DIE = DIELDRIN
R226 =RADIUM-226
R228 = RADIUM-228
4MET = 4-METHYLPHENOL
B2P = BIS(2-ETHYLHEXYL) PHTHALATE
DP = DIETHYL PHTHALATE
PCA = 1,1,2,2-TETRACHLOROETHANE'
DCA = 1,1-DICHLOROETHANE'
DCP = 1,2-DICHLOROPROPANE'
DCE = 1,2-CIS-DICHLOROETHENE'
1,2TS = 1,2-TRANS-DICHLOROETHENE'
2-BUT = 2-BUTANONE
ACET = ACETONE
B = BENZENE
E = ETHYLBENZENE
T = TOLUENE
X = XYLENES, TOTAL

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RESULTS OF GROUNDWATER ANALYSES
FROM MONITORING WELLS
SOUTH CENTRAL LANDFILL (SWMU 1)
FORT STEWART, GEORGIA

DRAWN BY:	REV. NO./DATE:	CAD FILE:
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Figure 5-5. Results of Groundwater Analyses from Monitoring Wells

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5.4.1 Direct-Push Groundwater Sampling Results

The direct-push groundwater samples were collected from a total of 25 direct-push probe stations. This total included 10 within the boundary of the old, inactive landfill, 13 around the perimeter of the old, inactive landfill, and 2 vertical profiles, one within the boundary of the old, inactive landfill and one north (downgradient) of the old, inactive landfill (Figure 3-1). The samples were analyzed for VOCs only. The direct-push groundwater sampling focused on the extent of VOC contamination, the primary indicator of groundwater contamination at the site.

VOCs. Twelve individual VOCs were reported above the detection limit in direct-push groundwater samples and are considered SRCs in groundwater. Of these 12, 5 were detected only once in a single sample out of 29 samples. Figure 5-3 presents the distribution of VOCs in groundwater from direct-push locations. Figure 5-4 presents the vertical distribution of detected VOC contaminants in groundwater. Only one sample (GP-7) detected a VOC (trichloroethene) above its respective MCL of 5 µg/L, with a detected concentration of 5.4 µg/L.

- 1,2-*cis*-Dichloroethene was detected in four samples: GP-2, GP-7, VP-1 between 15 and 20 feet, and VP-1 between 35 and 40 feet. 1,2-*cis*-Dichloroethene concentrations ranged from 1.4 µg/L at VP-1 (35 to 40 feet) to 21 µg/L at GP-7; however none of the detections exceeded the MCL of 70 µg/L.

- Acetone was indicated in 9 out of 29 groundwater samples. The acetone concentrations ranged from 15.6 µg/L at GP-11 to 1140 µg/L at GP-18. Three of the acetone detections were measured, with the three depths at VP-2 (24.5 µg/L, 37.5 µg/L, and 31.3 µg/L).

- Chloroform was indicated at stations GP-3 and GP-15 at concentrations of 0.51 µg/L and 22 µg/L, respectively.

- Ethylbenzene was indicated in 13 out of 29 groundwater samples. The ethylbenzene concentrations ranged from 0.22 µg/L in GP-1 to 15.2 µg/L in GP-18.

- Toluene was indicated in 12 of the 29 groundwater samples. The toluene concentrations ranged from 0.19 µg/L at GP-11 to 17.8 µg/L in GP-13.

- Trichloroethene was detected in three samples, GP-7, VP-1 (15 to 20 feet), and VP-2 (15 to 20 feet) at concentrations of 5.4 µg/L, 0.55 µg/L, and 0.35 µg/L. Trichloroethene exceeded the MCL of 5 µg/L at GP-7.

- Xylenes were detected in 16 of 29 groundwater samples. The xylene concentration ranged from 0.43 µg/L in GP-13 to 212 µg/L in GP-2.

- 1,2-*trans*-Dichlorethene, benzene, chlorobenzene, styrene, and tetrachloroethene were indicated in a single groundwater sample out of 29 samples at concentrations of 1.6 µg/L, 0.23 µg/L, 9.8 µg/L, 0.29 µg/L, 0.29 µg/L, and 0.36 µg/L, respectively.

The VOC results of the vertical samples were included in the discussion above. Vertically, the extent of contamination was investigated using results from two vertical-profile push probes (VP-1 and VP-2). VP-1 was located within the boundary of the old, inactive landfill, while VP-2 was located downgradient and outside the perimeter of the old, inactive landfill (Figure 3-1). Results for VOC analyses in groundwater from the vertical profile samples are included on Figure 5-3. Figure 5-4 presents the vertical distribution of detected VOCs at VP-1 and VP-2. The vertical profiles indicate that the concentrations of VOCs are low and below MCLs from the water table (approximately 10 feet) to a depth of approximately 40 feet bgs (refusal), indicating that potential contamination from the buried material has not migrated into the saturated zone.

5.4.2 Groundwater Monitoring Well Sampling Results

Groundwater contamination was evaluated using the results from water samples taken from 22 permanent monitoring wells (13 existing wells and 9 installed during the Phase II fieldwork at the site). These samples were analyzed for VOCs, SVOCs, RCRA metals, pesticides/PCBs, Radium 226/228, and other natural attenuation parameters (iron and sulfate). Both filtered and unfiltered water samples were collected; only the total metal analysis on unfiltered water samples is presented in this section. Table 5-6 summarizes the analytical results for groundwater samples from monitoring wells. Figure 5-5 shows the distribution of VOCs, SVOCs, pesticides, and Radium 226/228 detected as well as RCRA metals detected above FSMR reference background and MCLs at the South Central Landfill site. This assessment presents Phase II contaminant data only.

VOCs. Ten individual VOCs were reported above the detection limit in groundwater samples from monitoring wells. Although detected, none of the concentrations were above MCLs.

- Benzene was detected at a concentration of 2.5 µg/L in SC-M4 and 0.32 µg/L in SC-M12.
- Toluene, ethylbenzene, xylenes, and 1,1,2,2-tetrachloroethane were detected at SC-M1A at a concentration of 0.27 µg/L, 0.3 µg/L, 0.74 µg/L, and 0.69 µg/L, respectively.
- 2-Butanone was detected at a concentration of 8.6 µg/L in SC-M11.
- Acetone was detected in 3 of 22 groundwater samples at a concentration ranging from 15.1 µg/L at SC-M1A to 151 µg/L at NMW-3.
- 1,2-*cis*-Dichlorethene was detected in five samples, with concentrations ranging from 0.4 µg/L at SC-M12 to 1.1 µg/L at SC-M4.
- 1,1-Dichloroethane and 1,2-dichloropropane were detected in SC-M9 at concentrations of 0.56 µg/L and 0.24 µg/L, respectively.

Site background concentrations for these constituents were nondetect, therefore, these chemicals are considered SRCs. The distribution of these VOCs is shown in Figure 5-5. The concentrations of VOCs in groundwater were low and variable across the site, with no clearly evident trends.

SVOCs. Three SVOCs were detected in 13 of 22 groundwater samples.

- 4-Methylphenol was detected at a concentration of 1.1 µg/L in SC-M16, which is upgradient of SWMU 1. Aerial photographs and historical information have never indicated that solid waste was disposed of east of GA/119/114.
- Bis(2-ethylhexyl)phthalate was detected in eight groundwater samples. The bis(2-ethylhexyl)phthalate concentrations ranged from 0.53 µg/L in NMW-1 to 61.4 µg/L in SC-M9. Bis(2-ethylhexyl)phthalate was detected above its MCL (6 µg/L) in two (NMW-2A and

SC-M9) of the eight groundwater samples at concentrations of 7.8 µg/L and 61.4 µg/L, respectively.

- Diethyl phthalate was detected in six groundwater samples. The diethyl phthalate concentrations ranged from 0.56 µg/L at SC-M5 and SC-M17 to 5.2 µg/L at SC-M4.

Site background concentrations for these constituents were nondetect; therefore, bis(2-ethylhexyl)phthalate, 4-methylphenol, and diethyl phthalate are considered SRCs in groundwater.

Pesticides/PCBs. Pesticides were detected in 2 of the 22 groundwater samples. The concentration of delta-BHC was 0.04 µg/L in NMW-1 and 0.025 µg/L in NMW-3. No PCBs were detected in the groundwater.

RCRA Metals. Arsenic, barium, cadmium, chromium, iron, lead, mercury, and selenium were detected in groundwater from the monitoring wells.

- Barium was detected in all groundwater samples at concentrations ranging from 20.9 µg/L at SC-M18 to 134 µg/L at SC-M11. Five of the detected barium concentrations (NMW-3, SC-M4, SC-M8, SC-M11, and SC-M19) were above the FSMR reference background.

- Chromium was detected in 8 of 22 groundwater samples at concentrations ranging from 0.71 µg/L at SC-M4 to 11.6 µg/L at SC-M12. Four of the detected chromium concentrations (SC-M6A, SC-M10, SC-M12, and SC-M19) were above the FSMR reference background.

- Iron was detected in all groundwater samples at concentrations ranging from 76.5 µg/L at SC-M13 to 22,000 µg/L at SC-M5. Overall, the iron concentrations and their distribution were consistent with iron data taken during the September 1997 compliance monitoring (Table A-2, Appendix A).

- Lead was detected in 18 of 22 groundwater samples at concentrations ranging from 0.12 µg/L at SC-M9 to 18.4 µg/L at SC-M17. Three of the detected lead concentrations (SC-M3, SC-M17, and SC-M19) were above the FSMR reference background. Lead was detected above its MCL (15 µg/L) at SC-M17. SC-M17 was one of five monitoring wells in which analysis for filtered metals as well as for total metals was performed. The filtered lead concentration at SC-M17 was nondetect. As discussed in Section 3.2, this value is approximately 36 times the filtered value. This high total value versus filtered may reflect lead in colloid particulates rather than in the groundwater.

- Arsenic was detected in 7 of 22 groundwater samples with concentrations ranging from 0.70 µg/L at SC-M19 to 1.7 µg/L at SC-M3.

- Cadmium was detected at SC-M5 and SC-M11 at concentrations of 0.25 µg/L and 0.59 µg/L, respectively. The cadmium concentration measured at SC-M11 was above FSMR reference background.

- Mercury was detected at SC-M12 and SC-M19 at concentrations of 0.04 µg/L and 0.07 µg/L, respectively.

- Selenium was detected at SC-M1A and SC-M6A at concentrations of 0.53 µg/L and 1.4 µg/L, respectively.

Metal concentrations detected above FSMR site reference background are presented in Figure 5-5. Only one metal was detected above its MCL, lead at 18.4 µg/L in SC-M17. Barium, cadmium, chromium, iron, and lead were detected above their respective FSMR reference background concentrations and are SRCs in groundwater.

Radium 226/228. Radium 226 was detected in 11 of 22 groundwater samples. The Radium 226 concentrations ranged from 0.501 pCi/L at NMW-2A to 1.63 pCi/L at SC-M19. Radium 226 was above the FSMR site reference background concentration (1.16 pCi/L) in 5 (SC-M2, SC-M4, SC-M5, SC-M17, and SC-M19) of these 11 samples. Radium 228 was detected in all of the 22 groundwater samples. The Radium 228 concentrations ranged from 1.33 pCi/g at SC-M15 to 6.9 pCi/L at SC-M5. Radium 228 was detected above the FSMR site reference background concentration The Radium 228 (3.62 pCi/L) detected in the groundwater at SC-M16 may be the result of the natural concentration of Radium 228 in the area because SC-M16 is side gradient of the old, inactive portion of SWMU 1. Aerial photographs and historical information have never indicated that solid waste was disposed of east of GA119/144. (3.42 pCi/L) in 5 (NMW-1, SC-M5, SC-M1, SC-M16, and SC-M19) of the 22 groundwater samples. The combined Radium 226/228 concentrations at SC-M5 and SC-M19 were 8.58 pCi/L and 5.78 pCi/L, respectively, which exceeded its MCL of 5 pCi/L (Table 5-6). A distribution of Radium 226/228 is presented in Figure 5-5. Radium 226/228 are SRCs in groundwater.

Other Analytes. Other geochemical parameters, including ferric iron and sulfate, were analyzed to assist in geochemical evaluation of contaminant fate and transport. Sulfate ranged from 133 mg/L in NMW-24 to 187,000 mg/L in SC-M5. Field parameter measurements performed during groundwater sampling from monitoring wells and direct-push stations included pH, conductivity, temperature, turbidity, dissolved oxygen, and Eh. In addition, ferric iron was performed during groundwater sampling at monitoring wells. The field measurements taken during groundwater sampling of direct-push stations and monitoring wells are presented in Tables 3-1 and 3-4, respectively.

Typically, low pH, negative Eh, low dissolved oxygen concentrations, and high conductivity are characteristics of leachate from buried material impacting groundwater. Eh ranged from -86.5 at GP-20 to 458 in SC-M8. Ten out of 39 Eh groundwater measurements were negative, indicating reducing conditions. The pH of the groundwater ranged from 3.58 at GP-23 to 7.32 at SC-M15.

Ferric iron ranged from 0.2 mg/L at SC-M3 to 3.2 mg/L at SC-M4. Conductivity ranged from 23 uS/cm at SC-M19 to 1205 uS/cm at VP-1(5- to 10-foot interval). Figure 5-6 presents the distribution of pH, conductivity, dissolved oxygen, and Eh. No specific areas of reducing conditions are evident in Figure 5-6 that would be characteristic of significant leachate impacting groundwater. In addition, in most instances the negative Eh data point is associated with a positive or elevated dissolved oxygen concentration (e.g., SC-M7, GP-9, and GP-2). Typically, negative Eh readings and low to zero dissolved oxygen concentrations are associated. Many areas around the landfill are swampy/marshy, and heavy rainfall had occurred during the field investigation, potentially causing areas of anoxic conditions. Figure 5-6 shows that leachate is not presently impacting the groundwater. In addition, because disposal in the old, inactive landfill was discontinued approximately 30 years ago, its primary leachate-producing period has likely expired.

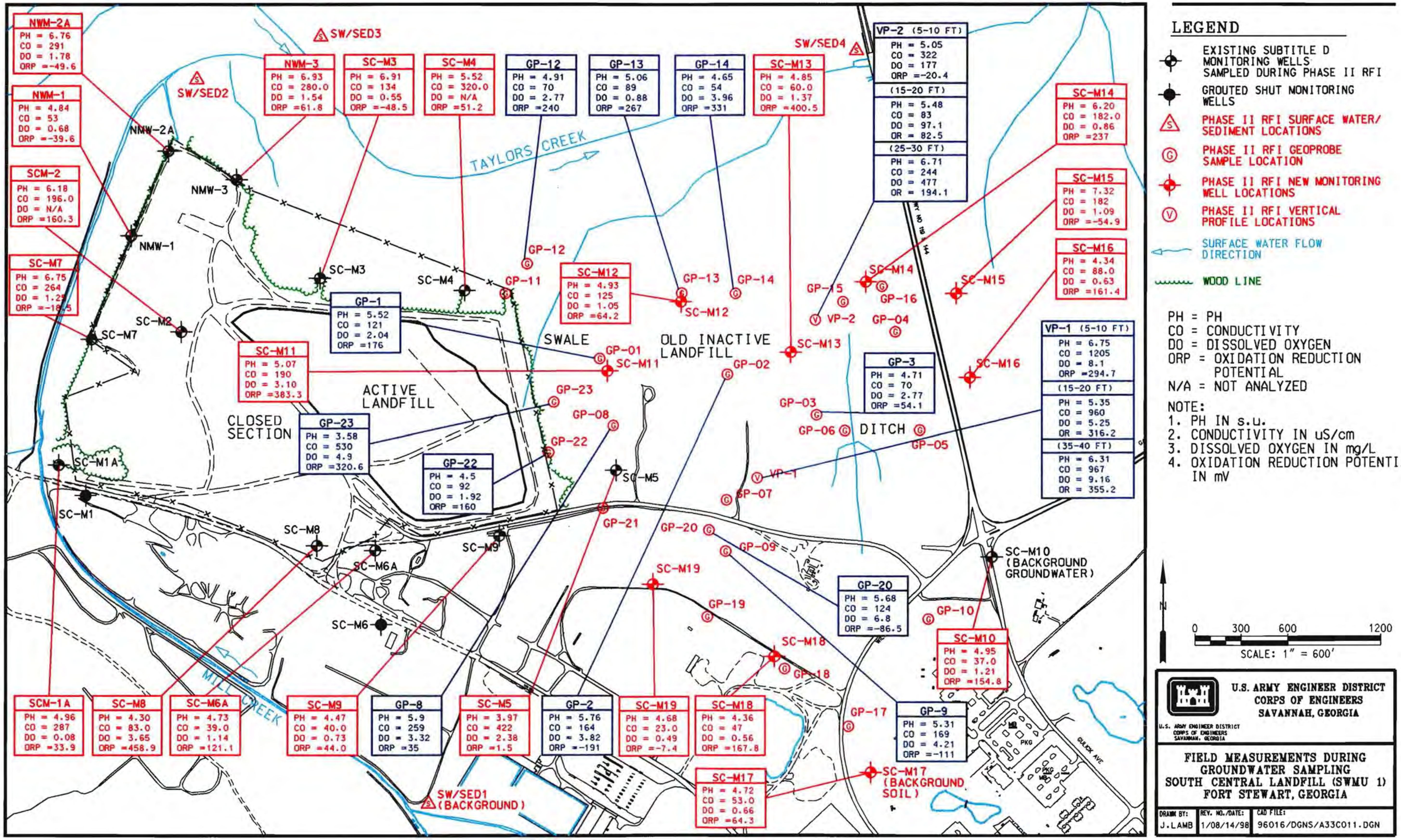

Figure 5-6. Field Measurements During Groundwater Sampling

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5.5 SURFACE WATER SAMPLING RESULTS

Four surface water samples, including one background sample, were collected and analyzed for VOCs, SVOCs, RCRA metals, pesticides/PCBs, and Radium 226/228. Table 5-7 summarizes the analytical results for surface water samples, and Figure 5-7 shows their distribution of detected analytes.

VOCs. No VOCs were detected in surface water at SWMU 1.

SVOCs. Pyrene was detected in SW/SED-1 at a concentration of 0.1 µg/L. Di-n-butyl phthalate was detected in SW/SED-1, the site-specific background station, at a concentration of 0.69 µg/L. Diethyl phthalate was detected in SW/SED-2 at a concentration of 0.86 µg/L. Pyrene and diethyl phthalate are SRCs in surface water.

Pesticides/PCBs. No pesticides or PCBs were detected in the surface water at SWMU 1.

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Pesticides/PCBs. No pesticides or PCBs were detected in the surface water at SWMU 1.

RCRA Metals. Barium, cadmium, and lead were detected in the surface water (including at the background station, SW/SED-1) at SWMU 1 but below site-specific background criteria (Table 5-7). The barium concentration at SW/SED-1, the site background station, was the maximum concentration measured at 30.4 µg/L. Lead was detected in all surface water samples at concentrations ranging from 1.2 µg/L at SW/SED-3 to 1.8 µg/L at SW/SED-2. Cadmium was detected at SW/SED-2 at a concentration of 0.32 µg/L, essentially the concentration measured at (0.31 mg/L) the site background location. Downstream cadmium and lead concentrations were essentially equal to the concentration measured at the site background location (SW/SED1). Barium, cadmium, and lead were detected below site-specific background criteria; therefore, they are not SRCs.

Radium 226/228. Radium 228 was detected at SW/SED-2, SW/SED-3, and SW/SED-4 above the site-specific background concentration (0.754 µg/L). The concentrations ranged from 2.7 pCi/L at SW/SED-3 to 3.97 pCi/L at SW/SED-4. Radium 228 is an SRC in surface water.

5.6 SEDIMENT SAMPLING RESULTS

Four sediment samples were collected at the same locations as surface water samples and were analyzed for VOCs, SVOCs, RCRA metals, pesticides/PCBs, and Radium 226/228. Table 5-7 summarizes the analytical results for sediment samples, and Figure 5-7 shows their distribution.

Table 5-7. Summary of Analytical Results for Surface Water and Sediment Samples, SWMU 1

Surface Water Results

Station	Site-specific Background Criteria	SW/SED-1	SW/SED-2	SW/SED-3	SW/SED-3	SW/SED-4
Sample ID		013111	013211	013311	013321	013411
Date		11/15/97	11/15/97	11/15/97	11/15/97	11/14/97
Sample Type		Grab[a]	Grab	Grab	Field Dup	Grab
RCRA Metals (µg/L)						
Barium	60.8	30.4	25.6	15.9	15.9	15.6
Cadmium	0.62	0.31	0.32			
Lead	3.4	1.7	1.8	1.2	1.3	1.6
Radionuclides (pCi/L)						
Radium 228	0.754	0.377	**3.76**	**3.69**	**2.7**	**3.97**
Semivolatile Organics (µg/L)						
Di-n-butyl Phthalate	0.00	**0.69**		NA		
Diethyl Phthalate	0.00		**0.86**	NA		
Pyrene	0.00			NA	**0.100**	
Field Parameters						
pH		5.35	5.41	5.01		5.09
Conductivity (µS/cm)		51	64	65		58
Temperature (°C)		9.50	13.00	13.85		16.01
Turbidity (NTU)		12.7				
DO (mg/L)		7.50	6.5	8.05		6.74
Eh (mv)		241.9	253	204		270.7

Sediment Results

Station	Site-specific Background Criteria	SW/SED-1	SW/SED-1	SW/SED-2	SW/SED-3	SW/SED-4
Sample ID		015111	015121	015211	015311	015411
Date		11/15/97	11/15/97	11/15/97	11/15/97	11/14/97
Sample Type		Grab[a]	Field Dup	Grab	Grab	Grab
RCRA Metals (mg/kg)						
Arsenic	0.4	0.2	NA			
Barium	11.4	5.7	NA	8.1		4.1
Cadmium	0.12	0.06	NA			
Chromium	2.4	1.2	NA	1.5	**3.5**	**2.5**
Lead	3.2	1.6	NA		**6**	3.2
Mercury	0.01			**0.02**		
Radionuclides (pCi/g)						
Radium 226	1.014	0.507	0.510	0.554	0.836	0.338
Radium 228	0.754	0.377		**1.04**	**1.29**	0.425
Volatile Organics (µg/kg)						
2-Butanone	0.00				**14.5**	
Acetone	0.00	**218**	**297**	**20.2**	**0.132**	
Semivolatile Organics (µg/kg)						
1,2,4-Trichlorobenzene	0.00					**3.4**

[a] Background Reference.
DO = Dissolved oxygen.
Dup = Duplicate.
Eh = Oxidation-reduction potential.
NA = Not analyzed.
NTU = Nephelometric turbidity unit.
RCRA = Resource Conservation and Recovery Act.
Bold indicates concentrations greater than reference background.

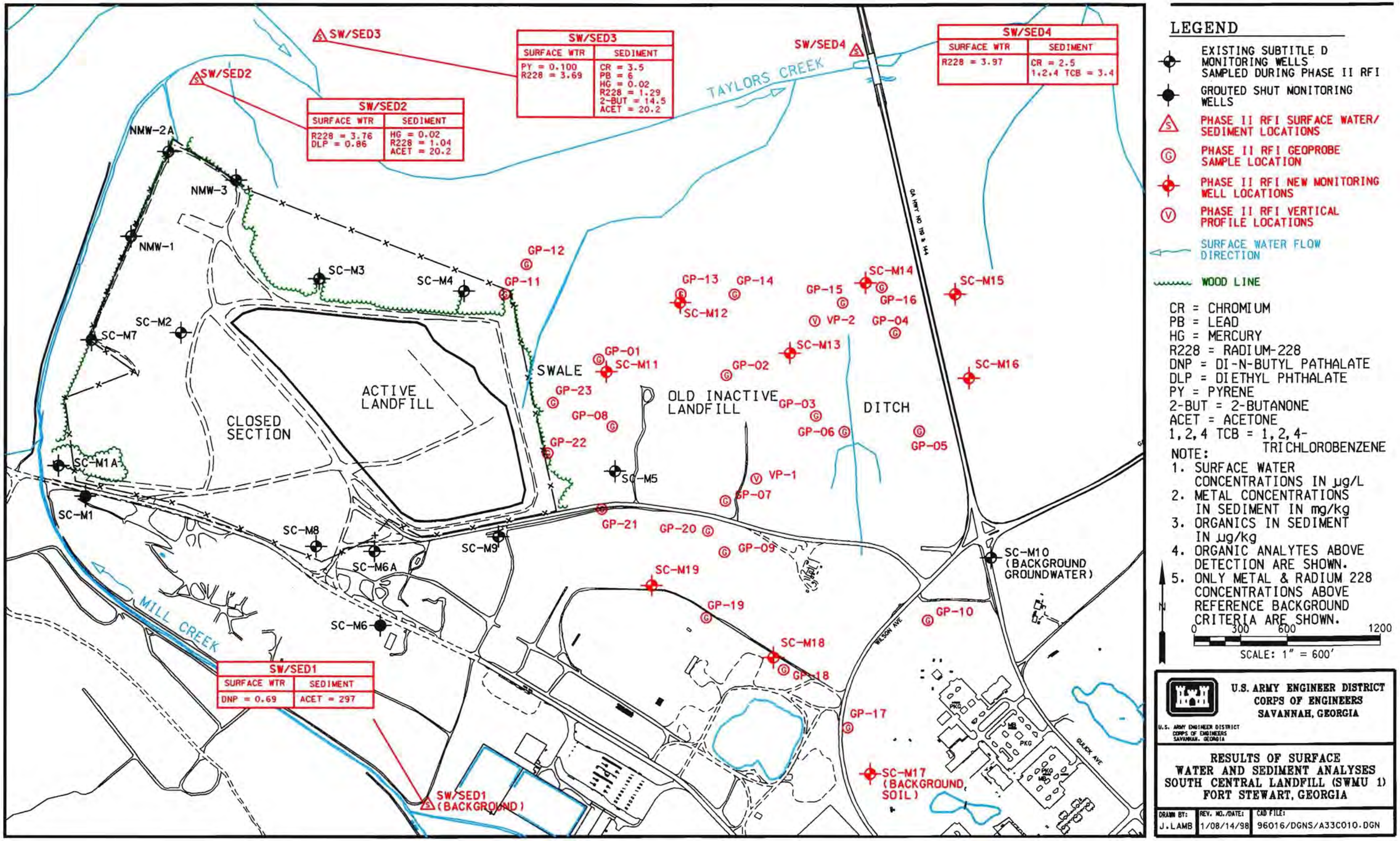

Figure 5-7. Results of Surface Water and Sediment Analyses

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VOCs. 2-Butanone and acetone were detected in the sediment above site-specific background criteria. 2-Butanone was detected at a concentration of 14.5 µg/Kg in SW/SED-3. Acetone was detected in three of five sediment samples. The concentrations of acetone ranged from 20.2 µg/L at SW/SED-3 to 297 µg/kg at SW/SED-1 (field duplicate). 2-Butanone and acetone are SRCs in sediment.

SVOCs. Only one SVOC, 1,2,4-trichlorobenzene, was detected in the sediment at one sample location. The concentration at SW/SED-4 was 3.4 µg/kg. 1,2,4-Trichlorobenzene is an SRC in sediment.

RCRA Metals. Arsenic, barium, cadmium, chromium, lead, and mercury were detected in the sediment.

- Arsenic was detected in SW/SED-1, the site-specific background station, at a concentration of 0.2 mg/kg.
- Barium was detected in three of three sediment samples, including that from the site-specific background station. The barium concentrations ranged from 4.1 mg/kg at SW/SED-4 to 8.1 mg/kg at SW/SED-3. SW/SED-1, the site-specific background station, had a barium concentration of 5.7 mg/kg.
- Cadmium was detected at a concentration of 0.06 mg/kg in SW/SED-1, the site background location.
- Chromium was detected in all the sediment samples. The chromium concentrations ranged from 1.2 mg/kg in SW/SED-1 to 3.5 mg/kg in SW/SED-3. Two of the detected chromium concentrations (SW/SED-3 and SW/SED-4) were above the site-specific background concentrations.
- Lead was detected in all the sediment samples and above its site-specific background concentration at one location (SW/SED-3). The concentrations ranged from 1.6 mg/kg in SW/SED-1 to 6 mg/kg in SW/SED-3.
- Mercury was detected slightly above the site-specific reference background concentration (0.01 mg/kg) at a concentration of 0.02 mg/kg at SW/SED-3.

Chromium, lead and mercury were detected above site reference background criteria and are SRCs in sediment.

Radium 226/228. Radium 226/228 were detected in the sediment samples including those from the site-specific background station, SW/SED-1. The concentrations of Radium 226 ranged from 0.507 pCi/g in SW/SED-1 to 0.836 pCi/g in SW/SED-3. The concentrations of Radium 228 ranged from 0.377 pCi/g at SW/SED-1 to 1.29 pCi/g in SW/SED-3. Radium 228 was detected above the site reference background criteria and is an SRC in sediment.

5.7 SUMMARY AND CONCLUSIONS OF THE NATURE AND EXTENT OF CONTAMINATION

The following section summarizes the significant findings of the Phase II RFI sampling and analysis.

Low levels of organic constituents (VOCs, SVOCs, and pesticides) and metals are present in soil; however no clear distribution or trends of constituents are evident.

- Isolated, low concentrations of acetone, methylene chloride, toluene, and 1,2,4-trichlorobenzene were detected in surface soil above reference background criteria.

- 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT were detected in two surface soil samples, SC-M13 and SC-M18.

- Selenium was detected in surface soil above FSMR reference background in a single soil sample. Selenium concentrations in surface soil were not above FSMR reference background concentrations for subsurface soil.

- Isolated, low concentrations of 1,2,4-trichlorobenzene, pyrene, heptachlor, 2-butanone, acetone, methylene chloride, styrene, and toluene were detected in subsurface soil above reference background criteria.

The groundwater flow at the site is essentially directed to the north toward Mill and Taylors creeks, with a slight groundwater divide near the southern part of SWMU 1 at the old, inactive landfill. Flow at the southern boundary may be directed to the southwest toward Mill Creek.

Low levels of VOCs, SVOCs, metals, and Radium 226/228 are present in the surficial aquifer; however, no clear distribution or trends of contaminants are evident.

- Trichloroethene and bis(2-ethylhexyl)phthalate were each detected in a single groundwater sample above their respective MCLs (direct-push sample VP-2 and monitoring well SC-M9, respectively).

- Metals were detected in groundwater, with only one sample detected above MCLs. Lead was detected at 18.4, µg/L at monitoring well SC-M17 (MCL 15 µg/L). However, the filtered lead concentration at SC-M17 was nondetect, indicating the lead may be associated with colloid particulates in the groundwater. Barium, cadmium, chromium, iron, and lead were detected above FSMR reference background concentrations. Iron concentrations were consistent with iron data collected under compliance monitoring.

- Low levels of Radium 226/228 were detected in the groundwater. Radium 228 was above its MCL in one groundwater sample at SC-M5.

- The groundwater field sampling data do not indicate that leachate is impacting the groundwater.

Low levels of organics, metals, and Radium 228 were detected in sediment and surface water.

- Chromium, lead, mercury, and Radium 228 were detected in sediment above site-specific background criteria.

- Two VOCs (acetone and 2-butanone) and one SVOC (1,2,4-trichlorobenzene) were detected in sediment samples above site-specific background criteria (nondetect), respectively.
- No metals were detected in surface water above the site-specific background criteria.
- Diethyl phthathate and pyrene were detected in surface water in one of three samples above site-specific background criteria.
- Radium 228 was detected in three of three surface water samples above the site-specific background criterion.

A summary of the SRCs by medium and the maximum concentration detected is presented in Table 5-8.

Table 5-8. Summary of Site-Related Contaminants, SWMU 1

Analyte	**Maximum Concentration**			**Maximum Concentration**	
	Surface Soil	**Subsurface Soil**	**Sediment**	**Groundwater**	**Surface Water**
Volatile Organic Compounds					
	µg/kg			*µg/L*	
1,1,2,2-Tetrachloroethane				0.69	
1,1-Dichloroethane				0.56	
1,2-Dichloropropane				0.24	
1,2-*cis*-Dichloroethene				21	
1,2-*trans*-Dichloroethene				1.6	
2-Butanone		14.1	14.5	8.6	
Acetone	44100	638	297	1140	
Benzene				2.5	
Chlorobenzene				9.8	
Chloroform				22	
Ethylbenzene				26.9	
Methylene Chloride	52.2	2.8			
Styrene		0.67		0.29	
Tetrachloroethene				0.36	
Toluene	59.4	6.1		17.8	
Trichloroethene				5.4	
Xylenes, Total				212	
Semivolatile Organic Compounds					
	µg/kg			*µg/L*	
1,2,4,Trichlorobenzene	3.2	2.4	3.4		
4-Methylphenol				1.1	
Bis(2-ethylhexyl)phthalate				61.4	
Diethyl Phthalate				5.2	0.86
Pyrene		2.5			0.1
Radionuclides					
	pCi/g			*pCi/L*	
Radium 226				1.63	
Radium 228			1.29	6.9	3.97

Table 5-8. Summary of Site-Related Contaminants, SWMU 1 (continued)

	Maximum Concentration			Maximum Concentration	
Analyte	**Surface Soil**	**Subsurface Soil**	**Sediment**	**Groundwater**	**Surface Water**
Pesticides					
4,4-DDD	3.8				
Dieldrin				0.025	
Heptachlor		0.39			
Metals					
	mg/kg			*mg/L*	
Barium				134	
Cadmium				0.59	
Chromium			3.5	11.6	
Iron				22,000	
Lead			6	18.4	
Mercury			0.02		
Selenium	0.69				

6.0 CONTAMINANT FATE AND TRANSPORT

6.1 INTRODUCTION

This chapter describes the potential migration pathways and mechanisms for transport of chemical substances found in surface and subsurface soils, surface water, sediment, and groundwater at the South Central Landfill. Based on the information presented in previous sections, the refined conceptual site model (CSM) is developed in this chapter. Simple analytical methods were used to define contaminant movement from source areas to receptor locations. The overall objective of these analyses is to evaluate potential future impact to human health and the environment.

Section 6.2 discusses the persistence, mobility, and other physical and chemical properties of the organics and metals found at the South Central Landfill. Section 6.3 presents a conceptual model for potential contaminant migration pathways and describes contaminant release mechanisms through the primary transport medium (groundwater). Section 6.4 discusses the fate and transport of the contaminants at the South Central Landfill with respect to their leachability and natural attenuation in the groundwater. Section 6.5 summarizes the conclusions drawn from the results of the analyses and discusses the uncertainties associated with the analyses.

6.2 PHYSICAL AND CHEMICAL PROPERTIES

The fate and transport of organic compounds and metals are functions of both site characteristics and the physical/chemical properties of the contaminants. Such properties include solubility in water, tendency to transform or degrade (usually described by a half-life or an environmental half-life in a given medium), and chemical affinity for solids or organic matter (usually described by a partitioning coefficient K_d, K_{oc}, or K_{ow}). These properties and how they affect inorganic and organic contaminant behavior are described below.

6.2.1 Metals

Inorganic SRCs greater than FMSR reference background criteria at the South Central Landfill site for either surface or subsurface soils include barium, mercury, and selenium. These metals are subject to movement with soil moisture and may be transported through the vadose zone to groundwater. Metals do not degrade, although some metals can transform to other oxidation states in soil, reducing their mobility and toxicity. Metals also react with soils or other solid surfaces by ion exchange, adsorption, precipitation, or complexation. Such reactions are affected by pH, oxidation-reduction conditions; and the type and amount of organic matter, clay, and hydrous oxides present. In general, these reactions are reversible and cause an element's mobility to be retarded. The retardation factor (R_d) describes numerically the extent to which the velocity of the contaminant relative to water is slowed. The R_d is largely derived from the partitioning coefficient (K_d) expressed by the following relation:

$$R_d = 1 + K_d \cdot \rho_b \;/\; \theta ,$$

where

ρ_b = the soil bulk density (g/cm^3) ,
θ = volumetric soil moisture content.

K_d for the metals at this site may vary by large ranges. It has been found that K_d can even vary by orders of magnitude between samples from the same site. The range of K_d values [obtained from EPA (1996a) and Sheppard and Thibault (1990)] and the corresponding range of calculated R_d values for the South Central Landfill SRCs are presented in Table 6-1.

Table 6-1. List of Distribution Coefficients Used to Describe the Retardation Factors for the Inorganic Site-Related Chemicals Detected at the South Central Landfill

Site-related Analytes	K_d Range[a] (mL/kg)	R_d Range[b]
Barium	11 to 52	64 to 300
Cadmium	15 to 4,300	18 to 24,770
Chromium	14 to 31	82 to 180
Iron[c]	290 to 2,240	1,670 to 12, 910
Lead[c]	19 to 1,405	110 to 8,095
Mercury	0.04 to 200	1.2 to 1,150
Radium 226[c]	1,262 to 530,000	7,270 to 3.05E+06
Radium 228[c]	1,262 to 530,000	7,270 to 3.05E+06
Selenium	2.2 to 18	14 to 105

[a]The K_d (distribution coefficient) ranges represent the pH-dependent values for metals developed for soil screening level application (EPA 1996a).

[b]The R_d (retardation factor) ranges represent calculated values using the K_d-range and site-specific parameters.

[c]*Source:* Sheppard and Thibault (1990).

6.2.2 Organic Compounds

The organic compounds detected in soils at the South Central Landfill site include VOCs, SVOCs, and pesticides. These contaminants may be degraded in the environment by various processes, including hydrolysis, oxidation/reduction, photolysis, or biodegradation. Half-lives of organic compounds in various media can vary from minutes to years, depending on the chemical and on the environmental conditions. Degradation may either enhance or reduce the toxicity of a chemical. The biodegradation rates for the organic compounds are presented in Table 6-2. These values are based on the biodegradation half-lives taken from the Handbook of Environmental Degradation Rates (Howard et al. 1991). Although a range of values is presented in this book, only the lowest biodegradation rates corresponding to the highest half-lives are presented here to ensure conservatism in discussing contaminant loss through degradation/decay.

The mobility of an organic compound is affected by its volatility and its partitioning behavior between solids and water, water solubility, and concentration. The Henry's Law constant value (K_H) for a compound is a measure of the ratio of the compound's vapor pressure to its aqueous solubility. The K_H value can be used to make general predictions about the compound's tendency to volatilize from water. Substances with K_H values less than 10^{-7} atm/m^3 mol will generally volatilize slowly, while compounds with K_H values greater than 10^{-3} atm/m^3/mol will volatilize rapidly. Vapor pressure is a measure of the pressure at which a compound and its vapor are in equilibrium. The value can be used to determine the extent to which a compound would travel in air, as well as the rate of volatilization from soil and solution. In general, compounds with vapor pressures lower than 10^{-7} mm Hg will not

Table 6-2. Physical and Chemical Properties of Organic Site-Related Chemicals at South Central Landfill

Constituents	Mol. Wt.	Solubility S_w (mg/L)	S_w @ Temp °C	K_{OW} (ml/ml)	Vapor Pressure (tor @ °C)	Henry's Constant (K_h) atm.m^3/mol	K_h @ Temp °C	Air Diff. Coeff. cm^2/s	K_{OC} mL/g		Calculated K_d (mL/g)	Biodegradation Rate Constant λ 1/day	Biodeg. half-life (day)	Log (K_{OW})
Volatile Organic Compounds														
1,1,2,2-Tetrachloroethane	167.9	2.00E+02	20	1.10E+03	10@19.3	1.10E-02		0.073	7.90E+01	m	1.58E-01	9.62E-04	721	3.04
1,1-Dichloroethane	99.0	5.50E+03	20	6.17E+01	234@25	5.45E-03	25	0.910	5.30E+01		1.06E-01	1.13E-03	613	1.79
1,2-Dichloroethene	96.9	8.00E+02	20	1.23E+02	202@25	6.60E-03		0.114	7.75E+01		1.55E-01	2.41E-04	2,876	2.09
1,2-cis-Dichloroethene	96.9	3.50E+03[c]	25	7.24E+01[c]	202@25	4.08E-03[c]	25		3.55E+01	x	7.10E-02			1.86
1,2-trans-Dichloroethene	96.9	6.30E+03[c]	20	1.17E+02[c]	331@25	9.38E-03[c]	25		3.80E+01	m	7.60E-02			2.07
1,2-Dichloroprpane	113.0	2.70E+03	20	1.91E+02	42@20	2.82E-03	25	0.080	4.70E+01	m	9.40E-02	1.34E-04	5,173	2.28
1,1,1-Trichloroethane	133.4	4.40E+03	20	2.95E+02	100 @ 25	4.08E-03	25	0.019	1.35E+02	m	2.70E-01	6.35E-04	1,092	2.47
1,2,4-Trichlorobenzene	181.5	1.90E+01	22	9.55E+03	1@38.4	1.42E-03	25	0.057	1.66E+03	m	3.32E+00	9.63E-04	720	3.98
2-Butanone	72.1	2.75E+05		1.82E+00	100 @ 25	6.61E-07[a]	25	0.092[b]	1.15		2.30E-03	2.48E-02	28	0.26
Acetone	58.1	1.00E+06		5.75E-01	270 @ 30	5.14E-07[a]	25	0.11[b]	0.575	x	1.15E-03	2.48E-02	28	-0.24
Benzene	78.1	1.78E+03	20	1.35E+02	95 @ 25	5.55E-03	25	0.0932[b]	6.20E+01	m	1.24E-01	9.63E-04	720	2.13
Chlorobenzene	112.6	4.88E+02	25	6.92E+02	11.8^25	3.93E-03	25	0.073	2.24E+02	m	4.48E-01	1.16E-03	598	2.84
Chloroform	119.4	9.30E+03	25	9.33E+01	160@20	3.39E-03	25	0.091[b]	53	m	1.06E-01	3.85E-04	1,800	1.97
Diethyl Phthalate	222.2	2.10E-02[a]		9.12E+02	0.05@70	1.17E-08[a]	25	0.053	8.22E+01	m	1.64E-01	3.09E-03	224	2.96
Ethylbenzene	106.2	1.52E+02	20	1.41E+03	10 @ 25.9	6.44E-03	25	0.075[c]	2.04E+02	m	4.08E-01	3.04E-03	228	3.15
Heptachlor	373.3	5.60E+02	25	2.51E+04	3E-4@25	1.48E-03		0.037	9.26E+03	m	1.85E+01	2.65E-03	262	4.40
Methylene Chloride	84.9	1.67E+04	25	1.78E+01	429 @ 25	3.19E-03	25	0.1037[b]	1.00E+01	m	2.00E-02	6.19E-03	112	1.25
Styrene	104.1	3.00E+02	20	1.45E+03	5 @ 20	2.28E-03		0.0071[b]	9.12E+02	m	1.82E+00	3.30E-03	210	3.16
Tetrachloroethene	165.8	1.50E+02	25	3.39E+02	19 @ 25	2.87E-02	25	0.077[b]	2.65E+02	m	5.30E-01	4.19E-04	1,653	2.53
Toluene	92.1	5.15E+02	20	4.90E+02	28 @ 25	5.92E-03	25	0.087	1.40E+02	m	2.80E-01	3.30E-03	210	2.69
Trichloroethene	131.4	1.10E+03	25	3.39E+02	77@25	1.03E-02	25	0.088	9.40E+01	m	1.88E-01	4.19E-04	1,654	2.53
Xylene	106.2	2.00E+02		5.89E+02	5 @ 20	5.25E-03	25	0.073[b]	1.96E+02	m	3.92E-01	1.93E-03	360	2.77
Semivolatile Organic Compounds														
Bis(2-ethylhexyl)phthalate	390.6	1.30E+00	25	2.00E+05	1.2@200	3.00E-07	20	0.032	1.11E+05	m	2.22E+02	1.78E-03	389	5.30
Pyrene	202.3	1.60E-01	26	1.51E+05	2.5@200	5.10E-06	25	0.051	6.80E+04	m	1.36E+02	9.12E-05	7,600	5.18
Pesticides and PCBs														
4,4'-DDD	320.0	1.60E-01	24	9.77E+05	1.0e-6@30	1.96E-07[a]	25	0.041	4.58E+04	m	9.16E+01	6.16E-05	11,252	5.99
4,4'-DDE	318.0	4.00E-02	20	4.90E+05	6.5E-6@20	5.72E-07[a]	25	0.041	8.64E+04	m	1.73E+02	6.16E-05	11,252	5.69
4,4'-DDT	354.5	3.10E-03	25	1.55E+06	1.5E-7@20	3.89E-05	25	0.039	6.78E+05	m	1.36E+03	6.16E-05	11,252	6.19

Solubilities, Henry's Constant and Log (K_{ow}) have been taken from Risk Reduction Engineering Laboratory Treatability Database (EPA 1993a), except when otherwise indicated.
Biodegradation half-lives are based on biodegradation half-lives taken from Handbook of Environmental Degradation Rates (Howard et. al. 1991), except when otherwise indicated.
Air diffusion coefficients are obtained from EPA 1987, except when otherwise indicated.

[a] Soil Transport and Fate Database (EPA 1991).
[b] Indicates Shen et. al 1993 as the source.
[c] EPA (1996a).

m = Measured K_{oc} values (EPA 1996a).
x = Calculated K_{oc} values (EPA 1996a).
$K_d = K_{oc} * f_{oc}$, where f_{oc} is fraction of organic carbon content with a value of 0.002 (EPA default) (EPA 1996a).

be present in the atmosphere or soil vapor in significant amounts, while compounds with vapor pressures higher than 10^{-2} mm Hg will exist primarily in the soil vapor. Unless the soil is saturated,

VOCs will exist primarily in the atmosphere and soil vapor. Polycyclic aromatic hydrocarbons and other SVOCs will exist in both the air and the soil. The air diffusion coefficient is a measure of the rate of spontaneous mixing, presented in units of cm^2/sec, of one substance with another when in contact or separated by a permeable membrane. The rate of diffusion is proportional to the concentration gradient of a substance, increases with temperature, and is inversely related to density and pressure. In soil systems the principal type of diffusion is from a region of high concentration to a region of low concentration. Diffusion occurs most readily in gases, to a lesser extent in liquids, and least in solids.

Water solubility and the tendency to adsorb to particles or organic matter can correlate with retardation in groundwater transport. The adsorption coefficient/partition coefficient (K_d) of an organic compound is related to the organic carbon/water partition coefficient (K_{oc}) by

$$K_d = f_{oc} \times K_{oc},$$

where

f_{oc} = fraction of soil organic carbon content.

Chemical-specific K_{oc} values may be obtained from literature or may be calculated using empirical formulas relating the octanol-water partitioning coefficient (K_{ow}) to the K_{oc}. The K_{ow} (mL/mL) is the ratio of a contaminant's concentration in a system containing water and octanol. K_{ow} is used to estimate the tendency for a chemical to partition between environmental phases of different polarity. Organic compounds with log K_{ow} values less than one are highly hydrophilic, while organic compounds with log K_{ow} values greater than four are nearly insoluble in water and will partition to soil particles. Pesticides/PCBs and semivolatiles usually have higher log K_{ow} values. The most commonly used formula to relate K_{ow} to K_{oc} is

$$K_{oc} = 0.63 \times K_{ow} \text{ (Mills et al. 1985).}$$

Chemicals with relatively high water solubilities and low adsorption coefficients (e.g., acetone, methylene chloride) are expected to remain primarily as dissolved phases and be transported at the same rate as the groundwater flow. Chemicals with lower water solubilities and higher adsorption coefficients (e.g., SVOCs and pesticides) are expected to remain primarily adsorbed to the surface of the soils; their transportation with the groundwater would be very limited and at a much slower rate. Table 6-2 presents the solubility, Henry's Law constant (K_H), vapor pressure, air diffusion coefficients, and biodegradation rate constants for the organic compounds detected in soils and groundwater at the South Central Landfill. Log K_{ow}, K_{ow}, K_{oc}, and K_d or these compounds are also presented in this table.

6.3 CONCEPTUAL SITE MODEL

The CSM is a statement of expected site conditions that serves as a paradigm with which observations can be compared and within which predictions can be made. The predictive function of the CSM, of primary importance to contaminant fate and transport analysis, relies on known information and informed assumptions about the site. The better the information and the greater the accuracy of the assumptions, the more accurately the CSM describes the site and, therefore, the more reliable the predictions.

The CSM presented in this section summarizes the hydrogeologic components (presented in Chapter 2.0) and the distribution of contaminants in the subsurface soils and groundwater (presented in Chapter 5.0). Contaminant migration pathways and release mechanisms are also based on the information presented in Chapter 5.0. The CSM for contaminant fate and transport at the South Central Landfill is illustrated in Figure 6-1. A summary of the model's elements follows.

6.3.1 Water Balance Components

The potential for contaminant transport begins with precipitation. The actual amount of rainwater available for flow is highly variable and dependent upon soil type and climatic conditions. A water balance calculation can be used as a tool to quantitatively account for all the components of the hydrologic cycle at the South Central Landfill. The components of a simple steady-state water balance model include precipitation (P), evapotranspiration (ET), surface runoff (Sr), and groundwater recharge or percolation (Gr) and is defined as follows:

$$\mathrm{P} = \mathrm{ET} + \mathrm{Sr} + \mathrm{Gr}$$

or

$$\text{Rainwater available for flow} = \quad \mathrm{Sr} + \mathrm{Gr} = \mathrm{P} - \mathrm{ET}$$

The annual average water balance estimates for the Fort Stewart area indicate an evapotranspiration of 65.5% (31.4 inches) of total precipitation (48 inches) as compared to 34.5% (16.6 inches) for rainwater available for flow. Of this 34.5% (16.6 inches), groundwater recharge (percolation) accounts for 30.7% (14.7 inches) and surface runoff accounts for the remaining 3.8% (1.8 inches). The water balance estimations were based on Hydrologic Evaluation of Landfill Performance model (EPA 1994a) calculations for an uncapped landfill cell using precipitation and temperature data for the years 1974 through 1978 at Savannah, Georgia.

6.3.2 Contaminant Release Mechanisms and Migration Pathways

Past and current pathways are listed below.

- Rainwater percolating through contaminated, buried materials/debris and soil below the South Central Landfill leached contaminants and transported contaminants to the water table.
- Buried material degraded and leached contaminants to adjacent soil and groundwater.
- Runoff from exposed material and surface contaminants migrated to surface water in Mill and Taylors creeks.
- Fluctuating groundwater levels contacted contaminated buried material or soil and distributed contaminants in the soil at the water table interface.
- Groundwater flow transported contaminants within the water-table aquifer to Mill or Taylors creeks.

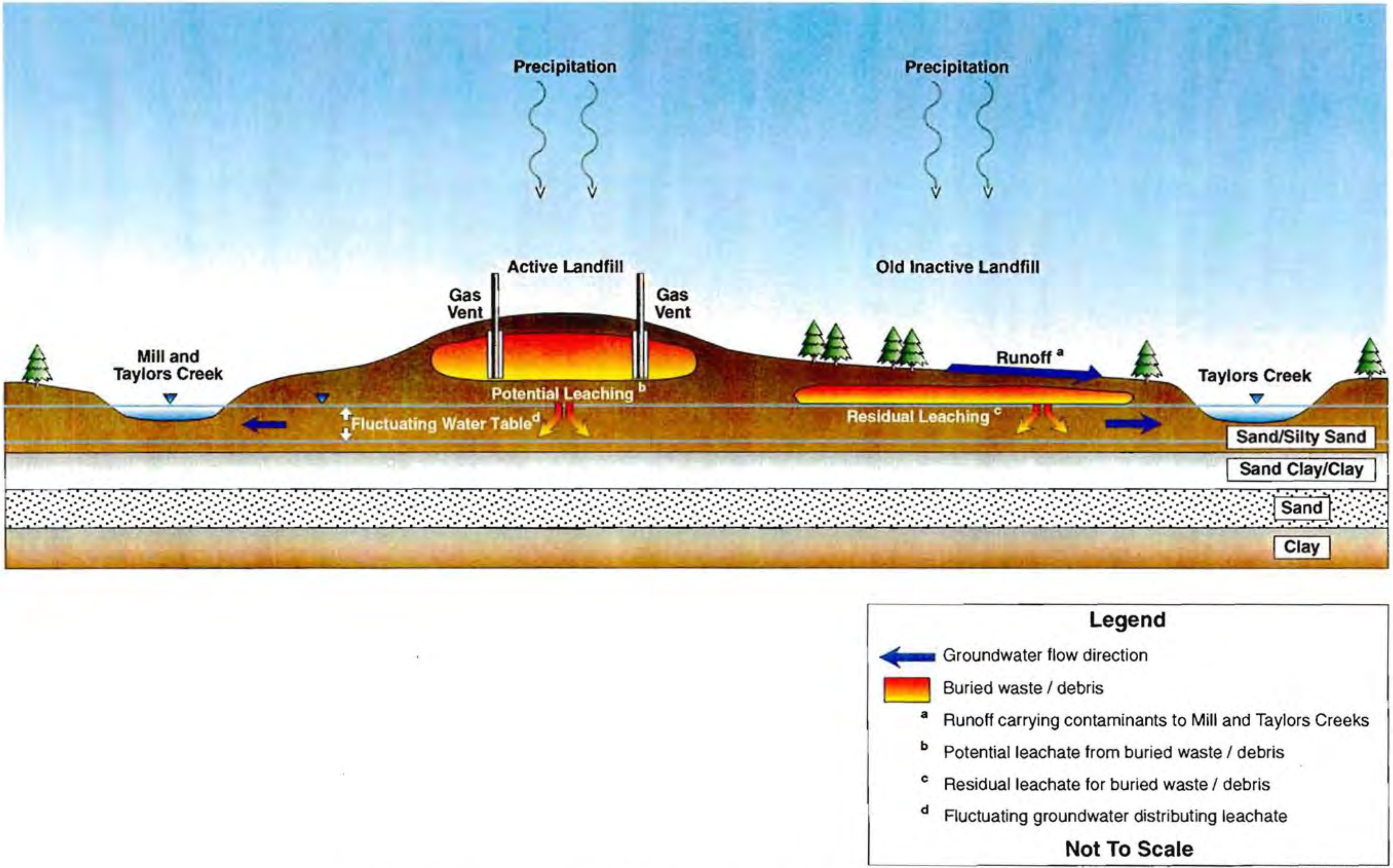

Figure 6-1. Conceptual Site Model for Contaminant Fate and Transport at South Central Landfill, Fort Stewart

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Additional current pathways may include the two described below.

- Organic compounds in groundwater and probably in soil are being biologically degraded.
- Organic compounds in soil and probably in groundwater are being volatized.

Release Mechanisms. Buried materials in the landfill may have decomposed, and leachate from these materials may have migrated to both subsurface soil and groundwater. The seasonal fluctuation of the surficial water table may have resulted in organic and/or inorganic constituents being released into the zone of fluctuation (i.e., 2 to 10 feet bgs) and may also allow for impacted soils and/or groundwater to "cross-contaminant" each other as the elevation of the water table changes. Another important release mechanism at the South Central Landfill site is infiltration of rainwater with leaching through the buried materials to groundwater. Precipitation that does not leave the site as surface runoff infiltrates into the subsurface. Some of this infiltrating water leaves the subsurface environment via evapotranspiration after little or no subsurface flow. The remainder of the water percolates into the subsurface flow system. The rate of percolation is controlled by soil cover, ground slope, saturated conductivity of the soil, and meteorological conditions. As discussed previously, the rate of percolation at this site is quite high (14.7 inches/year).

Water infiltrating through buried debris and contaminated subsurface soils is leaching hazardous constituents into the groundwater. The factors that affect leaching rate include a contaminant's solubility and partitioning coefficient (K_d) and the amount of percolation. Whether it is the partitioning coefficient or the solubility that controls the leaching of a constituent depends on whether leaching is sorption-controlled or solubility-controlled. Insoluble constituents will precipitate out of solution in the subsurface or remain in their insoluble form with little leaching. Those constituents with a small K_d will be leached more effectively than those with a larger K_d.

Another factor that affects the persistence of a contaminant is the contaminant's rate of decay. Most of the organic compounds decay or break down at characteristic rates that are described by the substance's half-life. For a given percolation rate, those contaminants with long half-lives have a greater potential for contaminating groundwater than do those contaminants with shorter half-lives. Organic contaminants with shorter half-lives and higher K_{oc}s will be completely degraded before reaching the water table.

