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REMEDIAL INVESTIGATION/RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION FOR SITE 1 INCINERATOR LANDFILL AND SITE 41 FORMER INCINERATOR VOLUME 1 OF 2 TEXT MCRD PARRIS ISLAND SC
6/1/2001
TETRA TECH NUS

REVISION 2
JUNE 2001

Remedial Investigation (RI)/ RCRA Facilities Investigation (RFI)
for
Site/SWMU 1 - Incinerator Landfill
and
SWMU 41 - Former Incinerator

Marine Corps Recruit Depot
Parris Island, South Carolina

Volume I - Text

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888

Contract Task Order 0020

June 2001

REMEDIAL INVESTIGATION (RI)/RCRA FACILITIES INVESTIGATION (RFI)
FOR
SITE/SWMU 1 - INCINERATOR LANDFILL AND
SWMU 41 - FORMER INCINERATOR

MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
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JUNE 2001

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The geologic work described and professional opinions rendered in the RI/RFI Report for Site/SWMU 1 – Incinerator Landfill and SWMU 41 – Former Incinerator at the Marine Corps Recruit Depot, South Carolina, were developed in accordance with commonly accepted procedures consistent with applicable standards of practice.

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ACRONYM LIST

µg/kg	Micrograms per kilogram
µg/l	Micrograms per liter
AET	apparent effects threshold
ARAR	Applicable or relevant and appropriate requirement
ASL	Above screening level
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
B&R Environmental	Brown & Root Environmental
BAF	Bioaccumulation factors
BCF	Bioconcentration factors
bgs	Below ground surface
BHC	Benzenehexachloride
BKG	Background levels
BSAF	Biota Sediment accumulation factors
BSL	Below screening level
BTAG	Biological Technical Assistance Group
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm/sec	Centimeters per second
CNS	Central nervous system
COC	chain-of-custody
COPC	Contaminant of potential concern
CSF	Cancer slope factor
CTO	Contract task order
CVS	Cardiovascular system
DQO	Data quality objective
EP	Extended procedure
EPA	Environmental Protection Agency
EPAWQs	EPA Water Quality Standards
ERA	Ecological risk assessment
ER-L	Effects Range - Low
ER-M	Effects Range - Median
ESVs	Ecological screening values

FDA	Food and Drug Administration
FDEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
ft	feet
g	grams
HEAST	Health Effects Assessment Summary Tables
Hg	Mercury
HI	Hazard Index
HQ	Hazard Quotient
IAS	Initial assessment study
ID	Inside diameter
IDW	Investigation-derived waste
IEUBK Model	Integrated Exposure Uptake Biokinetic Model
ILCR	Incremental Lifetime Cancer Risk
IR	Installation Restoration
IRIS	Integrated Risk Information System
LOAEL	Lowest Observed Adverse Effect Level
MCLs	Maximum Contaminant Levels
MCRD	Marine Corps Recruit Depot
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
mm	Milimeter
mol	Mole
mS/cm	milliSiemens per centimeter
msl	Mean sea level
NA	Not available/not applicable
NACIP	Naval Assessment and Control of Installation Pollutants
NAD83	North American Datum 1983
NAVFAC	Naval Facilities Engineering Command
Navy	United States Navy
NCEA	National Center for Environmental Assessment
ND	not detected
NEESA	Naval Energy and Environmental Support Activitiy
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPDES	National Pollution Discharge Elimination System
NRWQC	National Recommended Water Quality Criteria
NTU	Nephelometric Turbidity Units

NTX	No toxicity information
NUT	Essential nutrient
OSWER	Office of Solid Waste and Environmental Response
PAHs	Polycyclic Aromatic Hydrocarbons
PARCC	Precision, accuracy, representativeness, comparability, and completeness
PCBs	Polychlorinated biphenyls
PELs	Probable Effects Levels
PID	Photoionization detector
PSI	pounds per square inch
PVC	Polyvinyl chloride
QA/QC	Quality assurance/quality control
QAP	Quality Assurance Plan
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-based concentration
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Daily Allowance
RFA	RCRA Facilities Assessment
RfC	Reference concentration
RfD	Reference dose
RFI	RCRA Facilities Investigation
RGOs	Remedial Goal Options
RI	Remedial investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RPD	Relative Percent Difference
SARA	Superfund Amendments and Reauthorization Act
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SMCL	Secondary Maximum Contaminant Level
SMDP	Scientific/Management Decision Points
SOUTHDIV	Southern Division
SOUTHDIVNAVFAC	Southern Division Naval Facilities
SQL	Sample Quantitation Level
SSL	Soil screening level
SVOCs	Semivolatile organic compounds
SWMU	Solid waste management unit
TAL	Target Analyte List