Release by gaseous emission and airborne particulates is an important mechanism at the active landfill and is not as significant at the old, inactive portion of the South Central Landfill. The old portion of the landfill has been inactive for approximately 30 years, and active decomposition of the organic material in the buried material has likely subsided. Fifteen gas vents are located on the active portion of the landfill to allow venting of gaseous degradation compounds from the buried material as part of the Subtitle D permit. In addition, VOCs from the buried material may migrate to surface soil and be emitted to air by vaporization. The rate of emission is controlled by the vapor pressure of the organic compounds and decreases rapidly over a short period of time as the volatiles are depleted by release to the atmosphere. VOCs in the subsurface soil are emitted to the atmosphere via vertical diffusion through soil pores (and to the gas vents at the active portion of the landfill). Depending on how extensively diffusion has occurred, gaseous emissions from buried materials may be significant at the active portion of the landfill. The gas vents at the active portion of the landfill are monitored as part of the permit. Overall, concentrations of contaminants in the surface soil at the old, inactive landfill are insignificant, so gaseous emissions to the atmosphere would be minor.

Particulate matter from contaminated surface soil can become airborne as a result of wind erosion. This process is controlled by vegetative cover, wind speed, moisture and other fluids, and soil grain size in the surface soils. Wind erosion is not likely to be significant at the old, inactive portion of the landfill because of the native vegetative cover. Engineering controls are instituted at the active portion of the landfill during operation prior to placement of cover material in accordance with permit requirements.

Migration Pathways. The most likely pathways of contaminant migration at this site are via (1) overland flow to Mill and Taylors creeks located on two sides of the South Central Landfill (west and north) and (2) groundwater flow toward Mill and Taylors creeks located northwest and north, respectively, of the facility.

In the saturated zone, the contaminants are carried laterally either in solution or adsorbed to fine particulates (colloids) laterally to the hypothetical receptor locations. The horizontal hydraulic conductivity, which controls the flow rate, is a function of soil grain size and the pressure gradient. Saturated hydraulic conductivities for the South Central Landfill site range from 8.96×10^{-4} to 5.66×10^{-5} cm/sec, with an overall average of 4.76×10^{-4} cm/sec (see Chapter 3.0). The average horizontal hydraulic gradient at the site is 0.0086 foot/foot, with groundwater flow predominantly to the north. Assuming an effective porosity of 0.33 [based on specific yield of fine sands (Mills et. al. 1985)], the groundwater velocity is calculated to be approximately 12.8 feet/year toward Mill and Taylors creeks. Therefore, it is expected to take 94 years for the site groundwater at the northern boundary of the old inactive landfill, near SC-M12, to reach Taylors Creek, which is located approximately 1200 feet from the South Central Landfill.

Contaminants that are sorbed onto surface soil can be released by desorption in surface runoff or captured with particulate matter by sheet erosion during a storm event. Engineering controls are implemented at the active portion of the landfill to control runoff. The old, inactive portion of the landfill is covered with relatively native forest vegetation cover. A multiday storm may cause sheet flow. Sheet flow becomes shallow, concentrated flow. The area around Taylors Creek, north of the old, inactive landfill, is a wetland, and during significant rainfall events becomes flooded back to the perimeter of the old, inactive portion of the landfill.

6.4 FATE AND TRANSPORT ANALYSIS

6.4.1 Soil Leachability Analysis

Contaminant fate and transport analysis at this site involves a series of screening steps to define the contaminant migration COPCs. The contaminant migration COPCs are defined as the constituents that may pose the greatest problem if they migrate from the site source. The screening steps are discussed in the following sections.

The first step of the screening process represents the development of the SRCs. The SRCs are selected by comparing the maximum detected concentrations of all the analytes measured in surface and subsurface soils with their respective FMSR reference background criteria. The FMSR reference background criteria represent the average background concentration multiplied by a factor of two. If the maximum concentration of an analyte in the soil exceeds its reference background criterion, then that analyte is selected as an SRC.

The second step of the screening process involves comparing the maximum concentrations of the SRCs, developed in the previous step, with EPA generic soil screening levels (GSSLs). The GSSLs are set for Superfund sites for the migration to the groundwater pathway (EPA 1996a). For conservatism, a default dilution attenuation factor (DAF) of one, as applicable based on the large source area and shallow depth to water table, was applied to the GSSLs for the organics. A DAF of one is appropriate for organic chemicals because organic constituents are not easily adsorbed to the sandy inorganic soils present above the water table at the South Central Landfill site and because the depth to the water table is less than 2 feet. However, for the metals, because of their higher retardation factor, a DAF of 20 was used. The GSSL is defined as the concentration of a contaminant in soil that represents a level of contamination below which there is no concern under Comprehensive Environmental Response, Compensation, and Liability Act, provided conditions associated with soil screening levels (SSLs) are met. Generally, if contaminant concentrations in soil fall below the GSSL, and there are no significant ecological receptors of concern, then no further study or action is warranted for that area. However, it should be noted here that the purpose of this screening is not to identify the contaminants that may pose a risk at a downgradient location, but to target those contaminants that may pose the greatest problem if they migrate from the site. The results of this screening are presented in Table 6-3.

6.4.2 Natural Attenuation of the Contaminant Migration COPCs

Acetone and methylene chloride are the only organic chemicals identified as contaminant migration COPCs in soil for the South Central Landfill. The concentration of acetone is particularly high [44,100 µg/kg (surface soil)], which is well above its GSSL of 800 µg/kg. The 44,100 µg/kg concentration was 1 of only 9 detections of acetone out of 25 soil samples (3 of 10 surface and 6 of 15 subsurface samples). The other eight detections in soil samples were below the GSSL.

Methylene chloride was detected in 7 of 25 soil samples (5 of 10 surface and 2 of 15 subsurface soil samples) at concentrations ranging from 1.4 µg/kg to 52.2 µg/kg. The seven detected concentrations of methylene chloride were above the GSSL of 1 µg/kg.

To evaluate potential contaminant impact to groundwater, contaminant concentrations are compared to MCLs. If an MCL for the chemical is not available, the groundwater concentration is compared to the risk-based concentration (RBC) as established by EPA Region III. EPA Region III RBCs for carcinogens correspond to 10^{-6} risk, while those for noncarcinogens correspond to a Hazard Quotient (HQ) of 0.1. The concentration of acetone in groundwater is above the RBC. Methylene chloride was not detected in groundwater. Although bis(2-ethylhexyl)phthalate and trichloroethene were not detected in soil, they exceeded their MCLs. Maximum groundwater concentrations of bis(2-ethylhexyl)phthalate and trichloroethene were detected at 61.4 µg/L (MCL 6 µg/L) and 5.4 µg/L (MCL 5 µg/L), respectively. However, migration of these organic chemicals will be limited due to retardation, degradation, and slow 12.8 feet/year groundwater movement at the site.

Organic chemicals can be degraded in the environment, including through hydrolysis, oxidation/reduction, photolysis, biodegradation, or volatilization. As already discussed in Section 6.2, environmental half-lives of organic compounds in various media can vary from minutes to years, depending on the chemical and on the environmental conditions. Organic chemicals with differing chemical structures will biodegrade at different rates. Primary biodegradation consists of any biologically induced structural change in an organic chemical, while complete biodegradation is the

Table 6-3. Contaminant Migration COPCs Based on Surface and Subsurface Soil Screening for South Central Landfill

SRCs	Location in Soil	Maximum Concentration	GSSL	Is Maximum Concentration >GSSL?
Metals (mg/kg)				
Selenium	Surface Soil	0.69	5	No
Volatile Organic Compounds (μg/kg)				
2-Butanone	Subsurface Soil	14.1	38.4	No
Acetone	Surface and Subsurface Soil	44,100[a]	800	Yes[a]
Methylene Chloride	Surface and Subsurface Soil	52.2[b]	1	Yes[b]
Styrene	Subsurface Soil	0.67	200	No
Toluene	Surface and Subsurface Soil	59.4	600	No
Semivolatile Organic Compounds (μg/kg)				
1,2,4-Trichlorobenzene	Surface and Subsurface Soil	3.2	300	No
Pyrene	Subsurface Soil	2.5	210,000	No
Pesticides (μg/kg)				
4 4'-DDD	Surface Soil	3.8	800	No
4 4'-DDE	Surface Soil	3.3	3,000	No
4 4'-DDT	Surface Soil	2.1	2,000	No
Heptachlor	Subsurface Soil	0.39	1,000	No

[a] Indicated at SC-M16, a soil sampling location determined to not be impacted by operations at SWMU 1. Remaining acetone detections below GSSL.

[b] Maximum concentration of methylene chloride indicated at SC-M15, a soil sampling location determined to not be impacted by operations at SWMU 1. Remaining methylene chloride concentrations are also above GSSL.

GSSL = Generic soil screening level.

SRC = Site-related contaminant.

biologically mediated degradation of an organic compound into carbon dioxide, water, oxygen, and other metabolic inorganic products. The biodegradation rate of an organic compound is proportional to the concentration:

$$-dC/dt = kC^n ,$$

where

C = concentration,
k = biodegradation rate constant = 1/t Ln (a/[a-x]),
t = time,
a = initial concentration,
x = change in concentration with time,
n = reaction order, n=1 for first-order kinetics.

The half-life ($t_{1/2} = Ln2/k$) is the time necessary for half of the chemical concentration to react. The biodegradation rate of an organic chemical is generally dependent on the presence and population size of soil microorganisms capable of degrading the chemical. Based on the above equation and the maximum concentrations of these constituents, a simple first-order correlation can be obtained between the constituent's half-life and the time required to degrade the contaminant to the concentration equal to its MCL.

Using the lowest biodegradation rate from the Handbook of Environmental Degradation Rates (Howard et al. 1991) presented in Table 6-2, current maximum groundwater concentrations of acetone, bis(2-ethylhexyl)phthalate, and trichloroethene degrade to their respective MCL/RBC levels in 1, 3.9, and 0.5 years, respectively. Because groundwater from the South Central Landfill is expected to take 94 years to reach Taylors Creek (see Section 6.3.2), it may be concluded that acetone, bis(2-ethylhexyl)phthalate, and trichloroethene will be biodegraded before reaching the receptor through the groundwater pathway. Methylene chloride was detected in soil, but it has not been detected in groundwater. The half-life of methylene chloride presented in Table 6-2 is 112 days, so methylene chloride is also not expected to reach Taylors Creek through the groundwater pathway. In soil, in addition to biodegradation, volatilization of organics takes place, and organics usually decay at a faster rate. Organics also dilute through percolating rainwater in soil.

Selenium is the only inorganic chemical analyzed for leachability in soil. However, it did not exceed the GSSL. Among the inorganics and radionuclides, only lead and Radium 226/228 exceeded their respective MCLs/RBCs in groundwater. As discussed in Chapter 5.0, the one lead concentration above the MCL may be the result of colloid particulates on the groundwater. Using the lowest retardation factor presented in Table 6-1 and the groundwater velocity presented in Section 6.3.2, both lead and Radium 228 will take more than 1000 years to reach the receptor at Taylors Creek through the groundwater pathway.

6.5 SUMMARY AND CONCLUSIONS

The site characterization and monitoring data identified organics and metals in soil and groundwater at the South Central Landfill. Only selenium exceeded its reference background criteria in soil; however, selenium did not exceed its GSSL based on leaching to groundwater. In the groundwater, none of the metals, except lead, exceeded MCLs, and this value may be the result of colloid particulates in the groundwater. Radium 226/228 exceeded its MCL. However, off-site migration of lead and Radium 226/228 will be limited because of their high retardation factors. The organics in the site soils that exceeded EPA GSSLs were acetone and methylene chloride. Due to their high solubility and low retardation factors, both acetone and methylene chloride have the potential to contribute to groundwater contamination and migrate off-site. Acetone concentrations exceeded its RBC in groundwater, whereas methylene chloride was not detected in groundwater. Maximum concentration of acetone in surface soil is particularly high (44,100 µg/kg), which is much above its GSSL of 800 µg/kg. The 44,100 µg/kg at SC-M16 was the only detection (out of nine) of acetone that exceeds its GSSL. All of the detected methylene chloride concentrations (5 of 10 surface and 2 of 15 subsurface soil samples) exceeded its GSSL. Two of the soil sampling locations (SC-MW15 and SC-MW16) were located outside the area previously used for or impacted by landfill operations. Therefore, soil concentrations of acetone and methylene chloride at these locations were outside the influence of potential contaminants from SWMU 1. Methylene chloride was the only contaminant migration COPC in soil around the old, inactive portion of the landfill.

Bis(2-ethylhexyl)phthalate and trichloroethene, although not identified as contaminant migration COPCs in soil, are present in groundwater at concentrations that exceeded their respective MCLs. Off-site migration of these contaminants will be limited, however, due to retardation and degradation through various processes, as well as the slow movement of groundwater (approximately 12.8 feet/year). At the velocity of 12.8 feet/year, site groundwater will take 94 years to reach Taylors Creek. In reality, contaminants will move slower than the groundwater due to retardation, and the organic contaminants will gradually decay in nature.

Based on the leachability analysis, none of the constituents from the South Central Landfill site is expected to be of potential concern at the nearest receptor locations (Mill and Taylors creeks). The active portion of the landfill is monitored under the Groundwater Monitoring Program to evaluate the potential migration of contaminants. The source of potential contaminants (buried material) in the old, inactive portion of the landfill has likely decomposed. Residual contaminant concentrations and migration from remaining materials are minimal.

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7.0 HUMAN HEALTH PRELIMINARY RISK EVALUATION

This HHPRE used a Step 1 risk evaluation, based on guidance from the GEPD and EPA Region IV. This HHPRE was designed to determine if there are potential risks to human health associated with contamination detected at SWMU 1. This process involved the following steps:

- for inorganics, comparing detected concentrations to naturally occurring background levels to determine if detected inorganics were naturally occurring or were associated with past activities at the site;
- identifying potential migration and exposure pathways of contaminants associated with the site and potential exposure scenarios to determine appropriate action levels;
- identifying available risk-based action levels for each contaminant detected above background levels, or developing action levels if they did not exist; and
- comparing sample concentrations to action levels to determine if site conditions warranted further evaluation.

Chemicals that exceeded action levels will be identified as human health COPCs and will be evaluated in a baseline risk assessment (if necessary).

7.1 DATA EVALUATION

The objective of this evaluation is to develop a set of chemical data suitable for use in the HHPRE. The data for SWMU 1 were evaluated to establish (1) which data are of sufficient quality for use in the quantitative risk assessment and (2) which detected chemicals are believed to be site-related.

7.1.1 Data Quality Evaluation

The data used in the risk assessment were verified and validated using the methodology described in the QAPP of the Phase II RFI SAP (SAIC 1997). Data qualified during the validation as rejected data ("R") were not used in the risk assessment.

Detection limits achieved during sample analysis were reviewed to ensure that the required detection limits were met. Typically, detection limits are established to ensure that characterization levels are low enough to determine if chemicals are present at hazardous levels. These levels are chemical-specific and related to each chemical's toxicity. Required detection limits are presented in the QAPP of the Phase II RFI SAP (SAIC 1997). In some cases recommended detection limits cannot be achieved by a laboratory (e.g., if matrix or chemical interference requires that a sample be diluted).

An organic chemical was removed from further consideration if it was a common laboratory contaminant and the reported sample concentration was less than ten times the concentration in an associated QC sample (i.e., trip blank, field blank, equipment rinsate, or laboratory blank). Common laboratory contaminants include acetone, 2-butanone, methylene chloride, toluene, or phthalate esters. Other organic chemicals were not included if results were less than five times the highest concentration detected in an associated QC sample.

7.1.2 Background Screening

EPA Region IV methodology recommends screening inorganics data against background concentrations to determine what compounds are site-related contaminants. This screening analysis was previously done in Section 5.1, Background Data Analysis. Therefore, it will not be discussed further in this section. The reader is referred to Section 5.1 for a discussion of the methodology and results of the background screening.

7.2 EXPOSURE EVALUATION

The objective of this exposure evaluation was to identify potential human populations that might be exposed to SRCs at SWMU 1 under current and future land-use conditions. A complete exposure pathway consists of five elements: (1) a potential receptor population, (2) a source of contamination, (3) a transport or retention medium, (4) a point of contact for a receptor, and (5) a route of exposure (ingestion, dermal adsorption, or inhalation) at the point of contact through which the chemical may be taken into the body. When all of the elements of an exposure pathway are present, an exposure of a receptor population may occur. The assessment considers both on- and off-site receptors and their relationship to the potential migration pathways, exposure pathways, and points of exposure for SRCs.

7.2.1 Receptor Assessment

This section identifies those populations that may be exposed to SRCs. The receptor populations are identified under both current and future conditions. Potential changes in land-use are evaluated to determine whether they may result in the presence of more sensitive receptor populations in the future.

Projecting future land-use scenarios and associated receptors involves considerable uncertainty. The following sections present conservative estimates of potential receptor populations in the future, an approach intended to prevent premature elimination of human health COPCs from the screening process. Where the most conservative land-use assumptions resulted in highly unlikely receptor exposures, more probable future land-use scenarios are presented.

Generally, receptor populations are divided into two groups: on-site and off-site receptors. On-site receptors are those individuals who may be present within the site boundaries and come into direct contact with contaminants present. The exposure of an off-site receptor requires a migration pathway that transports a contaminant off-site to a point of exposure of the potential receptor.

Current On-Site Receptors. The SWMU 1 landfill is located within a currently operating military area. Current operations at the landfill include standard operations at the active landfill and clearing of trees from the old, inactive landfill. Current operations at the landfill result in ongoing exposure to on-site workers. Installation workers live approximately 1 mile to the east of SWMU 1; therefore, a juvenile trespasser may be able to gain access to the site. Under current

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land-use conditions, the on-site receptors would be represented by a Installation worker and a juvenile trespasser.

Current Off-Site Receptors. Currently, areas surrounding the SWMU 1 landfill include residential facilities as well as industrial facilities at which Installation workers are present. Migration pathways may be present to transport contamination to locations at which off-site receptors would be exposed. Under current land-use conditions, the off-site receptors would be represented by a Installation worker and a resident.

Future On-Site Receptors. Given that SWMU 1 is a landfill, land use in the future will be limited to activities associated with the continued maintenance of the landfill, after the currently active landfill is closed; therefore it is highly unlikely that any type of construction will take place on the landfill or that any type of structures will be placed on the landfill. Future on-site receptors will be the same as the current on-site receptors: Installation worker and juvenile trespasser. However, GEPD requires that the risk assessments address exposure of an on-site resident.

Future Off-Site Receptors. Future off-site receptor populations would be the same as the current receptor populations, namely, nearby Installation workers or residents. Migration pathways and transport mechanisms may be present, resulting in potential exposure of off-site receptors to contamination.

Receptor Summary. Potential receptor populations for the SWMU 1 landfill are as follows:

- Current on-site receptors–Installation worker and juvenile trespasser
- Current off-site receptors–Installation worker and resident
- Future on-site receptors–Installation worker and juvenile trespasser and resident
- Future off-site receptors–Installation worker and resident

Potential exposure pathways associated with these receptors are presented in the following section.

7.2.2 Migration Pathway Analysis

This section describes the potential pathways related to chemical transport that may result in potential exposure points for humans. In general, the major routes of migration from this site are volatilization into the air, wind erosion resulting in fugitive dust, surface water runoff, and leaching of contaminants into groundwater. The majority of the site is currently covered by vegetation; therefore, the migration of contaminants into the atmosphere via fugitive dust is unlikely to be a significant migration pathway under current conditions.

Soil. Contaminants in soil may migrate via runoff, leaching into groundwater, or suspension/volatilization into the air. Runoff may transport contaminants adsorbed to soil particles via erosion, resulting in an increase of surficial contamination and possible transport of contaminants to sediments in Mill Creek or Taylors Creek. Runoff may also result in the transportation of particulate-bound water-soluble compounds to surface water in the creeks. Because shallow groundwater is present at this site, leaching of contaminants into subsurface soil and then into groundwater is likely to be a significant migration pathway.

Groundwater. The migration of soil contaminants to groundwater due to infiltration and percolation of rainwater depends primarily on the amount of rainfall, evaporation, solubility of the chemical in water, adsorption coefficient, and distance to the groundwater. In general, VOCs travel more easily through soils than SVOCs such as high-boiling-point fuel hydrocarbons. Solubility of metals is dependent on the metal species and is difficult to generalize.

Groundwater flow follows the site topography, with flow primarily to the north entering Mill and Taylors creeks. However, given the low groundwater flow rate, organic contaminants are likely to have attenuated through biodegradation before reaching surface water (see Chapter 5.0). Inorganics, which are less mobile than organics, are likely to be significantly adsorbed to soil particles and not transported in significant concentrations by the groundwater. The groundwater flow rate is estimated to be 12.8 feet/year; therefore, it would take approximately 94 years to reach Mill and Taylors creeks. Therefore, exposure as a result of groundwater discharge to surface water is expected to be insignificant.

Surface Waters. Two surface waters exist near the site, Mill and Taylors creeks. The surface water in Mill Creek joins Taylors Creek north of SWMU 1 and eventually feeds into the Canoochee River, which drains much of the western portion of the FSMR. These creeks are likely to be migration pathways for contaminants through surface runoff and subsequent downstream transport because of their proximity to SWMU 1. Significant transport to the creeks via groundwater is unlikely, however, due to the low groundwater flow rate in this area and because of attenuation of contaminants due to biodegradation and adsorption.

Sediment. Sediments at this site include those within Mill and Taylors creeks. As discussed above, runoff from SWMU 1 may provide a migration pathway for contaminants to enter the surface water system and become incorporated into the sediments of Mill and Taylors creeks.

7.2.3 Identification of Exposure Pathways

Potential human exposure may occur by primary pathways (e.g., dermal contact, inhalation, or inadvertent ingestion of soil) or through secondary pathways involving the transfer of SRCs into food sources (i.e., crops, livestock, and game). The risk evaluation presented in this document focuses on primary pathways for each medium, with the exception of contaminant leaching to groundwater. Because there is an on-site receptor for each exposure pathway, analyzing primary pathways and leaching to groundwater will ensure a conservative assessment of possible exposures. The potential exposure pathways will be addressed for each of the potential receptor populations previously identified (Section 7.2.1).

Installation Worker. The Installation worker may currently be exposed to contaminants in soil, surface water, and sediments. Potential exposure pathways for soil and sediment include incidental ingestion of soil and inhalation of particulates and vapors. An on-site worker is not likely to come in direct contact with surface water or sediment in the creeks, given that his activity is limited to the landfill; therefore, the most significant exposure to the Installation worker would result from incidental soil ingestion and inhalation of particulates and vapors from surface and subsurface soil

Future land use at the Installation may include pumping of groundwater. It is unlikely that the surficial groundwater would be used as a source of drinking water, but it may be used for watering purposes (e.g., a lawn sprinkler system or an irrigation system for ornamental plants).

The on-site Installation worker may be exposed to chemicals volatilizing from groundwater being used for these purposes. However, the use of groundwater by Installation workers is unlikely to result in exposures greater than those experienced by an on-site resident; therefore, the groundwater pathway is conservatively assessed by considering residential exposures via inhalation and direct ingestion as described above.

Juvenile Trespasser. Residents living in the vicinity of SWMU 1 may trespass onto the site and be exposed to chemicals in surface water, sediment, and soils. The trespasser would most likely be a juvenile exposed via incidental ingestion of surface water, inhalation of vapors from surface water, ingestion of sediments, ingestion of soil, and inhalation of particulates and vapors from soils.

Resident. Residents would be exposed only to fugitive dust and volatile compounds emitted from soil at SWMU 1. Because transport from the Installation to the receptor location would result in significant dilution of constituent concentrations, more significant exposures to airborne contaminants would be experienced by an individual on-site.

Exposure of residents to groundwater is unlikely to occur given that the surficial aquifer is not a likely source of groundwater, especially within the vicinity of a landfill. The deeper Floridan Aquifer is used as a source of drinking water in the area. However, GEPD guidance (GEPD 1996) states that all groundwater should be assessed as a potential source of residential drinking water. Potential exposure pathways for a resident would include ingestion, dermal contact, and inhalation of volatiles while showering.

7.3 SELECTION OF SCREENING VALUES

Screening values represent concentrations that are publicly available and, due to their conservative nature, can be used with a high degree of confidence to identify sites for which no further action is required. Screening levels inherently incorporate assumptions about land-use. In identifying human health COPCs, it is generally accepted that screening levels will reflect any potential future land uses and, thus, usually reflect a conservative residential-use scenario (EPA 1991; EPA 1996a; ASTM 1995). As a conservative measure, the on-site residential scenario and the construction worker scenario will be used to screen contaminants in the appropriate environmental media.

If risk-based screening values are not available, their absence generally reflects (1) that the chemical is not considered to be toxic, except perhaps at extremely high concentrations (e.g., aluminum, sodium); (2) no dose-response data indicate a toxic effect; or (3) EPA is currently reviewing toxicity information and no reference dose or cancer slope factor is currently available. Table 7-1 summarizes the exposure pathways, receptors, and sources of the selected screening values for the media of interest at SWMU 1. A detailed discussion of the available screening values is presented below.

7.3.1 Screening Values for Soil and Sediment

Screening values for soil and sediment were based on the potential exposure pathways identified in Table 7-1. Acceptable surface soil exposures will be based on a residential ingestion scenario, as well as screening values for migration to groundwater and air. The screening values for soil

Table 7-1. Selected Exposure Pathways and Associated Screening Criteria, SWMU 1

Medium	Route	Receptor	Screening Value
Surface Soil	Ingestion	On-site resident	Region III RBCs for resident
Subsurface Soil	Ingestion	Construction worker	Region III RBCs for industrial
Groundwater	Ingestion	On-site resident	Region III RBCs for resident
	Inhalation	On-site resident	Included in Region III RBC calculation
Surface Water	Ingestion	On-site resident	Georgia State AWQC
Sediment	Ingestion	On-site resident	Region III RBCs for resident

AWQC = Ambient Water Quality Criteria.
RBC = Risk-based concentration.
SSL = Soil screening level.

are applied to sediment, under the conservative assumption that the frequency and route of exposure for the two media will be the same.

The following soil and sediment screening criteria were used in the evaluation:

- Risk-based concentrations developed by EPA Region III (EPA 1998) for residential ingestion of soil. These values are used to screen surface soil (0 to 2 feet bgs) for potential future Installation worker or juvenile trespasser on-site exposures.

- Risk-based concentrations developed by EPA Region III (EPA 1998) for industrial ingestion of soil. These values are used to screen subsurface soil (more than 2 feet bgs) because exposure to subsurface soil would be limited to an individual working in an excavation.

- Risk-based acceptable soil concentrations developed for use at U.S. Department of Energy (DOE) facilities (TM-106) for radiological constituents (DOE/ORO 1998). These values are used for screening radium results at SWMU 1 because Region III risk-based concentrations were not available for radionuclides.

- The lead action level of 400 mg/kg was used as a soil and sediment screening value. The acceptable lead concentration in soil is based on a blood lead level of 10 µg/dL in a receptor ingesting soil (EPA 1994d).

EPA Region III Risk-Based Residential Soil Concentrations. The EPA Region III risk-based soil concentrations for residential ingestion of surface soil are based on the following:

- Region III risk-based values were modified to obtain soil levels representative of exposure to multiple chemicals with similar toxic effects. Soil screening values that were based on a noncarcinogenic effect were divided by 10 to reflect a Hazard Index of 0.1.

- EPA Region III presents two chromium values based on the trivalent (Cr^{+3}) and hexavalent (Cr^{+6}) chromium states. Hexavalent chromium in the environment rapidly oxidizes to the trivalent state and would represent a small fraction of the total exposure to chromium. However, because hexavalent chromium is more mobile and more toxic than the trivalent state, during the screening process it is assumed that all chromium is hexavalent.

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EPA Region III Risk-Based Industrial Soil Concentrations. The EPA Region III risk-based soil concentrations for industrial exposure to subsurface soil are based on the following:

- Region III risk-based values were modified to obtain soil levels representative of exposure to multiple chemicals with similar toxic effects. Values that were based on a noncarcinogenic effect were divided by 10 to reflect a Hazard Index of 0.1.

- EPA Region III presents two chromium values based on the trivalent (Cr^{+3}) and hexavalent (Cr^{+6}) chromium states. Hexavalent chromium in the environment rapidly oxidizes to the trivalent state and would represent a small fraction of the total exposure to chromium. However, because hexavalent chromium is more mobile and more toxic than the trivalent state, during the screening process it is assumed that all chromium is hexavalent.

Risk-Based Soil Ingestion Concentration for DOE Facilities. Acceptable radionuclide soil concentrations have been developed for use at DOE facilities in the Oak Ridge area. The risk-based soil concentrations were calculated using EPA default exposure parameters assuming soil ingestion by a residential adult receptor. These screening values were used to assess radiological constituents for which no other screening values were available.

7.3.2 Screening Values for Groundwater

Screening values for groundwater were based on the potential exposure pathways identified in Table 7-1. Acceptable groundwater exposures will be based on residential use of groundwater for potable water. This is a conservative assumption given that actual exposure is likely to be limited to sporadic ingestion of groundwater, which is used for irrigation and watering.

The following groundwater screening criteria were used in the evaluation:

- Risk-based concentrations developed by EPA Region III (EPA 1996c) for residential use of tap water.

- The lead action level of 15 µg/L was used as a groundwater screening value. The acceptable lead concentration in groundwater is based on a blood lead level of 10 µg/dL in a receptor using groundwater as a potable water source.

- Risk-based residential groundwater concentrations developed for use at DOE facilities (TM-106) for radiological constituents. These values are used for screening radium results at SWMU 1 because Region III risk-based concentrations were not available for radionuclides.

EPA Region III Risk-Based Residential Groundwater Concentrations. The EPA Region III risk-based groundwater concentrations for residential use of groundwater as a potable water source are based on the following:

- Region III risk-based values were modified to obtain groundwater concentrations representative of exposure to multiple chemicals with similar toxic effects. Values that were based on a noncarcinogenic effect were divided by 10 to reflect a Hazard Index of 0.1.

- EPA Region III presents two chromium values based on the trivalent (Cr^{+3}) and hexavalent (Cr^{+6}) chromium states. Hexavalent chromium in the environment rapidly oxidizes to the trivalent state and would represent a small fraction of the total exposure to chromium. However, because hexavalent chromium is more mobile and more toxic than the trivalent state, during the screening process it is assumed that all chromium is hexavalent.

7.3.3 Screening Values for Surface Water

Screening values for surface water were based on the potential exposure pathways identified in Table 7-1. Screening values chosen for surface water represent the maximum concentrations of contaminants in water that will not present an unreasonable risk to human health if the waters are treated and used as a drinking water source or if aquatic life is harvested from the waters and consumed.

The following surface water screening criteria were used in the evaluation:

- State of Georgia Water Quality Criteria (WQC) for the protection of human health based on ingestion of water and fish.

- Risk-based recreational surface water concentrations developed for use at DOE facilities (TM-106) for radiological constituents are used for screening radium surface water results at SWMU 1 (DOE/ORO 1998).

State of Georgia WQC. These screening levels represent the maximum concentrations of contaminants in water that will not present unreasonable risk to human health. The Georgia WQC assume that fish may be consumed from the water and that the treated water may be used as a potable water source for residents.

Risk-Based Surface Water Concentrations for DOE Facilities. Acceptable surface water concentrations have been developed for use at DOE facilities in the Oak Ridge area, assuming incidental surface water ingestion by a recreational receptor over a 30-year period (DOE/ORO 1998). These screening values were used to assess radiological constituents for which no other screening values were available. The screening criteria are based on the following:

- Surface water exposure is to a recreational adult over a 30-year period.
- Adult is exposed in creeks 45 days per year for 1 hour per day.
- The incidental surface water ingestion rate is 0.05 liters per hour.

The screening criteria presented above are used to compared the detected concentration of constituents with risk-based concentrations intended to be protective of reasonable human exposures to contaminated media associated with SWMU 1. In addition to screening criteria, human health COPCs are determined based on weight-of-evidence analysis as described in detail below.

7.4 RISK EVALUATION

The risk evaluation compares the maximum value detected in each medium with its respective screening value. Exceeding the screening value does not imply that a potential risk to human health exists at the site. It does mean that a potential risk may exist and that those chemicals exceeding their respective screening values should be evaluated more carefully. Contaminants identified as human health COPCs may be evaluated further in a baseline risk assessment (Chapter 9.0).

The selection of human health COPCs for each environmental medium (surface soil, subsurface soil, groundwater, sediment, and surface water) is addressed below. The selection process involves two steps. The initial step is the comparison of the maximum concentrations to the appropriate screening values. Given the conservative nature of the screening values, a weight-of-evidence analysis is presented for those chemicals that exceed their respective screening values to determine whether a baseline risk assessment is required.

The weight-of-evidence screening includes an evaluation of the constituent's frequency of detection, detected concentration relative to detection limits, frequency of detection above background, and frequency of exceedance of screening criteria. The Risk Assessment Guidance for Superfund (RAGS) (EPA 1989) presents a weight-of-evidence threshold criterion of greater than a 5 percent frequency of detection before a constituent should be considered site-related. This criterion is used in the evaluation presented below.

7.4.1 Surface Soil

Contaminants detected above background in SWMU 1 surface soil were: selenium; DDD; DDE; DDT; 1,2,4-trichlorobenzene; acetone; methylene chloride; and toluene. None of these constituents exceeded risk-based screening levels (see Table 7-2).

7.4.2 Subsurface Soil

Contaminants detected above background in SWMU 1 subsurface soil were: heptachlor; 1,2,4-trichlorobenzene; pyrene; 2-butanone; acetone; methylene chloride; styrene; and toluene. All of the constituents detected above background criteria were below their respective risk-based screening values as indicated in Table 7-3.

7.4.3 Groundwater

SRCs in groundwater included metals, radium isotopes, pesticides, SVOCs, and VOCs. These constituents were compared to the risk-based screening criteria for residential use of groundwater as a potable water source with the results described below.

With the exception of chromium, iron, and lead, none of the metals detected above background criteria exceeded its risk-based screening criteria. The maximum concentration of chromium (11.6 µg/L) was slightly higher than the screening value of 10.9 µg/L (Table 7-4.) Iron had a maximum concentration of 22,000 µg/L as compared to a background screening value of 7560 µg/L and a risk-based screening value of 1100 µg/L (Table 7-4). Lead was detected at a maximum concentration of 18.4 µg/L, which exceeds the EPA action level of 15 µg/L in drinking water. As discussed previously in Chapter 5.0, the maximum groundwater lead concentration was detected in a total sample, although an unfiltered sample from the same location indicated nondetectable levels of lead. Despite the uncertainty in the data, lead is conservatively considered to be a human health COPC in groundwater.

Radium 226 and 228 were detected above reference background criteria in 5 of 21 groundwater samples. Radium 226 concentrations above reference background ranged from 1.22 pCi/L to 1.63 pCi/L. Radium 228 concentrations above reference background criteria ranged from

Table 7-2. Contaminant Screening of Surface Soil Results to Action Levels, SWMU 1

Analyte	Results > Detection Limit	Minimum Detect	Maximum Detect	EPA Region III Residential[a] (mg/kg)	Human Health COPC	Justification
Metals (mg/kg)						
Selenium	1/8	0.69	0.69	39	No	Max Detect < Risk Criteria
Pesticides (mg/kg)						
4,4'-DDD	1/8	0.0038	0.0038	2.7	No	Max Detect < Risk Criteria
4,4'-DDE	1/8	0.0033	0.0033	1.9	No	Max Detect < Risk Criteria
4,4'-DDT	2/8	0.0014	0.0021	1.9	No	Max Detect < Risk Criteria
Semivolatile Organics (mg/kg)						
1,2,4-Trichlorobenzene	2/8	0.0032	0.0032	78	No	Max Detect < Risk Criteria
Volatile Organics (mg/kg)						
Acetone	3/10	0.0065	44.1	780	No	Max Detect < Risk Criteria
Methylene Chloride	5/10	0.0014	0.0522	85	No	Max Detect < Risk Criteria
Toluene	2/8	0.00051	0.0594	1,600	No	Max Detect < Risk Criteria

[a] EPA Region III residential soil ingestion values were modified by dividing noncarcinogenic-based values by 10 to represent a Hazard Index of 0.1.

COPC = Contaminant of potential concern.

EPA = U.S. Environmental Protection Agency.

GW = Groundwater.

Table 7-3. Contaminant Screening of Subsurface Soil Results to Action Levels, SWMU 1

Analyte	Results > Detection Limit	Minimum Detect	Maximum Detect	EPA Region III Residential[a] (mg/kg)	Human Health COPC	Justification
Pesticides (mg/kg)						
Heptachlor	1/8	0.0004	0.0004	1.30	No	Max Detect < Risk Criteria
Semivolatile Organics (mg/kg)						
1,2,4-Trichlorobenzene	1/8	0.002	0.002	2,000	No	Max Detect < Risk Criteria
Pyrene	1/8	0.003	0.003	6,100	No	Max Detect < Risk Criteria
Volatile Organics (mg/kg)						
2-Butanone	1/15	0.014	0.014	100,000	No	Max Detect < Risk Criteria
Acetone	6/15	0.006	0.638	20,000	No	Max Detect < Risk Criteria
Methylene Chloride	2/15	0.002	0.003	760	No	Max Detect < Risk Criteria
Styrene	1/15	0.001	0.001	41,000	No	Max Detect < Risk Criteria
Toluene	6/15	0.0003	0.006	41,000	No	Max Detect < Risk Criteria

[a] EPA Region III residential soil ingestion values were modified by dividing noncarcinogenic-based values by 10 to represent a Hazard Index of 0.1.

COPC = Contaminant of potential concern.

EPA = U.S. Environmental Protection Agency.

GW = Groundwater.

ND = No data available.

Table 7-4. Contaminant Screening of Groundwater Results to Action Levels, SWMU 1

Analyte	Freq. of Detection	Minimum Detected	Maximum Detected	Human Health Criteria	Human Health COPC	Justification
Metals (μg/L)						
Barium	21/21	20.9	134	260	No	Max Detect < Risk Criteria
Cadmium	2/21	0.25	0.59	1.8	No	Max Detect < Risk Criteria
Chromium	7/21	0.71	11.6	10.9	Yes	Max Detect > Risk Criteria
Iron	21/21	76.5	22,000	1,100	Yes	Max Detect > Risk Criteria
Lead	17/21	0.12	18.4	15[a]	Yes	Max Detect > Risk Criteria
Radionuclides (pCi/L)						
Radium 226	10/21	0.501	1.63	0.161[b]	Yes	Max Detect > Risk Criteria
Radium 228	21/21	1.33	6.9	0.192[b]	Yes	Max Detect > Risk Criteria
Pesticides (μg/L)						
Delta-BHC	1/21	0.04	0.04	ND	No	Weight-of-Evidence[c]
Dieldrin	1/21	0.025	0.025	0.0042	No	Weight-of-Evidence[c]
Semivolatile Compounds (μg/L)						
4-Methylphenol	1/21	1.1	1.1	18	No	Max Detect < Risk Criteria
Bis(2-ethylhexyl)phthalate	8/21	0.53	61.4	4.8	Yes	Max Detect > Risk Criteria
Diethyl Phthalate	6/21	0.56	5.2	2,900	No	Max Detect < Risk Criteria
Volatile Compounds (μg/L)						
1,1,2,2-Tetrachloroethane	1/50	0.69	0.69	0.052	No	Weight-of-Evidence[c]
1,1-Dichloroethane	1/50	0.56	0.56	81	No	Max Detect < Risk Criteria
1,2-Dichloropropane	1/50	0.24	0.24	0.16	No	Weight-of-Evidence[c]
1,2-*cis*-Dichloroethene	9/46	0.4	21	6.1	Yes	Max Detect > Risk Criteria
1,2-*trans*-Dichloroethene	1/46	1.6	1.6	12	No	Max Detect < Risk Criteria
2-Butanone	1/50	8.6	8.6	190	No	Max Detect < Risk Criteria
Acetone	11/32	15.1	1,140	370	Yes	Max Detect > Risk Criteria
Benzene	3/50	0.23	2.5	0.36	Yes	Max Detect > Risk Criteria
Chlorobenzene	1/50	9.8	9.8	3.9	No	Weight-of-Evidence[c]
Chloroform	2/50	0.51	22	0.15	No	Weight-of-Evidence[c]
Ethylbenzene	13/50	0.22	26.9	130	No	Max Detect < Risk Criteria
Styrene	1/50	0.29	0.29	160	No	Max Detect < Risk Criteria
Tetrachloroethene	1/50	0.36	0.36	1.1	No	Max Detect < Risk Criteria
Toluene	11/50	0.27	17.8	75	No	Max Detect < Risk Criteria
Trichloroethene	3/50	0.35	5.4	1.6	Yes	Max Detect > Risk Criteria
Xylenes, Total	16/50	0.43	212	1,200	No	Max Detect < Risk Criteria

[a] Lead action level of 15 mg/L is based on a blood lead concentration of 10 mg/dL.

[b] Risk-based concentrations for radionuclides have been calculated for use at U.S. Department of Energy facilities (DOE/ORO 1998).

[c] Weight-of-evidence analysis indicated this constituent was detected infrequently (frequency of detection of 5 percent or less).

COPC = Contaminant of potential concern.

ND = No data available.

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3.62 pCi/L to 6.9 pCi/L, respectively. All of the Radium 226 and 228 concentrations exceeded their risk-based concentrations of 0.161 pCi/L and 0.192 pCi/L (Table 7-4), respectively. The fact that the risk-based criterion was exceeded by background radium levels implies a risk to residents using groundwater that is not impacted by SWMU 1. Radium 226 and 228 are considered human health COPCs in groundwater.

The pesticides delta-BHC and dieldrin were detected in 1 out of 21 samples analyzed (<5 percent frequency of detection); however, no background criteria were developed for these constituents. Risk-based criteria indicate that the detection of dieldrin at 0.025 µg/L exceeds the acceptable level of 0.0042 µg/L in groundwater used as a potable water source. The dieldrin detection is an estimated value that is uncertain based on the analytical detection limit of 0.04 µg/L for the sample. Because of the uncertainty in the dieldrin concentration and the infrequency of detection, dieldrin is not considered a human health COPC in groundwater associated with SWMU 1.

Delta-BHC was detected in 1 of 21 samples (<5 percent frequency of detection) at a concentration of 0.04 µg/L. No risk-based values for the delta isomer of BHC were available; however, the value for technical-grade BHC, a mixture of BHC isomers, was 0.037 µg/L, slightly less than the maximum detection in groundwater. The significance of delta-BHC in groundwater is not clear from the evaluation, especially considering that delta-BHC was not detected in soil and sediment at SWMU 1. Because of the uncertainty in relating delta-BHC to other media associated with the site and due to the low frequency of detection, delta-BHC is not considered a human health COPC in groundwater at SWMU 1.

SVOCs identified as SRCs included 4-methylphenol, bis(2-ethylhexyl)phthalate, and diethyl phthalate. 4-Methylphenol was detected in 1 of 21 samples (<5 percent frequency of detection) at a maximum concentration below the risk-based screening criteria and is not considered a human health COPC in groundwater. Diethyl phthalate was detected in 6 of 21 samples (approximately 25 percent frequency of detection) at a maximum concentration below the risk-based screening criteria and is not considered a human health COPC in groundwater.

Bis(2-ethylhexyl)phthalate was detected in 8 of 21 samples (approximately 40 percent frequency of detection); however, only two detections, 61.4 µg/L and 7.5 µg/L, exceeded the risk-based screening level of 4.8 µg/L. The maximum detected concentration of 61.4 µg/L appears to be an outlier in the data set and may be due to laboratory contamination. Although bis(2-ethylhexyl)phthalate is considered a common laboratory contaminant and is infrequently detected above risk-based criteria, bis(2-ethylhexyl)phthalate is considered a human health COPC in groundwater.

Of the 16 detected VOCs, 1,1-dichloroethane; 1,2-*trans*-dichloroethene; 2-butanone; ethylbenzene; styrene; tetrachloroethene; toluene; and xylenes were below their respective risk-based screening values and were eliminated from the analysis. VOCs that were detected in SWMU 1 groundwater in excess of risk-based screening levels are discussed below.

1,1,2,2-Tetrachloroethane was detected in 1 of 50 samples (2 percent frequency of detection) at a concentration of 0.69 µg/L, which exceeds the risk-based value of 0.052 µg/L. Because 1,1,2,2,-tetrachloroethane was infrequently detected, it is not considered a human health COPC in groundwater.

1,2-Dichloropropane was detected in 1 of 50 samples (2 percent frequency of detection) at a concentration of 0.24 µg/L, which exceeds the risk-based value of 0.16 µg/L. Because 1,2-dichloropropane was infrequently detected, it is not considered a human health COPC in groundwater.

1,2-*cis*-Dichloroethene was detected in 9 of 46 samples (20 percent frequency of detection) at a maximum concentration of 21 µg/L, which exceeds the risk-based value of 6.1 µg/L. However, the maximum detection appears to be an outlier in the data set and is the only result that exceeds the risk-based screening level. However, to maintain the conservative nature of the screening process, 1,2-*cis*-dichloroethene is considered a human health COPC in groundwater.

Acetone was detected in 11 of 32 samples (approximately 35 percent frequency of detection) at a maximum concentration of 1,140 µg/L, which exceeds the risk-based value of 370 µg/L. Three acetone results, all estimated quantities, exceed the risk-based screening criteria; therefore, acetone is considered a human health COPC in groundwater.

Benzene was detected in 3 of 50 samples (6 percent frequency of detection) at a maximum concentration of 2.5 µg/L, which exceeds the risk-based value of 0.36 µg/L. Although the maximum detection appears to be an outlier in the data set and is the only result that exceeds the risk-based screening criteria, benzene is considered a human health COPC in groundwater.

Chlorobenzene was detected in 1 of 50 samples (2 percent frequency of detection) at 9.8 µg/L, which exceeds the risk-based value of 3.9 µg/L. Because chlorobenzene was infrequently detected, it is not considered a human health COPC in groundwater.

Chloroform was detected in 2 of 50 samples (4 percent frequency of detection) at concentrations of 0.51 µg/L and 22 µg/L, which exceed the risk-based value of 0.15 µg/L. Because chloroform was detected infrequently, it is not considered a human health COPC in groundwater.

Trichloroethene was detected in 3 of 50 samples (6 percent frequency of detection) at a maximum concentration of 5.4 µg/L, which exceeds the risk-based value of 1.6 µg/L. Although the maximum detection appears to be an outlier in the data set and is the only result that exceeds the risk-based screening criteria, trichloroethene is considered a human health COPC in groundwater.

Iron, Radium 226, and Radium 228 were identified as groundwater human health COPCs based on the results of the screening. However, these constituents are not defined as hazardous constituents in the FSMR Hazardous Waste Facility Permit #HW-045 (Section I.E). In addition, they are not subject to the corrective action requirements under the terms and conditions of the permit or under Georgia Hazardous Waste Management Act, O.C.G.A 12-8-60, et seq., as amended and the Rules for Hazardous Waste Management, Chapter 391-3-11. Therefore, iron, Radium 226, and Radium 228 are not considered to be human health COPCs.

In summary, the following are considered human health COPCs in groundwater at SWMU 1: 1,2-*cis*-dichloroethene; acetone; benzene; bis(2-ethylhexyl)phthalate; chromium; lead; trichloroethene. Additional discussion of groundwater human health COPCs associated with SWMU 1 is presented in Section 7.5.

7.4.4 Sediment

SRCS in sediments were: chromium; lead; mercury; radium; 1,2,4-trichlorobenzene; and 2-butanone. All of the constituents detected were below their respective screening values except the Radium 228 (see Table 7-5) because Region III risk-based sediment screening values for radium isotopes Radium 228 were not available.

Risk-based radium isotope concentrations have been calculated for use at DOE facilities (DOE/ORO 1998), including acceptable soil concentrations corresponding to a risk level of 1E-6 for a residential exposure through ingestion of soil. For this evaluation the conservative soil-ingestion scenario is being applied to sediment exposures; therefore, the DOE risk-based soil values will provide conservative screening criteria for sediments. The maximum detected concentration of Radium 228 in sediment was 1.29 pCi/g, which is less than the risk-based concentration of 3.2 pCi/g. Therefore, Radium 228 is not considered a human health COPC in sediment associated with SWMU 1.

7.4.5 Surface Water

SRCs in surface water were: Radium 228, diethyl phthalate, and pyrene (Table 7-6). The maximum detected concentrations of diethyl phthalate and pyrene were below their respective Georgia WQC; however, values were not available for screening of radium.

Risk-based concentrations of radionuclides ingested during recreational use of surface water, have been developed for use at DOE facilities (DOE/ORO 1998). The acceptable risk-based Radium 228 concentration of 60 pCi/L for recreational use of surface water is greater than the maximum detected Radium 228 concentration of 3.97 pCi/L in surface water; therefore, radium should not be considered a human health COPC in surface water.

7.5 CONCLUSIONS OF THE HUMAN HEALTH PRELIMINARY RISK EVALUATION

Based on the results of the screening and the weight-of-evidence analysis, potential human health COPCs have been identified for soil, surface water, sediment, and groundwater. This section of the report presents a summary of the evaluation. The human health COPCs for each medium are as follows:

• Surface soil	No human health COPCs were identified.
• Subsurface soil	No human health COPCs were identified.
• Groundwater	Human health COPCs identified were chromium; lead; bis(2-ethylhexyl)phthalate; 1,2-*cis*-dichloroethene; acetone; benzene; and trichloroethene.
• Sediment	No human health COPCs were identified.
• Surface water	No human health COPCs were identified.

Table 7-5. Contaminant Screening of Sediment Results to Action Levels, SWMU 1

Station	SW/SED-2	SW/SED-3	SW/SED-4	EPA Region III Residential [a] (mg/kg)	Human Health COPC	Justification
Metals (mg/kg)						
Chromium	1.5	3.5	2.5	39	No	Max Detect < Risk Criteria
Lead	3.5	6	3.2	400 [b]	No	Max Detect < Risk Criteria
Mercury	0.02	<0.01	<0.01	2.3	No	Max Detect < Risk Criteria
Radionuclides (pCi/g)						
Radium 228	1.04	1.29	0.425	3.2 [c]	No	Max Detect < Risk Criteria
Semivolatile Organics (µg/kg)						
1,2,4-Trichlorobenzene	<454	<468	3.4	78	No	Max Detect < Risk Criteria
Volatile Organics (µg/kg)						
2-Butanone	<13.7	14.5	<13.5	4,700	No	Max Detect < Risk Criteria
Acetone	20.2	132	<13.5	780	No	Max Detect < Risk Criteria

[a] EPA Region III residential soil ingestion values were modified by dividing noncarcinogenic-based values by 10 to represent a Hazard Index of 0.1.

[b] Lead soil screening is based on the acceptable blood level of 10 mg/L.

[c] Risk-based concentration for residential ingestion of soil was calculated for use at U.S. Department of Energy facilities (DOE/ORO 1998).

COPC = Contaminant of potential concern.

EPA = U.S. Environmental Protection Agency.

GW = Groundwater.

ND = No data available.

Table 7-6. Contaminant Screening of Surface Water Results to Action Levels, SWMU 1

Station	SW/SED-2	SW/SED-3	SW/SED-3 (field dup)	SW/SED-4	Risk Criteria State of Georgia AWQC	Alternate Criteria	Human Health COPC	Justification
Radionuclides (pCi/g)								
Radium 228	3.76	3.69	2.7	3.97	ND	60 [a]	No	Max Detect < Risk Criteria
Semivolatile Organics (µg/kg)								
Diethyl Phthalate	0.86		<10	<10.2	120,000	ND	No	Max Detect < Risk Criteria
Pyrene	<10		0.1	<10.2	11,000	ND	No	Max Detect < Risk Criteria

[a] Risk-based concentration for recreational exposure to surface water of 60 pCi/L was calculated for use at U.S. Department of Energy facilities (DOE/ORO 1998).

AWQC = Ambient Water Quality Criteria.

COPC = Contaminant of potential concern.

ND = No data available.

The results of the analysis indicate that constituents present in surface soils, subsurface soils, surface water, and sediments do not pose a threat to current or future on-site receptors through direct contact. However, constituents in groundwater might present a potential risk to human health if groundwater is used as a potable water source. It should be noted that exposure of a human receptor via ingestion of groundwater is an unlikely scenario. The deeper Principal Artesian aquifer serves as the common source of drinking water throughout the region; therefore, it is unlikely that the shallow surficial aquifer would be used, especially in the proximity of a landfill. However, GEPD guidance states that groundwater must be considered a potential source of drinking water. Therefore, a baseline human health risk assessment (BHHRA) is required to further assess potential risks associated with constituents present in groundwater.

8.0 ECOLOGICAL PRELIMINARY RISK EVALUATION

The State of Georgia allows RCRA facilities to set remediation levels based on an assessment of risk to human health and the environment. All RCRA facilities in Georgia such as Fort Stewart that choose to set risk-based remediation levels must prepare risk assessment documentation and propose remediation levels in accordance with Guidance for Selecting Media Remediation Levels at RCRA Solid Waste Management Units (GEPD 1996). The guidance for ERAs (GEPD 1996) is based on the guidance contained in EPA Region IV Bulletins, Supplemental Guidance to RAGS (EPA 1996b) and a 1994 draft of Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments (EPA 1997). EPA has also proposed guidelines for conducting ecological risk assessments (ERAs) (EPA 1996c). Where GEPD guidance differs from EPA guidance, the GEPD guidance document takes precedence.

Risk is the likelihood of experiencing adverse effects. The assessment of risk for ecological receptors at SWMU 1 focuses on identifying and evaluating the potential for harmful effects on ecological receptors as a result of exposure to chemicals released to the environment.

The assessment of risk for ecological receptors at SWMU 1 is being conducted in a phased approach in accordance with GEPD (1996) and EPA (1996b) guidance. The two phases are

- the EPRE and
- the ERA.

The EPRE compares measured concentrations of detected substances to conservative ecological screening values to identify substances that pose a potential hazard to ecological receptors. An ERA is "a qualitative and/or quantitative appraisal of the actual or potential impacts of contaminants from a hazardous waste site on plants and animals other than humans or domesticated species" (EPA 1997). EPA Region IV (EPA 1996b) and GEPD (1996) guidance emphasizes that ERAs are based on quantitative and site-specific data.

According to GEPD guidance (GEPD 1996), the risk assessment process terminates with the EPRE if there is no potential hazard or risk to ecological receptors. If contaminants are found to be potential hazards in the EPRE, then additional work may be required. Only those substances that are indicated to be potential hazards in the EPRE are evaluated as ecological COPCs in an ERA, if one is required.

The need for an ERA is a risk-management decision based on the nature and magnitude of risk to ecological receptors in the environmental setting. If risk managers decide an ERA is not required, then no further data are collected and ecological risk-based remedial levels are developed based on existing data. Should an ERA be required for SWMU 1, additional site-specific data will be collected to quantify exposure and evaluate effects (GEPD 1996). Appropriate site-specific data for ERAs include concentrations of contaminants in animals and plants (tissue residues) and toxicity tests (EPA 1997). Remedial levels for protection of ecological resources (i.e., remedial goal options) are developed and proposed in the ERA for only those substances identified as ecological COCs in the ERA (GEPD 1996).

Both terrestrial and aquatic habitats present at SWMU 1 are evaluated in this EPRE. Media of concern to ecological receptors are surface soil, surface water, sediment, and groundwater.

Surface soil, surface water, and sediment can be contacted directly by ecological receptors, or their presence in these media can result in the accumulation of contaminants in plants and animals, which can cause ecological receptors ingesting biota to be exposed. Groundwater at SWMU 1 is also evaluated because it can potentially discharge to sediments, seeps, and surface water (EPA 1996b). Thus, four media—surface soil, surface water, sediment, and groundwater— are evaluated in the EPRE.

8.1 ECOLOGICAL PRELIMINARY RISK EVALUATION

The purpose of the EPRE is to identify substances detected at the facility that pose a potential hazard to ecological receptors. According to GEPD (1996), the ecological risk evaluation process consists of five steps:

i. Ecological screening value comparison,
ii. Preliminary problem formulation,
iii. Preliminary ecological effects evaluation,
iv. Preliminary exposure estimate, and
v. Preliminary risk calculation.

These five steps correspond to the five steps of the EPA Region IV EPRE (EPA 1996d).

As shown in the flowchart of the GEPD ERA process (Figure 8-1), the first step of the EPRE (Step i) is to screen all substances as ecological COPCs by comparing the maximum detected concentration to the ecological screening values (ESVs). This approach assumes that the most sensitive receptors are those that live in direct contact with the medium and are exposed to contaminants by multiple pathways. If no ecological COPCs are identified based on the ESV comparison (Step i), then no further evaluation is required. If ecological COPCs are identified based on the screening, then they are evaluated further (Steps ii through v). Because there are no ESVs for surface soil, all substances in surface soil at SWMU 1 are evaluated further in EPRE Steps ii through v.

The preliminary problem formulation (Step ii) identifies categories of potential ecological receptors that occur at SWMU 1 and substances in surface soil, sediment, surface water, and groundwater that may pose a risk to those receptors in the environmental setting. Preliminary assessment endpoints, ecological receptors, and surrogate species that represent of those receptors are selected for evaluation in the preliminary risk calculation (EPA 1996b).

The preliminary ecological effects evaluation (Step iii) identifies toxicity reference values (TRVs) for use in the preliminary risk calculation (EPA 1996b). For SWMU 1, TRVs are average daily doses for the surrogate species. Per GEPD guidance (GEPD 1996), TRVs are derived from published laboratory toxicity studies.

The preliminary exposure estimate (Step iv) evaluates the potential pathways of exposure for SWMU 1 ecological receptors and preliminary assessment endpoints. The equations for calculating daily exposure doses for surrogate species from published values for exposure parameters and measured maximum concentrations of contaminants in surface soil, sediment, surface water, and groundwater at SWMU 1 are described.

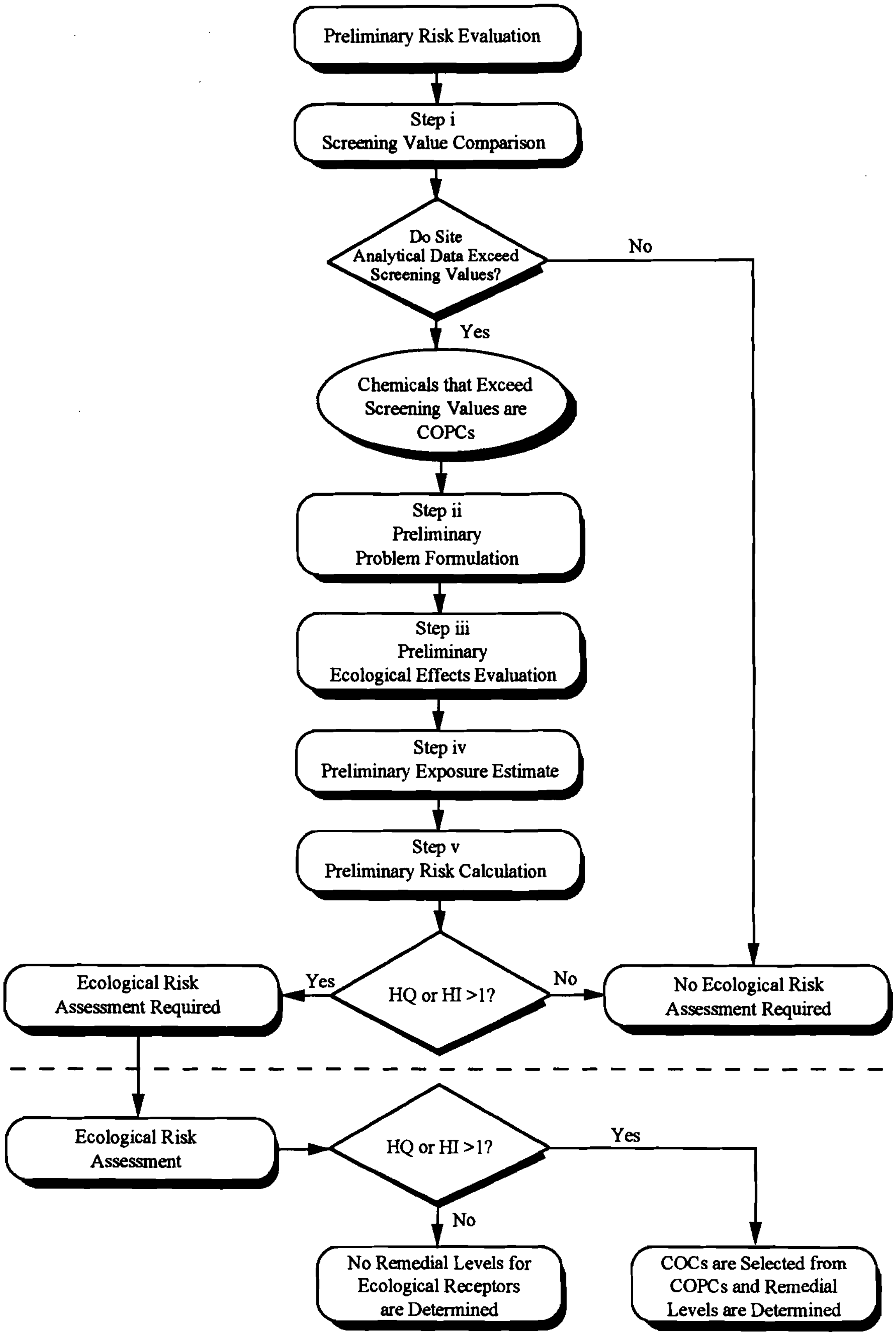

Figure 8-1. General Process for Assessing Risk and Selecting Remedial Levels for Ecological Receptors (GEPD 1996)

The preliminary risk calculation (Step v) calculates HQs, the ratio of the estimated daily exposure dose at SWMU 1 and the TRV for the surrogate species. HQs are used to evaluate the potential for risk to ecological receptors; to identify ecological COPCs in surface soil, sediment, surface water, and groundwater at SWMU 1 for ecological receptors; and to support a risk-management decision about the need for further evaluation in an ERA.

8.1.1 Ecological Screening Value Comparison (Step i)

The ESVs used to identify ecological COPCs at SWMU 1 are EPA Region IV screening values for hazardous waste sites. These are given in Tables 8-1, 8-2, and 8-3, respectively, for the substances detected in surface water, sediment, and groundwater at SWMU 1. Screening values for analytes without Region 4 ESVs are proposed based on data obtained from published sources (e.g., Suter and Tsao 1996; Clayton and Clayton 1981) and toxicological databases (e.g., Hazardous Substances Data Bank; Integrated Risk Information System). Screening values are conservative to prevent elimination of any contaminant that might pose ecological risk (EPA 1997). If no data are available to support the development of an ESV for an analyte in surface water, sediment, or groundwater, the analyte is an ecological COPC by default (GEPD 1997a).

Chemicals detected in surface water and sediment from four locations downgradient of SWMU 1 are screened (Figure 5-6), as well as an upgradient location on Mill Creek (SW/SED-1). Mill Creek has two sampling stations in the vicinity of SWMU 1 (SW/SED-1 and SW/SED-2). SW/SED-1 is upgradient of SWMU 1, while SW/SED-2 is upstream of the confluence with Taylors Creek. Taylors Creek has two sampling locations: one upstream of the confluence with Mill Creek (SW/SED-3) and one downstream of SWMU 1 (SW/SED-4).

The maximum concentration of all substances detected in 22 monitoring well, 22 Geoprobe, and 2 vertical-profile samples from locations around SWMU 1 are screened against surface water ESVs. The maximum total concentrations of substances detected in groundwater are screened against surface water ESVs in accordance with EPA Region IV guidance (EPA 1996d) because (1) there are no groundwater ESVs and (2) shallow groundwater at the site could discharge to the adjacent creeks during times of high groundwater stage so that ecological receptors could become exposed to contamination in groundwater.

For surface water and groundwater, EPA Region IV ESVs are chronic Ambient Water Quality Criteria (AWQC) for the protection of aquatic life, such as aquatic plants, invertebrates, and fish, or similarly derived values (EPA 1996b; Suter and Tsao 1996). There are no EPA Region IV ESVs for barium, Radium 228, 4-methylphenol, pyrene, and styrene. The proposed ESV for barium of 3.9 μg/L is the chronic Tier II benchmark value reported in Suter and Tsao 1996. The proposed ESVs for Radium 226 and Radium 228 are, respectively, 5.8×10^4 pCi/L and 1.67×10^7 pCi/L, which are equivalent to an effects benchmark of 1 rad/day for combined internal and external exposures to aquatic biota (Blaylock et al. 1993). The proposed ESVs for 4-methylphenol (1.3 μg/L) and pyrene (25 μg/L) are derived, respectively, from the chronic Tier II values for 2-methylphenol (Suter and Tsao 1996) and the 20-hour lethal concentration-zero (LC_0) for 7,12-dimethylbenz(a)anthracene for juvenile minnows (Eisler 1987). The proposed ESVs are the surrogate values multiplied by an uncertainty factor of 0.1. The EPA Region IV ESV for dieldrin is not used because it is based on the marketability of fish, which is a human risk matter. In accordance with EPA guidance (EPA 1996d), an alternative ESV is here proposed for dieldrin that has greater ecological significance. The proposed ESV for dieldrin is

Table 8-1. Ecological Screening Value Comparison for Surface Water at SWMU 1

Analyte	ESV	SWMU 1				
		SW/SED-2	SW/SED-3	SW/SED-3D	SW/SED-4	Maximum
Radionuclides (pCi/L)						
Radium 228	1.64E+07[a]	3.76	3.69	2.70	3.97	3.97
Semivolatile Organic Compounds (mg/L)						
Diethyl Phthalate	521	0.86	ND	<10	<10.2	<10.2
Pyrene	25[b]	<10	ND	0.10	<10.2	<10.2

ESV = U.S. Environmental Protection Agency (EPA) Region 4 Ecological Screening Values for freshwater (EPA 1996d) and, where indicated, alternative values for analytes without ESVs.
ND = Not detected.
SWMU = Solid Waste Management Unit.
SW/SED-1 = Upgradient sample in Mill Creek at SWMU 1.
SW/SED-3D = Duplicate at station SW/SED-3.
[a] Derived from 1 rad/day benchmark per Blaylock et al. (1993) as cited in U.S. Department of Energy (1998).
[b] Reported 20 hour LC_0 for 7, 12-dimethylbene(a)anthracene for juvenile minnows (Eisler 1987) H 0.1.

Table 8-2. Ecological Screening Value Comparison for Sediment at SWMU 1

Analyte	ESV	SWMU 1			
		SW/SED-2	SW/SED-3	SW/SED-4	Maximum
RCRA Metals (mg/kg)					
Chromium	52.3	1.5	3.5	2.5	3.5
Lead	30.2	3.5	6	3.2	6
Mercury	0.13	0.02	<0.01	<0.01	0.02
Radionuclides (pCi/g)					
Radium 228	7.33E+06[a]	1.04	1.29	0.425	1.29
Volatile Organic Compounds (mg/kg)					
Acetone	0.863[b]	0.0202	0.132	<0.0135	0.297
2-Butanone	27.3[b]	<0.0137	0.0145	<0.0135	0.0145
Semivolatile Organic Compounds (mg/kg)					
1,2,4- Trichlorobenzene	9.2[c]	<0.454	<0.468	0.0034	<0.468

ESV = U.S. Environmental Protection Agency Region 4 Ecological Screening Values for sediment (EPA 1996d) and, where indicated, alternative values for analytes without ESVs.
RCRA = Resource Conservation and Recovery Act.
SWMU = Solid Waste Management Unit.
[a] Proposed ESV for Radium 228 calculated as proposed surface water ESV (1.63E+07 mg/L) × K_d (450 L/kg) × 0.001 (mg/mg).
[b] Sediment quality benchmark (SQB) = surface water ESV (mg/L) × K_{ow} (L/kg).
[c] Office of Solid Waste and Emergency Response value (Jones et al. 1997).

For calculation of SQBs: Compound	K_{ow} (L/kg)	Surface Water ESV (mg/L)	Source of Surface Water ESV
Acetone	0.5754	1.5	Chronic Tier II value (Suter and Tsao 1996)
2-Butanone	1.95	14	Chronic Tier II value (Suter and Tsao 1996)

Table 8-3. Ecological Screening Value Comparison for Analytes Detected in Groundwater at SWMU 1

Analyte	ESV	Background Criterion	SWMU 1 Maximum
RCRA Metals (mg/L)			
Barium	3.9[a]	57.2	**134**
Cadmium	0.66[b]	0.593	0.59
Chromium	117.32[b,c]	5.2	11.6
Iron	1000	7560	**22,000**
Lead	1.32[b]	2.83	**18.4**
Radionuclides (pCi/L)			
Radium 226	58,000[d]	1.16	1.63
Radium 228	16,300,000[d]	3.42	6.9
Volatile Organic Compounds (mg/L)			
Acetone	1500[a]		1140
Benzene	53		2.5
2-Butanone	14000[a]		8.6
Chlorobenzene	195		9.8
Chloroform	289		22
1,1-Dichloroethane	47[a]		0.56
1,2-*cis*-Dichloroethene	590[a]		21
1,2-Dichloropropane	525		0.24
Ethylbenzene	453		26.9
Styrene	10,000[e]		0.29
Tetrachloroethene	84		0.36
1,1,2,2-Tetrachloroethane	240		0.69
Toluene	175		17.8
Trichloroethene	47		5.4
Xylenes, Total	1.8[a]		**212**
Semivolatile Organic Compounds (mg/L)			
Bis(2-ethylhexyl)phthalate	0.3		**61.4**
Diethyl Phthalate	521		5.2
4-Methylphenol	1.3[f]		1.1
Pesticides (mg/L)			
Delta-BHC	0.08[g]		0.04
Dieldrin	0.062[a]		0.025

Blank = No background criteria for organics.

ESV = U.S. Environmental Protection Agency (EPA) Region 4 Ecological Screening Values (EPA 1996b) and, where indicated, alternative values for analytes without ESVs.

RCRA = Resource Conservation and Recovery Act.

SVOC = Semivolatile organic compound.

SWMU = Solid Waste Management Unit.

VOC = Volatile organic compound.

Double borders indicate concentrations exceeding ESV or no ESV; boldface values also exceed background criteria.

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Table 8-3 (continued)

[a] Office of Solid Waste and Emergency Response Ambient Water Quality Criteria or Tier II value (Suter and Tsao 1996).
[b] Hardness-dependent; assumes 50 mg/L $CaCO_3$.
[c] Chromium (III); ESV for Chromium (VI) = 11.
[d] Derived from 1 rad/day benchmark per Blaylock et al. (1993) as cited in U.S. Department of Energy (1998).
[e] Fish LC_{50} (Clayton and Clayton 1981).
[f] ESV for 2-methylphenol (Suter and Tsao 1996) x 0.1.
[g] ESV for gamma-BHC (Lindane).

the chronic EPA AWQC value (0.062 µg/L) as reported in Suter and Tsao (1996). Substances exceeding surface water ESVs are potential hazards for aquatic biota such as fish and amphibians.

Sediment ESVs are based on observations of direct toxicity to sediment-dwelling organisms (EPA 1996d). EPA Region IV ESVs for sediment are not available for barium; Radium 226; Radium 228; acetone; 2-butanone; 1,2,4-trichlorobenzene; and delta-BHC. No ESV is proposed for barium. The proposed ESV for Radium 226 and Radium 228 are 2.61×10^4 and 7.33×10^6 pCi/g, respectively. These ESVs are equivalent to an effects benchmark of 1 rad/day for combined internal and external exposure to aquatic biota (Blaylock et al. 1993) assuming that sediment-dwelling biota are exposed to radium in sediment pore-water in equilibrium with sediment, as described by the K_d for radium. The K_d for radium is 450 L/kg (Baes et al. 1984). For acetone and 2-butanone, proposed ESVs are sediment quality benchmarks (SQBs) calculated from the K_{ow} of the compound and proposed ESVs for surface water, assuming equilibrium partitioning between the sediment and overlying water per EPA (1993b). The proposed surface water ESVs for acetone and 2-butanone used to derive the SQBs are chronic Tier II benchmark values reported in Suter and Tsao 1996. The proposed sediment ESVs for acetone and 2-butanone are derived in Table 8-2. The proposed ESV for 1,2,4-trichlorobenzene is the EPA value reported in Jones et al. 1997. The EPA Region IV Sediment ESV for gamma-BHC (Lindane) is used without modification for delta-BHC.

The results of the ESV comparisons for surface water are presented in Table 8-1. No inorganic substance, were detected above FSMR background. Mercury, Radium 228, diethyl phthalate, and pyrene do not exceed the ESVs.

The results of the screening value comparisons for sediment at SWMU 1 are presented in Table 8-2. No substance detected in sediment at SWMU 1 exceeds EPA Region IV sediment ESVs.

The results of the ESV comparison for chemicals detected in groundwater at SWMU 1 are presented in Table 8-3. The maximum detected concentrations of substances in groundwater samples from 21 monitoring well, 22 Geoprobe, and 2 vertical-profile sample locations at SWMU 1 (Figure 3-1) are screened against EPA Region IV surface water ESVs. The background criteria (two times average background concentration) include the detected concentrations from the monitoring well located upgradient of SWMU 1 (SC-M10).

Barium, iron, and lead in groundwater from SWMU 1 exceed ESVs and also exceed two times the average background concentrations (Table 8-3). Iron and lead were detected at concentrations exceeding their ESVs at 18 and 9 sampling stations, respectively. Thus, three metals (barium, iron, and lead) exceed ESVs and are ecological COPCs for groundwater at SWMU 1.

Xylenes (total) and bis(2-ethylhexyl)phthalate in groundwater at SWMU 1 exceed their ESVs. The Client Required Detection Limits (CRDLs) for the two organics are greater than the ESVs (Table 8-3). Xylenes (total) exceed the ESV (1.8 µg/L) in 12 of the Geoprobe samples, and bis(2-ethylhexyl)phthalate was detected at concentrations exceeding its ESV (0.3 µg/L) in 8 monitoring well samples. Thus, two organics [xylenes and bis(2-ethylhexyl)phthalate] exceed ESVs and are ecological COPCs for groundwater at SWMU 1.

The ecological COPCs in surface water, sediment, and groundwater at SWMU 1 are summarized in Table 8-4. There are no ecological COPCs identified in surface water and sediment from SWMU 1. Barium, iron, lead, bis(2-ethylhexyl)phthalate, and xylenes (total) are identified as ecological COPCs in groundwater at one or more sampling stations at SWMU 1. Thus, a number of ecological COPCs in groundwater require further examination in EPRE Steps ii through v (Table 8-4).

Table 8-4. Summary of Ecological COPCs Identified in ESV Comparison for Surface Water, Sediment, and Groundwater at SWMU 1

	Surface Water[a]	Sediment[a]	Groundwater[a]
Concentration exceeds ESV	None	None	Barium Iron Lead Bis(2-ethylhexyl)phthalate Xylenes (total)
No ESV	None	None	None

[a]Excludes upgradient samples.
COPC = Contaminant of potential concern.
ESV = Ecological screening value.

A preliminary problem formulation (Step ii), preliminary ecological effects evaluation (Step iii), preliminary exposure estimate (Step iv), and preliminary risk calculation (Step v) have been conducted for those detected analytes identified as ecological COPCs at SWMU 1 in the ESV comparison (EPRE Step i). These four steps go beyond the ecological screening value comparison to evaluate the potential for risk from ecological COPCs to categories of receptors potentially occurring at the facility.

8.1.2 Preliminary Problem Formulation (Step ii)

The preliminary problem formulation (Step ii) qualitatively identifies categories of potential ecological receptors and the substances that may pose a risk to those receptors in the environmental setting of SWMU 1. Preliminary assessment endpoints, ecological receptors, and surrogate species representative of ecological receptors are selected for evaluation in the preliminary risk calculation.

GEPD (1996) specifies that the EPRE develop "risk characterization for a model ecological receptor." Developing risk characterization for multiple ecological receptors (e.g., mammals and birds) is allowable for sites where more than one type of potentially hazardous chemical is

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detected (GEPD 1997b). Characterizing the risk to multiple receptors, where each is more sensitive to one or more chemical contaminant, can make the EPRE more protective of ecological resources. The risk characterization for surface soil, sediment, surface water, and groundwater at SWMU 1 considers both mammals and birds as ecological receptors.

Environmental Setting

SWMU 1 at Fort Stewart is located 1.2 miles to the west of the cantonment or garrison area of the FSMR (Figure 1-3). The old, inactive landfill is located immediately east of the active landfill and is bordered by forest to the north, south, and east. The top of the inactive landfill is vegetated with small trees, shrubs, and old field herbs and grasses. Large, old live oak trees (*Quercus sp.*) can be found in a relatively undisturbed area between the inactive landfill and the active landfill.

SWMU 1 is bounded on the north by Taylors Creek and the southwest and west by Mill Creek, a tributary of Taylors Creek. Taylors Creek flows eastward past SWMU 1 along its northern boundary, and Mill Creek flows north past the western edge of the active landfill where it joins Taylors Creek (Figure 3-1). Taylors Creek is approximately 1100 feet from the northern boundary of the old, inactive landfill. Taylors Creek and its floodplain form an extensive wetland north of the landfill. Mill Creek is approximately 200 feet from the western boundary fence of the active landfill and 4000 feet southwest and west of the old, inactive landfill. Taylors Creek is a tributary of Canoochee Creek, a tributary of Canoochee River, which ultimately discharges into the Ogeechee River. Additional surface water features include a pond located approximately 900 feet to the south of SWMU 1 (Figure 3-1).

The terrestrial habitat in the vicinity of SWMU 1 consists primarily of palmetto-pine flatwoods forest to the east and south and bottomland hardwood forests to the west and north. Major species in river bottomland forests include tupelo (*Nyssa aquatica*) and other gum trees, water oak (*Quercus sp.*), and bald cypress (*Taxodium distichum*). Loblolly pine (*Pinus taeda*) and long-leaf pine (*P. palustris*) comprise the forest canopy in drier areas in the vicinity of SWMU 1. The understory of pine forests is typically dominated by saw-palmetto (*Serenoa repens*).

Aquatic biota and amphibians occur in Taylors and Mill creeks. Typical fish species found in creeks, rivers, and lakes of the FSMR include bluegill, largemouth bass, crappie, sunfish, channel catfish, minnows, and shiners. Terrestrial fauna are abundant in the natural areas of the FSMR, such as the forests and wetlands surrounding SWMU 1. Numerous mammals and birds were noted at Fort Stewart by SAIC field personnel either through observation, hearing a call, or seeing scat or tracks. The red-headed woodpecker *(Melanerpes eryhrocephalus)* and the turkey vulture *(Cathartes aura)* were observed in the area on numerous occasions. Scat or tracks of white-tailed deer *(Odocoileus virginianus),* armadillo *(Dasypus novemcinctus),* and raccoon *(Procyon lotor)* were noted by SAIC field personnel.

Surface Soil

The EPRE for surface soil (0 to 2 feet) at SWMU 1 evaluates the potential for risk to ecological receptors from substances detected in soil from SWMU 1 sampling locations (Figure 5-1).

The categories of ecological receptors that are potentially directly exposed to substances in surface soil at SWMU 1 are soil bacteria and fungi, vegetation, and animals that come in direct contact with or ingest soil (e.g., soil-dwelling invertebrates). Other categories of receptors are potentially indirectly exposed to soil contaminants that are taken up and stored in the cells or tissues of those organisms directly exposed. Herbivorous invertebrates (e.g., insects) and vertebrates (e.g., birds and mammals) are potentially indirectly exposed when they ingest vegetation growing in contaminated soil. Carnivorous animals are potentially exposed when they ingest animals that are directly or indirectly exposed to contaminated soil such as soil-dwelling invertebrates (e.g., earthworms).

One RCRA metal, two radionuclides, three VOCs, one SVOC, and three pesticides were detected in surface soil samples from SWMU 1 (Table 5-1). Based on the greater amount of published data on the effects of these 16 substances on vertebrate wildlife, and in particular mammals and birds, the proposed ecological receptors for surface soil at SWMU 1 are small mammals and birds that prey upon soil-dwelling invertebrates such as earthworms.

The preliminary assessment endpoint for surface soil at SWMU 1 is protection of small mammals and bird populations from adverse effects. The surrogate species to represent the ecological receptors are the short-tailed shrew (*Blarina brevicauda*) and the American robin (*Turdus migratorius*). The home range of the shrew is small, and robins are territorial during the spring mating season. Earthworms and other soil-dwelling invertebrates potentially represent a large percentage of both species' diets. The life history and behavior of these two species ensure a conservative estimate of risk per GEPD (1996) and EPA (1997) guidance.

Groundwater

The EPRE for SWMU 1 evaluates the potential for risk to ecological receptors from exposure to groundwater, which potentially discharges to local surface water bodies.

The ecological receptors that are potentially directly exposed to substances in groundwater after it has emerged as surface water at SWMU 1 are aquatic plants and animals, terrestrial animals that come in direct contact with or ingest surface water, and those animals ingesting aquatic biota that live in the creeks, such as fish. Amphibians potentially breed in standing water on the wetland formed by Taylors Creek and its floodplain. Other terrestrial animals potentially drink from creeks or wetland pools. Terrestrial predators of aquatic biota, such as fish-eating birds and mammals, are also likely to be indirectly exposed to contaminants in surface water, and potentially groundwater, through ingestion of aquatic prey.

Barium, iron, lead, bis(2-ethylhexyl)phthalate, and xylenes (total) are ecological COPCs in groundwater. Based on the ecological COPCs, the habitat, and potential exposure pathways at SWMU 1, the proposed ecological receptors for groundwater are aquatic biota, such as fish and amphibians, and terrestrial animals. Aquatic biota are directly exposed to ecological COPCs in surface water. Terrestrial animals are potentially exposed by ingestion of surface water and ingestion of aquatic biota that have bioaccumulated substances in their tissues.

The preliminary assessment endpoints for groundwater at SWMU 1 are

- protection of aquatic biota,
- protection of terrestrial mammal populations from adverse effects of drinking surface water, and

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- protection of fish-eating mammals and bird populations from adverse effects from ingesting fish and other aquatic biota.

No further evaluation in the EPRE is conducted for the aquatic biota assessment endpoint. The results of the ESV comparison for groundwater identify the ecological COPCs for aquatic biota at SWMU 1.

The surrogate species to represent the terrestrial ecological receptors exposed to groundwater are the raccoon (*Procyon lotor*), the mink (*Mustela vison*), and the green heron (*Butorides striatus*). These species are potentially found at Fort Stewart (GEPD 1997c) and potentially use Taylors and Mill creeks as sources of nourishment. The raccoon is common to the coastal plain in Georgia. Raccoons drink water from shallow surface water bodies and ingest more water per unit body weight than do larger mammals such as the white-tailed deer (*Odocoileus virginianus*)—0.082 g/g/day (EPA 1993c) versus 0.065 g/g/day (Sample and Suter 1994). Mink and herons ingest fish and other aquatic biota living in streams; thus, the life history and behavior of these species ensure a conservative estimate of risk per GEPD (1996) and EPA (1997) guidance.

8.1.3 Preliminary Ecological Effects Evaluation (Step iii)

The preliminary ecological effects evaluation (Step iii) identifies TRVs for use in the preliminary risk calculation. TRVs are derived from no-observed-adverse-effect levels (NOAELs) from laboratory toxicity studies on test species. In the EPRE for SWMU 1, TRVs are required for shrews and robins ingesting contaminated biota exposed to surface soil at SWMU 1, raccoons ingesting contaminated water, fish-eating mammals (minks), and wading birds (green herons) ingesting contaminated biota potentially exposed to ecological COPCs in groundwater discharging to local water bodies. The derivation of TRVs for surrogate species is described below.

First, chronic NOAELs for test species are derived from published chronic or subchronic NOAEL or lowest-observed-adverse-effect level (LOAEL) benchmarks for the test species exposed to the contaminant in controlled laboratory studies. The derivations of NOAELs for mammals and birds are shown in Tables 8-5 and 8-6, respectively. If a chronic NOAEL is not available for a contaminant, a chronic NOAEL is estimated from a subchronic NOAEL by dividing by an uncertainty factor of 10 (Sample et al. 1996). Published LOAELs may be used to derive a NOAEL by dividing the LOAEL by a conservative uncertainty factor of 10 (EPA 1996d). Subchronic LOAELs are divided by an uncertainty factor of 100 to estimate a chronic NOAEL.

Most NOAELs and LOAELs for test species are those reported in Sample et al. (1996). Some NOAELs were found in published toxicity studies or other risk assessments. In some cases, if neither a NOAEL nor LOAEL is available for a contaminant, the benchmark for a related compound is used as a surrogate. The chronic NOAEL for pyrene for birds is derived by Shortelle et al. (1997), as cited in QST Environmental, Inc. (QST) 1997.

Table 8-5. Derivation of NOAELs for Mammal Test Species at SWMU 1

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kg/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor DCF	Endpoint Conversion Factor ECF	Noael (mg/kg/d) = Benchmark × DCF × ECF
RCRA Metals										
Barium	Rat	4.35E-01	5.06E+00	Chronic	NOAEL	Growth	Perry et al. (1983) in [1]	1.0	1.0	5.06E+00
Cadmium	Rat	3.03E-01	1.00E+00	Chronic	NOAEL	Reproduction	Sutou et al. (1980b) in [1]	1.0	1.0	1.00E+00
Chromium	Rat	3.50E-01	2.74E+03	Chronic	NOAEL	Reproduction	Ivankovic and Preussmann (1975) in [1]	1.0	1.0	2.74E+03
Iron	None	None	None	None	None	None	None	None	None	No NOAEL
Lead	Rat	3.50E-01	8.00E+00	Chronic	NOAEL	Reproduction	Azar et al. (1973) in [1]	1.0	1.0	8.00E+00
Methyl Mercury	Mink	1.00E+00	1.01E+00	Chronic	NOAEL	Reproduction	Aulerich et al. (1974) in [1]	1.0	1.0	1.01E+00
Mercury (Mercuric sulfide)	Mouse	3.00E-02	1.32E+01	Chronic	NOAEL	Reproduction	Revis et al. (1989) in [1]	1.0	1.0	1.32E+01
Selenium	Rat	3.50E-01	2.00E-01	Chronic	NOAEL	Reproduction	Rosenfeld and Beath (1954) in [1]	1.0	1.0	2.00E-01
Radionuclides										
Radium 226	None	None	None	None	None	None	None	None	None	No NOAEL
Radium 228	None	None	None	None	None	None	None	None	None	No NOAEL
VOCs										
Acetone	Rat	3.50E-01	1.00E+02	Subchronic	NOAEL	Liver and Kidney Damage	EPA (1988a) in [1]	0.1	1.0	1.00E+00
Methylene Chloride	Rat	3.50E-01	5.85E+00	Chronic	NOAEL	Liver Histology	NCA (1982) in [1]	1.0	1.0	5.85E+00
Toluene	Mouse	3.00E-02	2.60E+02	Chronic	LOAEL	Reproduction	Nawrot and Staples (1979) in [1]	1.0	0.1	2.60E+01
Xylene, Total	Mouse	3.00E-02	2.06E+00	Chronic	NOAEL	Reproduction	Marks et al. (1982) in [1]	1.0	1.0	2.06E+00

Table 8-5. Derivation of NOAELs for Mammal Test Species at SWMU 1 (continued)

Analyte	Test Species	Test Species Body Weight (kg) BW_t	Benchmark (mg/kg/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor DCF	Endpoint Conversion Factor ECF	Noael (mg/kg/d) = Benchmark × DCF × ECF
SVOCs										
BHC-Mixed Isomers	Rat	3.50E-01	1.60E+00	Chronic	NOAEL	Reproduction	Grant et al. (1977) in [1]	1.0	1.0	1.60E+00
Bis(2-ethylhexyl) phthalate	Mouse	3.00E-02	1.83E+01	Chronic	NOAEL	Reproduction	Lamb et al. (1987) in [1]	1.0	1.0	1.83E+01
Di-n-butyl Phthalate	Mouse	3.00E-02	5.50E+02	Chronic	NOAEL	Reproduction	Lamb et al. (1987) in [1]	1.0	1.0	5.50E+02
Diethyl Phthalate	Mouse	3.00E-02	4.58E+03	Chronic	NOAEL	Reproduction	Lamb et al. (1987) in [1]	1.0	1.0	4.58E+03
Pyrene	Mouse	3.00E-02	1.00E+01	Chronic	LOAEL	Reproduction	Opresko et al. (1995) in [2]	1.0	0.1	1.00E+00
1,2,4 - Trichlorobenzene	Rat	3.50E-01	1.48E+01	Chronic	NOAEL	Reproduction	IRIS (1998) [3]	1.0	1.0	1.48E+01
Pesticides										
4,4'-DDD	Rat	3.50E-01	8.00E-01	Chronic	NOAEL	Reproduction	Fitzhugh (1948) in [1]	1.0	1.0	8.00E-01
4,4'-DDE	Rat	3.50E-01	8.00E-01	Chronic	NOAEL	Reproduction	Fitzhugh (1948) in [1]	1.0	1.0	8.00E-01
4,4'-DDT	Rat	3.50E-01	8.00E-01	Chronic	NOAEL	Reproduction	Fitzhugh (1948) in [1]	1.0	1.0	8.00E-01
Dieldrin	Rat	3.50E-01	2.00E-01	Chronic	LOAEL	Reproduction	Treon and Cleveland (1955) in [1]	1.0	0.1	2.00E-02

DCF = Duration conversion factor; 1 if chronic, 0.1 if subchronic (Sample et al. 1996).

ECF = Endpoint conversion factor; 1 if NOAEL, 0.1 if LOAEL (Sample et al. 1996).

LOAEL = Lowest-observed-adverse-effect level.

NOAEL = No-observed-adverse-effect level.

RCRA = Resource Conservation and Recovery Act.

SVOC = Semivolatile organic compound.

VOC = Volatile organic compound.

[1] = Sample et al. (1996).

[2] = QST (1997); all values assumed to be chronic.

[3] = Integrated Risk Information System (IRIS), U.S. Environmental Protection Agency toxicological database, accessed online April 1998.

Table 8-6. Derivation of NOAELs for Bird Test Species at SWMU 1

Analyte	Test Species	Test Species Body Weight (Kg) BW_t	Benchmark (mg/kg/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor DCF	Endpoint Conversion Factor ECF	NOAEL (mg/kg/d) = Benchmark × DCF × ECF
RCRA Metals										
Barium	Chick (14 day old)	1.21E-01	2.08E+02	Subchronic	NOAEL	Mortality	Johnson et al. (1960) in [1]	0.1	1.0	2.08E+01
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
Chromium	Black Duck	1.25E+00	1.00E+00	Chronic	NOAEL	Reproduction	Haseltine et al. (unpubl.) in [1]	1.0	1.0	1.00E+00
Iron	None	None	None	None	None	None	None	None	None	No NOAEL
Lead	Quail	1.50E-01	1.13E+00	Chronic	NOAEL	Reproduction	Edens et al. (1976) in [1]	1.0	1.0	1.13E+00
Mercury (Mercuric Chloride)	Quail	1.50E-01	4.50E-01	Chronic	NOAEL	Reproduction	Hill and Schaffner (1976) in [1]	1.0	1.0	4.50E-01
Methyl Mercury Dicyandiamide	Mallard Duck	1.00E+00	6.40E-02	Chronic	LOAEL	Reproduction	Heinz (1979) in [1]	0.1	1.0	6.40E-03
Selenium	Mallard Duck	1.00E+00	5.00E-01	Chronic	NOAEL	Reproduction	Heinz et al. (1987) in [1]	1.0	1.0	5.00E-01
Radionuclides										
Radium 226	None	None	None	None	None	None	None	None	None	No NOAEL
Radium 228	None	None	None	None	None	None	None	None	None	No NOAEL
VOCs										
Acetone	None	None	None	None	None	None	None	None	None	No NOAEL
Methylene Chloride	None	None	None	None	None	None	None	None	None	No NOAEL
Toluene	None	None	None	None	None	None	None	None	None	No NOAEL
Xylene, Total	None	None	None	None	None	None	None	None	None	No NOAEL

Table 8-6. Derivation of NOAELs for Bird Test Species at SWMU 1 (continued)

Analyte	Test Species	Test Species Body Weight (Kg) BW_t	Benchmark (mg/kg/d)	Test Duration	Endpoint	Effect	Source	Duration Conversion Factor DCF	Endpoint Conversion Factor ECF	NOAEL (mg/kg/d) = Benchmark × DCF × ECF
SVOCs										
BHC-Mixed Isomers	Japanese Quail	1.50E-01	5.63E-01	Chronic	NOAEL	Reproduction	Vos et al. (1971) in [1]	1.0	1.0	5.63E-01
Bis(2-ethylhexyl) Phthalate	Ringed Dove	1.55E-01	1.11E+00	Chronic	NOAEL	Reproduction	Peakall (1974) in [1]	1.0	1.0	1.11E+00
Di-n-butyl Phthalate	Ringed Dove	1.55E-01	1.10E+00	Chronic	LOAEL	Reproduction	Peakall (1974) in [1]	1.0	0.1	1.10E-01
Diethyl Phthalate	None	None	None	None	None	None	None	None	None	No NOAEL
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
1,2,4 - Trichlorobenzene	Japanese Quail	1.50E-01	5.63E-01	Chronic	NOAEL	Reproduction	Surrogate Value (BHC mixed	1.0	1.0	5.63E-01
Pesticides										
4,4'-DDD	Brown Pelican	3.50E+00	2.80E-02	Chronic	LOAEL	Reproduction	Anderson et al. (1975) in [1]	1.0	0.1	2.80E-03
4,4'-DDE	Brown Pelican	3.50E+00	2.80E-02	Chronic	LOAEL	Reproduction	Anderson et al. (1975) in [1]	1.0	0.1	2.80E-03
4,4'-DDT	Brown Pelican	3.50E+00	2.80E-02	Chronic	LOAEL	Reproduction	Anderson et al. (1975) in [1]	1.0	0.1	2.80E-03
Dieldrin	Barn Owl	4.66E-01	7.70E-02	Chronic	NOAEL	Reproduction	Mendenhall et al. (1983) in [1]	1.0	1.0	7.70E-02

DCF = Duration conversion factor; 1 if chronic, 0.1 if subchronic (Sample et al. 1996).

ECF = Endpoint conversion factor; 1 if NOAEL, 0.1 if LOAEL (Sample et al. 1996).

LOAEL = Lowest-observed-adverse-effect level.

NOAEL = No-observed-adverse-effect level.

RCRA = Resource Conservation and Recovery Act.

SVOC = Semivolatile organic compound.

VOC = Volatile organic compound.

[1] = Sample et al. (1996).

[2] = QST (1997); all values assumed to be chronic.

The estimated bird NOAEL for pyrene reported in QST 1997 is used as the chronic NOAEL for the test species. Shortelle et al. (1997), as cited in QST 1997, uses linear regression of NOAELs for chemicals for which benchmark values for both mammals and birds are published in Opresko et al. 1995 to predict the bird NOAEL for SVOCs for which there are mammal but no bird data. These predicted NOAELs are for a "composite" bird with a body weight equal to the average of all bird test species for NOAELs used in the regression. These estimated bird NOAELs were used in ERAs for operable units at Fort Sheridan, Illinois (QST 1997; SAIC 1998).

Once the published and estimated NOAELs for test species are identified or derived, they are used to derive NOAELs for the SWMU 1 surrogate species, as described below, and these derived NOAELs are used as the TRVs in the EPRE.

Chronic NOAELs for test species of the same taxonomic class as the surrogate species are adjusted for the body weight of the surrogate species to derive TRVs for the surrogate species; that is, mammal test species data are used for mammal surrogate species, and bird test species data are used for bird surrogate species. NOAELs for test species based on average daily dose (mg/kg/day) are adjusted to the surrogate species based on body weight, according to the following equation:

$$\text{surrogate species NOAEL} = \text{test species NOAEL} \times (bw_{ts}/bw_{ss})^{z},$$

where

bw_{ts} and bw_{ss} = body weights (kg) of the test species and surrogate species, respectively,
$z = 0.25$ for mammals,
$z = 0$ for birds (Sample et al. 1996).

For example, the published NOAEL for a chemical might be based on data for a 0.35-kg rat. The NOAEL for a 0.022-kg field mouse would be nearly two times larger than the rat NOAEL. The calculated NOAELs for the surrogates species are the TRVs used in the EPRE.

The TRVs for ecological COPCs derived for shrews, raccoons, and mink are presented in Table 8-7, and those for robins and green heron in Table 8-8. No data are available to derive a TRV for 1,2,4-trichlorobenzene for birds; a TRV is here proposed for the robin that is one-tenth the TRV for mixed isomers of BHC, a more highly chlorinated benzene compound. The TRVs for Radium 226 and Radium 228 in soil are derived from the International Atomic Energy Agency (IAEA) 1992 benchmark of 0.1 rad/day using the IAEA (1992) model of internal and external exposure to a small burrowing animal, represented by the short-tailed shrew, and the Nuclear Regulatory Commission 1992 dose conversion factors. The calculated dose rates, which are based on exposures at a height of one meter, are multiplied by a factor of four to account for the greater proximity of shrews to the radiation source (i.e., soil). Surface soil TRVs for Radium 226 and Radium 228 are, respectively, 2.00×10^5 and 1.91×10^5 pCi/g.

The EPA Region IV ESVs for surface water used to identify ecological COPCs for surface water and groundwater at SWMU 1 are considered to be protective of aquatic life; therefore, the preliminary risk calculations for aquatic biota exposed to groundwater at SWMU 1 are not required to evaluate the preliminary assessment endpoint for aquatic biota.

Table 8-7. Derivation of TRVs for Mammal Surrogate Species at SWMU 1

Analyte	Test Species	Test Species Body Weight BW_t (kg)	Test Species $NOAEL_t$ (mg/kg/d)	Raccoon		Short-tailed Shrew		Mink	
				Body-weight Conversion Factor $BW_{conv} = (BW_t / BW)^{0.25}$	TRV (mg/kg/d) $= NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor $BW_{conv} = (BW_t / BW)^{0.25}$	TRV (mg/kg/d) $= NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor $BW_{conv} = (BW_t / BW)^{0.25}$	TRV (mg/kg/d) $= NOAEL_t \times BW_{conv}$
RCRA Metals									
Barium	Rat	4.35E-01	5.06E+00	5.56E-01	2.81E+00	2.32E+00	1.17E+01	8.12E-01	4.11E+00
Cadmium	Rat	3.03E-01	1.00E+00	5.08E-01	5.08E-01	2.12E+00	2.12E+00	7.42E-01	7.42E-01
Chromium	Rat	3.50E-01	2.74E+03	5.26E-01	1.44E+03	2.20E+00	6.02E+03	7.69E-01	2.11E+03
Iron	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Lead	Rat	3.50E-01	8.00E+00	5.26E-01	4.21E+00	2.20E+00	1.76E+01	7.69E-01	6.15E+00
Methyl Mercury	Mink	1.00E+00	1.01E+00	6.84E-01	6.91E-01	2.86E+00	2.89E+00	1.00E+00	1.01E+00
Mercury (Mercuric sulfide)	Mouse	3.00E-02	1.32E+01	2.85E-01	3.76E+00	1.19E+00	1.57E+01	4.16E-01	5.49E+00
Selenium	Rat	3.50E-01	2.00E-01	5.26E-01	1.05E-01	2.20E+00	4.40E-01	7.69E-01	1.54E-01
Radionuclides									
Radium 226	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
Radium 228	None	None	No NOAEL	None	No NOAEL	None	No NOAEL	None	No NOAEL
VOCs									
Acetone	Rat	3.50E-01	1.00E+01	5.26E-01	5.26E+00	2.20E+00	2.20E+01	7.69E-01	7.69E+00
Methylene Chloride	Rat	3.50E-01	5.85E+00	5.26E-01	3.08E+00	2.20E+00	1.29E+01	7.69E-01	4.50E+00
Toluene	Mouse	3.00E-02	2.60E+01	2.85E-01	7.40E+00	1.19E+00	3.09E+01	4.16E-01	1.08E+01
Xylene, Total	Mouse	3.00E-02	2.06E+00	2.85E-01	5.87E-01	1.19E+00	2.45E+00	4.16E-01	8.57E-01
SVOCs									
BHC-Mixed Isomers	Rat	3.50E-01	1.60E+00	5.26E-01	8.42E-01	2.20E+00	3.52E+00	7.69E-01	1.23E+00
Bis(2-ethylhexyl)phthalate	Mouse	3.00E-02	1.83E+01	2.85E-01	5.21E+00	1.19E+00	2.18E+01	4.16E-01	7.61E+00
Di-n-butyl Phthalate	Mouse	3.00E-02	5.50E+02	2.85E-01	1.57E+02	1.19E+00	6.54E+02	4.16E-01	2.29E+02
Diethyl Phthalate	Mouse	3.00E-02	4.58E+03	2.85E-01	1.31E+03	1.19E+00	5.45E+03	4.16E-01	1.91E+03

Table 8-7. Derivation of TRVs for Mammal Surrogate Species at SWMU 1 (continued)

Analyte	Test Species	Test Species Body Weight BW_t (kg)	Test Species $NOAEL_t$ (mg/kg/d)	Raccoon		Short-tailed Shrew		Mink	
				Body-weight Conversion Factor $BW_{conv} = (BW_t / BW)^{0.25}$	**TRV (mg/kg/d) $= NOAEL_t \times BW_{conv}$**	**Body-weight Conversion Factor $BW_{conv} = (BW_t / BW)^{0.25}$**	**TRV (mg/kg/d) $= NOAEL_t \times BW_{conv}$**	**Body-weight Conversion Factor $BW_{conv} = (BW_t / BW)^{0.25}$**	**TRV (mg/kg/d) $= NOAEL_t \times BW_{conv}$**
Pyrene	Mouse	3.00E-02	1.00E+00	2.85E-01	2.85E-01	1.19E+00	1.19E+00	4.16E-01	4.16E-01
1,2,4 - Trichlorobenzene	Rat	3.50E-01	1.48E+01	5.26E-01	7.79E+00	2.20E+00	3.25E+01	7.69E-01	1.14E+01
Pesticides									
4,4'-DDD	Rat	3.50E-01	8.00E-01	5.26E-01	4.21E-01	2.20E+00	1.76E+00	7.69E-01	6.15E-01
4,4'-DDE	Rat	3.50E-01	8.00E-01	5.26E-01	4.21E-01	2.20E+00	1.76E+00	7.69E-01	6.15E-01
4,4'-DDT	Rat	3.50E-01	8.00E-01	5.26E-01	4.21E-01	2.20E+00	1.76E+00	7.69E-01	6.15E-01
Dieldrin	Rat	3.50E-01	7.70E-02	5.26E-01	4.05E-02	2.20E+00	1.69E-01	7.69E-01	1.54E-02

BW = Body weight.

BW (kg) Mink = 1.

BW (kg) Raccoon = 4.56.

BW (kg) Shrew = 0.015.

LOAEL = Lowest-observed-adverse-effect level.

NOAEL = No-observed-adverse-effect level.

RCRA = Resource Conservation and Recovery Act.

SVOC = Semivolatile organic compound.

TRV = Toxicity reference value.

VOC = Volatile organic compound.

Table 8-8. Derivation of TRVs for Bird Surrogate Species at SWMU 1

Analyte	Test Species	Test Species Body Weight BW_t (kg)	Test Species $NOAEL_t$ (mg/kg/d)	American Robin		Green Heron	
				Body-weight Conversion Factor $BW_{conv} = (BW_t / BW)^0$	TRV (mg/kg/d) $= NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor $BW_{conv} = (BW_t / BW)^0$	TRV (mg/kg/d) $= NOAEL_t \times BW_{conv}$
RCRA Metals							
Barium	Chick (14 day old)	1.21E-01	2.08E+01	1.00E+00	2.08E+01	1.00E+00	2.08E+01
Cadmium	Mallard Duck	1.15E+00	1.45E+00	1.00E+00	1.45E+00	1.00E+00	1.45E+00
Chromium	Black Duck	1.25E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Iron	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Lead	Quail	1.50E-01	1.13E+00	1.00E+00	1.13E+00	1.00E+00	1.13E+00
Mercury (Mercuric Chloride)	Quail	1.50E-01	4.50E-01	1.00E+00	4.50E-01	1.00E+00	4.50E-01
Methyl Mercury Dicyandiamide	Mallard Duck	1.00E+00	6.40E-03	1.00E+00	6.40E-03	1.00E+00	6.40E-03
Selenium	Mallard Duck	1.00E+00	5.00E-01	1.00E+00	5.00E-01	1.00E+00	5.00E-01
Radionuclides							
Radium 226	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Radium 228	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
VOCs							
Acetone	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Methylene Chloride	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Toluene	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
Xylene, Total	None	None	No NOAEL	None	No NOAEL	None	No NOAEL
SVOCs							
BHC-Mixed Isomers	Japanese Quail	1.50E-01	5.63E-01	1.00E+00	5.63E-01	1.00E+00	5.63E-01
Bis(2-ethylhexyl)phthalate	Ringed Dove	1.55E-01	1.11E+00	1.00E+00	1.11E+00	1.00E+00	1.11E+00
Di-n-butyl Phthalate	Ringed Dove	1.55E-01	1.10E-01	1.00E+00	1.10E-01	1.00E+00	1.10E-01
Diethyl Phthalate	None	None	No NOAEL	None	No NOAEL	None	No NOAEL

Table 8-8. Derivation of TRVs for Bird Surrogate Species at SWMU 1 (continued)

				American Robin		Green Heron	
Analyte	Test Species	Test Species Body Weight BW_t (kg)	Test Species $NOAEL_t$ (mg/kg/d)	Body-weight Conversion Factor $BW_{conv} = (BW_t / BW)^0$	TRV (mg/kg/d) $= NOAEL_t \times BW_{conv}$	Body-weight Conversion Factor $BW_{conv} = (BW_t / BW)^0$	TRV (mg/kg/d) $= NOAEL_t \times BW_{conv}$
Pyrene	Composite Bird	8.50E-01	9.97E+00	1.00E+00	9.97E+00	1.00E+00	9.97E+00
1,2,4 - Trichlorobenzene	Japanese Quail	1.50E-01	5.63E-01	1.00E+00	5.63E-01	1.00E+00	5.63E-01
			Pesticides				
4,4'-DDD	Brown Pelican	3.50E+00	2.80E-03	1.00E+00	2.80E-03	1.00E+00	2.80E-03
4,4'-DDE	Brown Pelican	3.50E+00	2.80E-03	1.00E+00	2.80E-03	1.00E+00	2.80E-03
4,4'-DDT	Brown Pelican	3.50E+00	2.80E-03	1.00E+00	2.80E-03	1.00E+00	2.80E-03
Dieldrin	Barn Owl	4.66E-01	7.70E-02	1.00E+00	7.70E-02	1.00E+00	7.70E-02

BW = Body weight.

BW (kg) Green Heron = 0.25.

BW (kg) Robin = 0.077.

LOAEL = Lowest-observed-adverse-effect level.

NOAEL = No-observed-adverse-effect level.

RCRA = Resource Conservation and Recovery Act.

SVOC = Semivolatile organic compound.

VOC = Volatile organic compound.

8.1.4 Preliminary Exposure Estimate (Step iv)

The preliminary exposure estimate (Step iv) evaluates the potential pathways of exposure appropriate to the preliminary assessment endpoints and ecological receptors at SWMU 1. For receptors likely exposed by ingestion of contaminated soil, surface water, sediment, or biota, exposure factors are selected.

For shrews and robins, which are exposed indirectly by ingestion of biota, the maximum detected concentration of each analyte in the 0- to 2-foot interval of SWMU 1 surface soil samples are used as the exposure point concentrations to calculate the maximum average daily doses (ADDs). The maximum detected concentration of each analyte in samples from SWMU 1 monitoring wells, Geoprobe, and vertical profile locations are used as the exposure point concentrations to calculate the maximum ADDs for raccoons, mink, and green herons exposed directly or indirectly to groundwater potentially emerging as surface water.

The ADD to shrews and robins from substances in surface soil is calculated as the product of the maximum detected concentration, the unitless soil-to-invertebrate bioaccumulation factor (BAF_i), and the daily specific food ingestion rate (IR) of the receptor. That is,

$$ADD(mg/kg/d) = \max.soil\ concentration\ (mg/kg) \times BAF_i \times IR(kg/kg/d).$$

The ADD to raccoons by ingesting substances in groundwater is calculated as the product of the maximum detected concentration, the unit conversion factor (0.001 µg/mg), and the daily specific water ingestion rate (IR_w) of the receptor. That is,

$$ADD\ (mg/kg/d)\ =\ max.\ water\ concentration\ (\mu g/L) \times 0.001\ (\mu g/mg) \times IR_w\ (L/kg/d).$$

The ADD to mink and green herons from ingesting biota exposed to substances in groundwater is calculated as the product of the maximum detected concentration, the unitless bioconcentration factor (BCF) for the contaminant in fish tissue, and the daily specific food ingestion rate (IR) of the receptor. That is,

$$ADD\ (mg/kg/d)\ =\ max.\ water\ concentration\ (\mu g/L) \times 0.001\ (\mu g/mg) \times BCF \times IR\ (kg/kg/d).$$

The exposure parameters for shrews and robins exposed to substances in surface soil and raccoons, mink, and green herons exposed to ecological COPCs in groundwater are presented in Table 8-9.

The exposures of surrogate species are estimated using conservative assumptions (Table 8-9). It is assumed that the receptors spend their entire lives and obtain 100% of their diet or drinking water at the facility [i.e., the area use factor (AUF) equals one]. Shrews and robins are assumed to eat only soil-dwelling invertebrates such as worms that bioaccumulate contaminants from soil, in accordance with EPA Region IV requirements that the screen be based on exposure through two trophic transfers (EPA 1997). Raccoons are assumed to drink only groundwater at SWMU 1 and to obtain no solid food from SWMU 1. Mink are assumed to eat only fish from surface biota bodies exposed to SWMU 1 groundwater. Heron are assumed to eat only fish when evaluating groundwater. Chemicals in surface soil are assumed to bioaccumulate in the soil-dwelling invertebrate prey of ecological receptors at levels equal to published bioaccumulation factors for

Table 8-9. Exposure Parameters for Surrogate Species at SWMU 1

Parameter	Surrogate species				
	Shrew	Robin	Raccoon	Mink	Green Heron
Body Weight (kg)	0.015*	0.077*	4.31[a]	1*	0.25[b]
Food Ingestion Rate (kg/kg/day)	0.6[c]	1.2[c]	–	0.137[c]	0.192[b]
Water Ingestion Rate (L/kg/day)	–	–	0.08[a]	–	–
AUF	1	1	1	1	1
Relative Bioavailability	100%	100%	100%	100%	100%
Diet	100% Earthworm	100% Earthworm	–	100% Fish	100% Fish
Source Medium	Surface Soil	Surface Soil	Groundwater	Groundwater	Groundwater

*Sample et al. (1996), Table B.1.

[a] EPA (1993c).

[b] EPA Region IV Supplemental Guidance to RAGS (EPA 1996d), Table A.

[c] Converted from values reported as kg/day in Sample et al. (1996) by dividing by body weight (kg).

– = Not required for preliminary risk calculation.

AUF = area use factor

earthworms and other invertebrates as reported in Hazardous Waste Remedial Actions Program (HAZWRAP) 1994. Chemicals in groundwater are assumed to bioaccumulate in aquatic biota at levels equal to published bioconcentration factors for fish (HAZWRAP 1994).

8.1.5 Preliminary Risk Calculation (Step v)

The preliminary risk calculation (Step v) uses HQs, the ratio of the ADD resulting from the measured maximum concentration and the TRV, to identify and evaluate risk. The HQs of substances with consistent modes of toxicity and effects endpoints are added to produce a Hazard Index (HI). An HI greater than one for a category of substances is a useful indicator of potential risk when no individual chemical in that category has an HQ greater than one. An HI assumes that the effect of the individual chemicals in the category are additive.

Metals are assumed to have distinct modes of toxicity and effects endpoints; therefore, HIs are calculated only for radionuclide isotopes, VOCs, and SVOCs when HQs can be calculated for more than one compound.

Surface Soil

The preliminary risk calculation for shrews and robins exposed to substances detected in soil at SWMU 1 is presented in Table 8-10. The table shows the background criteria concentrations (two times average background), maximum detected concentrations, ADDs, TRVs, and HQs for shrews and robins. The HQ is the ratio of the ADD and the TRV.