TBC	To be considered
TBP	Theoretical Bioaccumulation Potential
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total dissolved solids
TEF	Toxicity Equivalence Factor
TELs	Threshold Effects Levels
TOC	Total Organic Carbon
TPVC	Top of PVC casing
TRVs	Toxicity Reference Values
TSS	Total suspended solids
TT	Treatment technique
TtNUS	Tetra Tech NUS, Inc.
U.S. EPA	United States Environmental Protection Agency
UCL	Upper confidence limit
VOCs	Volatile organic compounds
VS	Verification step
WQS	Water Quality Standard

RESPONSE TO REGULATORY COMMENTS

USEPA Comments on RI/RFI Report (Rev. 1)

Site 1/SWMU 1 Incinerator Landfill and SWMU 41 Former Incinerator

U.S. Marine Corps Recruit Depot, South Carolina

EPA ID# SC6170022762

General Comments:

1. **Comment:** The description of site history and site conditions is unclear on several key issues, such as: were wastes landfilled or buried in pits at the site, how were wastes disposed after the incinerator closed, and how much, if any, fill/cover overlies waste at the site.

   Response: The site history section (Page 1-3) identifies Site 1 "as the disposal site for combustion residues from the incinerator" until 1959. After 1959, wastes continued to be disposed at the site until 1965. The details on how the waste was placed is uncertain.

   There are no reports that fill/cover was placed over the waste. Also, since aged ash in many cases resembles soil, a clear distinction between ash and soil could not be made reliably in the field. Notes collected during the field program are presented in Appendix A and indicate that at some locations, waste was encountered at a depth of one foot, implying that a cover may be present at the site.

2. **Comment:** The composition and appropriateness of the background data set is unclear. The use of the picnic area samples and the use of data, which includes several organic compounds (indicating at least some disturbance), are not clearly explained. Further, the use of background values, however derived, as a primary data screen, rather than as a comparative value, will require additional justification as well as supplemental discussion of any results exceeding RBC's, regardless of background.

   Response: The background locations were selected by the partnering team in the work plan stage and are discussed on Page 4-2 of the report. Additional details on the background data are presented in Appendix A of the report. As discussed during the September 2000 partnering team and used in the report, these results are only being used to identify background concentrations for inorganics. It is recognized that most organic compounds represent contamination, however, some of these organics may be present because of anthropogenic sources. The two samples collected at the picnic area were collected to help identify non site related anthropogenic levels of select organic compounds. To clarify this point, the last sentence of the first full paragraph on page 4-2 will be deleted.

The human health risk assessment and ecological risk assessment use the background data set in accordance with appropriate guidance.

3. **Comment:** The data collected during the RI did not include sufficient characterization of waste materials or subsurface soils at the site to define the nature of the waste, the vertical extent of the waste, subsurface soil exposure risk, or future pathway risks.

   Response: The data was collected to support a presumptive remedy of landfill capping in place. The design of remedial options and selection of a remedy will need to address these uncertainties.

4. **Comment:** Field documentation processes need improvement. Sample data sheets tend to provide incomplete or sketchy information, and custody on many of the samples collected is suspect.

   Response: The field data or this site was collected at the same time as that for the Site 2 and Site 3 RI's. The EPA commented on specific instances in the Site 2 report and detailed responses were prepared. The same responses to the Site 2 RI comments and responses were incorporated into the Site 1 RI.

5. **Comment:** Please add a list of appendices to the table of contents.

   Response: Agreed.

6. **Comment:** Section 7.1 to Section 7.3.1 represent a screening-level ecological risk assessment following current EPA guidance. However, Section 7.3.2 through 7.5, if included at all, should be added to the Section 7.6 (Step 3a - Refinement of COPCs).

   Response: The ecological risk assessment text was organized following standard procedures for ecological risk assessments at MCRD Parris Island. The reviewer's comment reflects recently amended guidance from U.S. EPA Region IV regarding the implementation of EPA's (1997) *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Under the amended guidance (EPA, 2000), most topics currently presented in Sections 7.3.2 through 7.5 (e.g., food chain modeling methodology) would be presented in Step 3 of the risk assessment process. However, the ecological risk assessment for Site 1 and SWMU 41 was conducted prior to dissemination of EPA's amended guidance. According to Lynn Wellman (2000) of U.S. EPA Region IV, reorganization of risk assessments

already in process will not be required. The Navy will organize future ecological risk assessments as requested and this change will be discussed in the RI report.