Table 8-10. Preliminary Risk Calculation for Ecological COPCs in Surface Soil at SWMU 1

			Short-tailed Shrew			American Robin		
Ecological COPC	**C_{Max} (mg/kg)**	**BAF_i**	**ADD (mg/kg/d) = $C_{Max} \times BAF_i \times IR_S$**	**TRV (mg/kg/d)**	**HQ =ADD/TRV**	**ADD (mg/kg/d) = $C_{Max} \times BAF_i \times IR_R$**	**TRV (mg/kg/d)**	**HQ =ADD/TRV**
RCRA Metals								
Selenium	0.69	7.60E-01	2.78E-01	2.00E-01	1.39E+00	7.97E-01	5.00E-01	1.59E+00
VOCs								
Acetone	44.1	5.00E-02	1.17E+00	1.00E+01	1.17E-01	3.35E+00	No TRV	--
Methylene Chloride	0.05	5.00E-02	1.33E-03	5.85E+00	2.26E-04	3.80E-03	No TRV	--
Toluene	0.06	5.00E-02	1.59E-03	2.60E+01	6.12E-05	4.56E-03	No TRV	--
				HI=	1.17E-01		**HI=**	--
SVOCs								
1,2,4-Trichlorobenzene[a,b]	0.003	5.00E-02	8.48E-05	1.60E+00	5.30E-05	2.43E-04	5.63E-01	4.32E-04
Pesticides								
4,4'-DDD[c]	0.004	3.30E+00	6.65E-03	8.00E-01	8.31E-03	1.91E-02	2.80E-03	6.81E+00
4,4'-DDE[c]	0.003	1.70E+00	2.97E-03	8.00E-01	3.72E-03	8.53E-03	2.80E-03	3.05E+00
4,4'-DDT	0.002	5.70E-01	6.34E-04	8.00E-01	7.93E-04	1.82E-03	2.80E-03	6.50E-01

ADD = Average daily dose (mg/kg/d).

Background Criteria = Two times average background concentration; no background criteria for organics.

BAF_i = Soil-to-invertebrate biaccumulation factor (HAZWRAP 1994).

BHC = Benzene hexachloride.

C_{Max} = Maximum detected surface soil concentration (mg/kg).

COPC = Contaminant of potential concern.

HQ = Hazard quotient; HI = hazard index = sum of HQs.

IR_S = Shrew food ingestion rate (kg/kgBW/d) = 0.53.

IR_R = Robin food ingestion rate (kg/kgBW/d) = 1.52.

NOAEL = N-observed-adverse-effect level.

PAH = Popolycyclic aromatic hydrocarbon.

RCRA = Resource Conservation and Recovery Act.

TRV = Toxicity reference value; see Tables 8-7 and 8-8.

[a] Robin TRV for 1,2,4-trichlorobenzene is based on NOAEL for BHC-mixed isomers (Sample et al. 1996) x 0.1.

[b] Default BAF for 1,2,4-trichlorobenzene assumed to be same as PAHs as reported in HAZWRAP (1994).

[c] TRVs for 4,4'-DDD and 4,4'-DDET are based on NOAEL for DDT and its metabolites (Sample et al. 1996); see Tables 8-7 and 8-8.

Double borders indicate HQ > 1.

-- = Cannot be calculated due to lack of data.

One metal and two pesticides in surface soil at SWMU 1 are present at concentrations resulting in ADDs exceeding TRVs for the surrogate receptors (Table 8-10). The selenium HQs for the shrew and robin, and the robin's HQs for 4,4'-DDD and 4,4'-DDE are greater than one. Selenium, DDD, and DDE in surface soil are ecological COPCs at SWMU 1.

The HI is 10.5 for the robin for the three pesticides in SWMU 1 surface soil: 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT. The HI for the pesticides is less than one for the shrew. The HI of 10.5 is further evidence that DDT and its metabolites in surface soil at SWMU 1 are ecological COPCs for populations of birds ingesting earthworms and other soil-dwelling invertebrates.

Groundwater

The preliminary risk calculations for raccoons, mink, and green herons exposed to ecological COPCs detected in groundwater at SWMU 1 are presented in Table 8-11. This table shows the background criteria concentrations, maximum detected concentrations in each sample, ADDs, TRVs, and HQs. The HQ is the ratio of the ADD and the TRV. An HI is not calculated for groundwater because there is only one ecological COPC in the VOCs and SVOCs.

No ecological COPCs are present in groundwater sampled from SWMU 1 at concentrations resulting in ADDs exceeding the TRVs for the raccoon and the mink. One ecological COPC has an HQ exceeding one for the green heron. The green heron HQ for bis(2-ethylhexyl)phthalate is 3.3. The maximum detected concentration of bis(2-ethylhexyl)phthalate in SWMU 1 groundwater exceeds its background criteria for bis(2-ethylhexyl)phthalate (see Table 5-5). Thus, there is one ecological COPC for terrestrial ecological receptors exposed to groundwater at SWMU 1: bis(2-ethylhexyl)phthalate.

8.2. CONCLUSIONS OF THE ECOLOGICAL PRELIMINARY RISK EVALUATION

According to GEPD guidance (1996), the need for an ERA depends on the results of the ESV comparison and the preliminary risk calculation. Below is a summary of the results of the EPRE for SWMU 1 (Section 8.2.1) followed by a discussion of the uncertainties associated with the results of the EPRE (Section 8.2.2).

8.2.1 Summary and Conclusions

An EPRE for potential terrestrial and aquatic receptors was performed at SWMU 1. The EPRE for SWMU 1 identified five ecological COPCs in groundwater based on a comparison of their maximum site concentrations to their EPA Region IV ecological screening values (Table 8-12).

No constituents in surface water or sediment are ecological COPCs. All substances detected in surface soil at SWMU 1 are evaluated further in the EPRE because there are no EPA Region IV ESVs for soil.

Preliminary risk calculations identified ecological COPCs in surface soil and groundwater based on a comparison of conservative ADDs to conservative TRVs for surrogate species representing terrestrial ecological receptors. No ecological COPCs are identified in surface water and sediment for ecological receptors exposed at SWMU 1.

Table 8-11. Preliminary Risk Calculation for Ecological COPCs in Groundwater at SWMU 1

Ecological COPC	C_{Max} (ug/L)	BCF (L/kg)	Raccoon ADD (mg/kg/d) = C_{Max} x 0.001 x IR_W	Raccoon TRV (mg/kg/d)	Raccoon HQ =ADD/ TRV	Mink ADD (mg/kg/d) = C_{Max} x BCF x 0.001 x IR_M	Mink TRV (mg/kg/d)	Mink HQ =ADD/ TRV	Green Heron ADD (mg/kg/d) = C_{Max} x 0.001 x BCF x IR_H	Green Heron TRV (mg/kg/d)	Green Heron HQ =ADD/ TRV
RCRA Metals											
Barium	134	4.00E+00	1.07E-02	2.81E+00	3.81E-03	7.34E-02	4.11E+00	1.79E-02	1.03E-01	2.08E+01	4.94E-03
Iron	22000	No BCF	1.76E+00	No TRV	--	--	No TRV	--	--	No TRV	--
Lead	18.4	3.00E+02	9.05E-04	4.21E+00	2.15E-04	4.64E-01	6.15E+00	7.55E-02	6.51E-01	1.13E+00	5.76E-01
VOCS											
Xylenes (Total)	212	1.70E+01	1.70E-02	5.87E-01	2.89E-02	4.94E-01	8.57E-01	5.76E-01	6.92E-01	No TRV	--
SVOCs											
Bis(2-ethylhexyl)phthalate	61.4	3.10E+02	4.91E-03	5.22E+00	9.42E-04	2.61E+00	7.61E+00	3.42E-01	3.65E+00	1.10E+00	**3.32E+00**

0.001 (mg/µg) = conversion from µg to mg.

ADD = Average daily dose (mg/kg/d).

BCF = Water-to-fish bioconcentration factor (HAZWRAP 1994).

C_{Max} = Maximum detected concentration (µg/L).

COPC = Contaminant of potential concern.

Double borders indicate HQ > 1; boldface values also exceed background criteria.

IR_W = Raccoon water ingestion rate (L/kg/d) = 0.8.

IR_M = Mink food ingestion rate (kg/kg/d) = 0.137.

IR_H = Heron food ingestion rate (kg/kg/d) = 0.192.

HQ = Hazard Quotient; HI = Hazard Index = sum of HQs.

RCRA = Resource Conservation and Recovery Act.

SVOC = Semivolatile organic compound.

SWMU = Solid Waste Management Unit.

TRV = Toxicity reference value; see Tables 8-7 and 8-8.

VOC = Volatile organic compound.

-- = Cannot be calculated due to the lack of data.

Table 8-12. Summary of Ecological COPCs Identified in EPRE for Surface Soil, Surface Water, Sediment, and Groundwater at SWMU 1

	Surface Soil	Surface Water	Sediment	Groundwater
Concentration exceeds ESV or TRV for indicated ecological receptor	Selenium (mammals, birds) 4,4'-DDT 4,4'-DDE 4,4'-DDD (birds)	None	None	Barium (aquatic biota) Iron (aquatic biota) Lead (aquatic biota) Bis(2-ethylhexyl)phthalate (aquatic biota, birds) Xylenes, Total (aquatic biota)
No ESV or TRV for indicated ecological receptor	None	None	None	None

ESV = ecological screening value
TRV = toxicity reference value

Selenium, DDE, and DDD were detected above background criteria concentrations in surface soil at SWMU 1 and at levels producing exposures above TRVs for terrestrial animals, such as shrews or robins, that eat earthworms and other soil-dwelling invertebrates. The HI for the robin for DDT and its metabolites exceeded one. Therefore, selenium and the pesticides DDT and its metabolites are ecological COPCs in surface soil at SWMU 1 (Table 8-12).

According to EPA Region IV guidance (EPA 1996d), groundwater is treated as surface water in the ecological EPRE. This approach was taken for groundwater from SWMU 1. Barium, iron, lead, bis(2-ethylhexyl)phthalate, and xylenes (total) are present in SWMU 1 groundwater at concentrations that exceed surface water ESVs. Thus, these five substances are ecological COPCs for aquatic biota in Taylors and Mill creeks at SWMU 1 (Table 8-12). Bis(2-ethylhexyl)phthalate was detected in groundwater above background criteria concentrations and at concentrations that resulted in estimated exposures exceeding TRVs for terrestrial ecological receptors that ingest fish and other aquatic biota. Thus, bis(2-ethylhexyl)phthalate in groundwater at SWMU 1 is also an ecological COPC for terrestrial receptors.

8.2.2 Uncertainties

The EPRE for SWMU 1 is designed to minimize the probability of falsely concluding that there is no risk when in fact there is (GEPD 1996). The EPA Region IV ESV comparison is designed to be conservative and screen out only those substances for which there is little probability of posing a hazard to ecological receptors. The preliminary ecological effects and exposure assessments are designed to produce preliminary risk calculations that overestimate risk. Using conservative exposure assumptions (e.g., AUF = 1), maximum detected concentrations, and TRVs based on NOAELs, as required by guidance (GEPD 1996; EPA 1997), results in overestimates of risk to ecological receptors at SWMU 1. Therefore, HQs and HIs for contaminants less than one indicate little to no likelihood of hazard to the ecological receptors.

On the other hand, because of the conservatism of the TRVs and exposure estimates, HQs exceeding one do not necessarily mean that the ecological receptors are at risk of ecologically significant adverse effect.

There is some uncertainty about whether selenium in surface soil at SWMU 1 is an ecological COPC for mammals and birds ingesting soil-dwelling invertebrates. Selenium was detected in only 1 of 8 surface soil samples at SWMU 1. Although the selenium detection (0.69 mg/kg) exceeds the background criterion for surface soil (0.63 mg/kg), it is less than the background criterion for subsurface soil (1.64 mg/kg). Mammal and bird HQs based on the single detected concentration of selenium in SWMU 1 surface soil and NOAELs are less than two. Selenium LOAELs are 1.65 and 2 times larger than NOAELs for mammals and birds, respectively, and are associated with reproductive effects with possible adverse consequences for populations (Sample et al. 1996). The observed LOAEL for mammals exposed to selenium in drinking water may overestimate the toxicity of selenium in soil and food ingested by shrews at SWMU 1 because the absorption form natural sources would be lower, but this is not likely the case for the bird LOAEL, which comes from an oral diet study.

DDT and its metabolites in surface soil at SWMU 1 are ecological COPCs for birds with small home ranges ingesting soil-dwelling invertebrates. DDT and its metabolites are likely to be present in surface soil in most areas of Georgia and the southeast due to past widespread use as an insecticide. The background criteria presented in Table 5-1 is 0.002 mg/kg. The concentrations of DDT, DDE, and DDD detected in 2 surface soil samples at SWMU 1 result in exposures to robins that exceed the estimated NOAEL, which is 10 times less than the observed LOAEL associated with serious adverse reproductive effects on brown pelicans (Sample et al. 1996). Assuming the effects of DDT, DDE, and DDD are additive, the combined exposure at each of the two sampling locations do not exceed the LOAEL dose. However, the fact that maximum estimated doses lie between the NOAEL and LOAEL suggests that further evaluation of the magnitude of exposure of robins to DDT and its metabolites in surface soil at SWMU 1 is warranted.

The ecological COPCs in groundwater are barium, iron, lead, bis(2-ethylhexyl)phthalate, and xylenes for aquatic biota and bis(2-ethylhexyl)phthalate for birds ingesting fish exposed to groundwater potentially discharging to surface water. The concentrations of these constituents in numerous monitoring wells and Geoprobe samples exceed background criteria and risk-based screening or reference values. However, none of these constituents are ecological COPCs in surface water and sediment at SWMU 1. This suggests that dilution, degradation, adsorption, or other processes are operating to reduce the concentrations in groundwater discharging in Taylors and Mill creeks or that groundwater at SWMU 1 has not yet migrated to the creeks. According to the flow rate calculated in Chapter 6.0, it takes on the order of 94 years for groundwater to reach the creeks. Therefore, groundwater constituents are unlikely to be ecological COPCs at the present time.

8.2.3 Conclusions

In conclusion, the EPRE for SWMU 1 indicates that there are four ecological COPCs (selenium, 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD) in surface soil and five ecological COPCs (barium, iron, lead, bis(2-ethylhexyl)phthalate, and xylenes) in groundwater (Table 8-12). The results and uncertainties associated with the EPRE, together with other site-specific considerations, are the basis for the risk-management decision as to whether further evaluation of ecological risk for SWMU 1 is needed (Chapter 9.0).

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9.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The purpose of the BHHRA 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). The conclusions from the ecological PRE stated that constituents present at SWMU 1 are not likely to have a significant impact upon ecological receptors. Therefore, quantitative analysis of the potential risks to ecological is not required. Figure 9-1 presents the decision flowchart used to determine the types of analysis required to evaluate the potential risks associated with possible contamination at SWMU 1.

The fate and transport analysis found that methylene chloride present in soils 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. Therefore, the BHHRA is designed to quantify the potential risks associated with exposure to estimated concentrations of methylene chloride in groundwater as a result of leaching from soils.

The HHPRE concluded that constituents present in groundwater present a potential risk to human health based on exposure of a resident to the maximum detected concentrations in groundwater. The HHPRE concluded that constituents present in other media (surface soil, subsurface soil, surface water, and sediment) do not present a significant risk to human health. Based on GEPD (1996) and EPA Region IV (EPA 1995) guidance, a BHHRA is required for those constituents identified as COPCs in groundwater.

The BHHRA given below has quantified the potential risks associated with constituents identified in the fate and transport analysis and the HHPRE as presenting a potential risk to human health. The previous risk analysis concluded that there are potential risks to residential receptors at the site as a result of using surficial groundwater as a source of drinking water. This risk is associated with constituents currently present in groundwater (human health COPCs) and constituents present in soils that might leach into groundwater in the future (contaminant migration COPCs).

The BHHRA consists of five elements: identification of COPCs, exposure assessment, toxicity assessment, risk characterization, and assessment of uncertainties. The discussion presented in the following sections presents the information required to evaluate the human health risks associated with COPCs at SWMU 1. 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.

9.1 IDENTIFICATION OF COPCs

The contaminant migration COPCs and human health COPCs have been previously identified in the sections on contaminant fate and transport (Section 6.5) and the HHPRE (Section 7.5), respectively. The contaminant migration COPCs were limited to organics in soils that may leach into groundwater at significant concentrations (i.e., above MCLs). Human health COPCs were identified for groundwater but no other medium.

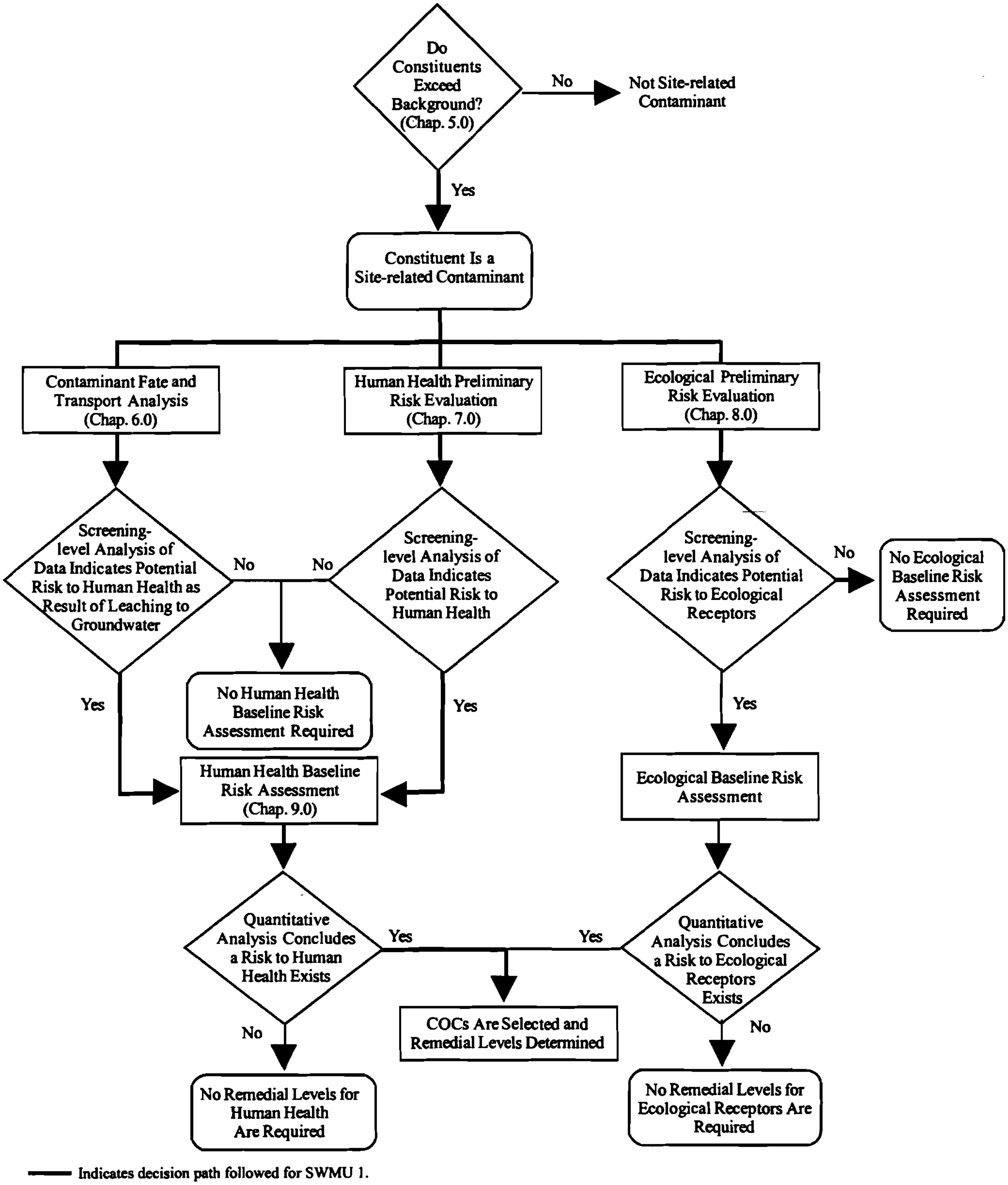

Figure 9-1. General Process for Evaluating Hazards Associated with Constituents at SWMU 1

As discussed under each medium (surface soil, subsurface soil, and groundwater) in Chapter 5.0, Contaminant Nature and Extent, two of the sampling locations (monitoring well SC-MW15 and SC-MW16) are located outside the area previously used for landfill operations. Aerial photographs and historical information have never indicated that solid waste was disposed of east of GA 119/144. These sampling sites are separated from SWMU 1 by a major road (GA 119/144) and are cross gradient to upgradient of the groundwater flow direction of the old, inactive portion of SWMU 1 (Figures 4-5 and 4-6); therefore, it is unlikely that potential contaminants from the old, inactive portion of SWMU 1 would impact these locations. Therefore, the contaminant concentrations detected in surface and subsurface soil and groundwater samples at SC-M15 and SC-M16 are probably not the result of potential contamination from SWMU 1 and were not included in the COPCs for the BHHRA.

The selection of COPCs conducted previously was done by comparing maximum detected concentrations in various environmental media (soils, groundwater, etc.) to risk-based or ARAR-based screening values. Methylene chloride was identified as a contaminant migration COPC in soils. In addition, acetone was identified as a contaminant migration COPC; however, it was detected above its GSSL in only SC-M16, which was located in an area not impacted by SWMU 1 (Section 5.2). Therefore, the potential for acetone to leach into groundwater from soil was not evaluated in the BHHRA. The human health COPCs include the following chemicals: chromium, lead, acetone, benzene, bis(2-ethylhexyl)phthalate, 1,2-*cis*-dichloroethene, and trichloroethene.

9.2 EXPOSURE ASSESSMENT

For the purposes of this BHHRA, the exposure assessment will address migration and exposure to constituents present in groundwater. Therefore, not all of the exposure pathways and receptors identified in the HHPRE will be addressed in this assessment.

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 complete.

The exposure assessment consists of the following elements: characterization of the exposure setting, identification of migration pathways, identification of receptor populations and exposure pathways, estimation of exposure point concentrations, and quantification of exposure for both current and projected future receptor populations at the site. The exposure assessment is given below. A detailed discussion of the selection of receptors, exposure pathways, and assumptions used to quantify exposure are given in Section I.2 of Appendix I.

9.2.1 Exposure Setting

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

Fort Stewart is under the control of the U.S. Army as an active facility and is expected to remain so for the foreseeable future. Currently, the Installation is relatively open to the public, except for certain restricted areas. The landfill is located within a currently operating military area.

The active landfill consist of consists of a closed section which is currently covered and maintained with grasses for erosion control. The remaining portion is being used for tumulus refuse disposal operations and disposal of demolition/construction debris (non-putrescible waste).

The old, inactive landfill is covered primarily with forests. There is a small maintenance area for groundskeeping equipment located on the southern portion of the landfill and a recreational field located in the southeastern corner.

The South Central Landfill is bounded on the north by Taylors Creek and on the west by Mill Creek, a tributary of Taylors Creek (Figure 3-1). Taylors Creek is approximately 1,200 feet from the northern boundary of the old, inactive landfill, while Mill Creek is approximately 4,000 feet southwest of the old, inactive landfill. Wetland areas are located along Mill and Taylors Creeks. The old landfill is bordered by an active landfill to the west. A small wetlands area is located between the active landfill and the old, inactive landfill. There is a 2-acre pond located to the south of the landfill. The remaining areas south of the landfill are either active military or forested.

At this time, there are no long-range plans (i.e., through 2020) to construct any facilities on the inactive portions of SWMU 1.

9.2.2 Identification of Migration Pathways

The release and migration of contaminants at this site have been discussed in detail in Section 6.3.2 (Contaminant Release Mechanisms and Migration Pathways) of this report. Constituents in groundwater may be transported laterally toward Mill and Taylors Creeks, with the predominant gradient toward the north toward Taylors Creek. The groundwater gradient underlying the site is very low, with an estimated groundwater flow of 12.8 feet/year.

Groundwater migrating to the north is likely to discharge into Taylors Creek. However, there is a drainage ditch north of the old, inactive landfill approximately halfway between the northern boundary of the old landfill and Taylors Creek. This drainage ditch may receive groundwater discharges, especially during rain events, when groundwater levels are likely to be elevated. This drainage ditch originates in the area separating the active landfill and the old, inactive landfill. The ditch is generally dry in the upper reaches, but appears to have constant water flow beginning in the stretch north of the landfill. The ditch discharges into Taylors Creek.

9.2.3 Identification of Receptor Populations and Exposure Scenarios

Potential receptor populations are generally divided into two groups: current receptors and receptors that may be exposed in the future given any change in land use at the site. Potential risk to human receptor populations may occur as a result of exposure to groundwater. Currently surficial groundwater at the site is not used. Constituents in groundwater may migrate to surface waters; however, given the low groundwater flow rate, it is unlikely that constituents have migrated to surface waters at this time. However, this remains a potential exposure pathway for the future.

Under current conditions surficial groundwater is not used for drinking water and/or irrigation, and constituents in groundwater have not migrated to downgradient surface water bodies. Therefore, there are no current potential receptor populations that may be exposed to constituents in groundwater.

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Future populations may be at risk from exposure to constituents that have migrated into surface waters. Access to Taylors Creek in the area of SWMU 1 is difficult given the marshy floodplain that borders either side of Taylors Creek. However, recreational users, including children playing in the creek, may be exposed to constituents present in surface waters.

Future populations may also be at risk if the groundwater in the surficial aquifer is used as a source of drinking water or for other purposes. However, it is unlikely that a receptor would be exposed to groundwater given that the surficial aquifer is not a likely source of groundwater because of its low groundwater yield. The deeper Principal Artesian aquifer, which is separated from the surficial aquifer by the Hawthorn Confining Unit (clay), is used as a source of drinking water in the area because it produces significantly greater groundwater yield.

GEPD (1996) states that all groundwater should be considered a potential drinking water source. Therefore, the future land-use scenarios will address the risk associated with the use of groundwater as a drinking water source. Development of the land adjacent to SWMU 1 is likely to be restricted to industrial/military operations. Therefore, an Installation worker is the only likely receptor population. However, residential receptors will be evaluated in accordance with GEPD guidance requirements. Both receptors will be used to evaluate both on-site and off-site risk.

9.2.4 Identification of Potential Exposure Pathways

Exposure scenarios were developed for each receptor population. These scenarios address where a receptor is likely to come into contact with groundwater and identify the appropriate exposure pathways (ingestion, dermal contact, etc.) for that receptor. A detailed discussion of the potential exposure pathways for the various receptors is given in Appendix I (Section I.2.3).

On-Site Worker. Under future conditions, an on-site worker could be exposed to groundwater underlying the site as a result of using groundwater in the surficial aquifer as a source of drinking water. Potential exposure pathways include ingestion of drinking water and dermal contact. Another potential exposure pathway is inhalation of VOCs that volatilize from the groundwater. However, exposure via this pathway is expected to be insignificant.

On-Site Resident. Although not a likely receptor for this site, the on-site resident is included as a worst-case scenario for exposure to groundwater. This scenario assumes that a family lives on the site and obtains its drinking water from a groundwater well screened in the surficial aquifer. This scenario uses both an adult and a child receptor. The adult is used as the more conservative scenario for estimating potential cancer risks given the longer exposure duration for an adult. The child is used to evaluate potential risks associated with systemic risks, given the child's lower body weight and relatively higher water ingestion rate per unit body weight.

Potential exposure pathways include ingestion of groundwater used as drinking water, dermal contact with household water, and inhalation of VOCs released during use of household water. The exposure pathways evaluated for an adult include ingestion and inhalation of VOCs while showering.

The exposure pathways evaluated for child resident include ingestion of water and dermal uptake. Young children are more likely to bathe than shower; therefore, inhalation exposure to VOCs released from household use of groundwater is not evaluated for the child receptor. However, dermal uptake of organic chemicals is quantified. It is assumed that dermal uptake of metals from household water is negligible and is not quantified.

Juvenile Playing in Taylors Creek. Children playing in Taylors Creek may be exposed to constituents in surface waters while wading. As a conservative measure it was assumed that the child would come into contact with COPCs at the point at which groundwater discharges into the drainage ditch north of the old, inactive landfill. The concentration of COPCs at this point is likely to be higher than concentrations found in groundwater discharging to Taylors Creek; given that groundwater would migrate twice as far to Taylors Creek and given the slow groundwater migration rate, the concentration of COPCs is likely to decrease significantly. Surface water exposure pathways for a wading scenario are limited to dermal contact.

Off-Site Worker and Residential Receptors. The potential exposure of the off-site worker and residential receptors would be similar to that of the on-site receptors (worker and resident); however, it is assumed that they obtain their drinking water from wells located downgradient of the site. As a conservative measure it is assumed that these receptors will be located in the area of maximum potential impact, the area north of SWMU 1. The potential exposure pathways for these receptors are the same as those listed for the on-site receptors.

9.2.5 Estimation of Exposure Concentration

This BHHRA is based on a reasonable maximum exposure assumption. The intent is to provide an estimate of the highest exposure concentration with which a receptor may reasonably be expected to come in contact, but not necessarily the worst possible case (EPA 1989; EPA 1991).

Exposure Concentrations for On-Site Receptors. Exposure concentrations in groundwater were calculated using the groundwater analytical data collected during the Phase II RFI, with the exception of samples from SC-M15 and SC-M16. These wells are located upgradient of the site; therefore, samples from these wells are not representative of groundwater impacted by the site.

The exposure point concentrations of COPCs in groundwater for the on-site receptors are equal to the upper 95 percent confidence limit on the mean, unless this value was greater than the maximum detected groundwater concentration. Then, the exposure concentration defaulted to the maximum groundwater concentration.

Exposure concentrations resulting from constituents leaching into groundwater were estimated using the Seasonal Soil Compartment Model (SESOIL). As a conservative measure, it was assumed that an on-site receptor would be exposed to the maximum predicted concentration of methylene chloride in groundwater based on the SESOIL model. Therefore, the maximum predicted groundwater concentration was used as the exposure concentration. It should be noted that methylene chloride was detected in only six of the 25 soil samples collected at the site. As discussed in Section 9.1, the methylene chloride detection in soil at SC-M16 was not considered in the BHHRA because it was located outside areas impacted by SWMU 1. In addition, factors such as hydrolysis and biodegradation were not taken into account in the leachate modeling. This is significant given that the potential on-site receptor population is for a future land-use scenario.

As the methylene chloride leaches to groundwater, the source concentration will decrease over time. As the source becomes depleted, the amount of methylene chloride leaching to groundwater will decrease. The results of the leachate modeling demonstrate that methylene chloride concentrations in the leachate will decrease to insignificant concentrations (i.e., concentrations below the MCL of 5 µg/L) after a period of approximately 15 months (Figure H-1). Methylene chloride in groundwater will undergo degradation over time. A conservative estimate of the half-life of methylene chloride in groundwater is 112 days or a 90 percent reduction of the initial concentration of methylene chloride in a one-year period. Therefore, the maximum estimated

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concentration of methylene chloride (21 µg/L) would decrease to 2.2 µg/L after one year and would decrease to concentrations below 0.001 µg/L after five years.

A detailed discussion of the calculation of the exposure concentrations is given in Section I.2.5. The SESOIL model and the assumptions used in the model are given in Section H.1.

Exposure Concentrations for Off-Site Receptors. For the purposes of assessing the reasonable maximum exposure for off-site receptors, it was assumed that the receptors would be exposed to groundwater downgradient of the site.

The groundwater model AT123D was used to model groundwater concentrations from their potential source to the points of exposure for off-site receptors. As a conservative measure the maximum measured groundwater concentration for a COPC was assumed to be present at the northern boundary of the SWMU 1. For methylene chloride the estimated concentration from the SESOIL model was used. This groundwater concentration was then modeled to the point of exposure for either the child wading in Taylors Creek or for the off-site worker and resident. A discussion of the AT123D model and the assumptions used are given in Section H.2.

The point of exposure for the child wading in Taylors Creek is a drainage ditch located approximately 600 feet from the northern boundary of the old, inactive landfill, the closest point to the SWMU 1 at which groundwater might discharge to a surface water body.

The closest potential point of exposure for the off-site worker and resident downgradient of the site is to the north of Taylors Creek. The area between SWMU 1 and Taylors Creek is a marshy floodplain; therefore, structures or drinking water wells would not be placed in this area. However, surficial groundwater migrating north of the site would probably discharge into Taylors Creek. As a conservative assumption it was assumed that these off-site receptors would be exposed to COPC concentrations in groundwater that are equal to the concentrations present in groundwater in Taylors Creek. The exposure concentrations were estimated using the AT123D groundwater model (Appendix H, Section H.2).

The potential groundwater concentrations are given in Table 9-1. Only on-site receptors were identified as potentially being exposed to contaminants in groundwater. The results of the groundwater modeling concluded that the COPCs would not migrate to the downgradient areas where off-site receptors may be exposed to groundwater. Therefore, potential risks to off-site receptors will not be assessed further in this BHHRA.

9.2.6 Quantification of Exposure

The equations used to estimate exposures to the future receptor populations are discussed in Appendix I (Section I.2.6). The Integrated Exposure Uptake Biokinetic Model (Ver. 0.99D) was used to evaluate lead exposure to the child receptor. The estimated doses for on-site and off-site receptors are given in Tables 9-2 through 9-4. The average daily dose for carcinogens and noncarcinogens are calculated using different averaging times; therefore, the doses used to estimate carcinogenic risk and systemic health effects are different.

Table 9-1. Groundwater Exposure Concentrations

Chemical	Exposure Concentrations in Groundwater (mg/L)		
	On-Site Receptors	Child Wading in Taylors Creek	Off-Site Receptors
Inorganics			
Chromium	4.29E-03	0[b]	0[b]
Lead	1.84E-02	0[b]	0[b]
Organics			
1,2-*cis*-Dichloroethene	3.28E-03	0[b]	0[b]
Acetone	1.51E-01	0[b]	0[b]
Benzene	1.55E-03	0[b]	0[b]
Bis(2-ethylhexyl)phthalate	1.26E-02	0[b]	0[b]
Methylene chloride[a]	2.10E-02	0[b]	0[b]
Trichloroethene	2.40E-03	0[b]	0[b]

[a] Exposure concentration represents the estimated concentration in groundwater based on leaching from soils.

[b] Modeling results indicate that the concentration does not reach the receptor as predicted by the AT123D model.

Table 9-2. Estimated Intakes for On-Site Installation Worker

Chemical	Exposure Concentration (mg/L)	Dermal Exposure: Average Daily Dose for Carcinogens (mg/kg/day)	Dermal Exposure: Average Daily Dose for Noncarcinogens (mg/kg/day)	Oral Exposure: Average Daily Dose for Carcinogens (mg/kg/day)	Oral Exposure: Average Daily Dose for Noncarcinogens (mg/kg/day)
Inorganics					
Chromium	4.29E-03	6.39E-09	1.79E-08	1.56E-06	4.37E-06
Lead	1.84E-02	NA	NA	NA	NA
Organics					
1,2-cis-Dichloroethene	3.28E-03	4.89E-08	1.37E-07	1.19E-06	3.34E-06
Acetone	1.51E-01	1.28E-07	3.59E-07	5.49E-05	1.54E-04
Benzene	1.55E-03	4.85E-08	1.36E-07	5.63E-07	1.58E-06
Bis(2-ethylhexyl)phthalate	1.26E-02	4.32E-07	1.21E-06	4.58E-06	1.28E-05
Methylene chloride[a]	2.10E-02	1.41E-07	3.94E-07	7.63E-06	2.14E-05
Trichloroethene	2.40E-03	5.72E-08	1.60E-07	8.72E-07	2.44E-06

[a] Exposure concentration represents the estimated concentration in groundwater based on leaching from soils.

NA = Not applicable. Lead risks are based upon blood lead levels, not direct doses.

Table 9-3. Estimated Intakes for On-Site Resident Adult

Chemical	Exposure Concentration (mg/L)	Oral Exposure		Inhalation Exposure	
		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)
Inorganics					
Chromium	6.39E-09	5.04E-05	1.18E-04	NA	NA
Lead	1.84E-02	NA	NA	NA	NA
Organics					
1,2-cis-Dichloroethene	4.89E-08	3.85E-05	8.99E-05	1.40E-04	3.40E-04
Acetone	1.28E-07	1.77E-03	4.14E-03	6.60E-03	1.60E-02
Benzene	4.85E-08	1.82E-05	4.25E-05	6.80E-05	1.60E-04
Bis(2-ethylhexyl)phthalate	4.32E-07	1.48E-04	3.45E-04	NA	NA
Methylene chloride[a]	2.10E-02	2.47E-04	5.75E-04	9.25E-04	2.20E-03
Trichloroethene	5.72E-08	2.82E-05	6.58E-05	1.10E-04	2.50E-04

[a] Exposure concentration represents the estimated concentration in groundwater based on leaching from soils.

NA = Not applicable. Lead risks are based upon blood lead levels, not direct doses. Exposure via inhalation is assessed only for volatile organics.

Table 9-4. Estimated Intakes for On-Site Resident Child

Chemical	Exposure Concentration (mg/L)	Dermal Exposure Average Daily Dose for Noncarcinogens (mg/kg/day)	Oral Exposure Average Daily Dose for Noncarcinogens (mg/kg/day)
Inorganics			
Chromium	6.39E-09	1.17E-07	2.74E-04
Lead	1.84E-02	NA	NA
Organics			
1,2-cis-Dichloroethene	4.89E-08	8.91E-07	2.10E-04
Acetone	1.28E-07	2.34E-06	9.65E-03
Benzene	4.85E-08	8.84E-07	9.91E-05
Bis(2-ethylhexyl)phthalate	4.32E-07	7.87E-06	8.05E-04
Methylene chloride[a]	2.10E-02	2.57E-06	1.34E-03
Trichloroethene	5.72E-08	1.04E-06	1.53E-04

[a] Exposure concentration represents the estimated concentration in groundwater based on leaching from soils.

NA = Not applicable. Lead risks are based upon blood lead levels, not direct doses.

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 contaminants. The toxicity assessment for SWMU 1 was carried out as described in Appendix I. The reference doses and cancer slope factors for the COPCs are listed in Table 9-5. Toxicity profiles for the COPCs identified at SWMU 1 are presented in Appendix J.

9.4 RISK CHARACTERIZATION RESULTS

The risk characterization followed the procedure outlined in Appendix I (Section I.4). Quantitative estimates of both carcinogenic and noncarcinogenic risk were calculated for each COPC. Carcinogenic risks to a resident child were not calculated because these values would be lower than the carcinogenic risks to the resident adult given the longer exposure duration for the adult. Potential risks associated with exposure to the estimated concentrations of methylene chloride have been included in the risk estimates for exposure to COPCs in groundwater.

On-Site Installation Worker. The total HI for the on-site Installation worker is 5.6E-3, which is more than two orders of magnitude below the target value of 1.0 (Table 9-6). The incremental lifetime cancer risk (ILCR) for the on-site worker is 1.9E-7, which is over an order of magnitude below the target risk value of 1E-6. The potential health risks associated with exposure of an on-site Installation worker are below target risk levels, and remedial actions to protect the health of a worker exposed to groundwater are not warranted.

On-Site Resident Adult. The total HI for the on-site resident is 1.3E-1, which is below the target risk value of 1.0 (Table 9-7). The ILCR for the on-site resident is 8.9E-6, which is greater than the target risk value of 1.0E-6. Exposure to methylene chloride leaching into groundwater contributed significantly to the risk (ILCR = 3.4E-6). The other chemicals of concern are benzene (ILCR = 2.5E-6) and bis(2-ethylhexyl)phthalate (ILCR = 2.1E-6). Adult residents are not likely to have adverse systemic health effects as a result of exposure to constituents in groundwater. However, the carcinogenic risks associated with groundwater exposure are above the acceptable level. Remedial levels for methylene chloride in soils and benzene and bis(2-ethylhexyl)phthalate in groundwater are required and are developed in Section 9.7.

On-Site Resident Child. The total HI for this receptor is 3.0E-1 (Table 9-8). The estimated blood lead concentrations ranged from 3.4 µg/dL for the 6 to 7 year old to 4.3 µg/dL for the 2 to 3 year old age group (Table 9-9). These values are below the target value of 10 µg/dL. Adverse systemic health effects are not expected based on the total HI of less than 1.0 and the estimated blood lead concentrations less than 10 µg/dL. Therefore, the on-site resident child is not expected to experience adverse health effects associated with exposure to constituents in groundwater, and remedial action to protect the health of a child exposed to groundwater is not warranted.

9.5 UNCERTAINTY ANALYSIS

There are uncertainties that are inherent in the risk assessment process. These uncertainties have been addressed in Appendix I.

The use of maximum concentrations for the purposes of modeling off-site exposure concentrations is a very conservative approach. In addition, the points of exposure for off-site

Table 9-5. Summary of Toxicity Data for Chemicals of Potential Concern

Chemical	CSFo (1/mg/kg/d)	Ref	CSFi (1/mg/kg/d)	Ref	WOE	RfDo (mg/kg/d)	Ref	UF-MF	Target Organs	RfDi (mg/kg/d)	Ref	UF-MF	Target Organs	Gastro-intestinal Absorption Factor	Dermal RfD (mg/kg/day)	Dermal CSFd (1/mg/kg/d)
Acetone						1.00E-01	I	1000	Liver, kidney					0.83	8.30E-02	
Chromium			4.10E+01	I	A	3.00E-03		300	Clinical	3.00E-05	I	90	Resp	0.02	6.00E-05	
Benzene	2.90E-02	I	2.90E-02	I	A									0.97		2.99E-02
Bis(2-ethylhexyl) phthalate	1.40E-02	I			B2	2.00E-02	I	1000	Liver					0.19	3.80E-03	7.37E-02
cis-1,2-Dichloroethene						1.00E-02	H	3000	Hemepoietic system					1	1.00E-02	
Lead					B2											
Methylene chloride	7.5E-03	I	1.65E-03	I	B2	6.0E-02	I	100	Liver	8.57E-01	H	10	Resp	0.95	5.7E-02	7.89E-03
Trichloroethene	1.10E-02		6.00E-03	H	B2	6.00E-03	H	NG	Liver					0.15	9.00E-04	7.33E-02

CSFo = Oral cancer slope factor.
CSFi = Inhalation cancer slope factor.
Ref = Source of information: I = IRIS, H = HEAST.
RfDo = Oral reference dose.
RfDi = Inhalation reference dose.
Target Organs = Primary organ systems affected by non-carcinogenic chemicals.
Resp = Respiratory system.
Clinical = Endpoints included clinical effects such as change in body weight, enzyme levels, etc. Effects cannot be associated with any specific organ system.
UF-MF = Product of the uncertainty and modifying factors.
WOE = Cancer weight of evidence classification.

Table 9-6. Hazard Indices and Carcinogenic Risks—On-Site Installation Worker

Chemical	Dermal HQ	Ingestion HQ	TOTAL HAZARD INDEX
Inorganics			
Chromium	3.0E-04	1.5E-03	**1.8E-03**
Lead	NA	NA	NA
Organics			
1,2-cis-Dichloroethene	1.4E-05	3.3E-04	**3.5E-04**
Acetone	4.3E-06	1.5E-03	**1.5E-03**
Benzene	NA	NA	NA
Bis(2-ethylhexyl)phthalate	3.2E-04	6.4E-04	**9.6E-04**
Methylene chloride[a]	6.9E-06	3.6E-04	**3.6E-04**
Trichloroethene	1.8E-04	4.1E-04	**5.9E-04**
TOTAL	5.2E-04	3.3E-03	***5.6E-03***

Chemical[b]	Dermal ILCR	Ingestion ILCR	TOTAL CANCER RISK
Organics			
Benzene	1.5E-09	1.6E-08	**1.8E-08**
Bis(2-ethylhexyl)phthalate	3.2E-08	6.4E-08	**9.6E-08**
Methylene chloride[a]	1.1E-09	5.7E-08	**5.8E-08**
Trichloroethene	4.2E-09	9.6E-09	**1.4E-08**
TOTAL	3.9E-08	1.5E-07	***1.9E-07***

[a] The risk associated value given for exposure to estimated groundwater concentrations based on leaching from soils.

[b] Only chemicals that have cancer slope factors are listed in the table for carcinogenic risks.

HQ = Hazard quotient.

ILCR = Incremental lifetime cancer risk.

NA = Not applicable, toxicity values were not available to quantify risk.

Table 9-7. Hazard Indices and Carcinogenic Risks—On-Site Resident Adult

Chemical	Ingestion HQ	Inhalation HQ	TOTAL HAZARD INDEX
Inorganics			
Chromium	3.9E-02	NA	**3.9E-02**
Lead	NA	NA	
Organics			
1,2-cis-Dichloroethene	9.0E-03	NA	**9.0E-03**
Acetone	4.1E-02	NA	**4.1E-02**
Benzene	NA	NA	
Bis(2-ethylhexyl)phthalate	1.7E-02	NA	**1.7E-02**
Methylene chloride[a]	9.6E-03	2.5E-03	**9.6E-03**
Trichloroethene	1.1E-02	NA	**1.1E-02**
TOTAL	1.3E-01	2.5E-03	***1.3E-01***

Chemical[b]	Ingestion ILCR	Inhalation ILCR	TOTAL CANCER RISK
Organics			
Benzene	5.3E-07	2.0E-06	**2.5E-06**
Bis(2-ethylhexyl)phthalate	2.1E-06	NA	**2.1E-06**
Methylene chloride[a]	1.9E-06	1.5E-06	**3.4E-06**
Trichloroethene	3.1E-07	6.3E-07	**9.4E-07**
TOTAL	4.8E-06	4.1E-06	***8.9E-06***

[a] The risk associated value given for exposure to estimated groundwater concentrations based on leaching from soils.

[b] Only chemicals that have cancer slope factors are listed in the table for carcinogenic risks.

HQ = Hazard quotient

ILCR = Incremental lifetime cancer risk

NA = Not applicable, toxicity values were not available to quantify risk.

Table 9-8. Hazard Indices—On-Site Resident Child

Chemical	Dermal HQ	Ingestion HQ	TOTAL HAZARD INDEX
Inorganics			
Chromium	1.9E-03	9.1E-02	**9.3E-02**
Lead	NA	NA	
Organics			
1,2-cis-Dichloroethene	8.9E-05	2.1E-02	**2.1E-02**
Acetone	2.8E-05	9.7E-02	**9.7E-02**
Benzene	NA	NA	
Bis(2-ethylhexyl)phthalate	2.1E-03	4.0E-02	**4.2E-02**
Methylene chloride[a]	4.5E-05	2.2E-02	**2.2E-02**
Trichloroethene	1.2E-03	2.6E-02	**2.7E-02**
TOTAL	5.3E-03	3.0E-01	***3.0E-01***

[a] The risk associated value given for exposure to estimated groundwater concentrations based on leaching from soils.

HQ = Hazard quotient.

NA = Not applicable, toxicity values were not available to quantify risk.

Table 9-9. Calculated Lead Blood Levels for On-Site Resident Child

Age Group (years)	Lead Uptake from Groundwater (μg/day)	Blood Level (μg/dL)
1 to 2	11.03	4.1
2 to 3	11.53	4.3
3 to 4	11.59	4.1
4 to 5	11.61	3.9
5 to 6	11.87	3.6
6 to 7	12.25	3.4

exposure were established at points closer to the boundary of the landfill than the most realistic points of exposure. The use of these overly conservative assumptions is likely to result in a significant overestimation of actual exposure concentrations.

Similarly, the use of the maximum soil concentrations for estimating the groundwater concentration of methylene chloride as a result of leaching is a conservative assumption, which results in an overestimation of exposure concentrations.

Not all of the COPCs evaluated had toxicity values for certain exposure pathways, especially inhalation. Acetone, benzene, 1,2-cis-dichloroethene, and trichloroethene did not have inhalation RfDs; therefore, the potential noncarcinogenic risks associated with inhalation exposure to these constituents could not be quantified. Similarly benzene did not have an oral RfD. Therefore, the noncarcinogenic risks associated with oral exposure to benzene could not be quantified.

9.6 CONCLUSIONS

Constituents present in groundwater at SWMU 1 do not present a significant risk to current receptor populations because surficial groundwater at the site is not currently used as a source of drinking water.

Analysis of potential risks to human health given changes in future land use concluded that noncarcinogenic risks to human health and carcinogenic risks for off-site receptor populations and on-site Installation workers are below target risk values. The noncarcinogenic risks for the on-site resident are within the acceptable range. However, the carcinogenic risks for the on-site residential receptor exceeded the target value with an ILCR of 8.9E-6.

Remedial levels should be calculated for all chemicals that have an ILCR greater than 1E-6 if the total ILCR is greater than 1E-6 (GEPD 1996). Benzene and bis(2-ethylhexyl)phthalate have ILCRs of 2.5E-6 and 2.1E-6, respectively. Therefore, remedial levels must be calculated for benzene and bis(2-ethylhexyl)phthalate in groundwater. The ILCR resulting from exposure to methylene chloride leaching into groundwater is 3.3E-6. Therefore, soil remedial levels should be estimated for methylene chloride in soils based on acceptable concentrations of the constituents in groundwater.

9.7 REMEDIAL LEVELS

Because there are no human health COPCs for surface soil, subsurface soil, surface water, or sediment, remedial levels based on direct exposure to these media were not developed. Remedial levels for soils were developed for methylene chloride based on its potential to leach into groundwater at concentrations that present a significant carcinogenic risk as a result of residential use of groundwater.

Remedial levels for groundwater may include both risk-based concentrations and regulatory levels, such as MCLs. Given that MCLs take into consideration both human health and the limitations of technology to remove contaminants from water, these regulatory levels have been selected for remedial levels for groundwater. Both benzene and bis(2-ethylhexyl)phthalate have MCLs (5 ug/L and 6 ug/L, respectively) that will serve as remedial levels (Table 9-10).

The maximum concentration of benzene (2.5 μg/L) is less than its remedial level/MCL of 5 μg/L. Therefore, remedial action for benzene is not required for this site.

Groundwater concentrations of bis(2-ethylhexyl)phthalate exceeding the remedial level were detected in groundwater wells NMW-2A and SC-M9 (Table 9-11). These wells are located around the active landfill, indicating that this constituent is associated with the active landfill and not the old, inactive landfill.

The remedial level for methylene chloride in soils was calculated based on its potential to leach into groundwater. The target value for groundwater is 5 μg/L, the MCL for methylene chloride. The remedial levels are given in Table 9-10. In addition, Table 9-11 lists the sampling locations that indicated methylene chloride in soil above the remedial level of 3.3 mg/kg.

Table 9-10. Remedial Levels for Groundwater and Soil

Chemical	Remedial Level for Groundwater		Remedial Level for Soils—Leaching		
	Groundwater Remedial Level MCL (µg/L)	Maximum Groundwater Concentration (µg/L)	Target Groundwater Concentration (µg/L)	Remedial Level Soils (mg/kg)	Maximum Soil Concentration (mg/kg)
Benzene	5	2.5	NA	NA	NA
Bis(2-ethylhexyl)phthalate	6	61.4	NA	NA	NA
Methylene chloride	NA	NA	5	3.3	13.7

Table 9-11. Location of Exceedances above Remedial Levels

Chemical	Groundwater		Soil	
	Concentration above Remedial Level (µg/L)	Location[a]	Concentration above Remedial Level (mg/kg)	Location[b]
Bis(2-ethylhexyl)phthalate	61	SC-M9	NA	NA
	7.8	NMW-2A	NA	NA
Methylene chloride	NA	NA	9.2	SC-M11
	NA	NA	13.7	SC-M12
	NA	NA	3.9	SC-M14

Note: Exceedances of acetone in surface soil were only at SC-M19, which was not impacted by SWMU 1 (Section 5.2).

[a] Groundwater locations are presented on Figure 5-5.

[b] Surface soil locations are presented on Figure 5-1.

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10.0 CONCLUSIONS AND RECOMMENDATIONS

10.1 SUMMARY OF FINDINGS

The RFI presented in this report was conducted to collect additional analytical data for determining the nature and extent of contamination in environmental media and their potential adverse effects to human health and the environment in the vicinity of the South Central Landfill. The data were derived from a series of screening and primary samples collected from surface and subsurface soil, sediment, surface water, and groundwater in the study area. The samples collected were analyzed for a number of COPCs, including VOCs, SVOCs, pesticides/PCBs, RCRA metals, and Radium 226/228.

The following section summarizes the significant findings of the Phase II RFI sampling and analysis.

Soil. Low levels of organic constituents (VOCs, SVOCs, and pesticides) and metals are present in soil; however no clear distribution or trends of constituents are evident.

- Isolated, low concentrations of acetone, methylene chloride, toluene, 1,2,4-trichlorobenzene were detected in surface soil above reference background criteria.
- 4,4'-DDD; 4,4'-DDE; and 4,4'-DDT were detected in two surface soil samples, SC-M13 and SC-M18.
- Selenium was detected in surface soil above FSMR reference background in a single soil sample. Selenium concentrations in surface soil were not above FSMR reference background concentrations for subsurface soil.
- Isolated, low concentrations of 1,2,4-trichlorobenzene, pyrene, heptachlor, 2-butanone, acetone, methylene chloride, styrene, and toluene were detected in subsurface soil above reference background criteria.

Groundwater. The groundwater flow at the site is essentially directed to the north toward Mill and Taylors creeks, with a slight groundwater divide near the southern part of SWMU 1 at the old, inactive landfill. Flow at the southern boundary may be directed to the southwest toward Mill Creek. Low levels of VOCs, SVOCs, metals, and Radium 226/228 are present in the surficial aquifer; however, no clear distribution or trends of contaminants are evident.

- Trichloroethene was detected in a single groundwater sample (direct-push location GP-7) above its MCL. Bis(2-ethylhexyl)phthalate was detected in groundwater above its MCL at two locations (NMW-2A and SC-M9) at concentrations of 7.8 μg/L and 61.4 μg/L, respectively.
- Metals were detected in groundwater, with only one sample detected above MCLs. Lead was detected at 18.4 μg/L at monitoring well SC-M17 (MCL 15 μg/L). However, the filtered lead concentration at SC-M17 was nondetect, indicating the lead may be associated with colloid particulates in the groundwater. Barium, cadmium, chromium, iron, and lead

were detected above FSMR reference background concentrations. Iron concentrations were consistent with iron data collected under compliance monitoring.

- Low levels of Radium 226/228 were detected in the groundwater. Radium 226/228 were detected above the MCL in two groundwater samples at SC-M5 and SC-M19.
- The groundwater field sampling data do not indicate that leachate is impacting the groundwater.

Surface Water and Sediment. Low levels of organics, metals, and Radium 228 were detected in sediment and surface water.

- No metals were detected in surface water above the site-specific background criteria.
- Diethyl phthalate and pyrene were detected in surface water one of three samples above site-specific background criteria.
- Radium 228 was detected in three of three surface water samples above the site-specific background criterion.
- Chromium, lead, mercury, and Radium 228 were detected in sediment above site-specific background criteria.
- Two VOCs (acetone and 2-butanone) and one SVOC (1,2,4-trichlorobenzene) were detected in sediment samples above site-specific background criteria (nondetect), respectively.

10.2 CONCLUSIONS

Several assessments were conducted to determine the significance of the contaminant concentrations found at the South Central Landfill with respect to their impact on human health and the environment. The assessments included:

- A contaminant fate and transport analysis (Chapter 6.0), which provided an assessment of the potential migration pathways and transport mechanisms affecting the chemical compounds found at the site.
- An HHPRE (Chapter 7.0), which employed a Step 1 risk screening to develop human health COPCs that were evaluated during the baseline risk assessment.
- An EPRE (Chapter 8.0) for terrestrial and aquatic receptors in the study area.

The following summarizes the conclusions regarding contaminant fate and transport:

- Selenium exceeded its reference background criteria in surface soil; however, it did not exceed its GSSL based on leaching to groundwater. Therefore, selenium is not considered a contaminant migration COPC.

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- In the groundwater, none of the metals, except lead, exceeded its MCL; however, this elevated value may be due to colloid particulates in the groundwater. Radium 228 also exceeded its MCL. Off-site migration of lead and Radium 228 will be limited because of their high retardation factors.

- Organics in the site soil that exceeded EPA GSSLs and are, therefore, of concern for leaching from soil to groundwater, include acetone and methylene chloride. The concentration of acetone in surface soil is particularly high (44,100 μg/kg), which is above its GSSL of 800 μg/kg. The 44,100 μg/kg was the only detection (out of six) of acetone that exceeds its GSSL. All of the detected methylene chloride concentrations (5 of 11 surface and 1 of 9 subsurface soil samples) exceeded its GSSL. Solubility of acetone is very high, and retardation in groundwater is low and has the potential to migrate off-site. Concentration of acetone in groundwater is above its RBC. Methylene chloride was not detected in groundwater. Two of the soil sampling locations (SC-MW15 and SC-MW16) were located outside the area impacted by landfill operations. Therefore, soil concentrations of acetone and methylene chloride at these locations were outside the influence of potential contaminants from SWMU 1. Methylene chloride was the only contaminant migration COPC in soil around the old, inactive portion of the landfill.

- Bis(2-ethylhexyl)phthalate and trichloroethene exceeded their respective MCLs in one of 51 groundwater samples, but were not screened as contaminant migration COPCs in soils because they were not detected in surface or subsurface soils. Maximum groundwater concentrations of bis(2-ethylhexyl)phthalate and trichloroethene were detected at 61.4 μg/L (MCL 6 μg/L) and 5.4 μg/L (MCL 5 μg/L), respectively. These two concentrations above MCLs represent only a single detection out of 51 groundwater samples (23 direct-push, 2 vertical profiles, and 22 groundwater monitoring wells). Bis(2-ethylhexyl)phthalate and trichloroethene were detected in the groundwater only and not in soil, indicating that these contaminants may have leached in the past or are potentially leaching directly from a very confined or small point source. Off-site migration of these organic contaminants will be limited due to retardation and degradation through various processes as well as the slow movement of groundwater (12.8 feet/year). At the velocity of 12.8 feet/year, it is expected to take 94 years for the site groundwater at the northern boundary of the old, inactive landfill, near SC-M12 to reach Taylors Creek (approximately 1,200 feet). In reality, contaminants will move slower than groundwater due to retardation, and the organic contaminants will gradually decay in nature.

- The contaminant fate and transport analysis concluded that methylene chloride may present a risk to human health as a result of leaching into groundwater. Therefore, a baseline risk assessment was performed to quantify the potential risk associated with this constituent and to determine if it presents a potential risk to human health.

The following summarizes the conclusions of the HHPRE.

- Based on the results of the screening and the weight-of-evidence analysis, potential human health COPCs have been identified for surface soil and groundwater. There are no human health COPCs for subsurface soil, surface water, or sediment.

- The initial human health COPCs for groundwater were identified because they present a potential threat to human health as a result of using groundwater as a source of drinking water. The initial human health COPCs for groundwater are iron; lead; chromium; Radium 226; Radium 228; acetone; benzene; bis(2-ethylhexyl)phthalate; 1,2-*cis*-dichloroethene; and trichloroethene. Iron, Radium 226, and Radium 228 are not hazardous constituents as defined by Section I.E of FSMR's Hazardous Waste Facility Permit #HW-045(S&T) and are not subject to the corrective action requirements under the terms and conditions of the permit or under the Georgia Hazardous Waste Management Act, O.C.G.A ξ12-8-60, et seq., as amended, and the Rules for Hazardous Waste Management, Chapter 391-3-11, promulgated pursuant thereto, as amended. Therefore, iron, Radium 226, and Radium 228 are eliminated as human health COPCs in groundwater at SWMU 1.

- The HHPRE identified human health COPCs for groundwater. Therefore, a baseline risk assessment was performed to quantify the potential risk associated with these constituents and to determine if they present a potential risk to human health.

The following summarizes the conclusions of the EPRE.

- Selenium and the pesticide DDT and its metabolites were detected in surface soil at the South Central Landfill at concentrations that exceeded both reference background criteria and that resulted in exposures that exceed the TRVs for terrestrial receptors. Selenium was detected in only one of nine surface soil samples at SWMU 1 at only slightly above its reference background concentration (0.69 mg/kg versus 0.41 mg/kg, respectively). Selenium was not detected in the other eight surface soil samples. Therefore, selenium is not considered an ecological COPC in surface soil at SWMU 1. DDT and its metabolites in surface soil at SWMU 1 are ecological COPCs for birds with small home ranges ingesting soil-dwelling invertebrates. DDT and its metabolites are likely to be present in surface soil in most areas of Georgia and the southeast due to past widespread use as an insecticide. Assuming the effects of DDT, DDE, and DDD are additive, the combined exposure at each of the two sampling locations do not exceed the LOAEL dose. The fact that maximum estimated doses lie between the NOAEL and LOAEL suggests that the pesticides and its metabolites are not ecological COPCs in surface soil at SWMU 1.

- Barium, iron, lead, bis(2-ethylhexyl)phthalate, and xylenes (total) are present in groundwater at the South Central Landfill at concentrations that exceed EPA Region IV ESVs for surface water. Bis(2-ethylhexyl)phthalate was detected in groundwater at concentrations above background criteria and that result in estimated exposures exceeding TRVs for terrestrial ecological receptors that ingest fish and other aquatic biota. The ecological COPCs in groundwater are barium, iron, lead, bis(2-ethylhexyl)phthalate, and xylenes for aquatic biota and bis(2-ethylhexyl)phthalate for birds ingesting fish exposed to groundwater emerging as surface water. The concentration of these constituents in numerous monitoring wells and direct-push groundwater samples exceed background criteria and risk-based screening or reference values. However, none of these constituents is an ecological COPC in surface water and sediment at SWMU 1. This suggests that dilution, degradation, adsorption, or other processes are operating to reduce the low concentrations in groundwater discharging to Taylors and Mill creeks or that groundwater at SWMU 1 has not yet migrated to the creeks. Groundwater flow rates indicate that it takes approximately 94 years for groundwater to reach Mill and Taylors creeks. Therefore, groundwater constituents are not ecological COPCs at the present time because they have not been indicated as ecological COPCs in surface water and sediment. The groundwater constituents are not likely to be ecological COPCs in the future because of their low concentrations and

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associated small hazard quotients and the continued natural attenuation processes occurring in the subsurface soil (i.e., dilution, degradation, absorption, etc.).

The following summarizes the conclusions of the BHHRA.

- The human health COPCs identified in groundwater include acetone, benzene, bis(2-ethylhexyl)phthalate, 1,2-*cis*-dichloroethene, trichloroethene, chromium, and lead. Methylene chloride was identified as a contaminant migration COPC based on its potential to leach into groundwater, resulting in potential exposure of receptors.

- Constituents in groundwater do not present a significant risk to off-site receptors because the groundwater concentrations of the COPCs at the point of exposure are negligible.

- Constituents present in groundwater at SWMU 1 do not present a significant noncarcinogenic risk to human health. The quantitative estimates of noncarcinogenic risks were below their target values for both on-site occupational and residential receptor populations. The carcinogenic risks for the occupational receptor population was below the target risk value of 1E-6; however, the carcinogenic risk for the on-site residential receptor exceeded the target value with an ILCR of 8.9E-6. This value includes an ILCR of 3.4E-6 resulting from exposure to methylene chloride that may leach into groundwater. The other risk drivers are benzene (ILCR = 2.5E-6) and bis(2-ethylhexyl)phthalate (ILCR = 2.1E-6).

- The remedial levels for benzene and bis(2-ethylhexyl)phthalate were based on the MCLs (5 µg/L and 6 µg/L, respectively) for these constituents. The MCL for benzene (5 µg/L) was greater than the maximum detected value of 2.5 µg/L. Therefore, corrective action is not required to address the presence of benzene in groundwater. Bis(2-ethylhexyl)phthalate exceeded its remedial level (MCL) at two locations (SC-M9 and NMW-2A) located around the active portion of the landfill. The remedial soil level for methylene chloride was determined to be 3.3 mg/kg and to represent a concentration of the constituent in soil that is not likely to leach into groundwater resulting in groundwater concentrations that exceed the MCL for methylene chloride (5 µg/L).

10.3 RISK MANAGEMENT AND SITE RECOMMENDATIONS

The results of the RFI and the conclusions reached through analysis of data and conduct of the assessments referenced above indicate that the following future additional actions are warranted at the South Central Landfill site. Recommendations for further action are as follows:

- An ERA is not warranted because the EPRE at the South Central Landfill indicated there is no present ecological risk and the site is unlikely to pose an ecological risk in the future.

- The results of the BHHRA on groundwater indicate that bis(2-ethylhexyl)phthalate exceeds its remedial level (MCL) in two groundwater monitoring wells (NMW-2A and SC-M9) around the active portion of the landfill. In addition, methylene chloride present in soils at three locations around the old, inactive landfill (SC-M11, SC-M12, and SC-M14) may leach into groundwater, resulting in groundwater concentrations that exceed the MCL.

- Results of the SESOIL modeling have shown that three of the detected concentrations of methylene chloride in soils from the old, inactive landfill (SC-M11, SC-M12, and SC-M14), exceeded the soil remedial levels for protection of groundwater. Therefore, the methylene chloride at these locations may leach into groundwater at concentrations that present a carcinogenic risk above the target risk (>10E-6) to an on-site resident using the surficial groundwater as a source of drinking water. However, the potential of this type of exposure taking place is very small. The exposure scenario assumes that in the future a residence will be built on-site and that the household drinking water supply comes directly from the surficial aquifer. Current planning, which goes through the year 2020, does not include the construction of any facilities on the inactive portion of the landfill. Given that methylene chloride degrades rapidly in groundwater (half-life in groundwater equals 112 days), the methylene chloride leaching into groundwater would completely degrade before any structure would be built on the site. It should be noted that methylene chloride was not detected in any of the groundwater samples associated with the old, inactive landfill, including those located in the area of the methylene chloride soil contamination (SC-MW11, SC-M12, or SC-W14). Therefore, potential exposure of a residential receptor to methylene chloride is not a likely scenario. Given the unlikely possibility of exposure of an on-site resident to methylene chloride in the surficial groundwater, Fort Stewart respectively requests that the old, inactive portion of SWMU 1 be assigned a "No Further Action Required" status for investigative purposes.

- At the active portion of SWMU 1, which is operated under Permit No. 089-010D (SL) and 089-020D (L), the few constituents detected above MCLs [i.e., bis(2-ethylhexyl)phthalate at SC-M9 and NMW-2A] will continue to be monitored through the GMP, approved by the GEPD Land Protection Division, and corrective action to reduce the identified concentrations of bis(2-ethylhexyl)phthalate in these two wells is not required. The GMP will allow continued evaluation of potential contaminant migration of the groundwater and surface water and will identify if any contaminant levels become elevated and/or any trends develop in contaminant distribution across the active portion of the landfill. In addition, the present operational and design procedures are structured to prevent off-site migration of contaminants from the active landfills. Thus, it is recommended that the active portion of SWMU 1 continue to be monitored in association with the approved GMP. All analytical data will continue to be submitted to the GEPD Land Protection Division.

- Based on the information in this report, Fort Stewart recommends that a CAP proposing institutional controls (deed restrictions, land use restrictions, etc.) be prepared for the old, inactive portion of the landfill. FSMR recommends that the monitoring wells (SC-M11 through SC-M19) around the old, inactive portion of the landfill be abandoned by grouting the wells to the surface and removing the surface completion. The monitoring wells around the old, inactive portion of the landfill will be abandoned upon approval of the CAP by GEPD. It is anticipated that the CAP will be submitted to GEPD in the first fiscal quarter (October through December) 2000.

11.0 REFERENCES

ASTM (American Society for Testing and Materials), 1995. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites, ASTM Designation E:1739-95, Annual Book of ASTM Standards, West Conshohocken, Pennsylvania.

Arora, R., 1984. Hydrologic Evaluation for Underground Injection Control in the Coastal Plain of Georgia, Department of Natural Resources, Environmental Protection Division, Georgia Geological Survey.

Baes, C. F., III, R. D. Sharp, A. L. Sjoreen, and R. W. Shor, 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture, ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Blaylock, B. G., M. L. Frank, and B. R. O'Neal, 1993. Methodology for Estimating Radiation Dose Rates to Freshwater Biota Exposed to Radionuclides in the Environment, ES/ER/TM-78, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Clayton, G.D., and F.E. Clayton (eds.), 1981. Patty's Industrial Hygiene and Toxicology, Vol. 2A: Toxicology, 3rd Revised Edition, John Wiley & Sons, New York.

DOE (U.S. Department of Energy), 1998. Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee, Vol. 4, DOE/OR/01-1641/V4&D1.

DOE/ORO (U.S. Department of Energy–Oak Ridge Operations), 1998. Risk Assessment Information System Web Page, Preliminary Remediation Goals, <http://risk.lsd.ornl.gov/prg/prg_document.html>.

Eisler, 1987. Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, Biological Report 85(1.11), U.S. Fish and Wildlife Service, U.S. Department of the Interior, Patuxent, Maryland.

Eisler, 1988. Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, Biological Report 85(1.14), U.S. Fish and Wildlife Service, U.S. Department of the Interior, Patuxent, Maryland.

Environmental Science and Engineering, 1982. Fort Stewart Military Reservation RCRA Studies: Final Engineering Report.

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

EPA, 1991. Soil Transport and Fate (STF) Database and Model Management System, Ver. 2.0, R.S. Kerr Environmental Research Laboratory, Ada, Oklahoma.

EPA, 1993a. Risk Reduction Engineering Laboratory (RREL) Treatability Database, Ver. 4.0, Office of Research and Development, Cincinnati, Ohio.

EPA, 1993b. Guidelines for Deriving Site-Specific Sediment Quality Criteria for the Protection of Benthic Organisms, EPA-822-R-93-017.

EPA, 1993c. Wildlife Exposure Factors Handbook, Vol. 1, EPA/600/R-93/187a.

EPA, 1994a. The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3, EPA/600/R-94/168b, Office of Research and Development, Washington, D.C.

EPA, 1994b. Technical Background Document for Soils Screening Guidance, EPA/540/R-94/106, NTIS PB95-963532.

EPA, 1994c. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Review Draft), Environmental Response Team, Edison, New Jersey, September.

EPA, 1994d. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, OSWER Directive #9355.4-12, July.

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. Health Effects Assessment Summary Tables (HEAST), Office of Solid Waste and Emergency Response, Washington, D.C.

EPA, 1996c. Risk-Based Concentration Table, January–June 1996, EPA Region III, Office of RCRA Technical and Program Support Branch, April 19.

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

EPA, 1996e. Proposed Guidelines for Ecological Risk Assessment, EPA/630/R-95/002B, Washington, D.C.

EPA, 1997. Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments, EPA-540-R-97-006, Environmental Response Team, Edison, New Jersey, Interim Final, June.

EPA, 1998. Supplemental Guidance to RAGS: Region IV Bulletins <http://www.epa.gov/region4/wastepgs/oftecser/otsguid.htm>.

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.

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GEPD, 1997a. Personal communication from Rod Stafford, GEPD, Department of Natural Resources, Atlanta, Georgia, April 17.

GEPD, 1997b. Personal communication from Rod Stafford, GEPD, Department of Natural Resources, Atlanta, Georgia, October 6.

GEPD, 1997c. Personal communication from Rod Stafford, GEPD, Department of Natural Resources, Atlanta, Georgia, November.

Geraghty and Miller, 1992. RCRA Facility Investigation Final Work Plan, Fort Stewart, Georgia, June.

HAZWRAP (Hazardous Waste Remedial Actions Program) 1994. Loring Air Force Base Ecological Risk Methodology, Martin Marietta Energy Systems, Inc., Draft.

Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko, 1991. Environmental Degradation Rates, Lewis Publishers, Inc., Chelsea, Michigan.

IAEA (International Atomic Energy Agency), 1992. Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards, Technical Report Series No. 332,Vienna.

Jones, D.S., G.W. Suter, II, and R.N. Hull, 1997. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Sediment-Associated Biota: 1997 Revision, ES/ER/TM-95/R4, Lockheed Martin Energy Systems, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Metcalf and Eddy, 1996. Final Work Plan for RCRA Facility Investigation at Bulk Fuel Storage System, Wright Army Airfield, Fort Stewart, Georgia.

Miller, J.A., 1990. Groundwater Atlas of the United States, Segment 6, U.S. Department of the Interior, U.S. Geological Survey, Hydrologic Inventory Atlas 730G.

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.

NRC (Nuclear Regulatory Commission), 1992. Residual Radioactive Contamination from Decommissioning, Technical Basis for Translating Contamination Levels to Animal Total Effective Dose Equivalent, Vol. 1, Final Report, NUREG/CR-5512, PNL-7994.

Opresko, D. M., B. E. Sample, and G. W. Suter, II, 1995. Toxicological Benchmarks for Wildlife, 1995 Revision, ES/ER/TM-86/R3, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

QST (QST Environmental Inc.), 1997. Draft Final Remedial Investigation/Baseline Risk Assessment for the Landfills 3 and 4 Operable Unit, Fort Sheridan, Illinois, June.

Rust (Rust Environmental and Infrastructure, Inc.), 1996. Phase I RCRA Facility Investigation Report for 24 Solid Waste Management Units at Fort Stewart, Georgia, Vols. I–III, May.

SAIC (Science Applications International Corporation), 1997. Sampling and Analysis Plan for the Phase II RCRA Facility Investigation at the South Central Landfill (SWMU 1) at Fort Stewart, Georgia, May.

SAIC, 1998. Draft Final RI Report for the Department of Defense Operable Unit at Fort Sheridan, Illinois, February.

Sample, B.E., and G.W. Suter, II, 1994. Estimating Exposure of Terrestrial Wildlife to Contaminants, ER/ES/TM-125, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Sample, B.E., D.M. Opresko, and G.W. Suter, II, 1996. Toxicological Benchmarks for Wildlife: 1996 Revision, ES/ER/TM-86/R3.

Shen, T.T., C.E. Schmidt, and T.R. Card, 1993. Assessment and Control of VOC Emissions from Waste Treatment and Disposal Facilities, Van Nostrand Reinhold, New York.

Sheppard, M.I., and D.H. Thibault, 1990. Default Soil Solid/Liquid Partition Coefficients for Four Major Soil Types: A Compendium, Health Physics, Vol. 59, No. 4, pp. 471–482.

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, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

USACE (U.S. Army Corps of Engineers), 1995. Groundwater Monitoring Plan for the Operation, Closure, and Post-Closure of Sanitary and Non-Putrescible Landfills, Fort Stewart, Georgia, Revised: July 21.

U.S. Department of Commerce, 1990. 1990 Census, Bureau of the Census.

APPENDIX A

PHASE II RCRA RFI REPORT
SOUTH CENTRAL LANDFILL (SWMU 1)
FORT STEWART, GEORGIA

ANALYTICAL RESULTS
FROM
GROUNDWATER MONITORING PROGRAM
AT SOUTH CENTRAL LANDFILL

Table A.1. Groundwater Compliance Summary for January 1997

Sample Location Sample ID Sampling Date	MCL	Site Back-ground[a]	FSMR Back-ground[b]	NWM-1 AB44317 1/27/97	NWM-2A AB44318 1/27/97	NWM-3 AB44319 1/27/97	SC-M1A AB44323 1/28/97	SC-M2 AB44329 1/28/97	SC-M3 AB44321 1/27/97	SC-M3-DUP1 AB44322 1/27/97	SC-M4 AB44320 1/27/97	SC-M5 AB44315 1/27/97	SC-M6A AB44324 1/28/97
VOCs, µg/L													
Methylene Chloride	5			19	21	21				22	15	21	
2-Butanone(MEK)								17			12		
Metals, µg/L													
Antimony		4					32						
Arsenic	50		3.05			15	87						
Barium	2000	48.6	57.2	70	60	160	130	50	60	40	110	40	160
Beryllium	4						2	2	2				2
Cadmium	5	280	0.593	4	90	40	170	16		50	50	40	140
Chromium	100	23.4	5.2	70	140	60	70	40		70	20	6	100
Cobalt				10		20		20	20				
Copper	* 1000	132			310	130	160	180	200	170	140	160	220
Lead	15	4	2.83	7		15	22	17					28
Nickel	100	6		70		70				80	70	7	
Selenium	50		0.58				14						
Silver	* 100	220		30	80	20	160	120		30	30	30	110
Vanadium				30		60	30	20	20				50
Zinc	* 5000	176.6		200	350	27	280	230	20	220	190	220	310

* Secondary Drinking Water Standard

[a] Two times the average of available data from January 1997, September 1997, and January 1998 not including undetected values.

[b] FSMR Reference Background Data (see Section 5)

Table A.1 (continued)

Sample Location Sample ID Sampling Date	MCL	Site Background^a	FSMR Background^b	SCM-6A-DUP2 AB44325 1/28/97	SC-M7 AB44316 1/27/97	SC-M8 AB44328 1/28/98	SC-M9 AB44326 1/28/97	SC-M10 AB44327 1/28/97
VOCs, μg/L								
Methylene Chloride	5				22			
2-Butanone(MEK)						12		
Metals, μg/L								
Antimony		4						
Arsenic	50		3.05					
Barium	2000	48.6	57.2	150	40	110	20	20
Beryllium	4					2	2	
Cadmium	5	280	0.593	150	4		140	140
Chromium	100	23.4	5.2	80	40	40	40	30
Cobalt						20	20	
Copper	* 1000	132		210	140	130	180	190
Lead	15	4	2.83	29		12		
Nickel	100	6						
Selenium	50		0.58					
Silver	* 100	220		110	30	30	110	110
Vanadium				40	10	20		
Zinc	* 5000	176.6		280	150		220	240

* Secondary Drinking Water Standard

[a] Two times the average of available data from January 1997, September 1997, and January 1998 not including undetected values.

[b] FSMR Reference Background Data (see Section 5)

Table A.2. Groundwater Compliance Summary for September 1997

Sample Location Sample ID Sampling Date	MCL	Site Back-ground[a]	FSMR Back-ground[b]	NMW-1 N70017805 9/4/97	NMW-2A N70017806 9/4/97	NMW-3 N70017807 9/4/97	SC-M1A N70017812 9/4/97	SC-M2 N70017810 9/4/97	SC-M3 N70017809 9/4/97	SC-M4 N70017808 9/4/97	SC-M5 N70017801 9/4/97	SC-M5-DUP1 N70017802 9/4/97
Metals, µg/L												
Aluminum	* 50-200	2800		12000	680	380	12000	180	140	240	1900	1700
Antimony	6	4										
Arsenic	50		3.05								9	
Barium	2000	48.6	57.2	63	55	90	69	45	38	95	56	50
Beryllium	4											
Cadmium	5	280	0.593									
Calcium		1720		2200	31000	38000	12000	24000		24000	27000	28000
Chromium	100	23.4	5.2	15			15					3
Copper	* 1000	132		7		4	9				4	30
Iron	* 300	5600		2700	910	880	11000	8600	960	2400	19000	18000
Lead		4	2.83	16			14		7			4
Magnesium		960		920	3600	8900	3200	8900	2300	5800	9100	9000
Manganese	* 50	46		21	50	100	120	350	190	130	330	390
Nickel	100	6		4		8	15			4	4	6
Potassium		1040		1600	940	920	2200	720	1100	1500	2900	3400
Selenium	50		0.58									
Silver	* 100	220										
Sodium		6400		2000	11000	12000	24000	17000	4100	16000	6200	5900
Thallium	2											
Vanadium		6		19			20					
Zinc	* 5000	176.6		18	22	26	40		42	13	28	52
Miscellaneous, mg/L												
Hardness				8.1	130	170	51	120	47	110	140	140
Total Dissolved Solids	500			79	180	190	180	170	90	200	270	300
Total Suspended Solids				220	9	14	430	16		220	6	16
Alkalinity					160	180	54	110	67	150		
Chloride	* 250			4.7	6.8	4.4	35	38	3.5	26	2.8	3.7
Ammonia							1.2	0.073			0.64	0.8
TKN							2.8					
Nitrate-Nitrite	10				0.73		6.4	8.6			2	2.1
Sulfate	* 250										180	190
BOD							17	5.3		>750		
COD				35			120	16	6.3	38	8	11

* Secondary Drinking Water Standard

[a] Two times the average of available data from January 1997, September 1997, and January 1998 not including undetected values.

[b] FSMR Reference Background Data (see Section 5)

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Table A.2 (continued)

Sample Location Sample ID Sampling Date	MCL	Site Background[a]	FSMR Background[b]	SC-M6A N70017813 9/4/97	SC-M7 N70017803 9/4/97	SC-M7-DUP2 N70017804 9/4/97	SC-M8 N70017811 9/4/97	SC-M9 N70017814 9/4/97	SC-M10 N70017815 9/4/97
Metals, µg/L									
Aluminum	* 50-200	2800		8200	730	530	5200	1900	1400
Antimony	6	4							
Arsenic	50		3.05						
Barium	2000	48.6	57.2	35	41	44	77	28	23
Beryllium	4								
Cadmium	5	280	0.593						
Calcium		1720		2600	21000	23000	4900	1400	860
Chromium	100	23.4	5.2	11			7	3	3
Copper	* 1000	132		9	3		4		5
Iron	* 300	5600		2000	1800	1500	1200	1100	2800
Lead		4	2.83	6			4		
Magnesium		960		910	6700	7200	1400	570	480
Manganese	* 50	46		26	150	86	25	32	23
Nickel	100	6		4	18	5		6	3
Potassium		1040		1200	1300	1100	2300		520
Selenium	50		0.58	31				26	
Silver	* 100	220							
Sodium		6400		1900	8800	9300	1900	1800	3200
Thallium	2								
Vanadium		6		10			5		
Zinc	* 5000	176.6		22	15	16		12	12
Miscellaneous, mg/L									
Hardness				10	110	110	20	7.1	7.1
Total Dissolved Solids	500			61	140	150	44	16	16
Total Suspended Solids				97	6	6	6	28	30
Alkalinity					130	130			
Chloride	* 250			2.4	9.5	7.8	3.9	3.5	6.8
Ammonia									
TKN									
Nitrate-Nitrite	10			5.5			1.2	16	2.3
Sulfate	* 250							8.5	
BOD						5.1			
COD				9.4	5.2			5.6	

* Secondary Drinking Water Standard

[a] Two times the average of available data from January 1997, September 1997, and January 1998 not including undetected values.

[b] FSMR Reference Background Data (see Section 5)

Table A.3. Groundwater Compliance Summary for January 1998

Sample Location Sample ID Sampling Date	MCL	Site Back-ground[a]	FSMR Back-ground[b]	NMW-1 N80114103 1/30/98	NMW-2A N80114104 1/30/98	NMW-3 N80114105 1/30/98	SC-M1A N80114112 1/31/98	SC-M2 N80114108 1/30/98	SC-M3 N80114107 1/30/98	SC-M4 N80114106 1/30/98	SC-M5 N80114109 1/31/98
Metals, µg/L											
Antimony		4								2	4
Arsenic	50		3.05			7					
Barium	2000	48.6	57.2	120	47	150	48	18	40	89	50
Beryllium	4					2					
Chromium	100	23.4	5.2	28	2	30	39		5	7	2
Cobalt				2		14				2	2
Copper	* 1000	132		7		6	4			2	3
Lead	15	4	2.83	17		7	7	2			
Nickel	100	6		6		19	11		4	6	2
Selenium	50		0.58			3					3
Vanadium		6		39	3	38	14			3	2
Zinc	* 5000	176.6		25	9	44	10	10	9		22

* Secondary Drinking Water Standard

[a] Two times the average of available data from January 1997, September 1997, and January 1998 not including undetected values.

[b] FSMR Reference Background Data (see Section 5)

Table A.3 (continued)

Sample Location Sample ID Sampling Date	MCL	Site Back-ground[a]	FSMR Back-ground[b]	SC-M5DUP N80114110 1/31/98	SC-M6A N80114113 1/31/98	SC-M7 N80114101 1/30/98	SC-M7DUP N80114102 1/30/98	SC-M8 N80114111 1/31/98	SC-M9 N80114114 1/31/98	SC-M10 N80114115 1/31/98
Metals, µg/L										
Antimony		4		2		2		2		2
Arsenic	50		3.05			2				
Barium	2000	48.6	57.2	51	31	62	46	69	21	30
Beryllium	4									
Chromium	100	23.4	5.2		8	8	3	4		2
Cobalt				2		2				
Copper	* 1000	132		2	3	4	2	4		3
Lead	15	4	2.83		4	3		2		2
Nickel	100	6				4				3
Selenium	50		0.58	3						
Vanadium		6		2	7	10		4		3
Zinc	* 5000	176.6		20	10	18	5	12	10	13

* Secondary Drinking Water Standard

[a] Two times the average of available data from January 1997, September 1997, and January 1998 not including undetected values.

[b] FSMR Reference Background Data (see Section 5)

APPENDIX B

PHASE II RCRA RFI REPORT
SOUTH CENTRAL LANDFILL (SWMU 1)
FORT STEWART, GEORGIA

BORING LOGS

HTRW DRILLING LOG	DISTRICT Savannah	HOLE NUMBER SC-M11
1. COMPANY NAME S.A.I.C.	2. DRILL SUBCONTRACTOR Miller Drilling Co.	SHEET 1 OF SHEETS 2

3. PROJECT Ft. Stewart SWMU-1	4. LOCATION Ft. Stewart SWMU-1 (South Central Landfill)
5. NAME OF DRILLER Allen Gonsuron	6. MANUFACTURERS DESIGNATION OF DRILL Ingersol Rand A-300
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 7-7/8" OD x 5' long, Hollow Stem Augers 4" ID x 5' long, CME Continuous Samplers 3" ID x 2' long, Shelby Tubes	8. HOLE LOCATION See Sketch Below 9. SURFACE ELEVATION 10. DATE STARTED 11/16/97 11. DATE COMPLETED 11/16/97
12. OVERBURDEN THICKNESS N/A	15. DEPTH GROUNDWATER ENCOUNTERED ~3.5 ft BGS
13. DEPTH DRILLED INTO ROCK N/A	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A
14. TOTAL DEPTH OF HOLE 15.0 ft BGS	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
1	N/A	Shelby Tube	N/A

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
2	1	RCRA	SVOC	Pesticides/PCB	Radium	N/A

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Well	N/A	Yes	N/A	Laura Lumley

LOCATION SKETCH/COMMENTS

SCALE: NOT TO SCALE

SAMPLE LOCATIONS AS PROPOSED

IN WORKPLAN (SAIC 1997)

'ROJECT Ft. Stewart SWMU-1	HOLE NO. SC-M11

ENG FORM 5056-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG

HOLE NUMBER SC-M11

PROJECT Ft. Stewart SWMU-1

INSPECTOR Laura Lumley

SHEET 2 of 2

ELEV (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO (E)	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		SAND, fine to medium grained, Light Yellowish Brown, 10YR-6/4.	0.0'- 2.5' 0.0 ppm		011111 011121	
	1					
	2		2.5'- 5.0' 0.3 ppm		011112 011132	
	3					Water Level ~ 3.5' BGS
	4					
	5	SAND, fine to medium grained, Strong Brown, 7.5YR-5/8.	5.0' -7.5' 0.0 ppm	5.0' - 7.0' BGS Shelby Tube 011113		
	6					
	7	SANDY CLAY, Light Gray, 5Y-7/1, with Strong Brown streaks.	7.5'- 10.0' 0.0 ppm			
	8					
	9					
	10	SILTY SAND, Light Gray, 5Y-7/1.	10.0 - 12.5 0.3 ppm			
	11					
	12					
	13					
	14					
	15	Bottom of Hole at 15.0 ft BGS.				
	16					
	17					
	18					
	19					

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HTRW DRILLING LOG	DISTRICT Savannah	HOLE NUMBER SC-M12
1. COMPANY NAME S.A.I.C.	2. DRILL SUBCONTRACTOR Miller Drilling Co.	SHEET 1 OF SHEETS 2

3. PROJECT Ft. Stewart SWMU-1	4. LOCATION Ft. Stewart SWMU-1 (South Central Landfill)
5. NAME OF DRILLER Doug Bishop	6. MANUFACTURERS DESIGNATION OF DRILL CME-550X
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 7-7/8" OD x 5' long, Hollow Stem Augers 4" ID x 5' long, CME Continuous Samplers 3" ID x 2' long, Shelby Tubes	8. HOLE LOCATION See Sketch Below 9. SURFACE ELEVATION 10. DATE STARTED 11/16/97 — 11. DATE COMPLETED 11/16/97
12. OVERBURDEN THICKNESS N/A	15. DEPTH GROUNDWATER ENCOUNTERED ~3.0 ft BGS
13. DEPTH DRILLED INTO ROCK N/A	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A
14. TOTAL DEPTH OF HOLE 12.0 ft BGS	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A

18. GEOTECHNICAL SAMPLES 1	DISTURBED Ziplock Bag	UNDISTURBED N/A	19. TOTAL NUMBER OF CORE BOXES N/A

20. SAMPLES FOR CHEMICAL ANALYSIS 2	VOC 1	METALS RCRA	OTHER (SPECIFY) SVOC	OTHER (SPECIFY) Pesticides\PCB	OTHER (SPECIFY) Radium	21. TOTAL CORE RECOVERY N/A
22. DISPOSITION OF HOLE Well	BACKFILLED N/A	MONITORING WELL Yes	OTHER (SPECIFY) N/A	23. SIGNATURE OF INSPECTOR Chadd Grubbs		

LOCATION SKETCH/COMMENTS SCALE: NOT TO SCALE

SAMPLE LOCATIONS AS PROPOSED

IN WORKPLAN (SAIC 1997)

ROJECT Ft. Stewart SWMU-1	HOLE NO. SC-M12

HTRW DRILLING LOG			HOLE NUMBER SC-M12
PROJECT Ft. Stewart SWMU-1	INSPECTOR Chad Grubbs		SHEET 2 of 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO. (E)	ANALYTICAL SAMPLE NO (F)	REMARKS (G)
	1 2	SILTY SAND (SM), fine grained, moist from 3' - 5', Pinkish Gray, 7.5YR-6/2.	0.0'- 2.5' No Headspace readings due to instrument malfunction		011211	
	3 4		2.5'- 5.0'	2.5'- 5.0' Ziplock Bag 011213	011212	Water Level ~ 3.0' BGS
	5 6	Insufficient Recovery	5.0' -7.5'	5.0' - 7.0' Shelby Tube (Insufficient Recovery)		
	7	SILTY SAND (SM), fine grained, Pinkish Gray, 7.5YR-6/2.				
	8 9		7.5'- 10.0'			
	10 11	Insufficient Recovery	10.0 - 12.0			
	12 13 14 15 16 17 18 19	Bottom of Hole at 12.0 ft BGS.				

HTRW DRILLING LOG	DISTRICT Savannah	HOLE NUMBER SC-M13
1. COMPANY NAME S.A.I.C.	2. DRILL SUBCONTRACTOR Miller Drilling Co.	SHEET 1 OF SHEETS 2

3. PROJECT Ft. Stewart SWMU-1	4. LOCATION Ft. Stewart SWMU-1 (South Central Landfill)
5. NAME OF DRILLER Doug Bishop	6. MANUFACTURERS DESIGNATION OF DRILL CME-550X
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 7-7/8" OD x 5' long, Hollow Stem Augers 4" ID x 5' long, CME Continuous Samplers 3" ID x 2' long, Shelby Tubes	8. HOLE LOCATION See Sketch Below 9. SURFACE ELEVATION 10. DATE STARTED 11/16/97 — 11. DATE COMPLETED 11/16/97
12. OVERBURDEN THICKNESS N/A	15. DEPTH GROUNDWATER ENCOUNTERED ~7.5 ft BGS
13. DEPTH DRILLED INTO ROCK N/A	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A
14. TOTAL DEPTH OF HOLE 15.0 ft BGS	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A

18. GEOTECHNICAL SAMPLES N/A	DISTURBED N/A	UNDISTURBED N/A	19. TOTAL NUMBER OF CORE BOXES N/A

20. SAMPLES FOR CHEMICAL ANALYSIS 2	VOC 1	METALS RCRA	OTHER (SPECIFY) SVOC	OTHER (SPECIFY) Pesticides\PCB	OTHER (SPECIFY) Radium	21. TOTAL CORE RECOVERY N/A
22. DISPOSITION OF HOLE Well	BACKFILLED N/A	MONITORING WELL Yes	OTHER (SPECIFY) N/A	23. SIGNATURE OF INSPECTOR Chadd Grubbs		

LOCATION SKETCH/COMMENTS

SCALE: NOT TO SCALE

SAMPLE LOCATIONS AS PROPOSED

IN WORKPLAN (SAIC 1997)

ROJECT Ft. Stewart SWMU-1	HOLE NO. SC-M13

ENG FORM 5056-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG		HOLE NUMBER SC-M13
PROJECT Ft. Stewart SWMU-1	INSPECTOR Chad Grubbs	SHEET 2 of 2

ELEV (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO. (E)	ANALYTICAL SAMPLE NO (F)	REMARKS (G)
	1 2	SILTY SAND (SM), fine grained, Dark Reddish Brown, 5YR-3/2.	0.0'- 2.5' 12.3 ppm		011311	
	3 4	CLEAN SAND (SW), fine grained, White, 5YR-8/1.	2.5'- 5.0' 18.0 ppm			
	5 6 7	SANDY CLAY (CL), fine to medium grained, dry, Pinkish Gray, 7.5YR-6/2.	5.0' -7.5' 13.5 ppm		011312	
	8 9	SILTY SAND (SM), fine grained, moist, Light Gray, 10YR-7/2.	7.5'- 10.0' 12.0 ppm			Water Level ~ 7.5' BGS
	10 11	Insufficient Recovery	10.0' - 12.0'	10.0' -12.0' BGS Shelby Tube (Insufficient Recovery)		
	12 13 14	SILTY SAND (SM), fine to medium grained, saturated, Light Gray, 10YR-7/2.	12.0 - 15.0			
	15 16 17 18 19	Bottom of Hole at 15.0 ft BGS.				

HTRW DRILLING LOG	DISTRICT Savannah	HOLE NUMBER SC-M14
1. COMPANY NAME S.A.I.C.	2. DRILL SUBCONTRACTOR Miller Drilling Co.	SHEET 1 OF SHEETS 2

3. PROJECT Ft. Stewart SWMU-1	4. LOCATION Ft. Stewart SWMU-1 (South Central Landfill)
5. NAME OF DRILLER Doug Bishop	6. MANUFACTURERS DESIGNATION OF DRILL CME-550X
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 7-7/8" OD x 5' long, Hollow Stem Augers 4" ID x 5' long, CME Continuous Samplers 3" ID x 2' long, Shelby Tubes	8. HOLE LOCATION See Sketch Below 9. SURFACE ELEVATION 10. DATE STARTED 11/16/97 11. DATE COMPLETED 11/16/97
12. OVERBURDEN THICKNESS N/A	15. DEPTH GROUNDWATER ENCOUNTERED ~1.0 ft BGS
13. DEPTH DRILLED INTO ROCK N/A	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A
14. TOTAL DEPTH OF HOLE 10.0 ft BGS	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A

18. GEOTECHNICAL SAMPLES 1	DISTURBED Ziplock Bag	UNDISTURBED N/A	19. TOTAL NUMBER OF CORE BOXES N/A

20. SAMPLES FOR CHEMICAL ANALYSIS 2	VOC 1	METALS RCRA	OTHER (SPECIFY) SVOC	OTHER (SPECIFY) Pesticides\PCB	OTHER (SPECIFY) Radium	21. TOTAL CORE RECOVERY N/A
22. DISPOSITION OF HOLE Well	BACKFILLED N/A	MONITORING WELL Yes	OTHER (SPECIFY) N/A	23. SIGNATURE OF INSPECTOR Chadd Grubbs		

LOCATION SKETCH/COMMENTS

SCALE: NOT TO SCALE

SAMPLE LOCATIONS AS PROPOSED

IN WORKPLAN (SAIC 1997)

ROJECT Ft. Stewart SWMU-1	HOLE NO. SC-M14

ENG FORM 5056-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG

HOLE NUMBER	SC-M14
PROJECT	Ft. Stewart SWMU-1
INSPECTOR	Chad Grubbs
SHEET	2 of 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO (E)	ANALYTICAL SAMPLE NO (F)	REMARKS (G)
	0–1	SANDY ORGANIC SOIL (OL-OH), med. grained, Black Hydric, Gley (1) 2.5/N.	0.0'- 1.0' 143 ppm		011411	
	1	SILTY SAND (SM), fine grained, saturated, Gray, 7.5YR-6/1.				Water Level ~ 1.0' BGS
	2					
	2.5	SILTY SAND (SM), fine grained, saturated, Brown, 7.5YR-4/3.	2.5'- 5.0' 12.7 ppm			
	3					
	4					
	5		5.0' -6.0' 17.0 ppm	5.0' - 7.5' Ziplock Bag 011413	011412	
	6	SANDY CLAY (CL), firm, fine grained, saturated, Light Greenish Gray, Gley (1) 7/5GY.	6.0' -10.0' 13.3 ppm			
	7					
	8					
	9					
	10	Bottom of Hole at 10.0 ft BGS.				
	11					
	12					
	13					
	14					
	15					
	16					
	17					
	18					
	19					

PROJECT Ft. Stewart SWMU-1 HOLE NO. SC-M14

HTRW DRILLING LOG	DISTRICT Savannah	HOLE NUMBER SC-M15
COMPANY NAME S.A.I.C.	2. DRILL SUBCONTRACTOR Miller Drilling Co.	SHEET 1 OF SHEETS 2

3. PROJECT Ft. Stewart SWMU-1	4. LOCATION Ft. Stewart SWMU-1 (South Central Landfill)
5. NAME OF DRILLER Doug Bishop	6. MANUFACTURERS DESIGNATION OF DRILL CME-550X
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 7-7/8" OD x 5' long, Hollow Stem Augers 4" ID x 5' long, CME Continuous Samplers 3" ID x 2' long, Shelby Tubes	8. HOLE LOCATION See Sketch Below 9. SURFACE ELEVATION 10. DATE STARTED 11/15/97 — 11. DATE COMPLETED 11/15/97
12. OVERBURDEN THICKNESS N/A	15. DEPTH GROUNDWATER ENCOUNTERED ~0.0 ft BGS
13. DEPTH DRILLED INTO ROCK N/A	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A
14. TOTAL DEPTH OF HOLE 16.0 ft BGS	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
1	Ziplock Bag	N/A	N/A

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
2	1	RCRA	SVOC	Pesticides\PCB	Radium	N/A

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Well	N/A	Yes	N/A	Chadd Grubbs

LOCATION SKETCH/COMMENTS SCALE: NOT TO SCALE

SAMPLE LOCATIONS AS PROPOSED

IN WORKPLAN (SAIC 1997)

ROJECT Ft. Stewart SWMU-1	HOLE NO. SC-M15

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG			HOLE NUMBER SC-M15
PROJECT Ft. Stewart SWMU-1	INSPECTOR Chad Grubbs		SHEET 2 of 2

ELEV (A)	DEPTH (ft BGS) (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO. (E)	ANALYTICAL SAMPLE NO (F)	REMARKS (G)
	1	SANDY ORGANIC SOIL (OL-OH), fine grained, roots & organics, silty sand, moist, Brown, 10YR-5/3.	0.0'- 1.5' 12.0 ppm		011511	Water Level ~ 0.0' BGS
	2 3 4	No Recovery.				
	5 6 7	SILTY SAND (SM), fine grained, moist, Light Gray, 10YR-7/2.	5.0' -7.5' 7.0 ppm	5.0' - 7.5' Ziplock Bag 011513	011512	
	8	CLAY (CL), with little fine sand, dry, Gley (1) 5/10GY.	7.5' - 10.0' 5.5 ppm			Impermeable layer, no significant water above the clay.
	9	CLAY (CL), with fine sand, dry, Gley (1) 5/10GY.				
	10 11 12 13 14 15	CLAY (CL), with fine sand, wet, Gley (1) 5/10GY.	10.0' - 12.5' 5.0 ppm 12.5' - 15.0' 5.0 ppm			
	16 17 18 19	Bottom of Hole at 16.0 ft BGS.				

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HTRW DRILLING LOG	DISTRICT Savannah	HOLE NUMBER SC-M16
1. COMPANY NAME S.A.I.C.	2. DRILL SUBCONTRACTOR Miller Drilling Co.	SHEET 1 OF SHEETS 2

3. PROJECT Ft. Stewart SWMU-1	4. LOCATION Ft. Stewart SWMU-1 (South Central Landfill)
5. NAME OF DRILLER Doug Bishop	6. MANUFACTURERS DESIGNATION OF DRILL CME-550X
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 7-7/8" OD x 5' long, Hollow Stem Augers 4" ID x 5' long, CME Continuous Samplers 3" ID x 2' long, Shelby Tubes	8. HOLE LOCATION See Sketch Below 9. SURFACE ELEVATION 10. DATE STARTED 11/15/97 — 11. DATE COMPLETED 11/15/97
12. OVERBURDEN THICKNESS N/A	15. DEPTH GROUNDWATER ENCOUNTERED ~1.0 ft BGS
13. DEPTH DRILLED INTO ROCK N/A	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A
14. TOTAL DEPTH OF HOLE 11.0 ft BGS	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
1	Ziplock Bag	N/A	N/A

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
2	1	RCRA	SVOC	Pesticides\PCB	Radium	N/A

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Well	N/A	Yes	N/A	Chadd Grubbs

LOCATION SKETCH/COMMENTS SCALE: NOT TO SCALE

SAMPLE LOCATIONS AS PROPOSED

IN WORKPLAN (SAIC 1997)

ROJECT Ft. Stewart SWMU-1	HOLE NO. SC-M16

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG		HOLE NUMBER SC-M16
PROJECT Ft. Stewart SWMU-1	INSPECTOR Chad Grubbs	SHEET 2 of 2

ELEV (A)	DEPTH (ft BGS) (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO. (E)	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		SILTY SAND (SM), fine grained, organics, Brown, 10YR-5/3.	0.0'- 2.5' 15.0 ppm		011611	
	1					Water Level ~ 1.0' BGS
	2				011612	
	3	SILTY SAND (SM), fine to medium grained, Black, Gley (1) 2.5/N.	2.5'- 5.0' 5.0 ppm			
	4					
	5	SILTY SAND (SM), fine grained, Light Gray, 10YR-7/2.	5.0' -7.5' 12.0 ppm			
	6					
	7					
	8		7.5' - 10.0' 16 ppm	7.5' - 10.0' Ziplock Bag 011613		
	9					
	10					
	11					
	12					
	13	Bottom of Hole at 16.0 ft BGS.				
	14					
	15					
	16					
	17					
	18					
	19					

HTRW DRILLING LOG

DISTRICT Savannah

HOLE NUMBER SC-M17

1. COMPANY NAME S.A.I.C.	2. DRILL SUBCONTRACTOR Miller Drilling Co.	SHEET 1 OF SHEETS 2

3. PROJECT Ft. Stewart SWMU-1	4. LOCATION Ft. Stewart SWMU-1 (South Central Landfill)
5. NAME OF DRILLER Allen Gonsuron	6. MANUFACTURERS DESIGNATION OF DRILL Ingersol Rand A-300
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 7-7/8" OD x 5' long, Hollow Stem Augers 4" ID x 5' long, CME Continuous Samplers 3" ID x 2' long, Shelby Tubes	8. HOLE LOCATION See Sketch Below 9. SURFACE ELEVATION 10. DATE STARTED 11/16/97 — 11. DATE COMPLETED 11/16/97
12. OVERBURDEN THICKNESS N/A	15. DEPTH GROUNDWATER ENCOUNTERED ~8.0 ft BGS
13. DEPTH DRILLED INTO ROCK N/A	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A
14. TOTAL DEPTH OF HOLE 15.0 ft BGS	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
1	Ziplock Bag	N/A	N/A

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
2	1	RCRA	SVOC	Pesticides/PCB	Radium	N/A

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Well	N/A	Yes	N/A	Laura Lumley

LOCATION SKETCH/COMMENTS

SCALE: NOT TO SCALE

SAMPLE LOCATIONS AS PROPOSED

IN WORKPLAN (SAIC 1997)

PROJECT Ft. Stewart SWMU-1	HOLE NO. SC-M17

HTRW DRILLING LOG

HOLE NUMBER SC-M17

PROJECT Ft. Stewart SWMU-1

INSPECTOR Laura Lumley

SHEET 2 of 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO. (E)	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		SAND, fine to medium grained, Reddish Brown, 5YR-4/4.	0.0'- 2.5' 0.0 ppm		011711	
	1				Equipment Rinsate 012741	
	2	Brown, 5YR-4/3 with Light Gray and Reddish Brown.				
	3		2.5'- 5.0' 0.0 ppm			
	4	Dark Brown, 7.5YR-3/2				
	5	SILTY SAND, Light Brown, 7.5YR-6/3.	5.0' -7.5' 0.0 ppm		011712	
	6					
	7					
	8		7.5'- 10.0' 0.0 ppm			Water Level ~ 8.0' BGS
	9					
	10	SILTY SAND, Light Gray, 10YR-7/2.	10.0 - 12.5 0.0 ppm	10' -12.5' Ziplock Bag 011713		
	11					
	12					
	13	Insufficient Recovery				
	14					
	15	Bottom of Hole at 15.0 ft BGS.				
	16					
	17					
	18					
	19					

HTRW DRILLING LOG	DISTRICT Savannah	HOLE NUMBER SC-M18
1. COMPANY NAME S.A.I.C.	2. DRILL SUBCONTRACTOR Miller Drilling Co.	SHEET 1 OF 2 SHEETS

3. PROJECT Ft. Stewart SWMU-1	4. LOCATION Ft. Stewart SWMU-1 (South Central Landfill)
5. NAME OF DRILLER Allen Gonsuron	6. MANUFACTURERS DESIGNATION OF DRILL Ingersol Rand A-300
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 7-7/8" OD x 5' long, Hollow Stem Augers 4" ID x 5' long, CME Continuous Samplers 3" ID x 2' long, Shelby Tubes	8. HOLE LOCATION See Sketch Below 9. SURFACE ELEVATION 10. DATE STARTED 11/15/97 — 11. DATE COMPLETED 11/15/97
12. OVERBURDEN THICKNESS N/A	15. DEPTH GROUNDWATER ENCOUNTERED ~2.5 ft BGS
13. DEPTH DRILLED INTO ROCK N/A	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A
14. TOTAL DEPTH OF HOLE 15.0 ft BGS	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
1	Ziplock Bag	N/A	N/A

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
2	1	RCRA	SVOC	Pesticides/PCB	Radium	N/A

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Well	N/A	Yes	N/A	Laura Lumley

LOCATION SKETCH/COMMENTS

SCALE: NOT TO SCALE

SAMPLE LOCATIONS AS PROPOSED

IN WORKPLAN (SAIC 1997)

ROJECT Ft. Stewart SWMU-1	HOLE NO. SC-M18

ENG FORM 5056-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG		HOLE NUMBER SC-M18
PROJECT Ft. Stewart SWMU-1	INSPECTOR Laura Lumley	SHEET 2 of 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO. (E)	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		SAND, fine to medium grained, Very Dark Gray, 10YR-3/1, Light Olive Gray, 5Y-6/2.	0.0'- 2.0' 0.0 ppm		011811	
	1				Equipment Rinsate 012841	
	2	No Recovery				Water Level ~ 2.5' BGS
	3					
	4					
	5	SAND with Clay, Reddish Yellow, 7.5YR-6/8.	5.0' -7.5' 0.0 ppm		011812	
	6	Light Gray, 5Y-7/1.				
	7					
		SANDY CLAY	7.5'- 10.0' 0.0 ppm	7.5' - 10.0' Ziplock Bag 011813		
	8					
	9	CLAYEY SAND, Light Gray, 5Y-7/2.				
	10	SAND, medium grained, saturated, Light Gray, 5Y-7/2.	10.0' - 12.5' 0.0 ppm			
	11					
	12					
	13					
	14					
	15	Bottom of Hole at 15.0 ft BGS.				
	16					
	17					
	18					
	19					

HTRW DRILLING LOG	DISTRICT Savannah	HOLE NUMBER SC-M19
1. COMPANY NAME S.A.I.C.	2. DRILL SUBCONTRACTOR Miller Drilling Co.	SHEET 1 OF SHEETS 2

3. PROJECT Ft. Stewart SWMU-1	4. LOCATION Ft. Stewart SWMU-1 (South Central Landfill)
5. NAME OF DRILLER Allen Gonsuron	6. MANUFACTURERS DESIGNATION OF DRILL Ingersol Rand A-300
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 7-7/8" OD x 5' long, Hollow Stem Augers 4" ID x 5' long, CME Continuous Samplers 3" ID x 2' long, Shelby Tubes	8. HOLE LOCATION See Sketch Below 9. SURFACE ELEVATION 10. DATE STARTED 11/16/97 — 11. DATE COMPLETED 11/16/97
12. OVERBURDEN THICKNESS N/A	15. DEPTH GROUNDWATER ENCOUNTERED ~7.5 ft BGS
13. DEPTH DRILLED INTO ROCK N/A	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED N/A
14. TOTAL DEPTH OF HOLE 15.0 ft BGS	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) N/A

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
1	Ziplock Bag	N/A	N/A

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
2	1	RCRA	SVOC	Pesticides/PCB	Radium	N/A

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Well	N/A	Yes	N/A	Laura Lumley

LOCATION SKETCH/COMMENTS SCALE: NOT TO SCALE

SAMPLE LOCATIONS AS PROPOSED

IN WORKPLAN (SAIC 1997)

PROJECT Ft. Stewart SWMU-1	HOLE NO. SC-M19

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EG)

HTRW DRILLING LOG			HOLE NUMBER SC-M19
PROJECT Ft. Stewart SWMU-1	INSPECTOR Laura Lumley		SHEET 2 of 2

ELEV. (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO. (E)	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
	0	SILTY SAND, Black, 10YR-2/1.	0.0'- 2.5' 0.1 ppm		011911	
	1					
	2	Fine to medium grained, Pale Yellow, 2.5Y-8/2.				
	2.5		2.5' - 5.0' 0.4 ppm			
	3					
	4					
	5	SAND, fine to medium grained, Dark Brown, 7.5YR-3/2.	5.0' -7.5' 0.6 ppm		011912	
	6					
	7	SILTY SAND, Black, 10YR-2/1.				Water Level ~ 7.5' BGS
	7.5		7.5'- 10.0' 0.0 ppm	7.5' - 10.0' Ziplock Bag 011913		
	8					
	9					
	10	SANDY CLAY, Very Dark Grayish Brown, 10YR-3/2.	10.0' - 12.5' 0.0 ppm			
	11	CLAY, Grayish Brown, 10YR-5/2.				
	12					
	12.5		12.5' - 15.0' 0.0 ppm			
	13					
	14	SAND, fine to medium grained, Grayish Brown, 10YR-5/2.				
	15	Bottom of Hole at 15.0 ft BGS.				
	16					
	17					
	18					
	19					

HTRW DRILLING LOG	1. DISTRICT Savannah	HOLE NUMBER GP-1
1. COMPANY NAME SAIC	2. DRILL SUBCONTRACTOR Fugro/Miller	SHEET SHEETS

3. PROJECT Ft Stewart SWMU-1	4. LOCATION SWMU-1 Ft Stewart, GA inside old landFill
5. NAME OF DRILLER S. Morales / B. McGorty	6. MANUFACTURER'S DESIGNATION OF DRILL
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 4' unsplit sample barrel 1.5" shoe	8. HOLE LOCATION SWMU-1 inside old landFill
	9. SURFACE ELEVATION
	10. DATE STARTED 11/6/97 / 11. DATE COMPLETED 11/6/97
12. OVERBURDEN THICKNESS	15. DEPTH GROUNDWATER ENCOUNTERED
13. DEPTH DRILLED INTO ROCK NA	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED NA
14. TOTAL DEPTH OF HOLE	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

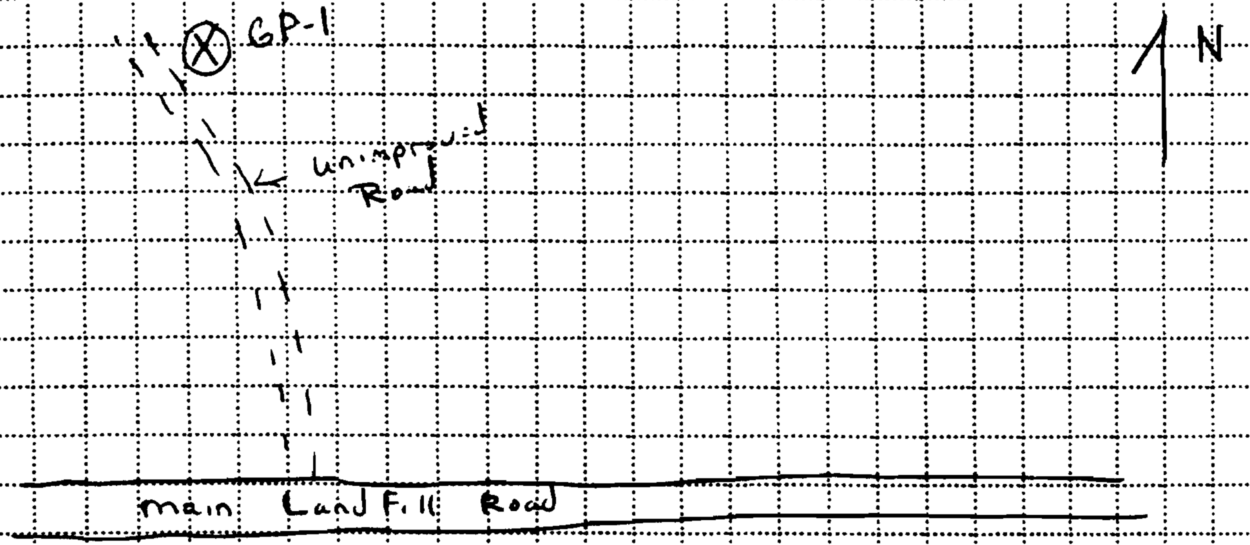
18. GEOTECHNICAL SAMPLES NA	DISTURBED NA	UNDISTURBED NA	19. TOTAL NUMBER OF CORE BOXES NA

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
				Collen Day

LOCATION SKETCH/COMMENTS

SCALE: 1" = 165'



(Signature and Date)

etc.)