7. **Comment:** There is a general flaw in the logic presented in Section 7.4.2. A food chain model is selected as the method to evaluate all COPCs with screening HQs of 1 or more. However, since food chain models are used primarily to evaluate contaminants that bioaccumulate (and/or biomagnify), the risk posed by contaminants that act primarily as direct toxins may be overlooked or underestimated. It is recommended that the ecological risk assessment subgroup (with the assistance of the trustees) review the screening level risk assessment and present a more appropriate way to evaluate risk from all contaminants.

   Response: Food chain modeling was conducted for contaminants (excluding VOCs) whose concentrations exceeded ecological screening values. Until recently amended guidance from U.S. EPA Region IV was disseminated (see response to general comment # 6), this has been a standard procedure for ecological risk assessments in EPA Region IV and at MCRD Parris Island. The Navy concurs that unnecessary evaluation should be prevented to the maximum extent possible, and food chain modeling in future ecological risk assessments will follow EPA's (2000) guidance.

   Nevertheless, the food chain HQs were not the sole criteria for evaluating COPCs. Instead, as explained in Section 7.6 (pages 7-22 and 7-23), several factors were considered in a weight of evidence approach to assess potential risks posed by COPCs. These factors included habitat quality, toxicological evaluation of COPCs, frequency of detection, background concentrations, and comparisons of COPC concentrations to alternate guidelines.

8. **Comment:** Toxicity profiles should be added for all COPCs to assist in determining appropriate assessment endpoints to evaluate for the risk assessment. This information should be added to the Sections discussing Step 3 of EPAs ecological risk assessment process.

   Response: The Navy believes that the assessment endpoints are appropriate as presented. As mentioned at the end of Section 7.2.4, toxicological profiles for COPCs are presented in Appendix F.

Specific Comments:

1. **Comment: Page ES-2, 2nd paragraph, 2nd sentence.** Please clarify whether the waste disposed between 1959 and 1965 was landfilled, disposed by open burning, or both.

Response: The records are not clear on this practice.

2. **Comment: Page ES-2, 2nd paragraph, 4th sentence.** Consider revising this statement to clarify that a thin cover soil appears to have been placed over wastes at the site.

Response: Agreed. The statement will be revised to read, "A thin cover soil appears to have been placed over the fill material...".

3. **Comment: Pages ES-2 and ES-3**. The depth of the surface soil samples at each location relative to cover soil thickness is critical to evaluating the significance of the analytical results. The data can be used to evaluate current exposure risk, but may not be suitable to characterize the waste material. Please elaborate on the significance of the surface soil data.

Response: As discussed under the general comment responses, the site was investigated with an assumption that a presumptive remedy would be selected. Therefore, waste characterization was not a goal, and the surface soil data was collected primarily to evaluate whether a significant current risk is present.

4. **Comment: Page ES-3.** Please clarify the use of surface soil data collected from the adjacent picnic area for background comparison. Note that the suitability of this location for background data may be questionable, as waste disposal operations do not appear to have been well documented or well controlled.

Response: The data collected from the picnic area were not considered for use as background data. Background data was collected from remote locations that are unlikely to have been associated with waste disposal practices. Rather, the picnic sample locations were selected to generate data for evaluation of pesticide and PAH results that may be present due to historic control of insects and road use. Both of these scenarios represent anthropogenic sources that are not related to either waste disposal or hazardous waste disposal. There is no evidence of waste disposal in the areas evaluated. The collection of these samples were discussed with the partnering team and presented in the work plan addendum for this site.

5. **Comment: Page ES-3, last paragraph.** Given the local topography, it would be expected that only the upper portion of the shallow aquifer would discharge subaerially to nearby creeks and tidal channels. For this reason, surface water data may not reflect contaminant loading in groundwater. Please clarify that all shallow groundwater may not discharge in the immediate area.

Response: This statement can neither be confirmed or refuted with the data available.

6. Comment: Page 1-3, section 1.4.2, 5th paragraph, 2nd sentence. Clarify how the un-incinerated wastes were disposed.

Response: The records are not clear on this practice.

7. **Comment: Page 2-1, 1st paragraph.** The discussion of environmental setting should also include site-specific information, such as stratigraphy, depth to water, and habitats.

Response: The following statements will be added to this section.

Section 2.2: "The elevation at Site 1 ranges from sea level to approximately 12 feet above mean sea level.

Section 2.3: " Surface water at Site 1 drains into Archers Creek. "

Section 2.5: "The geology of this site is detailed in Section 3.3."

Section 2.6: "The hydrogeology of this site is detailed in Section 3.4."

Section 2.7: "A discussion of the site specific ecology is provided in Section 7.2.