PROJECT Ft Stewart SWMU-1	HOLE NO. GP-1

ENG FORM 5056-R, AUG 94

(Proponent: CECW-EG)

HTRW DRILLING LOG

GP-1

Ft Stewart SWMU-1

INSPECTOR Collin Day

SHEET

			FIELD SCREENING RESULTS			REMARKS
		0 - 0.2 Dark Brown				
	1.0	Sandy clay SC top soil w/ abundant roots Dry	BZ=0ppm HS= 36.7ppm	NA		
	2	0.2-4 SC Gray				
	3	(10YR 7/1) Sandy Clay dry and poorly Sorted qtz sand.	HS= 47.31ppm	NA		
	4	4-8 SC Sandy	61.21ppm ~~No Return~~ CO 11/6/97		Enviro Samples 011151 011161 1402hrs	No return CO 11/6/97 ~~8-6' interval~~ 6-8' interval
	5	Clay gray (10YR 7/1) Wet at 5' bgl.		NA		
	6		~~HS= 61.21ppm~~ CO 11/6/97 No Return			
	7			NA		
	8					
	9					
	10					
	11					
	12					
	13					

PROJECT Ft S

HOLE NO. GP-1

33

227

HTRW DRILLING LOG

DISTRICT: Savannah		HOLE NUMBER: GP-2
1. COMPANY NAME: SAIC	2. DRILL SUBCONTRACTOR: Miller	SHEET 1 of 2 SHEETS

3. PROJECT: Ft Stewert SWMU-1	4. LOCATION: Ft Stewert
5. NAME OF DRILLER: HAZ Hutoon / Don Jerome	6. MANUFACTURERS DESIGNATION OF DRILL: Deidrich D-25
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:	8. HOLE LOCATION: ~~SMU-1~~ SWMU-1 inside LandFill
	9. SURFACE ELEVATION:
	10. DATE STARTED: 11/7/97 11. DATE COMPLETED: 11/7/97
12. OVERBURDEN THICKNESS:	15. DEPTH GROUNDWATER ENCOUNTERED:
13. DEPTH DRILLED INTO ROCK: NA	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:
14. TOTAL DEPTH OF HOLE:	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

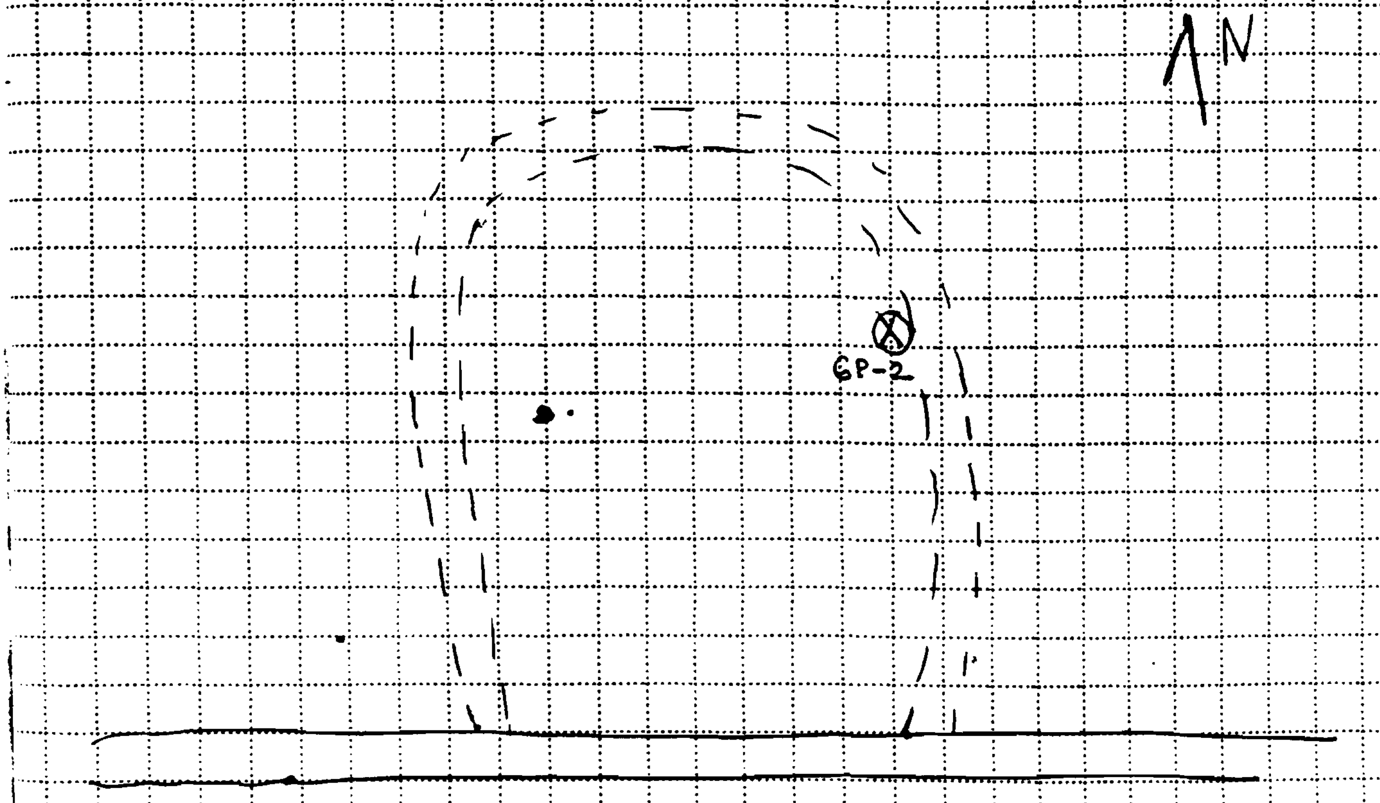
18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
NA	NA	NA	NA

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Temporary Piezometer				

LOCATION SKETCH/COMMENTS

SCALE: 1" = 1000'



PROJECT: Ft Stewert SWMU-1	HOLE NO. GP-2

ENG FORM 5056-R, AUG 94 (Proponent CECW-EG)

well atmosphere, soil core, breathing zone, venting compresso
etc.)

QA CHECK BY: ____________ (Signature and Date)

HTRW DRILLING LOG GP-2 40

PROJECT Ft Stewart SWMU-1	INSPECTOR Collin Day		SHEET

ELEV.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX NO.	ANALYTICAL SAMPLE NO.	REMARKS
	1	0-4 SC gray brown (10YR 7/2) sandy clay dry	BZ=0ppm 0920 Hrs HS= 2.5ppm	NA		
	2 3 4	4-8 SP Yellow brown qtz sand very ~~wet~~ moist CD 11/7/97 from 5 ft and saturated 6 ft.	~~HS=2.5ppm~~ CD 11/7/97			Driller contacts water approx 6 ft Set piezometer from 7-12 ft for screening samples
	5 6 7 8 9 10 11				No soil samples collected	
	12					TD = 12 Ft

3

229

HTRW DRILLING LOG

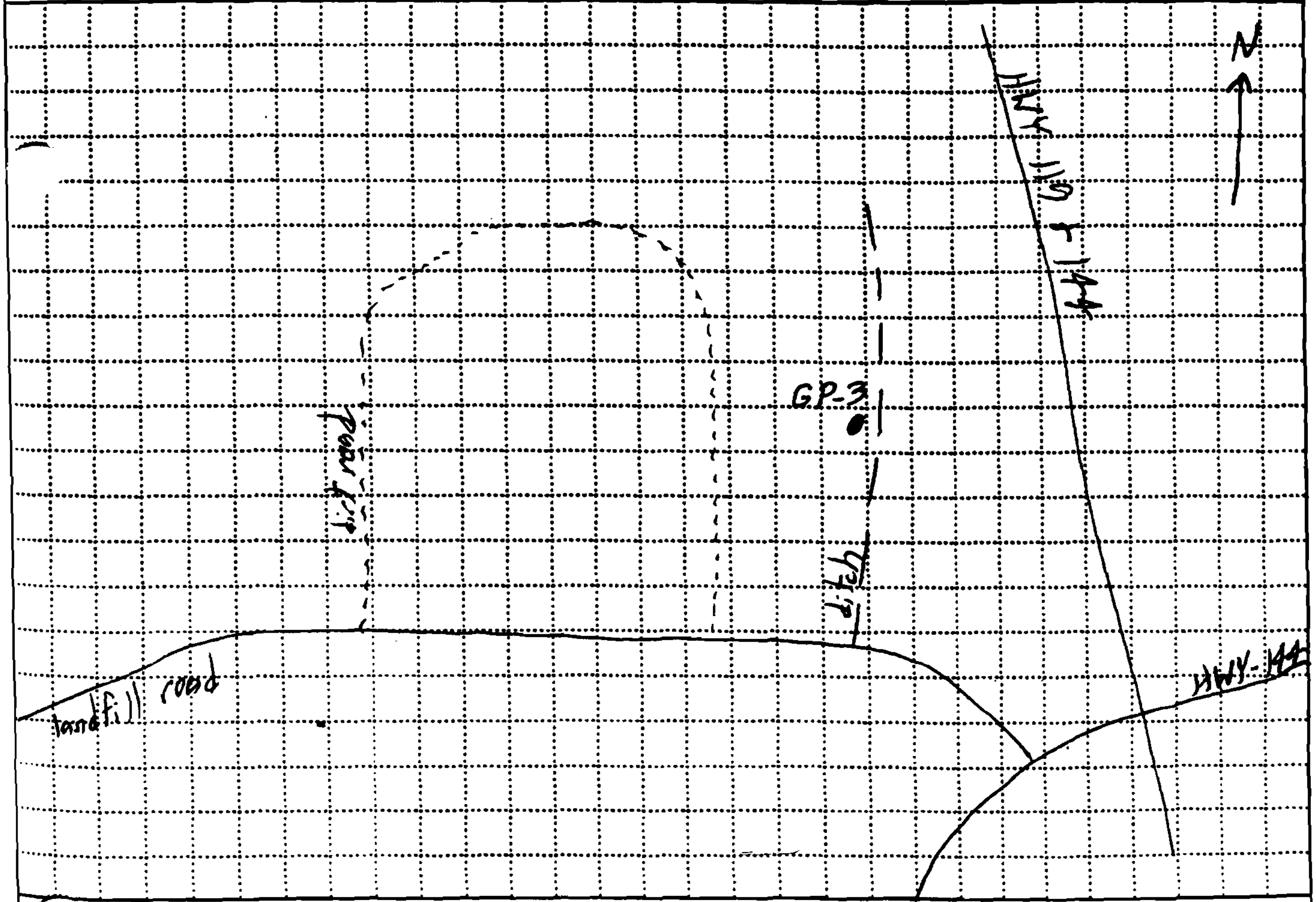
HTRW DRILLING LOG	DISTRICT Savannah	HOLE NUMBER GP-3
1. COMPANY NAME SAIC	2. DRILL SUBCONTRACTOR Miller	SHEET 1 of 2 SHEETS

PROJECT Ft. Stewart SWMU-1	4. LOCATION Ft. Stewart, GA
AME OF DRILLER H. Hutson	6. MANUFACTURERS DESIGNATION OF DRILL Deidrich D-25
SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8. HOLE LOCATION
	9. SURFACE ELEVATION
	10. DATE STARTED 11-7-97 / 11. DATE COMPLETED 11-7-97
12. OVERBURDEN THICKNESS	15. DEPTH GROUNDWATER ENCOUNTERED
13. DEPTH DRILLED INTO ROCK NA	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED
14. TOTAL DEPTH OF HOLE 13 Ft	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES NA	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR		
			Piezometer			

LOCATION SKETCH/COMMENTS SCALE: NTS



ECT Ft. Stewart SWMU-1	HOLE NO. GP-3

ENG FORM 5056-R, AUG 94 (Proponent CECW-EG)

4

HTRW DRILLING LOG

GP-3

PROJECT Ft. Stewart SWMU-1

INSPECTOR

SHEET 2 of 2

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	REMARKS (g)
		Insufficient recovery for lithologic description, only samples collected.				
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13	Bottom of hole 13.0'				

PROJECT Ft. Stewart SWMU-1

HOLE NO GP-3

21

231

HTRW DRILLING LOG

DISTRICT: Savannah

HOLE NUMBER: GP-4

1. COMPANY NAME: SAIC

2. DRILL SUBCONTRACTOR: Miller

SHEET 1 OF 2 SHEETS

PROJECT: Ft. Stewart SWMU-1

4. LOCATION: Ft. Stewart, GA

AME OF DRILLER: H. Hutoon

6. MANUFACTURERS DESIGNATION OF DRILL: Deidrich D-25

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:

8. HOLE LOCATION:

9. SURFACE ELEVATION:

10. DATE STARTED: 11-7-97

11. DATE COMPLETED: 11-7-97

12. OVERBURDEN THICKNESS:

15. DEPTH GROUNDWATER ENCOUNTERED:

13. DEPTH DRILLED INTO ROCK: NA

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:

14. TOTAL DEPTH OF HOLE: 6 Ft.

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18. GEOTECHNICAL SAMPLES NA	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
			Piezometer	

LOCATION SKETCH/COMMENTS See sketch page 3

SCALE:

JECT: Ft. Stewart SWMU-1

HOLE NO. GP-4

HTRW DRILLING LOG

PROJECT Ft. Stewart SWMU-1	INSPECTOR	SHEET 2 of 2	GP-4

ELEV (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO. (E)	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
		Did not collect soil				
	1	samples due to				
		saturation of soil				
	2	caused by high water				
	3	table.				
	4					
	5					
	6	Bottom of Hole 6.0'				

PROJECT Ft. Stewart SWMU-1

HOLE NO GP-4

3

2

233

HTRW DRILLING LOG

DISTRICT: Savannah

HOLE NUMBER: GP-5

1. COMPANY NAME: SAIC

2. DRILL SUBCONTRACTOR: Miller

SHEET 1 of 2 SHEETS

3. PROJECT: Ft Stewert SWMU-1

4. LOCATION: Ft Stewert, GA

5. NAME OF DRILLER: Haz Hutoon

6. MANUFACTURERS DESIGNATION OF DRILL: Diedrich D-25

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:

8. HOLE LOCATION: SWMU-1

9. SURFACE ELEVATION:

10. DATE STARTED: 11/7/97

11. DATE COMPLETED: 11/7/97

12. OVERBURDEN THICKNESS: > 12 Ft

13. DEPTH DRILLED INTO ROCK: NA

14. TOTAL DEPTH OF HOLE: 12 Ft

15. DEPTH GROUNDWATER ENCOUNTERED:

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

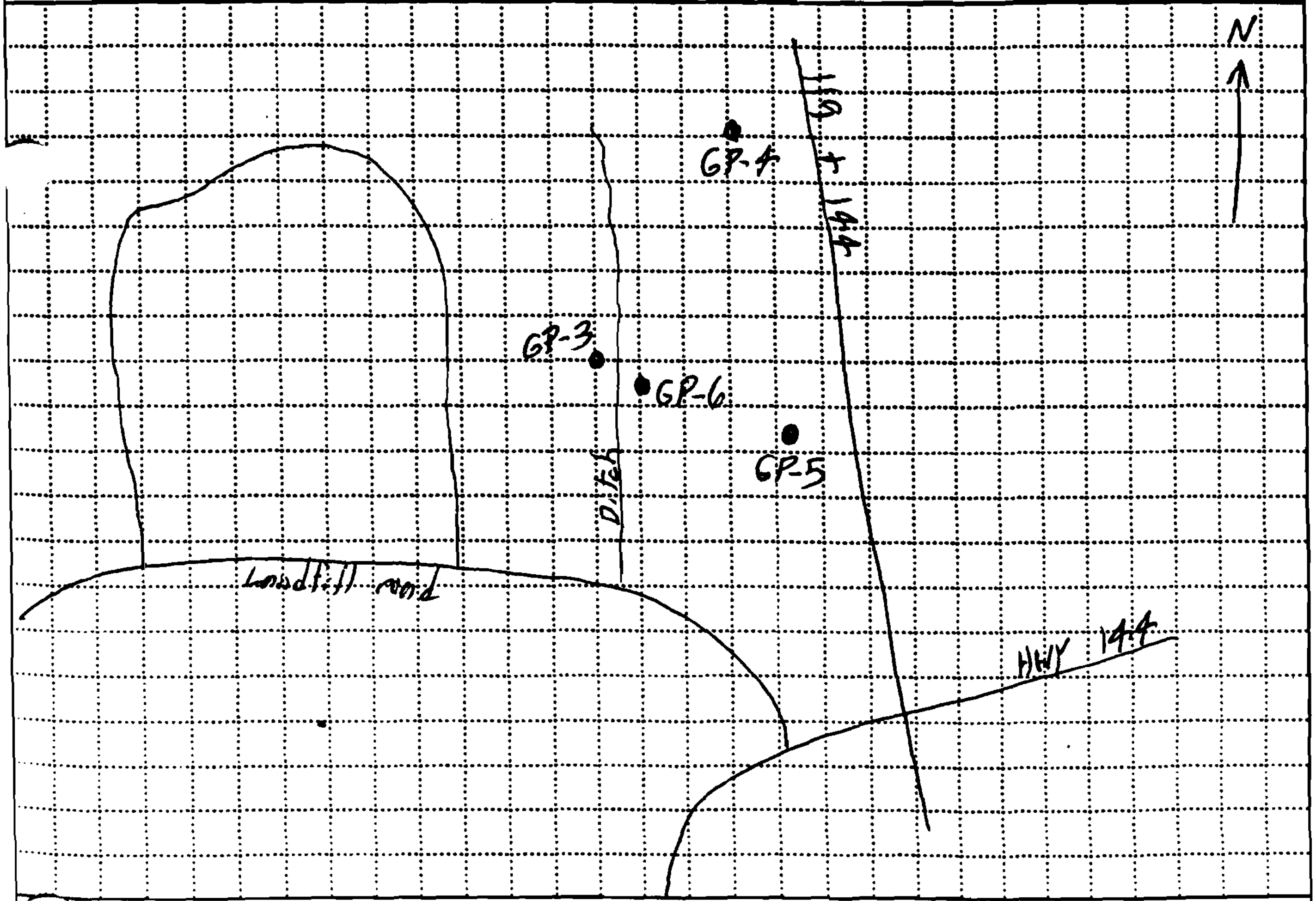
18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
NA			

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Convert to Piezometer			Piezometer	Collen Day

LOCATION SKETCH/COMMENTS

SCALE: NTS



PROJECT: Ft Stewert SWMU-1

HOLE NO. GP-5

ENG FORM 5056-R, AUG 94

(Proponent CECW-EG)

HTRW DRILLING LOG

PROJECT SWMU-1	INSPECTOR -	SHEET 2 of 2	GP-5

ELEV (ft)	DEPTH (ft)	DESCRIPTION OF MATERIALS	FIELD SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX NO.	ANALYTICAL SAMPLE NO.	REMARKS
	1	Insufficient recovery for lithologic description, samples only.				
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12	Bottom of Hole 12.0'				

12

235

HTRW DRILLING LOG

DISTRICT: Savannah

HOLE NUMBER: GP-6

1. COMPANY NAME: SAIC

2. DRILL SUBCONTRACTOR: Miller

SHEET 1 of 2 SHEETS

3. PROJECT: Ft. Stewart SWMU-1

4. LOCATION: Ft. Stewart, GA

AME OF DRILLER:

6. MANUFACTURERS DESIGNATION OF DRILL: Deidcich D-25

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT:

8. HOLE LOCATION:

9. SURFACE ELEVATION:

10. DATE STARTED: 11-7-97

11. DATE COMPLETED: 11-7-97

12. OVERBURDEN THICKNESS:

15. DEPTH GROUNDWATER ENCOUNTERED:

13. DEPTH DRILLED INTO ROCK: NA

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:

14. TOTAL DEPTH OF HOLE: 13 Ft.

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
NA			

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
			Piezometer	

LOCATION SKETCH/COMMENTS See Sketch page 3

SCALE:

ECT: Ft. Stewart SWMU-1

HOLE NO. GP-6

ENG FORM 5056-R, AUG 94

(Proponent CECW-EG)

HTRW DRILLING LOG

GP-6

PROJECT Ft. Stewart SWMU-1	INSPECTOR	SHEET 2 of 2

ELEV (A)	DEPTH (B)	DESCRIPTION OF MATERIALS (C)	FIELD SCREENING RESULTS (D)	GEOTECH SAMPLE OR CORE BOX NO. (E)	ANALYTICAL SAMPLE NO. (F)	REMARKS (G)
	1 2 3 4 5 6 7 8 9 10 11 12	Insufficient recovery for lithologic description, only samples were collected,				
	13	Bottom of Hole 13.0′				

PROJECT Ft. Stewart SWMU-1

HOLE NO GP-6

Savannah

HOLE NUMBER GP 7

SHEET / SHEETS

1. COMPANY NAME: SAIC ~~Savannah District~~ CD 11/5/97

2. DRILL SUBCONTRACTOR: Fugro

3. PROJECT: Ft Stewart South Central LandFill Phase II

4. LOCATION: Ft Stewart SWMU-1 Inside LF boundary

5. NAME OF DRILLER: Bill McGarty / Sal Morales

6. MANUFACTURERS DESIGNATION OF DRILL:

7. SIZES AND TYPES OF DRILLING & SAMPLING EQUIPMENT: 4 Ft barrel Sampler

Unsplit 1.5 in Shoe

Flush threaded split barrel sampler

8. HOLE LOCATION: GP-7

9. SURFACE ELEVATION:

10. DATE STARTED: 11/5/97

11. DATE COMPLETED: 11/5/97

12. OVERBURDEN THICKNESS: 7

13. DEPTH DRILLED INTO ROCK:

14. TOTAL DEPTH OF HOLE:

15. DEPTH GROUNDWATER ENCOUNTERED:

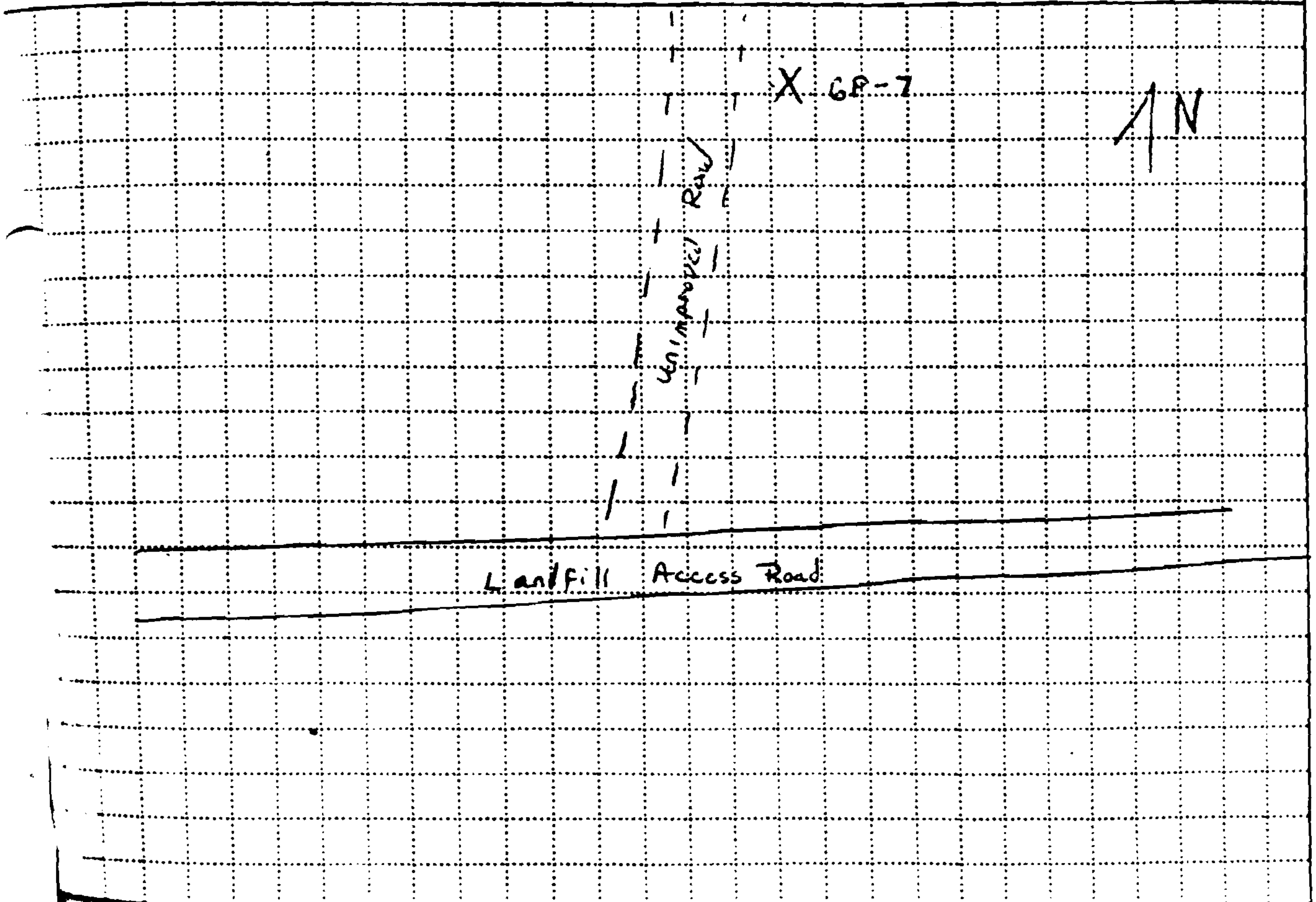
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
NA	NA					
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR		
				Collin Day		

LOCATION SKETCH/COMMENTS

SCALE:



PROJECT: Ft Stewart South Central LandFill

HOLE NO. GP-7

FORM 5056-R, AUG 94

(Proponent CECW-EG)

237

GP 7

SHEET 2 of 2

Wallin Dey

	[illegible]	FIELD SCREENING RESULTS	[illegible]	ANALYTICAL SAMPLE NO.	REMARKS
1 2	0-0.8 SM gray (10YR 5/1) silty sand top soil, very moist, subangular qtz grains, low plasticity	HS: ~~1??ppm~~ 118.5ppm CO 11/5/97	NA	Enviro Sample 011751 1550 hrs	
3 4	0.8-2 SC gray (2.5Y 5/1) sandy Clay, medium plasticity very moist w/. moisture increasing with depth.	10:2.5ppm BZ=0ppm		NA	
5 6 7 8	2-4 No return 4-8 SC gray (2.5Y 6/1) sandy clay as moisture increases from previous interval to saturated Clay percentage increases for ~~8-9~~ CO 11/5/97 7-8'.	HS=2.8ppm BZ=0ppm	NA	NA	
9 10 11 12	8-12 No return			NA	TD = 12 Ft
13 14 15 16 17					

PROJECT Ft. Stewart South Central LF

HOLE NO GP-7

30

239

DRILLING LOG

DISTRICT: Savannah

HOLE NUMBER: GP-8

1. COMPANY NAME: SAIC

2. DRILL SUBCONTRACTOR: Fugro/Miller

SHEET 1 of 2 SHEETS

3. PROJECT:

4. LOCATION: Ft Stewart, GA

5. NAME OF DRILLER:

6. MANUFACTURERS DESIGNATION OF DRILL: A.

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4' Sampling Barrel
Unsplit with 1.5" Shoe
All materials Carbon steel
Press - pneumatic

8. HOLE LOCATION: GP-8 SWMU 1

9. SURFACE ELEVATION:

10. DATE STARTED: 11/6/97

11. DATE COMPLETED: 11/6/97

12. OVERBURDEN THICKNESS: >12 Ft

13. DEPTH GROUNDWATER ENCOUNTERED:

15. DEPTH DRILLED INTO ROCK: NA

14. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:

16. TOTAL DEPTH OF HOLE: 12 Ft

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): NA

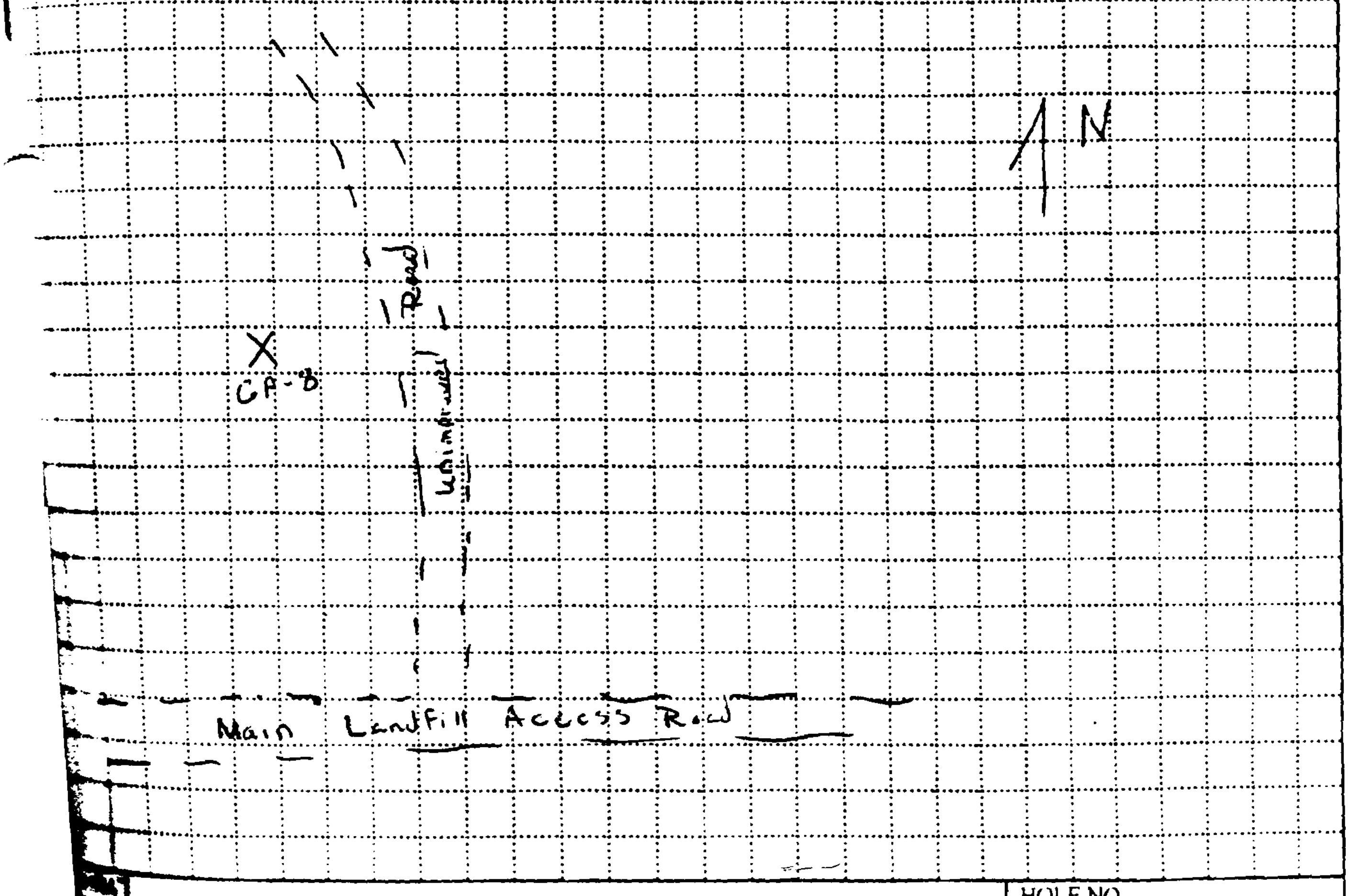
18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
NA	NA	NA	NA

20. SAMPLES FOR CHEMICAL ANALYSIS Envi-	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
311851	2(1)					95

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
Temp Piezometer				Collin Day

LOCATION SKETCH/COMMENTS

SCALE: Not to Scale



PROJECT: Savannah

HOLE NO. GP-8

ENG FORM 5056-R, AUG 94

(Proponent CECW-EG)

Callin Day

SHEET 2 of 2

ELEV.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX NO.	ANALYTICAL SAMPLE NO.	REMARKS
	0 1 2 3	0-0.2 SC Dark gray (10YR 5/1) sandy clay w/ organic matter 0.2-4 SM Gray-brown 10YR 5/2 Silty sand, Poorly Sorted, subangular qtz grains Dry.	~~0845~~ 0836 hrs CD 11/6/97 BZ=0ppm HS=25.5ppm ~~0845~~ 11/6/97 0836 HS=24.72	NA	~~0348 hrs~~ CD 11/6/97	Recover 3.7'
	4 5 6 7	4-8 Lithology Same as above wet From 4.5 Feet	~~0852~~ 0840 CD 11/6/97 BZ=0ppm HS=~~26.8~~ 11/6/97 26.01 ppm NA	NA	Enviro Sample 011851 0840 hrs	Recover 3.8 Driller contacts water 4.5 Ft bgl Piezometer installed screened 7'-12'
	8 9 10 11 12	8-12 Tan (10YR 6/2) SM/SP very poorly Sorted qtz sand w/ Some Clay and Silt Subangular to Subround grains. Wet	NA	NA		Recover 4'

PROJECT Ft Stewart SWMU-1

HOLE NO. GP-8

DRILLING LOG

Savannah

HOLE NUMBER: GP-9

SHEET 1 of 1 SHEETS

241

1. COMPANY NAME: SAIC

2. DRILL SUBCONTRACTOR:

3. PROJECT: Ft Stewart South Central LandFill

4. LOCATION: Ft Stewart

5. NAME OF DRILLER: Bill McGurty / Sal Morales

6. MANUFACTURERS DESIGNATION OF DRILL: A P Vanderburg

Inside LF boundary South Central LF

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4 Ft barrel sampler unsplit 1.5 in shoe Flush threaded unsplit barrel sampler - All materials carbon steel

8. HOLE LOCATION: GP - 9

9. SURFACE ELEVATION:

10. DATE STARTED: 11/5/97

11. DATE COMPLETED: 11/5/97

12. OVERBURDEN THICKNESS: > 8 Ft

15. DEPTH GROUNDWATER ENCOUNTERED: 0.5 Ft bgl

13. DEPTH DRILLED INTO ROCK: NA

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:

14. TOTAL DEPTH OF HOLE: 8 Ft

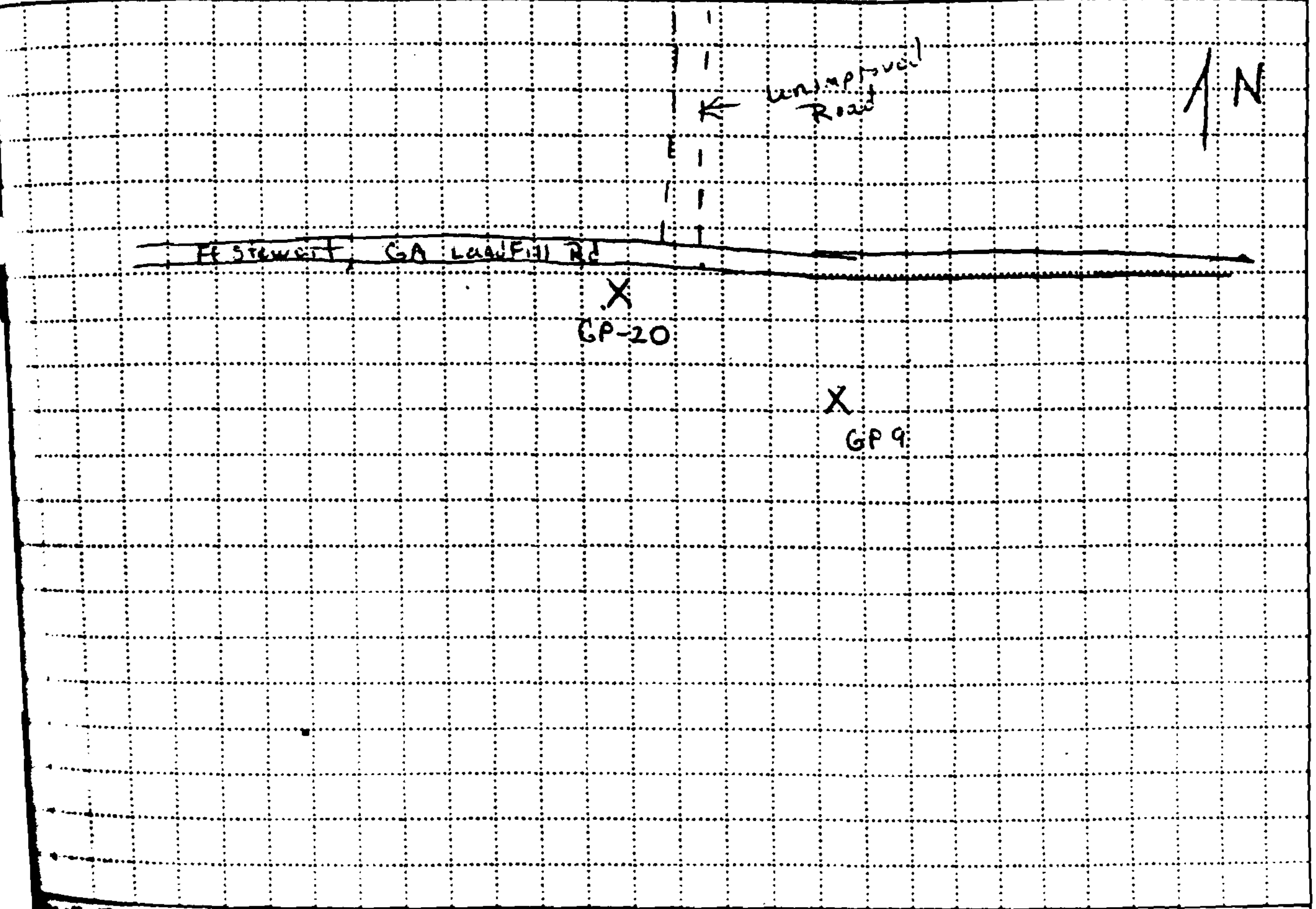
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
NA	NA	NA	

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
Enviro 012951	(2)					50

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
converted to temporary piezometer				Collin Day

LOCATION SKETCH/COMMENTS SCALE: 1" = 100'



PROJECT: Ft Stewart South Central LandFill

HOLE NO. GP-9

Collin Day | SHEET 2 of 2

DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREENING RESULTS	GEOTECH SAMPLE	ANALYTICAL SAMPLE	REMARKS
1 2	0 - 1 Brown (7.5YR 3/2) organic rich soil SC w/ roots and plant fragments (humus). Dry to moist	BZ= 0ppm CS = 0ppm HS = 3.5ppm	NA		Driller contacted water at approx 0.5 Ft below ground surface.
3 4	1 - 4 SC grey (10YR 7/1) Sandy clay, low plasticity angular to sub angular qtz grains, poorly sorted and wet.			Enviro Sample 01195i 1425 hrs	Install piezometer screened 3 - 8'
5 6 7 8	4 - 8 Lithology same as for previous interval wet				TD = 8 Ft
9 10 11 12 13 14 15 16 17 18 19 20					

PROJECT Ft Stewert South Central LandFill Inside LandFill Boundary

HOLE NO. GP-9

243

HTRW DRILLING LOG

DISTRICT

HOLE NUMBER

1. COMPANY NAME: SAIC

2. DRILL SUBCONTRACTOR: Miller

SHEET SHEETS

3. PROJECT: Ft. Stewart

4. LOCATION:

5. NAME OF DRILLER: Allen

6. MANUFACTURER'S DESIGNATION OF DRILL: Ingersoll-Rand A-300

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 2.25" Auger

8. HOLE LOCATION: GP-10

9. SURFACE ELEVATION:

10. DATE STARTED: 11/7/97

11. DATE COMPLETED: 11/7/97

12. OVERBURDEN THICKNESS: 9'

13. DEPTH DRILLED INTO ROCK:

14. TOTAL DEPTH OF HOLE: 9'

15. DEPTH GROUNDWATER ENCOUNTERED: 5'

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

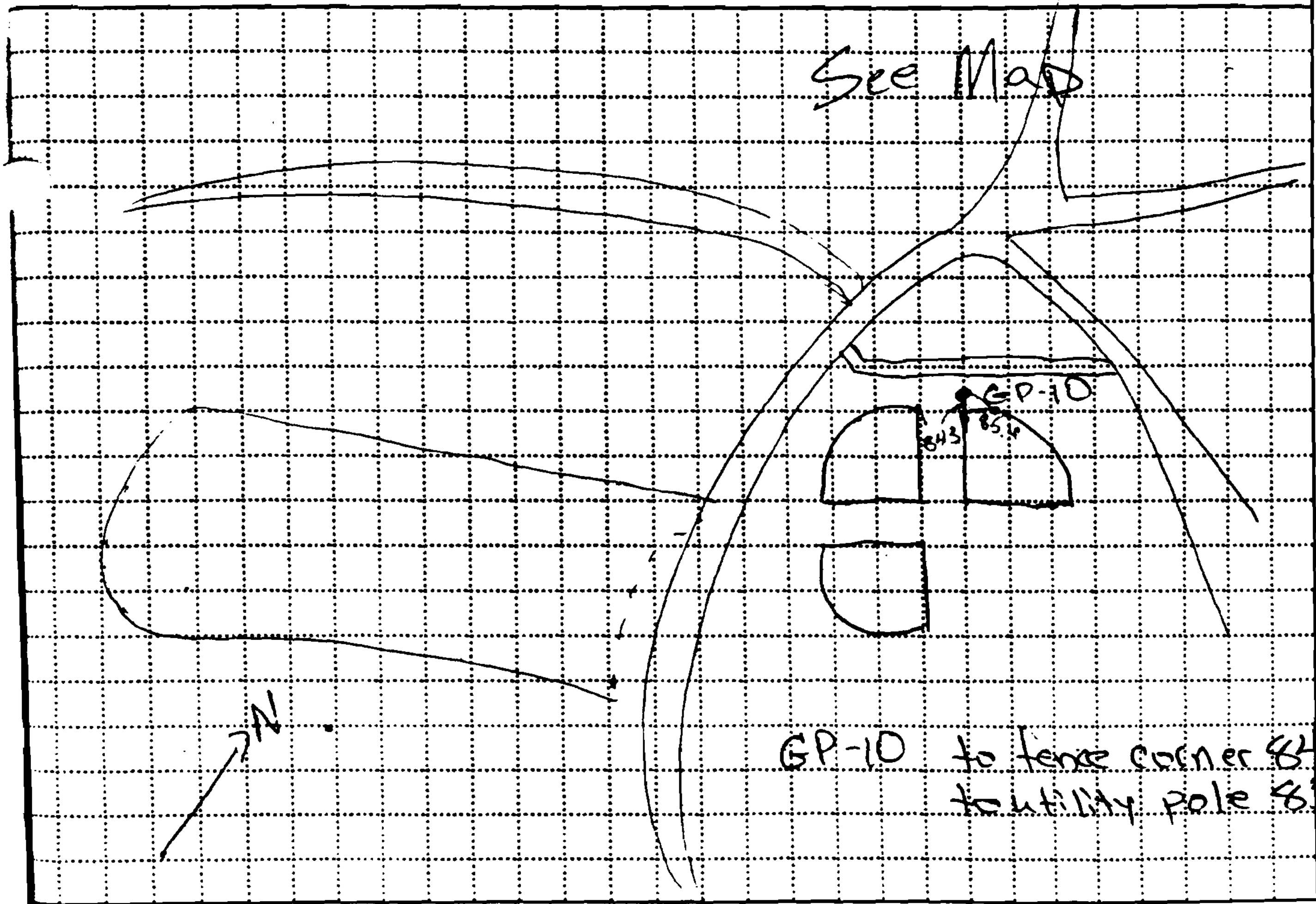
18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
	✓					

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
			Piezometer	Laura Lumley

LOCATION SKETCH/COMMENTS

SCALE:


See Map

GP-10 to fence corner 84.3'
to utility pole 85.6'

PROJECT: Ft. Stewart

HOLE NO. GP-10

INSPECTOR | SHEET

ELEV.	DEPTH	DESCRIPTION OF MATERIALS	FIELD SCREENING RESULTS	GEOTECH SAMPLE OR CORE BOX NO.	ANALYTICAL SAMPLE NO.	REMARKS
		fill silty fine grain sand red 2.5YR 4/6 dark gray 7.5YR 4/1				
	1	sandy clay lt. gray 2.5Y 7/2	HS=128			
	2					
	3	sandy clay lt. gray 2.5Y 7/2	HS=141			
	4	sandy clay 2.5YR 4/1 dark reddish gray ▽				
	5	screen	HS:94			
	6					
	7					
	8					
	9					

PROJECT | HOLE NO

245

APPENDIX C

PHASE II RCRA RFI REPORT
SOUTH CENTRAL LANDFILL (SWMU 1)
FORT STEWART, GEORGIA

MONITORING WELL CONSTRUCTION DIAGRAMS

MONITORING WELL INSTALLATION LOG

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

247

MONITORING WELL ID: SC-M11

START: **DATE:** 11-16-97 **TIME:** 1100

FINISH: **DATE:** ______ **TIME:** ______

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK:	**TYPE:**	DSI #1 Sand	**QUANTITY:**	(6) 50-lb. bags
BENTONITE SEAL:	**TYPE:**	Shur-Pell 3/8"	**QUANTITY:**	1.5 gallons
GROUT:	**TYPE:**	N/A	**QUANTITY:**	N/A

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.008" **SLOT CONFIGURATION:** Slotted

TOTAL OPEN AREA PER FOOT OF SCREEN: ______

OUTSIDE DIAMETER: 2.25" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: None

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 2.25" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Flush Threaded

CENTRALIZERS DESIGN AND COMPOSITION: N/A

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 4" × 4" square **COMPOSITION:** steel

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

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

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

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: 2 gallons

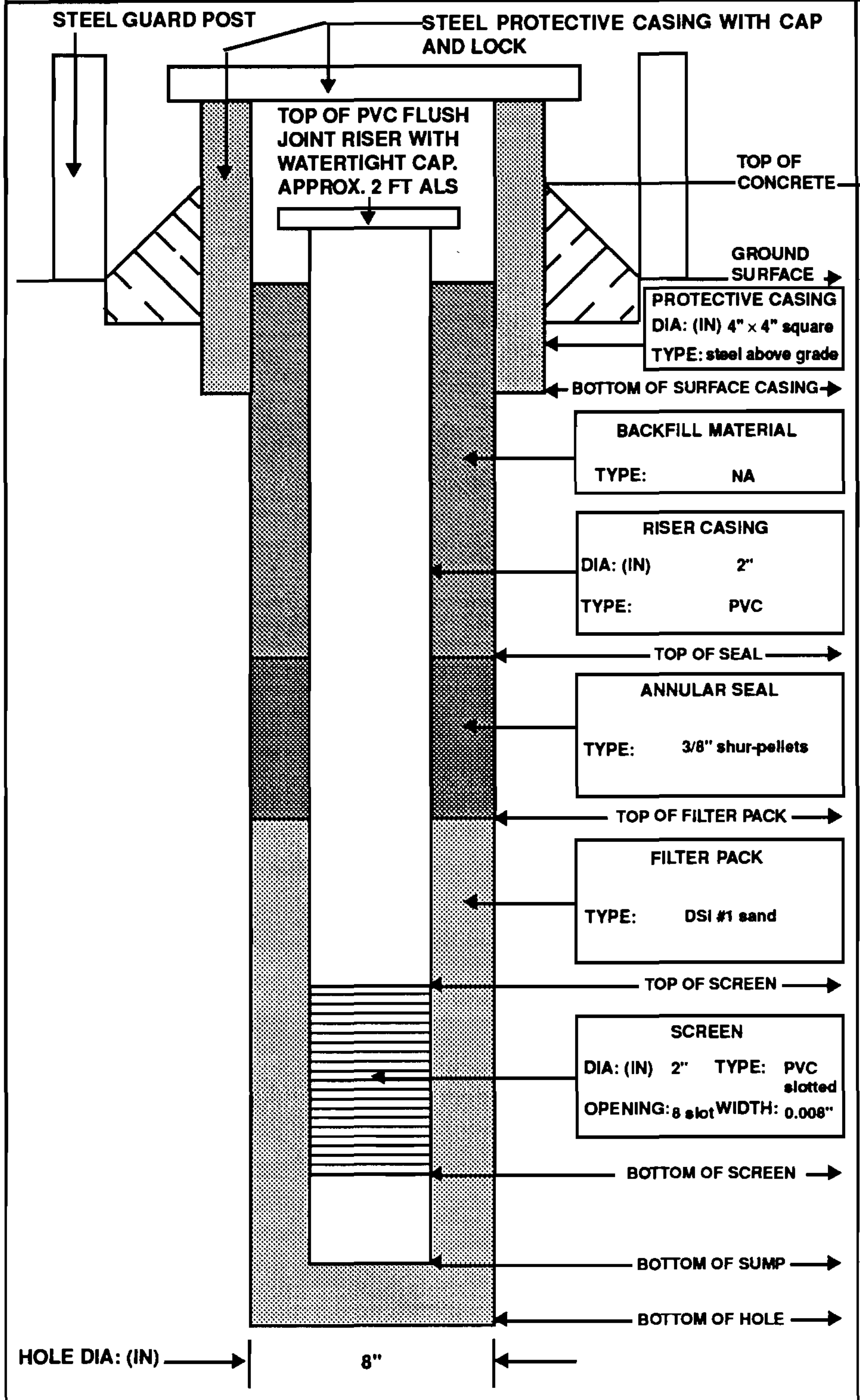
RECORDED BY: ______ **QA CHECK BY:** ______

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

MONITORING WELL

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER:** 0012

WELL NUMBER: SC-M11	**BEGIN:** 11-16-97 1100	**END:**
COORDINATES: N: 687128.264 E: 820149.122 NAD83	**REFERENCE POINT:** MSL	**ELEVATION:**



PROTECTIVE CASING
DIA: (IN) 4" x 4" square
TYPE: steel above grade

BACKFILL MATERIAL
TYPE: NA

RISER CASING
DIA: (IN) 2"
TYPE: PVC

ANNULAR SEAL
TYPE: 3/8" shur-pellets

FILTER PACK
TYPE: DSI #1 sand

SCREEN
DIA: (IN) 2" TYPE: PVC slotted
OPENING: 8 slot WIDTH: 0.008"

HOLE DIA: (IN) 8"

	DEPTH	ELEVATION
TOP OF CONCRETE		
GROUND SURFACE		
BOTTOM OF SURFACE CASING		
TOP OF SEAL	0 - surface	
TOP OF FILTER PACK	1.0'	
TOP OF SCREEN	2.0'	
BOTTOM OF SCREEN	15.0'	
BOTTOM OF SUMP		
BOTTOM OF HOLE	15.0'	

MONITORING WELL INSTALLATION LOG

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

MONITORING WELL ID: SC-M12

START: **DATE:** 11-16-97 **TIME:** 1830

FINISH: **DATE:** 11-16-97 **TIME:**

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK:	**TYPE:**	DSI #1 Sand	**QUANTITY:**	
BENTONITE SEAL:	**TYPE:**	DSI 3/8" pellets	**QUANTITY:**	(1) 5-gal. bucket
GROUT:	**TYPE:**		**QUANTITY:**	

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.008" **SLOT CONFIGURATION:** Standard

TOTAL OPEN AREA PER FOOT OF SCREEN: Standard

OUTSIDE DIAMETER: 2.3" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN:

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 2.3" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Flush Threaded

CENTRALIZERS DESIGN AND COMPOSITION: N/A

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 4" x 4" square **COMPOSITION:** steel

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

Some heave at base of augers, had to add 15 gallons of water for filter sand placement.

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

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

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: 15 gallons

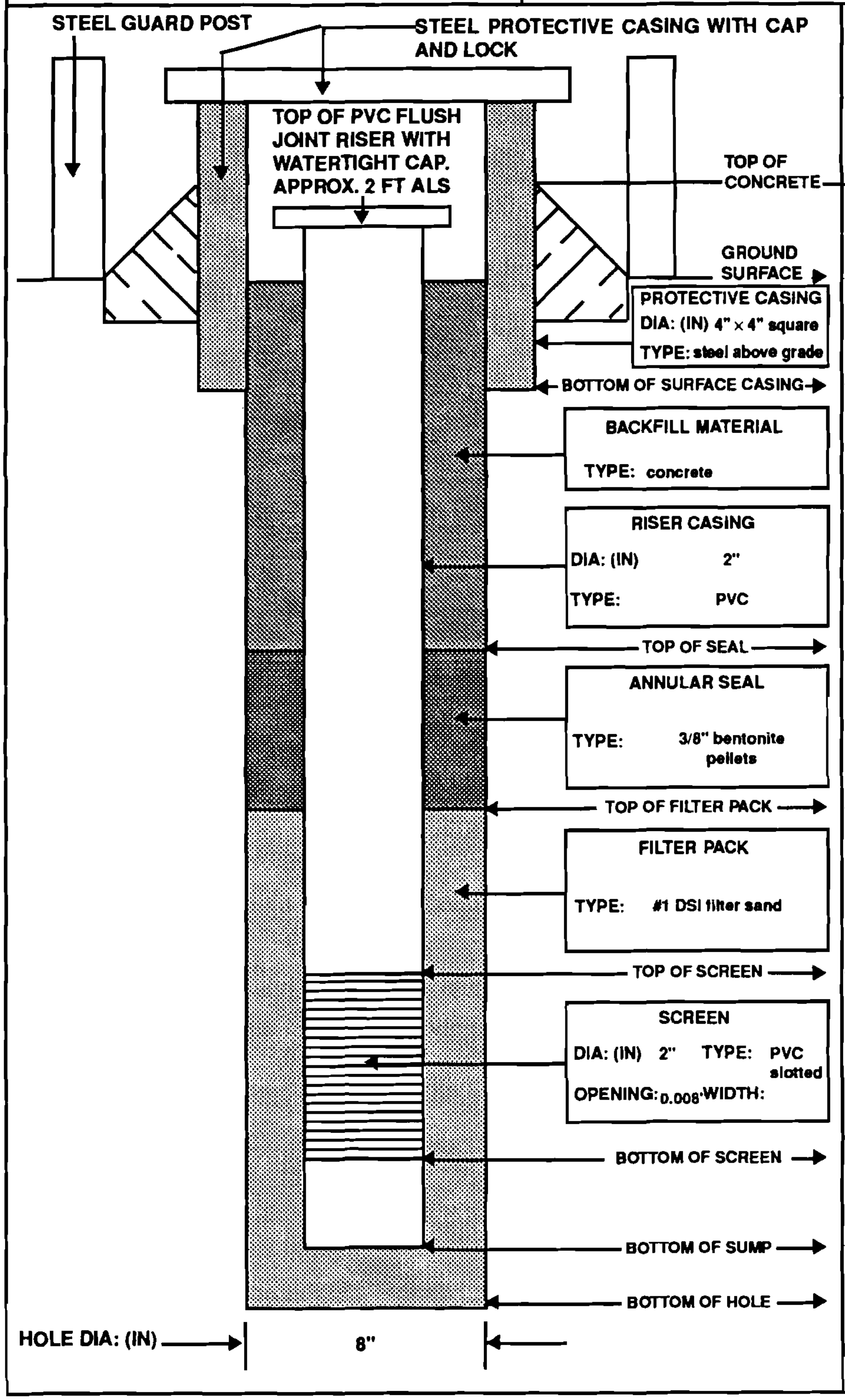
RECORDED BY: **QA CHECK BY:**

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

MONITORING WELL

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

WELL NUMBER: SC-M12	**BEGIN:** 11-16-97 1830	**END:** 11-16-97	
COORDINATES: N: 688152.652 E: 820611.971 NAD83	**REFERENCE POINT:** MSL		**ELEVATION:**



PROTECTIVE CASING
DIA: (IN) 4" x 4" square
TYPE: steel above grade

BACKFILL MATERIAL
TYPE: concrete

RISER CASING
DIA: (IN) 2"
TYPE: PVC

ANNULAR SEAL
TYPE: 3/8" bentonite pellets

FILTER PACK
TYPE: #1 DSI filter sand

SCREEN
DIA: (IN) 2" TYPE: PVC slotted
OPENING: 0.008' WIDTH:

HOLE DIA: (IN) 8"

	DEPTH	ELEVATION
TOP OF CONCRETE		
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING		
TOP OF SEAL		
TOP OF FILTER PACK	1.0'	
TOP OF SCREEN	2.0'	
BOTTOM OF SCREEN	12.0'	
BOTTOM OF SUMP		
BOTTOM OF HOLE	12.0'	

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MONITORING WELL INSTALLATION LOG

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

MONITORING WELL ID: SC-M13

START: **DATE:** 11-16-97 **TIME:** 1545

FINISH: **DATE:** 11-16-97 **TIME:**

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK:	**TYPE:**	DSI #1 Filter Sand	**QUANTITY:**	(6) 50-lb. bags
BENTONITE SEAL:	**TYPE:**	DSI 3/8" pellets	**QUANTITY:**	(1) 5-gal. bucket
GROUT:	**TYPE:**	N/A	**QUANTITY:**	N/A

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.008" **SLOT CONFIGURATION:** Standard

TOTAL OPEN AREA PER FOOT OF SCREEN: Standard

OUTSIDE DIAMETER: 2.3" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN:

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 2.3" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Flush Threaded

CENTRALIZERS DESIGN AND COMPOSITION: N/A

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 4" x 4" square **COMPOSITION:** steel

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

~2' of heavy sands

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

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

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT:

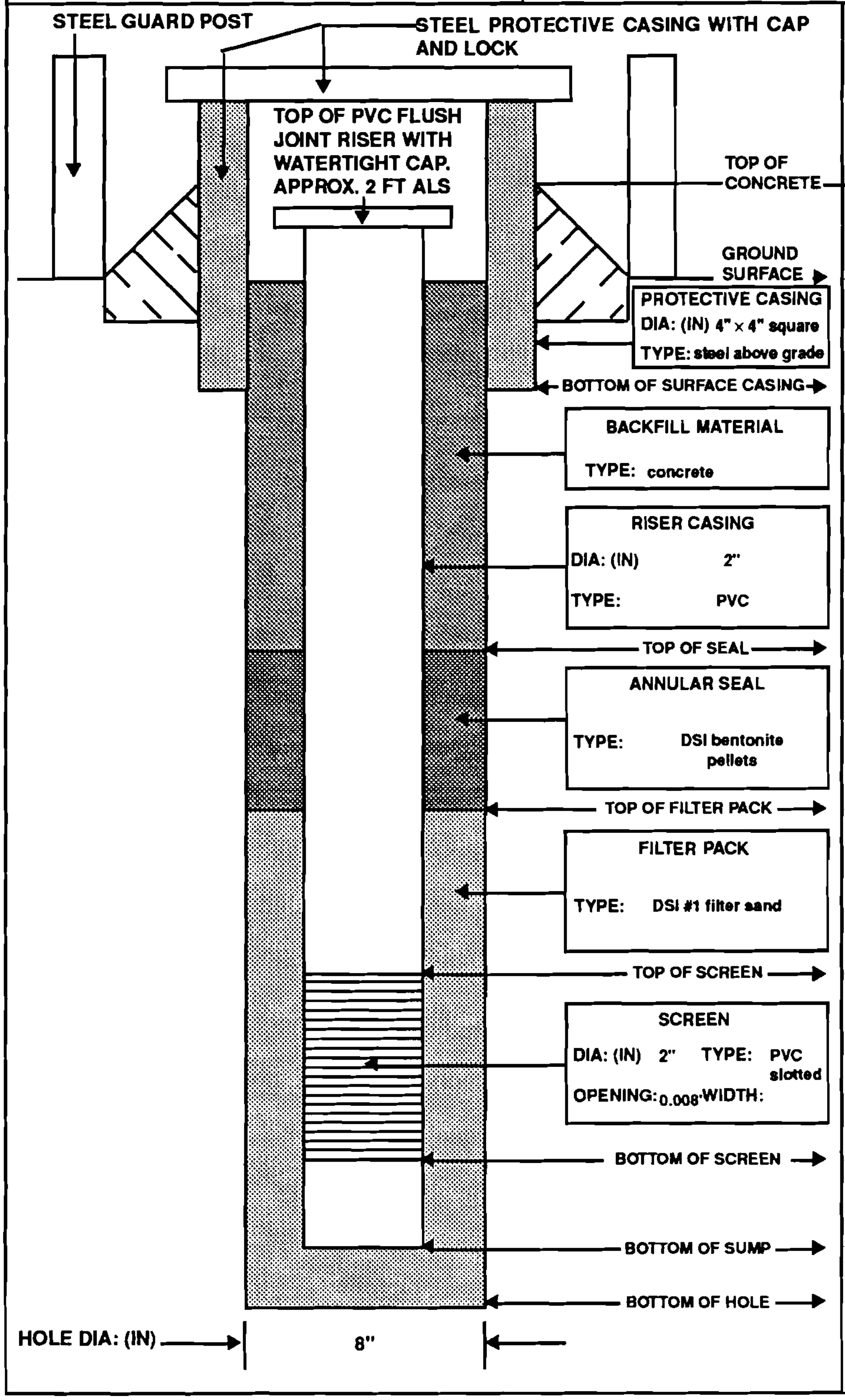
RECORDED BY: **QA CHECK BY:**

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

MONITORING WELL

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER:** 0012

WELL NUMBER: SC-M13	**BEGIN:** 11-16-97 1545	**END:** 11-16-97
COORDINATES: N: 687813.058 E: 821316.412 NAD83	**REFERENCE POINT:** MSL	**ELEVATION:**



PROTECTIVE CASING
DIA: (IN) 4" x 4" square
TYPE: steel above grade

BACKFILL MATERIAL
TYPE: concrete

RISER CASING
DIA: (IN) 2"
TYPE: PVC

ANNULAR SEAL
TYPE: DSI bentonite pellets

FILTER PACK
TYPE: DSI #1 filter sand

SCREEN
DIA: (IN) 2" TYPE: PVC slotted
OPENING: 0.008 WIDTH:

HOLE DIA: (IN) 8"

	DEPTH	ELEVATION
TOP OF CONCRETE		
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING		
TOP OF SEAL	1.0'	
TOP OF FILTER PACK	3.0'	
TOP OF SCREEN	5.0'	
BOTTOM OF SCREEN	15.0'	
BOTTOM OF SUMP		
BOTTOM OF HOLE	15.0'	

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MONITORING WELL INSTALLATION LOG

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

MONITORING WELL ID: SC-M14

START: **DATE:** 11-16-97 **TIME:** 1330

FINISH: **DATE:** 11-16-97 **TIME:**

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK:	**TYPE:**	DSI #1 Sand	**QUANTITY:**	(6) 50-lb. bags
BENTONITE SEAL:	**TYPE:**	DSI 3/8" pellets	**QUANTITY:**	(1) gallons
GROUT:	**TYPE:**	N/A	**QUANTITY:**	N/A

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (Inches): 0.008" **SLOT CONFIGURATION:** Standard

TOTAL OPEN AREA PER FOOT OF SCREEN: Standard

OUTSIDE DIAMETER: 2.3" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN:

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 2.3" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Flush Threaded

CENTRALIZERS DESIGN AND COMPOSITION: N/A

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 4" x 4" square **COMPOSITION:** steel

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

NA

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

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

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: NA

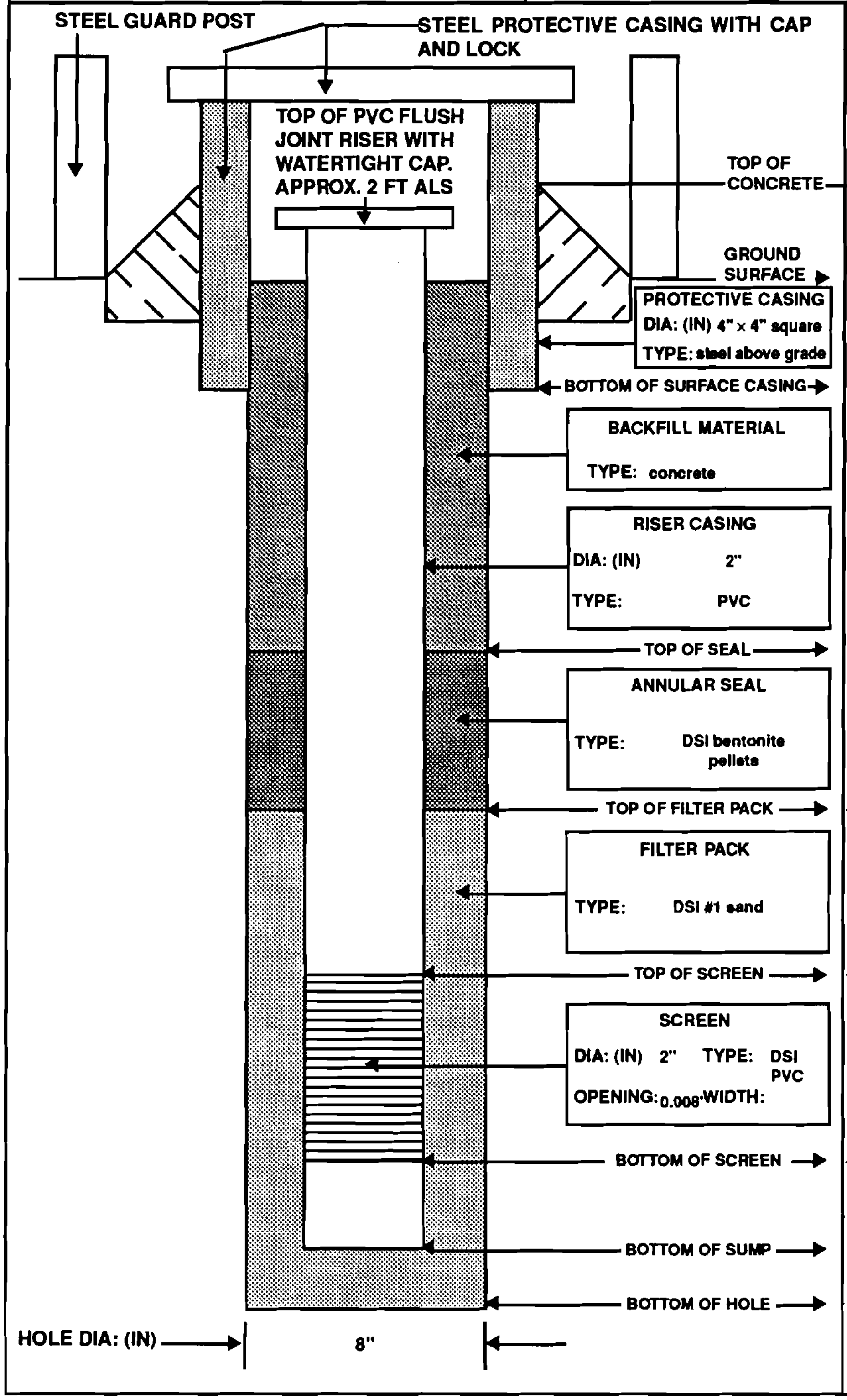
RECORDED BY: **QA CHECK BY:**

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

MONITORING WELL

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

WELL NUMBER: SC-M14	**BEGIN:** 11-16-97 1330	**END:**
COORDINATES: N: 688259.900 E: 821811.453 NAD83	**REFERENCE POINT:** MSL	**ELEVATION:**



PROTECTIVE CASING
DIA: (IN) 4" x 4" square
TYPE: steel above grade

BACKFILL MATERIAL
TYPE: concrete

RISER CASING
DIA: (IN) 2"
TYPE: PVC

ANNULAR SEAL
TYPE: DSI bentonite pellets

FILTER PACK
TYPE: DSI #1 sand

SCREEN
DIA: (IN) 2" TYPE: DSI PVC
OPENING: 0.008 WIDTH:

HOLE DIA: (IN) 8"

	DEPTH	ELEVATION
TOP OF CONCRETE		
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING		
TOP OF SEAL	3.0"	
TOP OF FILTER PACK	9.0"	
TOP OF SCREEN	1.0'	
BOTTOM OF SCREEN	11.0'	
BOTTOM OF SUMP		
BOTTOM OF HOLE	11.0'	

MONITORING WELL INSTALLATION LOG

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

MONITORING WELL ID: SC-M15

START: **DATE:** 11-15-97 **TIME:** 1700

FINISH: **DATE:** 11-15-97 **TIME:** 1900

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK:	**TYPE:**	DSI #1 Filter Sand	**QUANTITY:**	8 50-lb. bags
BENTONITE SEAL:	**TYPE:**	DSI 3/8" Pellets	**QUANTITY:**	1/3 bucket
GROUT:	**TYPE:**	N/A	**QUANTITY:**	N/A

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.008" **SLOT CONFIGURATION:** Standard

TOTAL OPEN AREA PER FOOT OF SCREEN:

OUTSIDE DIAMETER: 2.3" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN:

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 2.3" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Flush Threaded

CENTRALIZERS DESIGN AND COMPOSITION: N/A

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 4" x 4" square **COMPOSITION:** steel

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

Water table is at the ground surface, may be perched, or the top layer of surficial aquifer, after penetrating an impermeable layer from 7.5 - 9' an additional zone of water was encountered. The water flowed slowly out of the augers with 2' of head. Breached a slightly artesian or confined water zone. Confined aquifer regionally thought to be 200 feet bgs. Set well to 16' bgs with 15' screen.

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

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

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

RECORDED BY: **QA CHECK BY:**

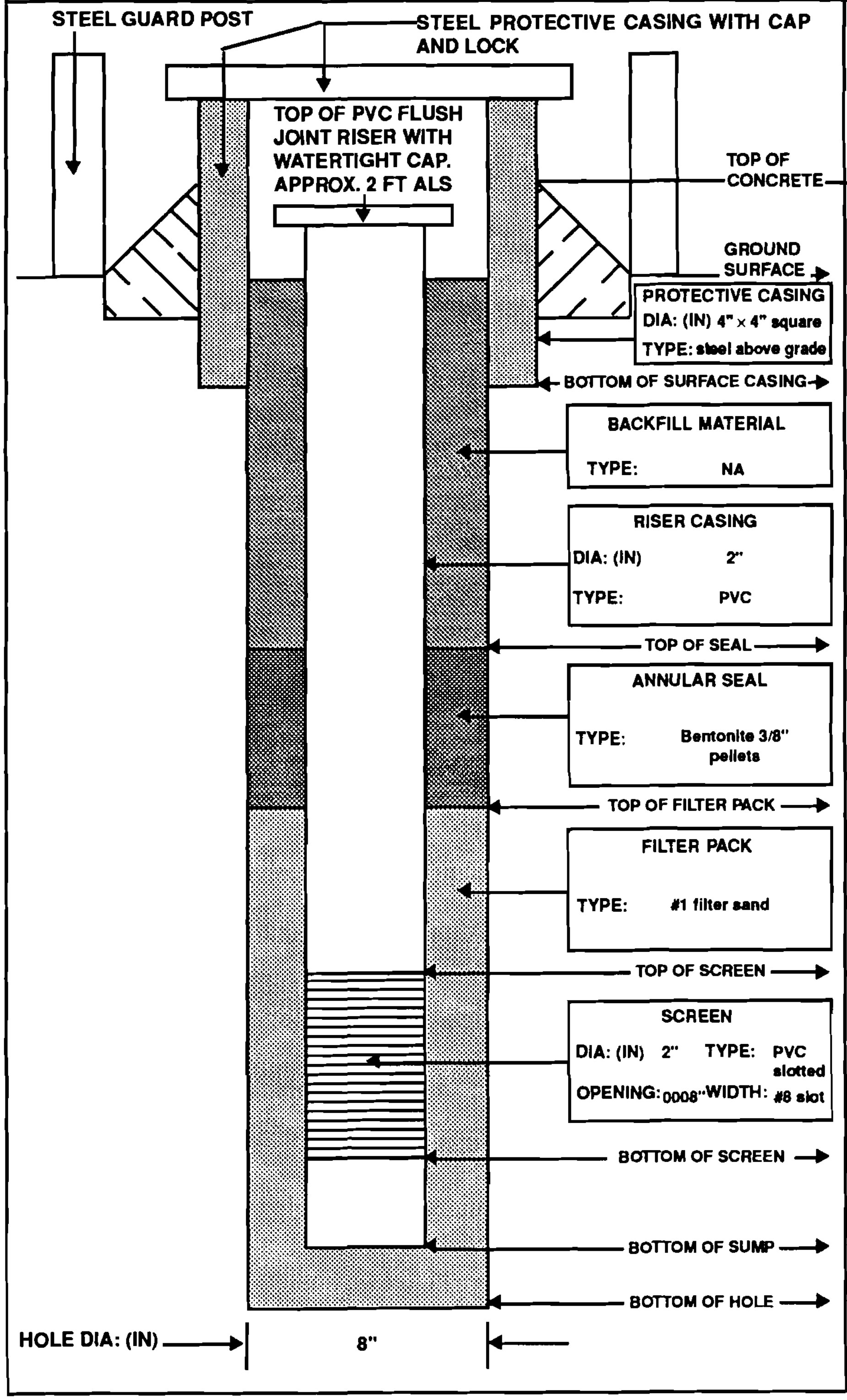
(Signature & Date) **(Signature & Date)**

MONITORING WELL

PROJECT: FORT STEWART - SWMU-1

DELIVERY ORDER: 0012

WELL NUMBER: SC-M15	**BEGIN:** 11-15-97 1700	**END:** 11-15-97 1900
COORDINATES: N: 688173.679 E: 822390.594 NAD83	**REFERENCE POINT:** MSL	**ELEVATION:**



PROTECTIVE CASING
DIA: (IN) 4" x 4" square
TYPE: steel above grade

BACKFILL MATERIAL
TYPE: NA

RISER CASING
DIA: (IN) 2"
TYPE: PVC

ANNULAR SEAL
TYPE: Bentonite 3/8" pellets

FILTER PACK
TYPE: #1 filter sand

SCREEN
DIA: (IN) 2" TYPE: PVC slotted
OPENING: 0008" WIDTH: #8 slot

HOLE DIA: (IN) 8"

	DEPTH	ELEVATION
TOP OF CONCRETE		
GROUND SURFACE		
BOTTOM OF SURFACE CASING		
TOP OF SEAL	0	
TOP OF FILTER PACK	6.0"	
TOP OF SCREEN	1.0'	
BOTTOM OF SCREEN	16.0'	
BOTTOM OF SUMP		
BOTTOM OF HOLE	16.0	

MONITORING WELL INSTALLATION LOG

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

MONITORING WELL ID: SC-M16

START: **DATE:** 11-15-97 **TIME:** 0900

FINISH: **DATE:** 11-15-97 **TIME:**

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK:	**TYPE:**	#1 Filter Sand DSI	**QUANTITY:**	(6) 50-lb. bags
BENTONITE SEAL:	**TYPE:**	3/8" pellets	**QUANTITY:**	1/4 bucket
GROUT:	**TYPE:**	N/A	**QUANTITY:**	N/A

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.008" **SLOT CONFIGURATION:** Standard

TOTAL OPEN AREA PER FOOT OF SCREEN:

OUTSIDE DIAMETER: 2.3" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN:

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 2.3" **NOMINAL INSIDE DIAMETER:** 2.0"

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: 4" x 4" square **COMPOSITION:** steel

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

Split spoon got caught in auger at 10 - 12.5' interval and had to remove auger and sampler, hole collapsed and increased size of hole, had to move forward, put plug in auger and re-drill off-set hole, no samples collected, potable water introduced.

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

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

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: 25 gallons

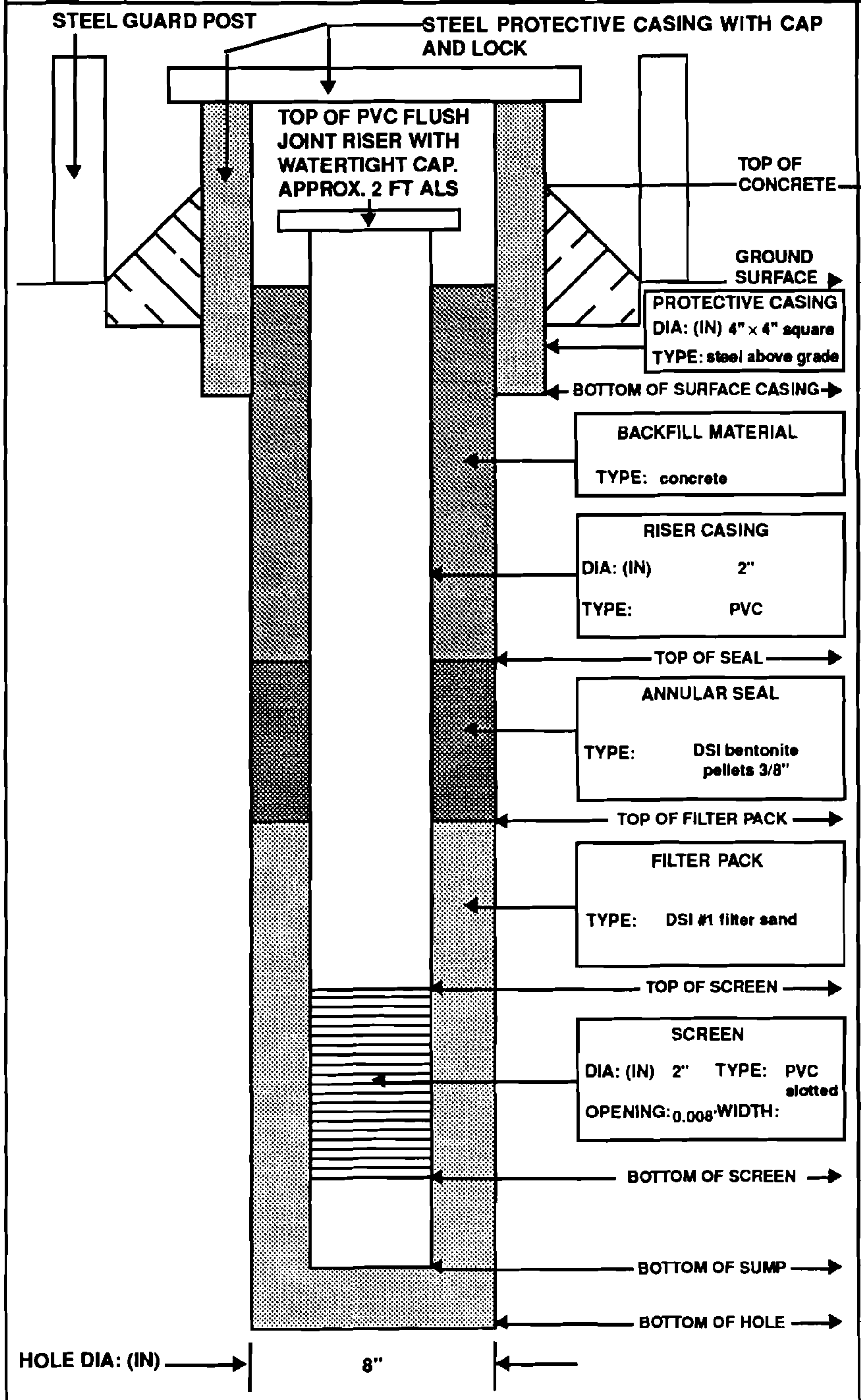
RECORDED BY: **QA CHECK BY:**

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

MONITORING WELL

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

WELL NUMBER: SC-M16	**BEGIN:** 11-15-97 0900	**END:** 11-15-97
COORDINATES: N: 687627.854 E: 822469.555 NAD83	**REFERENCE POINT:** MSL	**ELEVATION:**



PROTECTIVE CASING
DIA: (IN) 4" x 4" square
TYPE: steel above grade

BACKFILL MATERIAL
TYPE: concrete

RISER CASING
DIA: (IN) 2"
TYPE: PVC

ANNULAR SEAL
TYPE: DSI bentonite pellets 3/8"

FILTER PACK
TYPE: DSI #1 filter sand

SCREEN
DIA: (IN) 2" TYPE: PVC slotted
OPENING: 0.008 WIDTH:

HOLE DIA: (IN) 8"

	DEPTH	ELEVATION
TOP OF CONCRETE		
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING		
TOP OF SEAL	6.0"	
TOP OF FILTER PACK	9.0"	
TOP OF SCREEN	1.0'	
BOTTOM OF SCREEN	11.0'	
BOTTOM OF SUMP		
BOTTOM OF HOLE	11.0'	

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MONITORING WELL INSTALLATION LOG

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

MONITORING WELL ID: SC-M17

START: **DATE:** 11-16-97 **TIME:** 1410

FINISH: **DATE:** ______ **TIME:** ______

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK:	**TYPE:**	DSI #1 Filter Sand	**QUANTITY:**	(5) 50-lb. bags
BENTONITE SEAL:	**TYPE:**	shur-pel 3/8"	**QUANTITY:**	2 gallons
GROUT:	**TYPE:**	N/A	**QUANTITY:**	N/A

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.008" **SLOT CONFIGURATION:** Slotted

TOTAL OPEN AREA PER FOOT OF SCREEN: ______

OUTSIDE DIAMETER: 2.25" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: ______

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 2.25" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Flush Threaded

CENTRALIZERS DESIGN AND COMPOSITION: N/A

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 4" x 4" square **COMPOSITION:** steel

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

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

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

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: 3 gallons

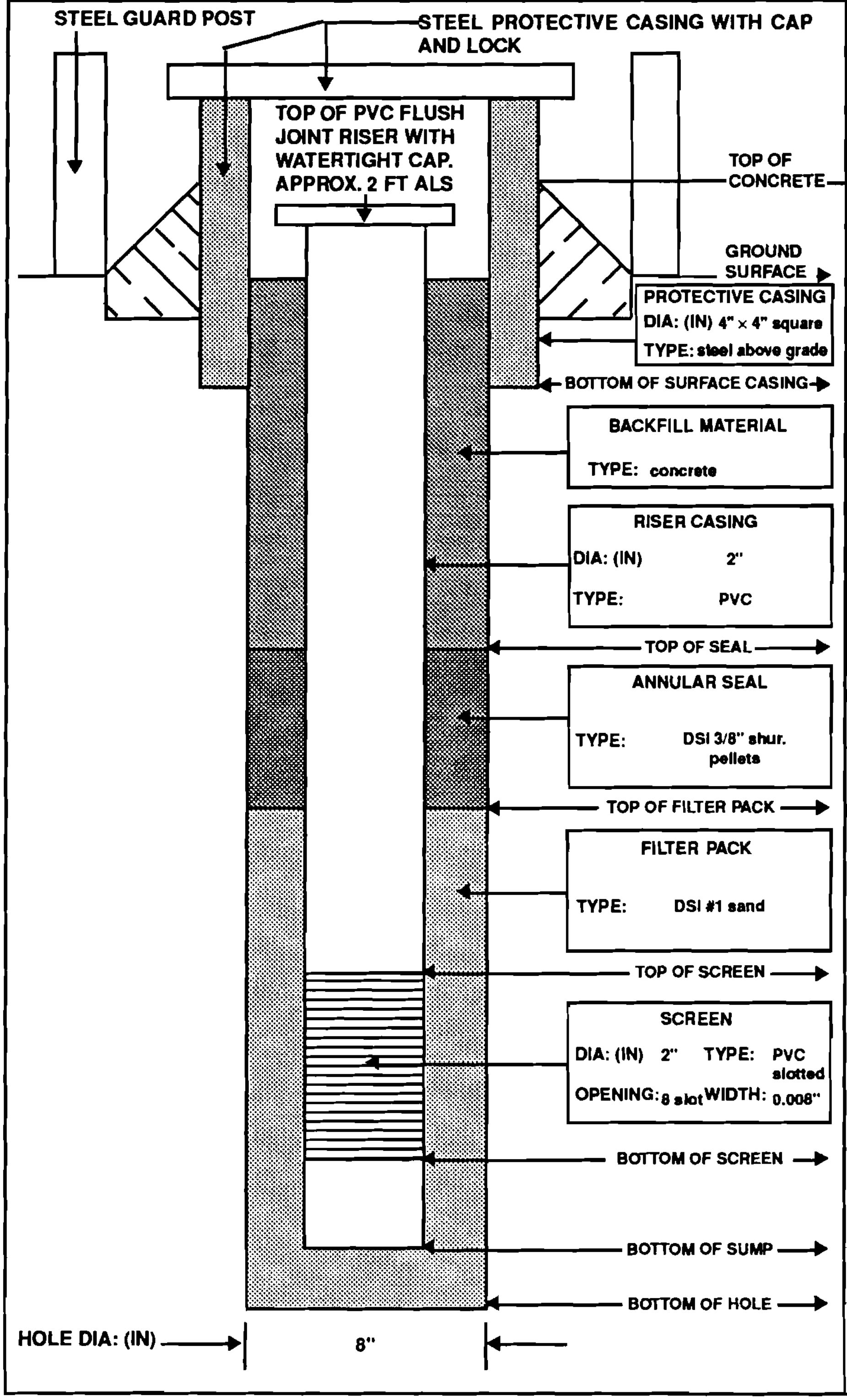
RECORDED BY: ______ **QA CHECK BY:** ______

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

MONITORING WELL

PROJECT: FORT STEWART - SWMU-1 DELIVERY ORDER: 0012

WELL NUMBER: SC-M17	BEGIN: 11-16-97 1100	END:
COORDINATES: N: 685063.839 E: 821789.437 NAD83	REFERENCE POINT: MSL	ELEVATION:



PROTECTIVE CASING
DIA: (IN) 4" x 4" square
TYPE: steel above grade

BACKFILL MATERIAL
TYPE: concrete

RISER CASING
DIA: (IN) 2"
TYPE: PVC

ANNULAR SEAL
TYPE: DSI 3/8" shur. pellets

FILTER PACK
TYPE: DSI #1 sand

SCREEN
DIA: (IN) 2" TYPE: PVC slotted
OPENING: 8 slot WIDTH: 0.008"

HOLE DIA: (IN) 8"

	DEPTH	ELEVATION
TOP OF CONCRETE		
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING		
TOP OF SEAL	1.0'	
TOP OF FILTER PACK	3.0'	
TOP OF SCREEN	5.0'	
BOTTOM OF SCREEN	15.0'	
BOTTOM OF SUMP		
BOTTOM OF HOLE	15.0'	

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MONITORING WELL INSTALLATION LOG

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

MONITORING WELL ID: SC-M18

START: **DATE:** 11-16-97 **TIME:** 0800

FINISH: **DATE:** ____ **TIME:** ____

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK:	**TYPE:**	DSI 1A Sand	**QUANTITY:**	(7) 50-lb. bags
BENTONITE SEAL:	**TYPE:**	shur-pel 3/8"	**QUANTITY:**	1.5 gallons
GROUT:	**TYPE:**	N/A	**QUANTITY:**	N/A

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.01" **SLOT CONFIGURATION:** Slotted

TOTAL OPEN AREA PER FOOT OF SCREEN: ____

OUTSIDE DIAMETER: 2.25" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: None

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 2.25" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Flush Threaded

CENTRALIZERS DESIGN AND COMPOSITION: N/A

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 4" x 4" square **COMPOSITION:** steel

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

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

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

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: 0

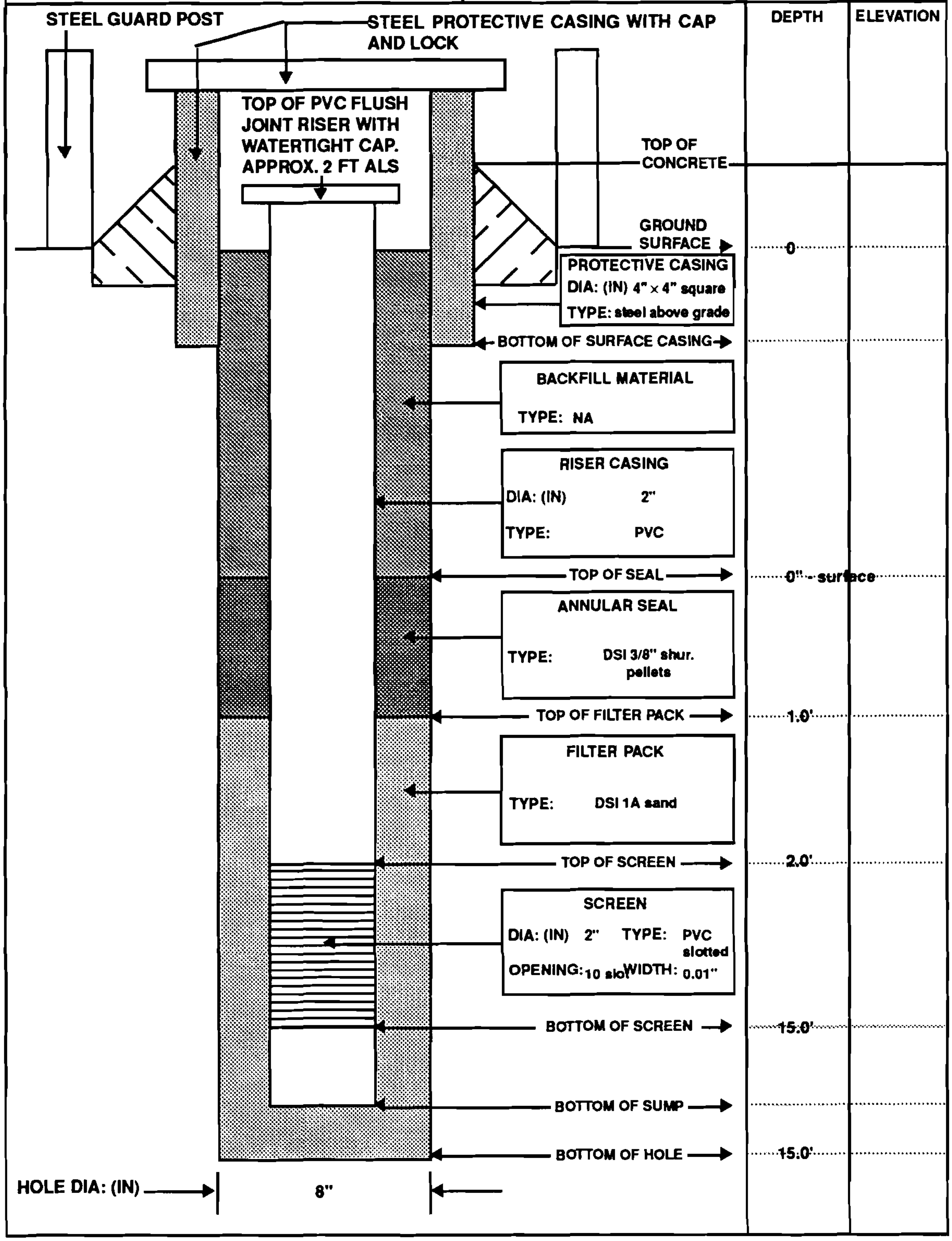
RECORDED BY: ____ **QA CHECK BY:** ____

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

MONITORING WELL

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

WELL NUMBER: SC-M18	**BEGIN:** 11-16-97 0800	**END:**
COORDINATES: N: 685834.087 E: 821176.949 NAD83	**REFERENCE POINT:** MSL	**ELEVATION:**



PROTECTIVE CASING
DIA: (IN) 4" x 4" square
TYPE: steel above grade

BACKFILL MATERIAL
TYPE: NA

RISER CASING
DIA: (IN) 2"
TYPE: PVC

ANNULAR SEAL
TYPE: DSI 3/8" shur. pellets

FILTER PACK
TYPE: DSI 1A sand

SCREEN
DIA: (IN) 2" TYPE: PVC slotted
OPENING: 10 slot WIDTH: 0.01"

HOLE DIA: (IN) 8"

	DEPTH	ELEVATION
TOP OF CONCRETE		
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING		
TOP OF SEAL	0" - surface	
TOP OF FILTER PACK	1.0'	
TOP OF SCREEN	2.0'	
BOTTOM OF SCREEN	15.0'	
BOTTOM OF SUMP		
BOTTOM OF HOLE	15.0'	

MONITORING WELL INSTALLATION LOG

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

MONITORING WELL ID: SC-M19

START: **DATE:** 11-16-97 **TIME:** 1740

FINISH: **DATE:** ______ **TIME:** ______

ANNULAR SPACE MATERIALS INVENTORY:

GRANULAR FILTER PACK:	**TYPE:**	DSI #1 Sand	**QUANTITY:**	(7) 50-lb. bags
BENTONITE SEAL:	**TYPE:**	shur-pel 3/8"	**QUANTITY:**	2 gallons
GROUT:	**TYPE:**	N/A	**QUANTITY:**	N/A

DESCRIPTION OF WELL SCREEN:

SLOT SIZE (inches): 0.008" **SLOT CONFIGURATION:** Slotted

TOTAL OPEN AREA PER FOOT OF SCREEN: ______

OUTSIDE DIAMETER: 2.25" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

TYPE OF MATERIAL BETWEEN BOTTOM OF BORING AND SCREEN: ______

DESCRIPTION OF WELL CASING:

OUTSIDE DIAMETER: 2.25" **NOMINAL INSIDE DIAMETER:** 2.0"

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

MANUFACTURER: DSI

JOINT DESIGN AND COMPOSITION: Flush Threaded

CENTRALIZERS DESIGN AND COMPOSITION: N/A

DESCRIPTION OF PROTECTIVE CASING:

NOMINAL INSIDE DIAMETER: 4" × 4" square **COMPOSITION:** steel

SPECIAL PROBLEMS ENCOUNTERED DURING WELL CONSTRUCTION AND THEIR RESOLUTION:

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

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

QUANTITY OF APPROVED WATER USED FOR FILTER PACK ENPLACEMENT: 0

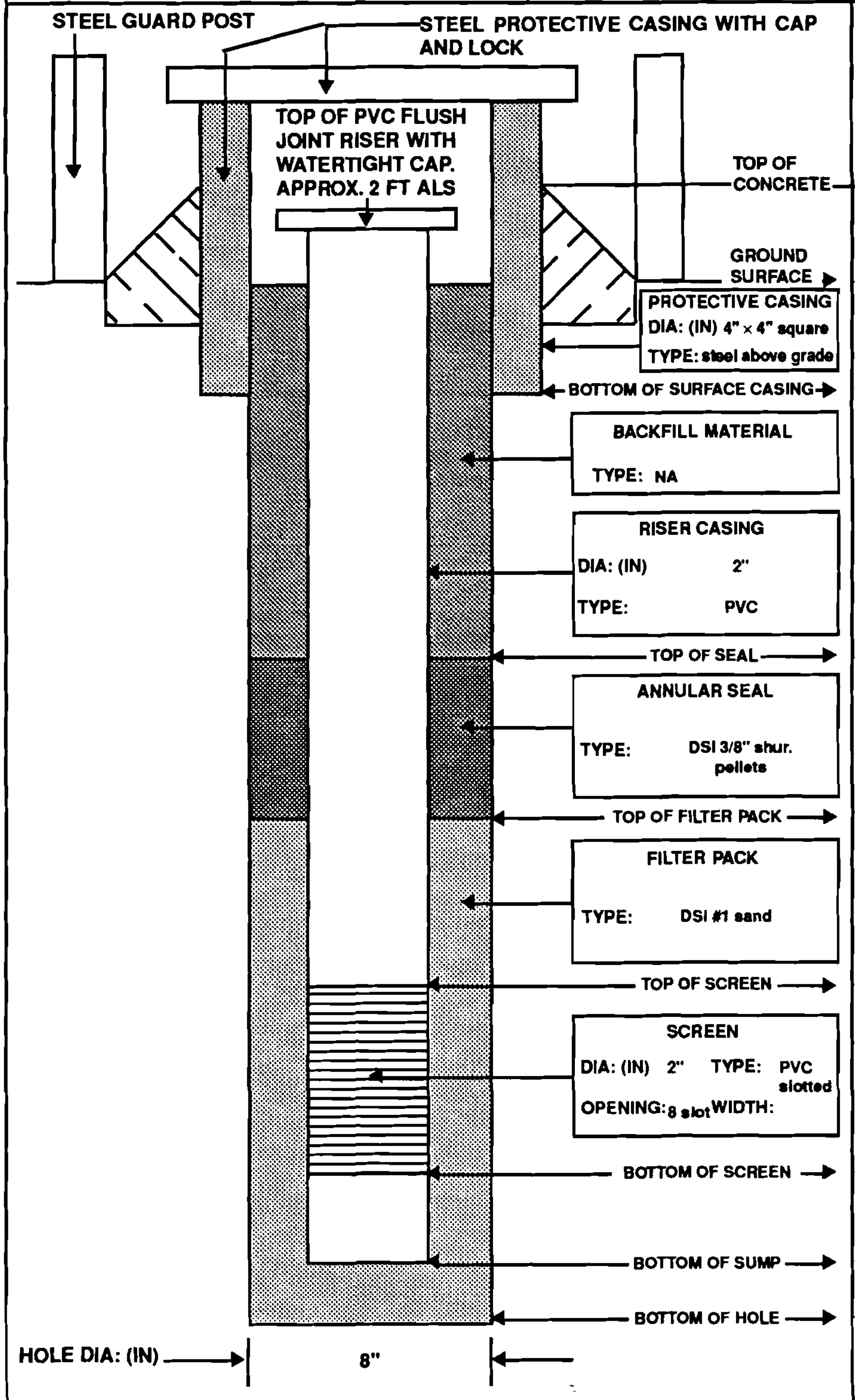
RECORDED BY: ______ **QA CHECK BY:** ______

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

MONITORING WELL

PROJECT: FORT STEWART - SWMU-1 **DELIVERY ORDER: 0012**

WELL NUMBER: SC-M19	BEGIN: 11-16-97 1740	END:
COORDINATES: N: 686318.717 E: 820398.074 NAD83	REFERENCE POINT: MSL	ELEVATION:



PROTECTIVE CASING
DIA: (IN) 4" x 4" square
TYPE: steel above grade

BACKFILL MATERIAL
TYPE: NA

RISER CASING
DIA: (IN) 2"
TYPE: PVC

ANNULAR SEAL
TYPE: DSI 3/8" shur. pellets

FILTER PACK
TYPE: DSI #1 sand

SCREEN
DIA: (IN) 2" TYPE: PVC slotted
OPENING: 8 slot WIDTH:

HOLE DIA: (IN) 8"

	DEPTH	ELEVATION
TOP OF CONCRETE		
GROUND SURFACE	0	
BOTTOM OF SURFACE CASING		
TOP OF SEAL	0	
TOP OF FILTER PACK	1.0'	
TOP OF SCREEN	2.0'	
BOTTOM OF SCREEN	15.0'	
BOTTOM OF SUMP		
BOTTOM OF HOLE	15.0'	

APPENDIX D

PHASE II RCRA RFI REPORT
SOUTH CENTRAL LANDFILL (SWMU 1)
FORT STEWART, GEORGIA

QUALITY CONTROL SUMMARY REPORT

QUALITY CONTROL SUMMARY REPORT

D.1 INTRODUCTION

The purpose of this project was to perform a Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for the South Central Landfill, Solid Waste Management Unit (SWMU) 1 at Fort Stewart, Georgia, to determine the nature and extent of contamination and to gather data to support a Corrective Action Plan (CAP). This RFI was conducted in accordance with COE Standard EM200-1-30.

SWMU 1 has been used for solid waste disposal since the 1940s, with landfill operations moving from its eastern sections to the west. Disposal practices at the landfill have ranged from burn-pit to trench-and-fill operations. The currently (active) permitted landfill operations are being constructed on the clay cap of the old (trench-and-fill) portion of the landfill. The old, inactive portion of SWMU 1 east of the active landfill is heavily forested and estimated to encompass approximately 80 acres. Results of the Phase I RFI of SWMU 1 conducted in July and October 1993 indicated that additional investigation, including investigation of the inactive portion (east of the active landfill), was required to define the nature and extent of contamination This Quality Control Summary Report consolidates quality control (QC) information for the Phase II studies.

D.1.1 PROJECT DESCRIPTION

Phase II field sampling activities were performed November through December 1997. Investigation activities consisted of collecting soil, sediment, groundwater, and surface water samples within and around the defined areas of the landfill to characterize the nature of these potential sources of contamination, installation and sampling of new permanent monitoring wells to verify downgradient water quality, and collection and analysis of samples from existing monitoring wells to confirm Phase I data.

Sample results were screened against background levels, Georgia Department of Natural Resources action levels, and risk-based action levels for those compounds identified by the Georgia Environmental Protection Division (GEPD).

D.1.2 PROJECT OBJECTIVES

The scope of the project involved performance of site investigation activities relative to the State of Georgia GEPD instructions and preparation of this Phase II RFI Report based on the results. The overall purpose of the study was to determine contamination extent and corrective action measures. Specific objectives for the Phase II RFI were defined in the Phase II RFI Sampling and Analysis Plan (SAIC 1997). In summary, the objectives of the project were as follows:

1. Determine the horizontal and vertical extent of contamination.
2. Determine whether contaminants present constitute a threat to human health or the environment.

3. Determine the need for future action or no further action.

4. Gather necessary data to support a CAP, if warranted.

The general quality assurance (QA) objectives of the project were as follows:

1. Ensure that the method used for borehole drilling will allow for collection of soil samples representative of surface and subsurface soil contamination conditions and for description of the hydrogeologic environment.

2. Ensure that the method used for collection of groundwater samples will allow for collection of samples representative of water table contamination conditions.

3. Ensure that sampling methods used for soil and groundwater collection minimize alteration of contaminant concentrations and that drilling and sampling equipment decontamination methods prevent cross-contamination between sampling locations.

4. Ensure that field measurement and analytical laboratory results are accurate, representative of site conditions, and fulfill data quality objectives (DQOs) defined for the project.

The first three QA objectives were accomplished through implementation of the procedures and requirements described in the Work Plan and the Field Sampling Plan. The fourth QA objective was accomplished through data management practices, associated internal laboratory QC analyses, related procedures and requirements defined in the Quality Assurance Project Plan (QAPP), and collection and analysis of field QC samples.

D.1.3 PROJECT IMPLEMENTATION

Phase II fieldwork was performed in November through December 1997 by Science Applications International Corporation (SAIC). A project-specific Site Health and Safety Plan was compiled for the work completed by SAIC and subtier contractors. Ms. Patty Stoll was designated as Field Team Leader for the project. She was responsible for the collection of samples in accordance with the Work Plan, completion of the Daily Quality Control Reports (DQCRs), coordination of site access, shipment of samples to the laboratories, and documentation and correction of problems as they occurred. Quality Control Officer for the project was Ms. Sharon Stoller. She was responsible for data QC for the SAIC sampling effort. This included, but was not limited to, validation of both field and laboratory data in accordance with the QAPP and the Sampling and Analysis Plan. As Laboratory and Analytical Data Coordinator, Mr. Nile Luedtke was responsible for maintaining analytical files for the project, approval of payment invoices from the laboratories, and documentation and correction of problems as they occurred. As the SAIC Project Manager, Mr. Jeffery Longaker was responsible for overall project success, budgetary control, Corps of Engineers (COE) interfaces, and completion of Monthly Progress Reports (MPRs).

One analytical laboratory was used by SAIC for testing samples collected by SAIC personnel. General Engineering Laboratory (GEL) of Charleston, South Carolina, completed all water and soil analysis for: volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticide polychlorinated biphenyl (PCB) compounds, RCRA metals, and miscellaneous parameters. The laboratory employed Environmental Protection Agency (EPA) analytical methods, and its results were validated through the COE Missouri River Division Center of Excellence,

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Omaha, Nebraska, laboratory review process. The QA laboratory for the entire project was the COE South Atlantic Savannah Division (SAS) Laboratory in Marietta, Georgia.

D.1.4 PURPOSE OF THIS REPORT

Environmental data must always be interpreted relative to their known limitations and intended use. As can be expected in environmental media of this type, there are areas and data points where the user needs to be cautioned relative to the quality of the project information presented. The data validation process and this data quality assessment are intended to provide current and future data users assistance throughout the interpretation of these data.

The purposes of this QCSR are to describe QC procedures followed to ensure that data generated by SAIC during these investigations at Fort Stewart would meet project requirements, to describe the quality of the data collected, and to describe problems encountered during the course of the study and their respective solutions. A QA report will be completed by the COE SAS Laboratory covering data generated from SAIC-collected samples remanded to their custody.

This appendix provides an assessment of the analytical information gathered during the course of the South Central Landfill investigations and documents that the quality of the data employed for the report met the objectives. Evaluation of field and laboratory QC measures constitutes the majority of this assessment; however, references are also directed toward those QA procedures that establish data credibility. The primary intent of this assessment is to illustrate that data generated for this investigation can withstand scientific scrutiny; are appropriate for their intended purpose; are technically defensible; and are of known and acceptable sensitivity, precision, and accuracy.

Multiple activities were performed to achieve the desired data quality in this project. As discussed in the text, decisions were made during the initial scoping to define the quality and quantity of data required. DQOs were established to guide the implementation of the field sampling and laboratory analysis. A QA program was established to standardize procedures and to document activities. This program provided a means of detecting and correcting any deficiencies in the process. Upon receipt by the project team, data were subjected to a verification and validation review that identified and qualified problems related to the analysis. The review steps contributed to this final Data Quality Assessment (DQA), which demonstrates that data used in the investigation met the criteria and are appropriately employed.

D.2 QUALITY ASSURANCE PROGRAM

A QAPP was developed for this project and may be found as part of the official Work Plan. The purpose of the document was to enumerate the quantity and type of samples to be taken to inspect the various sites and to define the quantity and type of QA/QC samples to be used to evaluate the quality of the data obtained.

The QAPP established requirements for both field and laboratory QC procedures. In general, field QC duplicates and QA split samples were required for each environmental sample matrix collected at sites being investigated at a frequency of 10%; VOC trip blanks were to accompany each cooler containing water samples for VOC determinations~~;~~ ~~and~~ analytical laboratory QC duplicates, matrix spikes (MSs), laboratory control samples (LCSs), and method blanks were required for every 20 samples or fewer of each matrix and analyte.

A primary goal of the QA program was to ensure that the quality of results for all environmental measurements were appropriate for their intended use. To this end a QAPP and standardized field procedures were compiled to guide the investigation. Through the process of readiness review, training, equipment calibration, QC implementation, and detailed documentation, the project has successfully accomplished the goals set by the QA program.

D.2.1 MONTHLY PROGRESS REPORTS

A Monthly Progress Report (MPR) was completed by the SAIC Project Manager for every month during project implementation. The MPRs contain the following information: work completed, problems encountered, corrective actions/solutions, and summary of findings and upcoming work. These reports were issued to the Savannah Corp Project Manager and may be obtained through his office.

D.2.2 DAILY QUALITY CONTROL REPORTS

The Field Team Leader, Patty Stoll, produced all Daily Quality Control Report (DQCRs). These include information such as, but not limited to, subtier contractors onsite, equipment onsite, work-performed summaries, QC activities, health and safety activities, problems encountered, and corrective actions. The DQCRs were submitted to the SAIC and Savannah Corp Project Managers and are on file with them.

D.2.3 LABORATORY "DEFINITIVE" LEVEL DATA REPORTING

The QAPP for this project identified requirements for laboratory data reporting and named GEL as the laboratory for the project. EPA "definitive" data have been reported, including the following basic information:

- laboratory case narratives,
- sample results,
- laboratory method blank results,
- laboratory control standard results,
- laboratory sample matrix spike recoveries,
- laboratory duplicate results,
- surrogate recoveries (VOCs, SVOCs, pesticides/PCBs),
- sample extraction dates, and
- sample analysis dates.

This information from the laboratory, along with field information, provided the basis for subsequent data evaluation relative to sensitivity, precision, accuracy, representativeness and completeness. Discussions of these evaluations are presented in Chapter D.4.

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D.3 DATA VALIDATION

The objective when evaluating the quality of the project data is to determine their usability. The evaluation is based on the interpretation of laboratory QC measures, field QC measures, and the project DQOs.

This project implemented the use of data validation checklists to facilitate laboratory data validation. These checklists were completed by the project-designated validation staff and were reviewed by the Project Laboratory Coordinator. SAIC has retained data validation checklists for each laboratory sample delivery group with laboratory data deliverables.

D.3.1 FIELD DATA VALIDATION

DQCRs were completed by the Field Team Leader. The DQCRs and other field-generated documents such as sampling logs, boring logs, daily health and safety summaries, daily safety inspections, equipment calibration and maintenance logs, and sample management logs were peer-reviewed on site. These logs and all associated field information have been delivered to the Savannah Corp Project Manager and can be obtained through his office.

D.3.2 LABORATORY DATA VALIDATION

Analytical data generated for this project have been subjected to a process of data verification, validation, and review. The following text describes this systematic process and the evaluation activities performed. Several criteria have been established against which the data are compared and from which a judgment is rendered regarding the acceptance and qualification of the data. The validation follows the QA/QC guidance outlined in EPA's Test Methods for Evaluation Solid Waste (EPA SW-846). Overall, these guidelines mimic the most current editions of the EPA's Functional Guidelines for Reviewing Organic and Inorganic Analyses conducted outside the EPA's Contract Laboratory Program. Because it is beyond the scope of this report to cite those criteria, the reader is directed to the following documents for specific detail:

- SAIC's Technical Support Contractor QA Technical Procedure TP-DM-300-7, Data Validation Guidelines for Analytical Data (1995)
- EPA's USEPA National Functional Guidelines for Inorganic Data Review (1994a)
- EPA's USEPA National Functional Guidelines for Organic Data Review (1994b)
- SAIC's Sampling and Analysis Plan for the Phase II RCRA Facility Investigation for the South Central Landfill (SWMU 1) (1997)

Upon receipt of field and analytical data, verification staff performed a systematic examination of the reports, following standardized data package checklists to ensure the content, presentation, and administrative validity of the data. Discrepancies identified during this process were recorded and documented using the QA program's Analytical Data Nonconformance Report and Nonconformance Report systems.

In conjunction with data package verification, laboratory electronic data diskettes were available. These diskette deliverables were subjected to review and verification against the hardcopy deliverable. Both structural and technical assessments of the laboratory-delivered electronic reports were performed. The structural evaluation ensured that all required data had been reported and that contract-specified requirements had been met (e.g., analytical holding times, contractual turnaround times).

During the validation phase of the review and evaluation process, data were subjected to a systematic technical review by examining all field and analytical QC results and laboratory documentation, following appropriate guidelines for laboratory data validation. These data validation guidelines define the technical review criteria, methods for evaluation of the criteria, and actions to be taken resulting from the review of these criteria. The primary objectives of this phase were to assess and summarize the quality and reliability of the data for the intended use and to document factors that might affect the usability of the data. Data verification/validation included, but was not necessarily limited to, the parameters listed below.

Inorganic	**Organic**
Data completeness	Data completeness
Holding times	Holding times
Calibration	Calibration
- Initial	- Initial
- Continuing	- Continuing
Blanks	Blanks
Sample results verification	Surrogate recovery
Matrix spike recovery	
Field duplicate sample analysis	
Laboratory control sample analysis	Internal standards performance
Furnace atomic absorption QC (when implemented)	
Detection limits	Compound quantitation and reported detection limits
Secondary dilutions	Secondary dilutions

As a result of this phase of the review, the data were qualified based on the technical assessment of the validation criteria. Qualifiers were applied to each field and analytical result to indicate the usability of the data for their intended purpose.

D.3.3 DEFINITION OF DATA QUALIFIERS (FLAGS)

During the data validation process, all laboratory data were assigned appropriate data validation flags and reason codes. Validation flags are defined as follows:

"U" When the material is analyzed for, but not detected above the level of the associated value.

"J" When the associated value is an estimated quantity, indicating there is cause to question accuracy or precision of the reported value.

"UJ" When the analyte is analyzed for, but not detected above the associated value; however, the reported value is an estimate, indicating a decreased knowledge of its accuracy or precision.

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"R" When the analyte value reported is unusable. The integrity of the analyte's identification, accuracy, precision, or sensitivity has raised significant questions as to the reliability of the information presented.

SAIC validation flagging codes are provided in Attachment 1, while copies of validation checklists and qualified data forms are onfile with the analytical laboratory deliverable.

D.3.4 DATA ACCEPTABILITY

A total of 118 environmental soil, sediment, groundwater, surface water, and field QC samples were collected, with approximately 8600 discrete analyses (i.e., analytes) being obtained, reviewed, and integrated into the assessment. (These totals do not include field measurements and field descriptions.) The project produced acceptable results for more than 99% of the sample analyses performed and successfully collected all required investigation samples. Rejected data were confined to VOC determinations in two soil samples, acetone in most groundwater samples, chromium in five soil samples, selenium in six groundwater samples, and semivolatile phenolic compounds in one surface water sample.

Table D-1 presents a summary of the number of investigation samples collected. It also tallies the successful collection of appropriate targeted field QC and QA split samples. Table D-2 provides a summary of rejected analyses grouped by medium and analyte category.

Table D-1. Ft. Stewart South Central Landfill SWMU 1 Phase II RCRA Investigations Quality Control Summary Report

Medium	Environmental Samples	Field Duplicates	Trip Blanks	Equipment Rinsate Blanks	QA Split Samples	QA Trip Blanks
Soil	27	2	-	-	2	-
Sediment	4	1	-	-	1	-
Surface Water	4	1	2	2	1	1
Groundwater	51	5	15	4	4	2
Totals	**86**	**9**	**17**	**6**	**8**	**3**

Through appropriate data verification, validation, and review, analytical information has been identified as estimated and rejected, where appropriate. None of the pesticide/PCB, anion, or radiological data were rejected. Nine VOC compounds in two soil samples (18 analyses) were rejected due to low internal standard area counts, while acetone results in 20 groundwater samples were rejected due to poor initial instrument relative response factors. Five chromium values in soil samples and six selenium values in groundwater samples were rejected due to calibration drift during analysis. In addition, 14 acid extractable SVOCs were rejected in one surface water sample in relation to very low surrogate compound recovery. The majority of estimated values were assigned to analyte concentrations observed between the reporting level and method detection levels. Rejected results reflect a tendency to exhibit extreme negative bias and were, therefore, unable to support the requirements of the project. All data have been appropriately identified and qualified.

Table D-2. Ft. Stewart South Central Landfill SWMU 1 Phase II RCRA Investigation Summary of Rejected Analytes (grouped by medium and analysis group)

Medium	Analysis Group	Rejected/ Total	Percent Rejected
Soil	Metals	5/ 152	3.2
	Volatile organics	18/ 973	1.8
	Semivolatile organics	0/ 1216	0.0
	Pesticides and PCBs	0/ 513	0.0
	Radiological	0/ 32	0.0
	Subtotal	23/ 2886	0.8
Sediment	Metals	0/ 33	0.0
	Volatile organics	0/ 169	0.0
	Semivolatile organics	0/ 320	0.0
	Pesticides and PCBs	0/ 135	0.0
	Radiological	0/ 10	0.0
	Subtotal	0/ 667	0.0
Surface Water	Metals	0/ 40	0.0
	Volatile organics	0/ 165	0.0
	Semivolatile organics	14/ 256	5.4
	Pesticides and PCBs	0/ 140	0.0
	Radiological	0/ 8	0.0
	Subtotal	14/ 609	2.3
Groundwater	Metals	6/ 256	2.3
	Volatile organics	20/ 1954	1.0
	Semivolatile organics	0/ 1536	0.0
	Pesticides and PCBs	0/ 654	0.0
	Radiological	0/ 48	0.0
	Anions	0/ 24	0.0
	Subtotal	26/ 4472	0.5
Project Total		**63/ 8634**	**0.7**

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D.4 DATA EVALUATION

D.4.1 ACCURACY

Accuracy provides a gauge or measurement of the agreement between an observed result and the true value for an analysis. Analytical accuracy is evaluated by measuring the agreement between an analytical result and its known or true value. This level of agreement is generally determined through the use of LCSs, MS analysis, and performance evaluation samples. Accuracy, as measured through the use of LCSs, determines the method implementation accuracy independent of sample matrix. The LCSs document laboratory analytical process control. Accuracy determined by the MS is a function of both matrix and analytical process. Tables D-3 and D-4 present average LCS recovery values for the various parameters under investigation during these studies. Method blank surrogate compound recoveries and method blank target compound spiked analyses are two forms of LCS analyses. Table D-5 consolidates the average sample MS recovery values for parameters.

Volatile Organic Compounds

VOC LCS, surrogate, and MS recovery information provides measures of accuracy. Recoveries determined for laboratory volatile organic method blank spike and method blank surrogate analyses indicated that the analytical processes for procedures were in control. Individual sample surrogate recoveries and sample MS recoveries indicated that analytical accuracy for these compounds was in control and that the data are usable.

Method blank surrogate recoveries (Table D-3) were predominantly within 90 to 125% for the volatile analyses. Only a few values for dibromofluoromethane exceeded these levels, but they remained below 135%. Summaries in Table D-4 show that soil and water average LCS values range from 93.4 to 108.3%, while most recoveries were within 90 to 125%, except for a single value for benzene at 67% recovery.

Sample MS recoveries (Table D-5) indicated that analytical accuracy was in control, with average soil MS recoveries ranging from 100.4 to 112.3%. Average groundwater sample MS recoveries ranged from 92.4 to 102.3%.

Semivolatile Organic Compounds

Average LCS percent recovery values for SVOCs in soils ranged from 70.5 to 98.5%, while water average LCSs ranged from 31.7 to 79.7%. These values are predominantly within the normally accepted advisory limits established by the analytical methods. They are also within project accuracy goals of 35 to 140% for SVOCs, with the exception of 4-nitrophenol and phenol in water. However, none of the data required qualification based on LCS recoveries. Method blank surrogate recoveries (Table D-3) were all well within acceptable ranges for SVOCs, reinforcing that the analytical process was in control.

Sample MS information (Table D-5) for SVOCs parallels LCS data. Average percent recoveries range between 54.0 and 96.8% for soils and between 23.1 and 95.0% for waters, with the overall accuracy for these measurements being considered acceptable. Individual exceptions, such as pentachlorophenol, have been qualified.

Table D-3. Ft. Stewart South Central Landfill SWMU 1 Phase II RCRA Investigation Laboratory Control Sample Evaluation—Method Blank Average Surrogate Percent Recovery

	Soil				Water			
Analysis	**Average %Rec**	**Min. %Rec**	**Max. %Rec**	**N**	**Average %Rec**	**Min. %Rec**	**Max. %Rec**	**N**
Volatile Organic Compounds								
Toluene-d8	98.2	86	106	9	104.1	86	117	16
Bromofluorobenzene	95.2	77	107	9	101.0	81	121	16
Dibromofluoromethane	114.1	92	135	9	114.0	90	134	16
Semivolatile Organic Compounds								
Nitrobenzene-d5	90.5	80	101	2	77.0	68	86	6
2-Fluorobiphenyl	86.5	84	89	2	83.2	81	94	6
Terphenyl-d14	99.0	90	108	2	96.5	81	104	6
2-Fluorophenol	78.0	76	80	2	47.5	42	58	6
Phenol-d5	86.5	79	94	2	30.5	26	38	6
2,4,6-Tribromophenol	109.5	90	129	2	99.7	61	130	6
Pesticides/PCBs								
4-CMX	35.8	8	64	4	70.9	48	114	12
Dibutylchlorendate	61.5	40	81	4	86.3	75	113	12
BTEX/GRO Compounds								
n-Propylbenzene	102.8	96	111	6	-	-	-	-
DRO Compounds								
o-Terphenyl	92	-	-	1	-	-	-	-

%Rec = percent recovery
AA = atomic absorption
BTEX = benzene, toluene, ethylbenzene, and xylenes
DRO = diesel-range organics
GRO = gasoline-range organics
ICP = inductively coupled plasma
PCB = polychlorinated biphenyl
N = number of determinations

Table D-4. Ft. Stewart South Central Landfill SWMU 1 Phase II RCRA Investigation Laboratory Control Sample Evaluation—Method Blank Matrix Spike Average Percent Recovery

Analysis	Soil				Water			
	Average %Rec	Min. %Rec	Max. %Rec	N	Average %Rec	Min. %Rec	Max. %Rec	N
Volatile Organic Compounds								
Benzene	107.8	92	116	10	101.3	85	111	16
Chlorobenzene	101.6	85	122	10	101.4	84	113	16
1,1-Dichloroethene	100.4	81	123	10	93.4	67	114	16
Toluene	99.0	88	110	10	100.4	88	116	16
Trichloroethene	108.3	86	118	10	99.6	81	110	16
BTEX Compounds								
Benzene	105.0	98	108	4	-	-	-	-
Toluene	106.3	98	111	4	-	-	-	-
Ethylbenzene	109.5	102	114	4	-	-	-	-
Xylene	108.5	100	113	4	-	-	-	-
Semivolatile Organic Compounds								
Acenaphthene	72.5	63	82	2	79.7	71	85	6
1,4-Dichlorobenzene	70.5	65	76	2	68.7	54	78	6
2,4-Dinitrotoluene	74.5	74	75	2	75.7	59	92	6
n-Nitrosodi-n-Propylamine	88.0	80	96	2	79.0	71	89	6
Pyrene	98.5	87	110	2	92.3	72	114	6
1,2,4-Trichlorobenzene	68.5	59	78	2	72.2	65	79	6
4-Nitrophenol	74.0	60	88	2	31.7	17	58	6
Pentachlorophenol	65.0	64	69	2	70.0	54	81	6
Phenol	72.0	68	76	2	34.3	24	68	6
2-Chlorophenol	67.0	64	70	2	70.0	62	75	6
4-Chloro-3-Methylphenol	82.5	82	83	2	70.3	34	81	6

Table D-4 (continued)

Analysis	Soil				Water			
	Average %Rec	Min. %Rec	Max. %Rec	N	Average %Rec	Min. %Rec	Max. %Rec	N
GRO Compounds	99.0	90	108	2	-	-	-	-
DRO Compounds	112	-	-	1	-	-	-	-
Pesticides/PCBs								
Gamma-BCH	79.0	79	79	2	88.3	69	100	6
Heptachlor	83.5	82	85	2	93.3	73	110	6
Aldrin	83.5	76	91	2	87.7	68	100	6
Dieldrin	84.0	84	84	2	85.3	68	100	6
Endrin	78.0	76	80	2	86.0	64	104	6
4,4'-DDT	91.5	84	99	2	88.7	64	104	6
Metals (ICP and AA)								
Arsenic	79.0	73	85	2	95.3	88	102	4
Barium	119.0	112	126	2	103.0	94	112	4
Cadmium	88.5	83	94	2	100.3	93	105	4
Chromium	92.0	92	92	2	96.3	91	101	4
Lead	87.3	83	95	2	94.5	93	98	4
Selenium	74.5	66	83	2	92.5	86	99	4
Silver	101.0	97	105	2	102.8	96	107	4
Mercury	93.0	90	102	2	97.5	82	112	4
Iron	-	-	-	-	104.3	98	110	3
Miscellaneous								
Radium 226	-	-	-	-	106.5	94	119	2
Radium 228	-	-	-	-	98.5	79	118	2
Sulfate	-	-	-	-	103.6	90	101	7

%Rec = percent recovery
AA = atomic absorption
BTEX = benzene, toluene, ethylbenzene, and xylenes
DRO = diesel-range organics
GRO = gasoline-range organics
ICP = inductively coupled plasma
PCB = polychlorinated biphenyl
N = number of determinations

Table D-5 Ft. Stewart South Central Landfill SWMU 1 Phase II RCRA Investigation Sample Matrix Spike Evaluation—Average Percent Recovery

	Soil				Water			
Analysis	**Average %Rec**	**Min. %Rec**	**Max. %Rec**	**N**	**Average %Rec**	**Min. %Rec**	**Max. %Rec**	**N**
Volatile Organic Compounds								
1,1-Dichloroethene	112.3	80	132	8	92.4	66	132	16
Benzene	101.0	94	107	8	101.6	84	121	16
Trichloroethane	100.4	93	107	8	97.4	77	121	16
Toluene	101.3	86	116	8	102.3	88	134	16
Chlorobenzene	101.4	82	116	8	99.0	86	116	16
Semivolatile Organic Compounds								
Acenapthene	73.8	67	84	4	78.1	66	89	8
1,4-Dichlorobenzene	65.5	61	69	4	70.5	59	79	8
n-Nitrosodi-n-Propylamine	92.8	71	109	4	76.4	61	89	8
1,2,4-Trichlorobenzene	66.8	63	74	4	70.0	60	83	8
2,4-Dinitrotoluene	79.5	68	89	4	71.5	58	88	8
Pyrene	96.8	85	110	4	95.0	75	113	8
Pentachlorophenol	87.0	81	93	2	23.1	0	40	8
Phenol	65.0	62	68	2	31.5	20	43	8
2-Chlorophenol	66.0	63	69	2	48.9	30	76	8
4-Chloro-3-Methylphenol	81.0	76	86	2	60.8	45	84	8
4-Nitrophenol	54.0	49	59	2	23.8	6	33	8
Pesticides/PCBs								
Gamma-BHC	88.0	83	93	2	78.4	58	100	8
Heptachlor	88.0	83	93	2	81.3	58	100	8
Aldrin	76.0	72	80	2	80.8	49	110	8
Dieldrin	74.0	69	79	2	78.5	56	92	8
Endrin	66.0	61	71	2	77.0	64	96	8
4,4'-DDT	77.5	76	79	2	81.0	60	96	8

Table D-5 (continued)

	Soil				Water			
Analysis	**Average %Rec**	**Min. %Rec**	**Max. %Rec**	**N**	**Average %Rec**	**Min. %Rec**	**Max. %Rec**	**N**
BTEX Compounds								
Benzene	109.3	104	114	4	-	-	-	-
Toluene	112.3	108	117	4	-	-	-	-
Ethylbenzene	110.0	106	114	4	-	-	-	-
Xylene	108.0	105	113	4	-	-	-	-
GRO Compounds	75.3	65	84	4	-	-	-	-
Metals (ICP and AA)								
Arsenic	81.0	81	81	2	95.0	88	101	4
Barium	97.5	91	104	2	103.3	93	112	4
Cadmium	94.0	89	96	2	99.3	93	103	4
Chromium	102.0	96	110	2	96.8	91	99	4
Lead	86.5	82	91	2	93.0	90	97	4
Selenium	77.5	76	79	2	91.3	86	97	4
Silver	101.0	97	105	2	102.0	96	108	4
Mercury	94.0	80	108	2	95.5	83	105	4
Iron	-	-	-	-	106.0	101	111	2
Miscellaneous								
Radium 226	-	-	-	-	98.0	87	109	2
Radium 228	-	-	-	-	100.0	90	110	2
Sulfate	-	-	-	-	103.3	100	108	6

%Rec = percent recovery
AA = atomic absorption
BTEX = benzene, toluene, ethylbenzene, and xylenes
GRO = gasoline-range organics
ICP = inductively coupled plasma
PCB = polychlorinated biphenyl
N = number of determinations

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Pesticide Compounds

Average LCS percent recovery values for pesticide compounds in soils ranged from 78.0 to 91.5%, while water average LCSs ranged from 85.3 to 93.3%. These values are predominantly within the normally accepted advisory limits established by the analytical methods. They are also within project accuracy goals of 35 to 140% for pesticide compounds. None of the data required qualification based on LCS recoveries. Method blank surrogate recoveries (Table D-3) were all within acceptable ranges for pesticide compounds, reinforcing that the analytical process was in control.

Sample MS information (Table D-5) for pesticide compounds parallels LCS data. Average percent recoveries ranged between 74.0 and 88.0% for soils and between 77.0 and 81.3% for waters, with the overall accuracy for these measurements being considered acceptable.

RCRA Metals and Miscellaneous Parameters

All metal water average LCS values fell within a 90 to 110% range, while average soil LCS recoveries ranged from 74.5 to 119.0%. MS information (Table D-5) was as good as were the LCS recoveries, with average water MS values ranging from 91.3 to 103.3% and average soil MS values ranging from 77.5 to 102.0%.

Blank surrogate recoveries, LCS values, and MS recoveries for gasoline-range organic and diesel-range organic analyses were acceptable and did not cause qualification of the data. Radium isotopic and sulfate determination also showed acceptable laboratory control information.

D.4.2 PRECISION

Laboratory Precision

Table D-6 contains average Relative Percent Differences (RPDs) for laboratory duplicate sample pairs for the various analytical groups as a measure of analytical precision. Data are presented for parameters in which both values met or exceeded five times the project-required detection limits for that analyte. Data presented compare MS and MS duplicate values. As the RPD approaches zero, complete agreement is achieved between the duplicate sample pairs. Sample homogeneity, analytical method performance, and the quantity of analyte being measured all contribute to this measurement of sample analytical precision.

Soil and water precision are considered acceptable when the RPD does not exceed 40. This limit was exceeded for only one analyte, pentachlorophenol. Most average RPD values were well within a 20% window of acceptance. In only a few instances did individual duplicate comparisons fall outside this level as demonstrated by the maximum RPDs presented in Table D-6. RPD values were very good for these samples and reflect great effort on the part of the field and laboratory teams to homogenize the samples prior to aliquotting and analysis.

Duplicate comparison for those data within five times the reporting level have also been reviewed and evaluated. Acceptance limits for these data were set at plus or minus two times the reporting level. In all cases laboratory duplicate comparisons at these low levels were in agreement.

Table D-6. Ft. Stewart South Central Landfill SWMU 1 Phase II RCRA Investigation Sample Matrix Spike Duplicate or Duplicate Evaluation—Relative Percent Difference

	Soil				**Water**			
Analysis	**Average %Rec**	**Min. %Rec**	**Max. %Rec**	**N**	**Average %Rec**	**Min. %Rec**	**Max. %Rec**	**N**
Volatile Organic Compounds								
1,1-Dichloroethene	4.5	1	10	4	8.1	0	22	8
Benzene	2.5	0	8	4	8.6	2	19	8
Trichloroethane	2.8	1	8	4	9.5	2	22	8
Toluene	6.0	2	12	4	4.1	1	9	8
Chlorobenzene	7.5	4	18	4	5.4	0	19	8
Semivolatile Organic Compounds								
Acenapthene	7.0	3	11	2	8.3	5	14	4
1,4-Dichlorobenzene	6.0	0	12	2	11.5	8	17	4
n-Nitrosodi-n-Propylamine	7.0	0	14	2	9.3	5	18	4
1,2,4-Trichlorobenzene	6.5	2	11	2	10.8	8	15	4
2,4-Dinotrotoluene	11.5	8	15	2	9.5	3	13	4
Pyrene	4.5	3	6	2	7.5	1	16	4
Pentachlorophenol	14	-	-	1	61.0	8	200	4
Phenol	9	-	-	1	21.3	0	49	4
2-Chlorophenol	9	-	-	1	30.0	6	87	4
4-Chloro-3-Methylphenol	12	-	-	1	15.8	12	21	4
4-Nitrophenol	18	-	-	1	39.8	7	108	4
Pesticides/PCBs								
Gamma-BHC	11	-	-	1	14.3	7	23	4
Heptachlor	11	-	-	1	12.3	4	23	4
Aldrin	10	-	-	1	14.3	4	25	4
Dieldrin	14	-	-	1	12.0	0	25	4
Endrin	15	-	-	1	10.3	0	22	4
4,4'-DDT	4	-	-	1	15.3	9	25	4

Table D-6 (continued)

Analysis	Soil				Water			
	Average %Rec	Min. %Rec	Max. %Rec	N	Average %Rec	Min. %Rec	Max. %Rec	N
BTEX Compounds								
Benzene	0.5	0	1	2	-	-	-	-
Toluene	0.5	0	1	2	-	-	-	-
Ethylbenzene	2.0	2	2	2	-	-	-	-
Xylene	2.0	0	4	2	-	-	-	-
GRO Compounds	4.5	2	7	2	-	-	-	-
Metals (ICP and AA)								
Arsenic	0.6	-	-	1	1.0	1	1	3
Barium	1.9	-	-	1	0.7	0	2	3
Cadmium	2.2	-	-	1	2.3	0	5	3
Chromium	1.9	-	-	1	1.7	0	3	3
Lead	2.7	-	-	1	1.7	0	4	3
Mercury	0.6	-	-	1	1.7	1	3	3
Selenium	1.3	-	-	1	1.3	0	2	3
Silver	2.9	-	-	1	3.3	0	8	3
Iron	-	-	-	-	6.3	1	14	3
Miscellaneous								
Radium 226	-	-	-	-	19.0	13	25	3
Radium 228	-	-	-	-	20.0	6	39	3
Sulfate	-	-	-	-	1.7	1	3	3

%Rec = percent recovery
AA = atomic absorption
BTEX = benzene, toluene, ethylbenzene, and xylenes
GRO = gasoline-range organics
ICP = inductively coupled plasma
PCB = polychlorinated biphenyl
N = number of determinations

Individual data points affected by poor precision measures appear in the data set qualified as estimated, when necessary. The precision for those data is considered acceptable, and the data have been determined to be usable for project objectives.

Field Precision

Field duplicate samples were collected to ascertain the contribution to variability (i.e., precision) due to the combination of environmental media, sampling consistency, and analytical precision. Field duplicate samples were collected from the same spatial and under the same temporal conditions as the primary environmental sample. Soil samples were collected from the same sampling device after homogenization for all analytes except VOCs.

Table D-7 provides a summary of field duplicate comparisons by analyte. The table presents both absolute-difference and RPD evaluations for field duplicate measurements. The RPD was calculated only when both samples were more than five times the analyte reporting level. When one or both sample values were between the quantitation level and five times the analyte reporting level, the absolute difference was evaluated. If both samples registered no detection for a given analyte, precision was considered acceptable. All field duplicate pairs are included in the tabulation.

To review information this DQA has implemented general criteria for comparison of absolute-difference measurements and RPDs. RPD criteria are identified below. Absolute difference criteria were set at three times the analyte reporting level.

	RPD Evaluation Categories			
Matrix	**Good**	**Fair**	**Poor**	**Unacceptable**
Water	<30%	<60%	<100%	>100%
Soil	<50%	<90%	<150%	>150%

Soil and sediment field duplicates exhibited low concentrations, and all comparisons were considered acceptable. Most groundwater analyte concentrations were not high enough to provide RPD evaluation; however, absolute-difference considerations and available RPD values indicated a "Good" comparison for the data, with only a single iron comparison exceeding 30%.

A subset of field duplicate analysis compares groundwater filtered and total values. Such an evaluation was made with the same criteria as for the other field duplicates, and the results showed a "Good" agreement between each of the sample pairs.

D.4.3 SENSITIVITY

Determination of minimum detectable values allows the investigation to assess the relative confidence that can be placed in a value in comparison to the magnitude or level of analyte concentration observed. The closer a measured value comes to the minimum detectable concentration, the lower confidence and the greater the variation in the measurement. Project sensitivity goals were expressed as quantitation level goals in the QAPP. These levels were achieved or exceeded throughout the analytical process. There were individual exceptions that generated qualification of the data or elevation of detections levels when the original goal was not

Table D-7. Ft. Stewart South Central Landfill SWMU 1 Phase II RCRA Investigation Soil/Sediment and Surface Water/Groundwater Field Duplicate Evaluation—Relative Percent Difference and Absolute Difference

Analysis	Soil 011151/011161 RPD	Soil 011111/011121 RPD	Sediment 262111/262121 RPD	Sediment 015111/015121 RPD	Surface Water 013311/013321 RPD
Volatile Organic Compounds					
All Compounds Except Acetone	*	*	*	31	-
Semivolatile Organic Compounds					
All Compounds	-	*	-	*	-
Pesticides/PCBs					
All Compounds	-	*	-	-	-
Metals (ICP and AA)					
Arsenic	-	*	*	-	*
Barium	-	*	*	-	*
Cadmium	-	*	*	-	*
Chromium	-	*	*	-	*
Lead	-	*	*	-	*
Mercury	-	*	*	-	*
Selenium	-	*	*	-	*
Silver	-	*	*	-	*
Iron	-	-	-	-	-
Miscellaneous					
Radium 226	-	*	-	-	*
Radium 228	-	*	-	-	*
Sulfate	-	-	-	-	-

Table D-7 (continued)

Analysis	Groundwater 012B51/012B61 RPD	Grounwater 012N51/012N61 RPD	Groundwater 012351/012361 RPD	Groundwater 012311/012321 RPD	Groundwater 012511/012521 RPD
Volatile Organic Compounds					
All Compounds Except Acetone	*	*	18	*	*
Semivolatile Organic Compounds					
All Compounds	-	-	-	*	*
Pesticides/PCBs					
All Compounds	-	-	-	*	*
Metals (ICP and AA)					
Arsenic	-	-	-	*	*
Barium	-	-	-	*	*
Cadmium	-	-	-	*	*
Chromium	-	-	-	*	*
Lead	-	-	-	*	*
Mercury	-	-	-	*	*
Selenium	-	-	-	*	*
Silver	-	-	-	*	*
Iron	-	-	-	23	57
Miscellaneous					
Radium 226	-	-	-	*	*
Radium 228	-	-	-	*	*
Sulfate	-	-	-	1	0

* Acceptable = At least one value is greater than five times the reported detection level, and duplicate ocmparison is within three times the reported detection level.

AA = atomic absorption

IPCP = inductively coupled plasma

PCB = polychlorinated biphenyl

UNAC = Unacceptable: At least one value is less than five times the reported detection level, and duplicate comparison is greater than three times the reported detection level.

achieved. Variations observed were caused by fluctuations in moisture content or the need to dilute high concentration analytes into linear range for analysis.

Evaluation of overall project sensitivity can be gained through review of field blank information. These actual sample analyses may provide a comprehensive look at the combined sampling and analysis sensitivity attained by the project. Field QC blanks obtained during sampling activities included samples of VOC trip blank waters. Summary information for those blank determinations exhibiting detectable levels is presented in Table D-8.

Table D-8. Ft. Stewart South Central Landfill SWMU 1 Phase II RCRA Investigation Trip Blank Summary

Analysis	**TBA001 (g/L)**	**TBA002 (g/L)**	**TBA003 (g/L)**	**TBA004 (g/L)**
Volatile Organic Compounds				
2-Butanone	42	95	10 U	10 U
2-Hexanone	14 J	6 J	10 U	10 U
4-Methyl-2-Pentanone	5 U	5 U	10 U	10 U
Acetone	139 J	100 J	10 R	10 R
Chloroform	2 U	2 U	2 U	5 U

Analysis	**TBA005 (g/L)**	**TBA006 (g/L)**	**TBA012 (g/L)**	**TBA013 (g/L)**
Volatile Organic Compounds				
2-Butanone	10 U	10 U	10 U	10 U
2-Hexanone	10 U	10 U	10 UJ	10 UJ
4-Methyl-2-Pentanone	5 J	4 J	10 UJ	10 UJ
Acetone	29 J	21 J	10 U	10 U
Chloroform	5 U	5 U	5 U	5 U

Analysis	**TBA014 (g/L)**	**TBA015 (g/L)**	**TBA016 (g/L)**	**TBA020 (g/L)**
Volatile Organic Compounds				
2-Butanone	10 U	10 U	10 U	10 U
2-Hexanone	10 U	10 U	10 U	10 U
4-Methyl-2-Pentanone	10 U	10 UJ	10 U	10 U
Acetone	10 U	10 U	10 U	10 R
Chloroform	5 U	5 U	5 U	5 U

Analysis	**TBA021 (g/L)**	**TBA024 (g/L)**	**TBA027 (g/L)**	**TBA029 (g/L)**	**TBA031 (g/L)**
Volatile Organic Compounds					
2-Butanone	10 U	10 UJ	10 U	10 U	10 U
2-Hexanone	10 U	10 UJ	10 U	10 U	10 U
4-Methyl-2-Pentanone	10 U	10 UJ	10 U	10 U	10 U
Acetone	10 R	6 J	10 UJ	4 J	4 J
Chloroform	5 U	5 U	5 U	1 J	1 J

See Section D.3.3 for definitions of data qualifiers.

A minimal number of VOCs were detected in project trip blanks. With the exception of a few acetone values, these were all below their associated reporting levels and only just above the laboratory instrument detection levels. These levels are not considered significant and have not caused data qualification. It has, therefore, been determined that VOC analyses have not been affected through the transportation and storage process, and that the procedures and precautions employed were effective in preserving sample analysis integrity.

D.4.4 REPRESENTATIVENESS AND COMPARABILITY

Representativeness expresses the degree to which data accurately reflect the analyte or parameter of interest for the environmental site and is the qualitative term most concerned with the proper design of the sampling program. Factors that affect the representativeness of analytical data include proper preservation, holding times, use of standard sampling and analytical methods, and determination of matrix or analyte interferences. No data points were rejected based on extended holding times, while only a few analyses were estimated and qualified. Sample preservation, analytical methodologies, and soil sampling methodologies were documented as being adequate and consistently applied. Both soil and groundwater sampling methods have been proven to have been effectively applied in this study.

Comparability, like representativeness, is a qualitative term relative to a project data set as an individual entity. The investigations employed appropriate sampling methodologies, site surveillance, use of standard sampling devices, uniform training, documentation of sampling, standard analytical protocols/procedures, QC checks with standard control limits, and universally accepted data reporting units to ensure comparability to other data sets. Through the proper implementation and documentation of these standard practices, the project has established the confidence that the data will be comparable to other project and programmatic information.

D.4.5 COMPLETENESS

Usable data are defined as those data that pass individual scrutiny during the verification and validation process and are accepted for unrestricted application to the human health risk assessment evaluation or equivalent-type applications. It has been determined that estimated data are acceptable for project objectives.

Objectives for this investigation have been achieved. The project produced valid results for more than 99% of the sample analyses performed and successfully collected all required investigation samples.

D.5 DATA QUALITY ASSESSMENT SUMMARY

The overall quality of the South Central Landfill investigation information met or exceeded the established project objectives. Through proper implementation of the project data verification, validation, and assessment process, project information has been determined to be usable.

Data, as presented, have been qualified as usable but as estimated, when necessary. Estimated data accuracy, precision, or sensitivity was less than desired, but adequate for interpretation.

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Data produced for this study demonstrated that they can withstand scientific scrutiny, are appropriate for their intended purpose, are technically defensible and are of known and acceptable sensitivity, precision, and accuracy. Data integrity has been documented through proper implementation of QA/QC measures. The environmental information presented has an established confidence that allows utilization for the project objectives and provides data for future needs.

D.6 REFERENCES

EPA (U.S. Environmental Protection Agency), 1994a. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, EPA 540/R-94/013, Office of Emergency and Remedial Response, Washington, D.C.

EPA, 1994b. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, EPA 540/R-94/012, Office of Emergency and Remedial Response, Washington, D.C.

SAIC (Science Applications International Corporation), 1995. Data Validation Guidelines for Analytical Data, Quality Assurance Technical Procedure TP-DM-300-7, Rev.1.

SAIC, 1997. Sampling and Analysis Plan for the Phase II RCRA Facility Investigation for the South Central Landfill (SWMU 1), Fort Stewart, Georgia.

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ATTACHMENT 1
TO
APPENDIX D

SAIC VALIDATION FLAGGING CODES

PHASE II RCRA FACILITY INVESTIGATION
SOUTH CENTRAL LANDFILL (SWMU 1)
FORT STEWART, GEORGIA

MAY 1998

DATA VALIDATION FLAGGING CODES

Blanks

F01	Sample data were qualified as a result of the method blank.
F02	Sample data were qualified as a result of the field blank.
F03	Sample data were qualified as a result of the equipment rinsate.
F04	Sample data were qualified as a result of the trip blank.
F05	Gross contamination exists.
F06	Concentration of the contaminant was detected at a level below the CRQL.
F07	Concentration of the contaminant was detected at a level less than the action limit, but greater than the CRQL.
F08	Concentration of the contaminant was detected at a level that exceeds the action level.
F09	No laboratory blanks were analyzed.
F10	Blank had a negative value >5×'s the IDL.
F11	Blanks were not analyzed at required frequency.
F12	Professional judgement was used to qualify the data.

Surrogate Recovery

G01	Surrogate recovery was above the upper control limit.
G02	Surrogate recovery was below the lower control limit.
G03	Surrogate recovery was <10%.
G04	Surrogate recovery was zero.
G05	Surrogate was not present.
G06	Professional judgement was used to qualify the data.

Matrix Spike/Matrix Spike Duplicate

H01	MS/MSD recovery was above the upper control limit.
H02	MS/MSD recovery was below the lower control limit.
H03	MS/MSD recovery was <10%.
H04	MS/MSD pairs exceed the RPD limit.
H05	No action was taken on MS/MSD results.
H06	Professional judgement was used to qualify the data.

Matrix Spike

I01	MS recovery was above the upper control limit.
I02	MS recovery was below the lower control limit.
I03	MS recovery was <30%.
I04	No action was taken on MS data.
I05	Professional judgement was used to qualify the data.

Laboratory Duplicate

J01	Duplicate RPD was outside the control limit.
J02	Duplicate sample results were >5× the CRDL.
J03	Duplicate sample results were <5× the CRDL.
J04	Professional judgement was used to qualify the data.

Internal Area Summary

K01	Area counts were outside the control limits.
K02	Extremely low area counts or performance was exhibited by a major drop off.
K03	IS retention time varied by more than 30 seconds.
K04	Professional judgement was used to qualify the data.

Laboratory Control Samples (LCSs)

P01	LCS recovery was above upper control limit.
P02	LCS recovery was below lower control limit.
P03	LCS recovery was <50%.
P04	No action was taken on the LCS data.
P05	LCS was not analyzed at required frequency.

Target Compound Identification

M01	Incorrect identifications were made.
M02	Qualitative criteria were not met.
M03	Cross contamination occurred.
M04	Confirmatory analysis was not performed.
M05	No results were provided.
M06	Analysis occurred outside 12 hr GC/MS window.
M07	Professional judgement was used to qualify the data.
M08	The %D between the two pesticide/PCB column checks was >25%

Initial/Continuing Calibration - Organics

C01	Initial calibration RRF was <0.05.
C02	Initial calibration RSD was >30%.
C03	Initial calibration sequence was not followed as required.
C04	Continuing calibration RRF was <0.05.
C05	Continuing calibration %D was >25%.
C06	Continuing calibration was not performed at the required frequency.
C07	Resolution criteria were not met.
C08	RPD criteria were not met.
C09	RSD criteria were not met.
C10	Retention time of compounds was outside windows.
C11	Compounds were not adequately resolved.
C12	Breakdown of endrin or DDT was >20%.
C13	Combined breakdown of endrin/DDT was >30%.
C14	Professional judgement was used to qualify the data.

APPENDIX E

PHASE II RCRA RFI REPORT
SOUTH CENTRAL LANDFILL (SWMU 1)
FORT STEWART, GEORGIA

GEOTECHNICAL LABORATORY TEST RESULTS

PERMEABILITY TEST ANALYSIS (ASTM D5084)

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Project : Fort Stewart, GA

Location of Project : SWMU-1

Description of Soil : Tan Sand w/ Clay

Job # : 97223
Date of Testing: 12/8-12/11/97
Tested by: BV-CA
Boring # :
Sample # : 011113
Sample Depth : 5-7ft.

Sample Type (Undisturbed or Remolded)
Standard Proctor:
Maximim Dry Density: ______ pcf
Optimum Moisture Content: ______ %

% Sample Compaction: ______ %
Sample Dry Density: ______ pcf
Sample Moisture Content: ______ %
Sample Wet Density: ______ pcf

Sample Permeation:

De-Aired Water
% Saturation: 100 %
Cell Pressure: 55 psi
Lower Pressure: 51 psi
Upper Pressure: 50 psi
Gradient: 8.38

Sample Dimensions		
	Before	After
Length (cm)	8.40	8.15
Diameter (cm)	7.50	7.35
Water Content (%)	14.8	13.4
Weight (g)	771.10	763.40

Constant Head Calculation:

$$K = [V(t_1,t_2)\ LR_T]/[P_B A t]\ (\text{cm/sec})$$

$V(t_1,t_2)$ = Volume of flow from t_1 to t_2 (cm^2)
L = Length of Sample = 8.40 cm
A = Area of Sample = 44.18 cm^2
t = $t_2 - t_1$ (sec)
P_B = Bias Pressure = 1 psi x 70.37 cm/psi (cm - H2O) 70.37 cm
R_T = Temperature correction = 0.931

t_2 (min)	t_1 (min)	$(t_2 - t_1)$*60 (sec)	V (cm³)	$[LR_T]/[P_BA]$ (cm²)	K (cm/sec)
9	8	60	1.4	2.52E-03	5.87E-05
10	9	60	1.4	2.52E-03	5.87E-05
11	10	60	1.3	2.52E-03	5.45E-05
12	11	60	1.3	2.52E-03	5.45E-05

K_{avg} = 5.66E-05 cm/sec

PERMEABILITY TEST ANALYSIS (ASTM D5084)

Project : Fort Stewart, GA

Location of Project : SWMU-1

Description of Soil : Gray Silty Sand

Job # : 97223
Date of Testing: 12/8-12/17/97
Tested by: BV-CA
Boring # : ________
Sample # : 01v213
Sample Depth : 10-12ft.

Sample Type ([✓ Undisturbed] or Remolded)
Standard Proctor:
Maximim Dry Density: ________ pcf
Optimum Moisture Content: ________ %

% Sample Compaction: ________ %
Sample Dry Density: ________ pcf
Sample Moisture Content: ________ %
Sample Wet Density: ________ pcf

Sample Permeation:

De-Aired Water
% Saturation: 98 %
Cell Pressure: 45 psi
Lower Pressure: 41 psi
Upper Pressure: 40 psi
Gradient: 11.35

Sample Dimensions		
	Before	After
Length (cm)	6.20	5.80
Diameter (cm)	7.40	7.20
Water Content (%)	17.7	18.7
Weight (g)	556.80	508.20

Constant Head Calculation:

$$K = [V(t_1,t_2)\ LR_T]/[P_B A t]\ \text{(cm/sec)}$$

$V(t_1,t_2)$ = Volume of flow from t_1 to t_2 (cm^2)
L = Length of Sample = 6.20 cm
A = Area of Sample = 43.01 cm^2
t = $t_2 - t_1$ (sec)
P_B = Bias Pressure = 1 psi x 70.37 cm/psi $_{(cm - H2O)}$ 70.37 cm
R_T = Temperature correction = 0.931

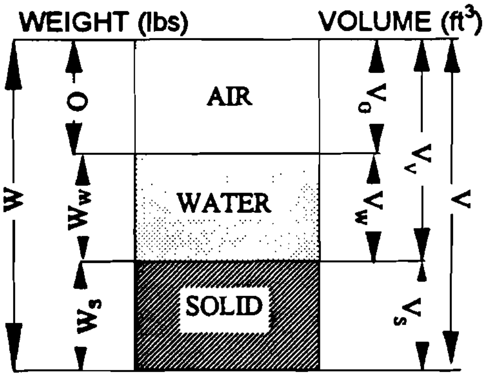
t_2 (sec)	t_1 (sec)	$(t_2 - t_1)$ (sec)	V (cm^3)	$[LR_T]/[P_BA]$ (cm^{-1})	K (cm/sec)
5	0	5	2.6	1.91E-03	9.92E-04
10	5	5	2.6	1.91E-03	9.92E-04
15	10	5	2.2	1.91E-03	8.39E-04
20	15	5	2.0	1.91E-03	7.63E-04

K_{avg} = 8.96E-04 cm/sec

SPECIFIC GRAVITY AND POROSITY

PROJECT: Fort Stewart, GA
LOCATION OF PROJECT: SWMU-1
DESCRIPTION OF SOIL: Tan Sand w/ Clay
TESTED BY: c. agustin

JOB NO.: 97223
SAMPLE NO. : 011113
DEPTH OF SAMPLE: 5-7 ft.
DATE OF TESTING: 12/24/97



$W =$ 3.00022
$W_W = W - W_S =$ 0.37054
$W_S = Y_d{*}V =$ 2.6297

$V =$ 0.02171
$V_W = W_W/Y_W =$ 0.0059
$V_S = W_S/G_S{*}Y_W =$ 0.0160
$V_G = V - (V_S + V_V) =$ -0.00018
$V_V = V_G + V_W$ 0.0058

MEASUREMENTS OF TUBE/CAN
HEIGHT= 15.1 cm
DIAMETER= 7.2 cm

CALCULATED VOLUME OF TUBE/CAN
V= 614.80 cm^3
0.02171 ft^3

WT. OF TUBE/CAN + WET SOIL= 1772.60 g
WEIGHT OF TUBE/CAN= 411.7 g
WEIGHT OF WET SOIL= 1360.90 g
W = 3.00022 lb

MOISTURE CONTENT
$M_{CWS} =$ 42.04 g
$M_{CDS} =$ 38.74 g
$M_W =$ 3.30 g
$M_C =$ 15.32 g
$M_S =$ 23.42 g
$w =$ 14.1 %

Wet Density, $Y_m = W / V$

Dry Density, $Y_d = W_s / V$ or $Y_d = Y_m / (1+ w)$	
double check	$Y_d = Y_m / (1+ w)$
$Y_d = W_s / V$	$Y_m =$ 138.17 lbs/ft^3
$Y_d =$ 121.10 lbs/ft^3	$Y_d =$ 121.10 lbs/ft^3

Void Ratio, $e = V_V/V_S$
$e =$ 0.3610

Porosity, $n = V_V / V$
$n =$ 0.27

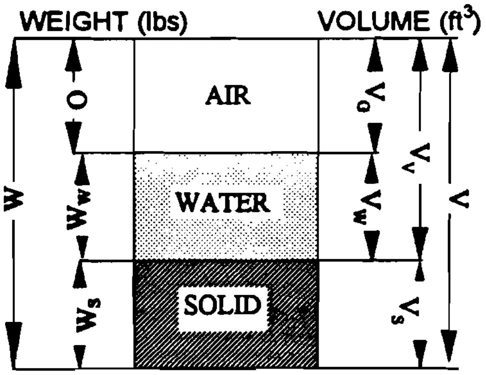
Specific Gravity = 2.64

Degree of Saturation, $S = V_W/V_V$
$S =$ 1.03

SPECIFIC GRAVITY AND POROSITY

PROJECT: Fort Stewart, GA
LOCATION OF PROJECT: SWMU-1
DESCRIPTION OF SOIL: Gray Silty Sand
TESTED BY: c. agustin

JOB NO.: 97223
SAMPLE NO.: 01v213
DEPTH OF SAMPLE: 0-2 ft.
DATE OF TESTING: 12/8/97



$W =$ 2.25397
$W_W = W - W_S =$ 0.31472
$W_S = Y_d{*}V =$ 1.9393

$V =$ 0.01869
$V_W = W_W/Y_W =$ 0.0050
$V_S = W_S/G_S{*}Y_W =$ 0.0115
$V_G = V - (V_S + V_V) =$ 0.00211
$V_V = V_G + V_W$ 0.0071

MEASUREMENTS OF TUBE/CAN

HEIGHT= 13.0 cm
DIAMETER= 7.2 cm

WT. OF TUBE/CAN + WET SOIL= 1376.40 g
WEIGHT OF TUBE/CAN= 354.0 g
WEIGHT OF WET SOIL= 1022.40 g
W = 2.25397 lb

CALCULATED VOLUME OF TUBE/CAN

V= 529.30 cm³
0.01869 ft³

MOISTURE CONTENT

$M_{CWS} =$	50.48	g	$M_C =$	15.53	g
$M_{CDS} =$	45.60	g	$M_S =$	30.07	g
$M_W =$	4.88	g	$w =$	16.2	%

Wet Density, $Y_m = W / V$

Dry Density, $Y_d = W_s / V$ or $Y_d = Y_m / (1 + w)$	
double check	$Y_d = Y_m / (1 + w)$
$Y_d = W_s / V$	$Y_m =$ 120.57 lbs/ft³
$Y_d =$ 103.73 lbs/ft³	$Y_d =$ 103.73 lbs/ft³

Void Ratio, $e = V_V/V_S$
e = 0.6189

Porosity, $n = V_V / V$
n = 0.38

Specific Gravity = 2.69

Degree of Saturation, $S = V_W/V_V$
S = 0.7053

ATTERBERG LIMITS DETERMINATION (ASTM D4318-93)

Project Fort Stewart Job No. 97223

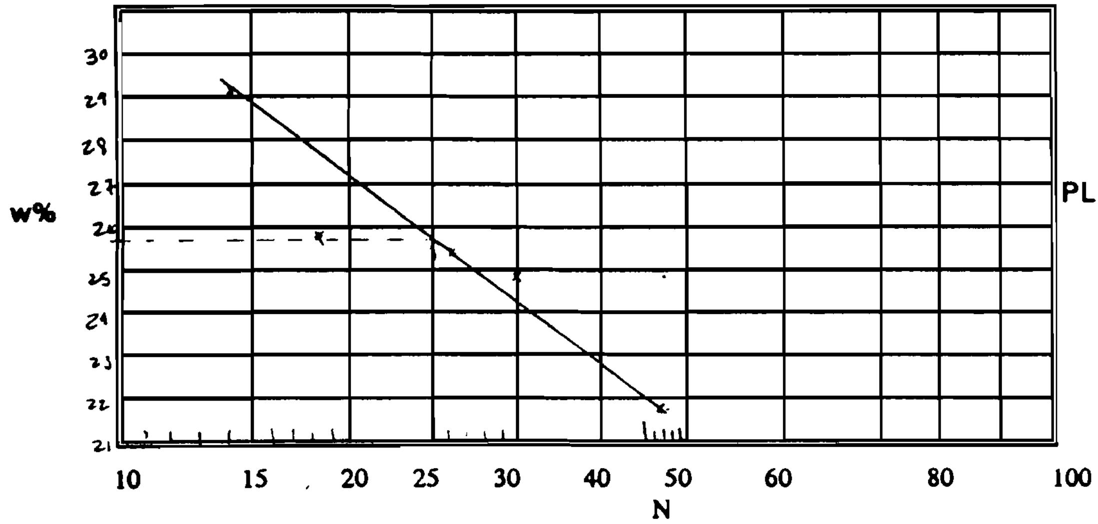
Location of Project Fort Stewart, GA : SWMU-1 Boring No. ________ Sample No. 011113

Description of Soil Tan Sand w/ Clay CL

Depth of Sample 5-7' Tested By C.A Date of Testing 12·18 97

Liquid Limit Determination

Can no.	C21	C12	C5	C20	C7	
Wt. of soil + can, M_{cws}	9.88	12.06	10.49	13.18	12.21	
Wt. of dry soil + can, M_{cds}	8.54	10.13	8.85	10.97	10.00	
Wt. of can, M_c	2.39	2.39	2.40	2.40	2.41	
Wt. of dry soil, M_s	6.15	7.74	6.45	8.57	7.59	
Wt. of moisture	1.34	1.93	1.64	2.21	2.21	
Water content, w%	21.79	24.94	25.43	25.79	29.12	
No. of blows, N	46	30	26	18	14	



LIQUID LIMIT = 25.7

PLASTIC LIMIT = 17.0

PLASTICITY INDEX = 8.7

CL

Plastic Limit Determination

Can no.	C9	C3	C4	
Wt. of wet soil + can, M_{cws}	2.57	2.72	2.68	
Wt. of dry soil + can, M_{cds}	2.47	2 60	2.57	
Wt. of can, M_c	1.88	1.91	1.91	
Wt. of dry soil, M_s	0.59	0.69	0.66	
Wt. of moisture, M_w	01	0.12	0.11	
Water content, w% = w_p	16.95	17.39	16.67	

GRAIN SIZE ANALYSIS-SIEVE (ASTM D422)

Project Fort Stewart
Job No. 97223
Location of Project Fort Stewart, GA : SWMU - 1
Sample No. 011113
Description of Soil
Depth of Sample
Boring No.
Tested By
Date of Testing 11/26/97

Sample preparation procedures outlined in ASTM D421 and D2217.

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Weight of sample used, M_{ws}= __________ g 403.4

M_{cws}	M_{cds}	M_c ____	M_w	M_s	w %	M_{ws}	M_s

Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	Σ % retained	% passing
3"		0	0	0	100
2"		0	0	0	100
1 1/2 "		0	0	0	100
3/4"		0	0	0	100
3/8"		0	0	0	100
#4		0	0	0	100
#10		5.45	2.24	2.24	97.76
#20		50.39	20.79	23.03	76.97
#40		42.34	17.47	40.50	59.5
#60		54.66	22.56	63.06	36.94
#140		76.68	31.64	94.70	5.30
#200		4.59	1.89	96.59	3.41
pan		8.24			
		242.34			

% retained = (Wt. retained/W_s) · 100

% passing = 100 - Σ % retained.

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GRAIN SIZE ANALYSIS-SIEVE (ASTM D422)

Project Fort Stewart Job No.

Location of Project SWMU-1 Sample No. 011213

Description of Soil Depth of Sample 2.5-5' Boring No.

Tested By BV. Date of Testing 11/28/97

Sample preparation procedures outlined in ASTM D421 and D2217.

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

P-55

Weight of sample used, M_{s1}= 5388 g

M_{cws}	M_{cds}	M_c	M_w	M_s	w %	M_{ws}	M_s
	654.3	119.5					

Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	Σ % retained	% passing
#4		18.0	3.35	3.35	96.65
#10		6.24	1.16	4.51	95.49
#20		26.82	4.99.	9.5	90.5
#40		59.56	11.08	20.58.	79.42
#60		111.96	20.83	41.41	58.59
#140		289.20	53.79.	95.2.	4.8
#200		14.7	2.73	97.93	2.07
#Pan		12.2	2.27	100.2	0
Total		537.6			

% retained = (Wt. retained/W_s) · 100

% passing = 100 - Σ % retained.

GRAIN SIZE ANALYSIS-SIEVE (ASTM D422)

Project Fort Stewart. Job No. 97223

Location of Project ______ Sample No. 011413

Description of Soil ______ Depth of Sample ______ Boring No. ______

Tested By ______ Date of Testing 11|30|97

Sample preparation procedures outlined in ASTM D421 and D2217.

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Weight of sample used, M_{ws} = 413.0 g

M_{cws}	M_{cds}	M_c ____	M_w	M_s	w %	M_{ws}	M_s

Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	Σ % retained	% passing
3"					
2"					
1 1/2"					
3/4"					
3/8"					
#4		0			
#10		0.76	0.29	0.29.	99.71
#20		102.93	39.57	39.86	60.14
#40		50.21	19.30	57.16.	40.84
#60		47.03	18.08	77.24	22.76.
#140		17.07	6.56	83.80	16.20
#200		20.9	8.04	91.84	8.16.
pan		21.2	8.15	99.99.	0.01
		260.1			

% retained = (Wt. retained/W_o) · 100

% passing = 100 - Σ % retained.

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GRAIN SIZE ANALYSIS-SIEVE (ASTM D422)

Project Fort Stewart Job No. 97223

Location of Project Sample No. 011513

Description of Soil Depth of Sample ______ Boring No.______

Tested By Date of Testing

Sample preparation procedures outlined in ASTM D421 and D2217.

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Weight of sample used, M_{w},= 332.4 g

M_{wcs}	M_{cds}	M_c ___	M_w	M_s	w %	M_{ws}	M_s

Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	Σ % retained	% passing
3"					
2"					
1 1/2 "					
3/4"					
3/8"					
#4		0			
#10		0.20	0.06	0.06	99.94
#20		51.36	15.48	15.54	84.46
#40		30.39	9.16	24.70	75.30
#60		33.24	10.02	34.72	65.28
#140		172.8	52.07	86.79	13.21
#200		23.3	7.02	93.81	6.19
pan		20.9	6.30	100.11	−0.11
Total		331.89			

% retained = (Wt. retained/W_s) · 100 % passing = 100 - Σ % retained.

GRAIN SIZE ANALYSIS-SIEVE (ASTM D422)

Project Fort Stewart Job No. _____

Location of Project SWMU-1 Sample No. 011613

Description of Soil _____ Depth of Sample 7.5-10' Boring No. _____

Tested By BV. Date of Testing 11/28/97.

Sample preparation procedures outlined in ASTM D421 and D2217.

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

P-60

Weight of sample used, M_{ws}= 333.1 g

M_{cws}	M_{cds}	M_c ___	M_w	M_s	w %	M_{ws}	M_s
	451.5	118.4					

Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	Σ % retained	% passing
3"					
2"					
1 1/2 "					
3/4"					
3/8"		—			
#4		5.13	1.54	1.54	98.46
#10		48.77	14.66	16.20	83.8
#20		33.10	9.95	26.15	73.85
#40		8.80	2.65	28.80	71.20
#60		13.42	4.03	32.83	67.17
#140		211.9	63.69	96.52	3.48
#200		3.0	0.90	97.42	2.58
pan		8.6	2.58	100.0	0
TOTAL		332.7			

% retained = (Wt. retained/W_s) · 100

% passing = 100 - Σ % retained.

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GRAIN SIZE ANALYSIS-SIEVE (ASTM D422)

Project Fort Stewart Job No. ____

Location of Project SWMU-1 Sample No. 011713

Description of Soil ____ Depth of Sample 10-12.5' Boring No. ____

Tested By BU Date of Testing 11/28/97

Sample preparation procedures outlined in ASTM D421 and D2217.

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

P10

Weight of sample used, M_{ws}= 539.9 g

M_{cws}	M_{cds}	M_c ____	M_w	M_s	w %	M_{ws}	M_s
	702.8	162.9.					

Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	Σ % retained	% passing
3"					
2"					
1 1/2 "					
3/4"					
3/8"		—			
#4		21.90	4.07	4.07	95.93
#10		86.23	16.02	20.09	79.91
#20		69.82	12.97	33.06	66.94
#40		58.74	10.91	43.97	56.03
#60		83.10	15.44	59.41	40.59
#140		205.40	[illegible]16.	97.57	2.43
#200		11.0	2.04	99.61	0.39
pan		2.0	0.37	99.98	0.02
TOTAL		538.2			

% retained = (Wt. retained/W_s) · 100 % passing = 100 - Σ % retained.

GRAIN SIZE ANALYSIS-SIEVE (ASTM D422)

Project Fort Stewart Job No. 97223

Location of Project ______ Sample No. 011013

Description of Soil ______ Depth of Sample ______ Boring No. ______

Tested By ______ Date of Testing 11/30/97

Sample preparation procedures outlined in ASTM D421 and D2217.

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Weight of sample used, M_{ws}= 531.5 g

M_{cws}	M_{cds}	M_c ____	M_w	M_s	w %	M_{ws}	M_s

Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	Σ % retained	% passing
3"					
2"					
1 1/2"					
3/4"					
3/8"					
#4		0			
#10		1.86	0.35	0.35	99.65
#20		88.81	16.72	17.07	82.93
#40		65.25	12.29.	29.36	70.64
#60		73.50	13.84	43.20	56.80
#140		274.8	51.75	[illegible]4.95	5.05
#200		12.9	2.43	97.38	2.62
pan		13.9	2.62.	100.0	0
		531.02			

% retained = (Wt. retained/W_s) * 100 **% passing = 100 - Σ % retained.**

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GRAIN SIZE ANALYSIS-SIEVE (ASTM D422)

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Project Fort Stewart Job No. 97223

Location of Project ______ Sample No. 011913

Description of Soil ______ Depth of Sample ______ Boring No. ______

Tested By ______ Date of Testing 11/30/97

Sample preparation procedures outlined in ASTM D421 and D2217.

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Weight of sample used, M_{wt}= 538.2 g

M_{wt}	M_{sb}	M_s ___	M_w	M_s	w %	M_{wt}	M_s

Sieve analysis and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	Σ % retained	% passing
3"					
2"					
1 1/2 "					
3/4"					
3/8"					
#4		0			
#10		0.83	0.15	0.15	99.85
#20		91.92	17.08	17.23	82.77
#40		176.14	32.73	49.96	50.04
#60		144.3	26.82	76.78	23.22
#140		107.6	19.99	96.77	3.23
#200		6.2	1.15	97.92	2.08
pan		11.1	2.06	99.98	0.02
		538.09			

% retained = (Wt. retained/W_s) · 100 % passing = 100 - Σ % retained.

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GRAIN SIZE ANALYSIS-SIEVE (ASTM D422)

Project Fort Stewart Job No. 97223

Location of Project Fort Stewart, GA : SWMU - 1 Sample No. 01V213

Description of Soil ______ Depth of Sample ______ Boring No. ______

Tested By ______ Date of Testing 11/26/97

Sample preparation procedures outlined in ASTM D421 and D2217.

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Weight of sample used, M_w = ______ g

M_{wo}	M_{ab}	M_c	M_w	M_s	w %	M_{ws}	M_s

Sieve analysis and grain shape

415.1

Sieve no.	Diam. (mm)	Wt. retained	% retained	Σ % retained	% passing
3"		0	0	0	100
2"		0	0	0	100
1 1/2"		0	0	0	100
3/4"		0	0	0	100
3/8"		0	0	0	100
#4		0	0	0	100
#10		0	0	0	100
#20		4.70	1.86	1.86	98.14
#40		15.59	6.17	8.03	91.97
#60		[illegible].06	14.68	22.71	77.29
#140		161.38	63.92	86.63	13.37
#200		18.55	7.35	93.98	6.02
pan		15.2			
		252.48			

% retained = (Wt. retained/W_s) · 100 **% passing = 100 - Σ % retained.**