8. **Comment: Page 2-2, section 2.6, 2nd paragraph, 5th sentence.** Please clarify whether, and to what extent, water table fluctuations are tidally influenced.

Response: The following will be added to this section: "Water table elevations were measured to fluctuate by up to 1.75 feet during a tidal study conducted at Site 1. "

9. **Comment: Page 3-3, 1st paragraph, last sentence, and Appendix A-4.** Please elaborate on the well development criteria and method used to measure water volume removed.

Response: The following text will be added to this section.

Development of the groundwater monitoring wells was performed using a surge block and electric pump with discharge tubing. The surge block was used to sweep the screen interval (and filter

pack) several times throughout the development process. The well water was pumped into 55-gallon drums and labeled as IDW. Water was collected for monitoring in a stainless steel beaker and a Horiba U-10 was used to measure field parameters consisting of temperature, specific conductance, pH, salinity, dissolved oxygen, and turbidity. At least three times the calculated well volume of water was removed during development. If potable water was used to fill the augers during drilling to prevent sand from flowing into the augers or to remove a sand bridge during installation of the sand pack, the amount of water used (measured in five-gallon buckets) was noted in the field book and five times the water added was removed prior to removing the minimum of three well volumes. Readings were collected until the field parameters, with the exception of dissolved oxygen, stabilized and the required removal volume of water for each well was removed. A target turbidity of 10 NTUs was used in an attempt to reduce the turbidity as much as possible during the development phase. Time pumped, volume of water pumped, and the turbidity of the water were used to determine whether to suspend development once stabilization had been achieved.

10. **Comment:** Page 3-3, section 3.2.3, 1st paragraph, 1st sentence. Since the wells were located around the perimeter of the site, is it correct to assume that no subsurface data from the waste disposal area is available.

Response: That is correct, the wells were installed and samples were collected in accordance with procedures for evaluating a presumptive remedy. Therefore, direct characterization of the waste material was not an objective. However, contaminant leachability and migration characteristics of the waste can be evaluated based on the groundwater results.

11. **Comment: Page 3-4, section 3.2.4, 2nd paragraph, last sentence.** The excess turbidity in two surface water samples (Table 3-5) was attributed to sampling difficulties. However, the data from these locations was not qualified, and includes the maximum detected concentrations of 15 of nineteen detected inorganics. Please explain.

Response: The human health and ecological risks assessments generally factor in uncertainties in the data especially for a transient media such as surface water. Since surface water was not identified as a primary risk driver, there was no need to qualify the data.

12. **Comment: Page 3-4, section 3.2.4, 3rd paragraph.** This paragraph states that, AAll surface water samples were taken during the receding tide@. RAGS section 4.5.4 states, ATo obtain a representative sample, sampling should be conducted through a tidal cycle by taking three sets of samples on a given day: (1) at low tide; (2) at high tide; and (3) at "half tide." Each layer of salinity

should be sampled" (U.S. EPA, 1989). A justification for the deviation from procedure should be provided. This paragraph also states that,@ The samples were obtained by dipping the appropriate containers in the surface water.@ The type of sampling container should be specified and the sample volume, head space, sample depth, and location that the sample was taken in the body of water (i.e., mid-stream or edge) should be specified, or reference should be made to the section of the work plan that contains this information. Table 3-4 lists the sample as Asurface@; however, the table and text in Section 3.2.4 should specify the depth in centimeters (cm).

Response: The following text will be added to Section 3.2.4.

"As presented in Section 7.2.1 of the work plan, surface water samples were collected during a receding tide to conservatively bias sample results to evaluate potential contaminant migration from the site. Normally, surface water samples can also be collected at mid tide and low tide to eliminate some of the bias. However, based on the site conditions, surface water at the site is normally only 4 to 12 inches high at high tide, and at mid tide and low tide, standing water is not present within several hundred feet of the site and therefore samples could not be collected under these conditions.

Based on the shallow depth of surface water at the site, stratification of surface water was not observed and therefore individual samples collected. "

Relevant information on the type of sample containers used are presented on the sample log sheets and chain of custody forms.

13. **Comment: Page 3-4, section 3.2.5, 2nd paragraph, 3rd sentence and last sentence.** No notations on the test holes were included with the log sheets for the June 98 sampling event. Also, there was no indication of the impacted area or limits of waste was indicated on Figure 3-3. Please explain.

Response: Test holes were not conducted during the June 1998 sampling event, only during the April 1999 sampling event were test holes dug.

The reference to Figure 3-3 will be deleted from this paragraph. A figure showing the extent of visible waste will be provided in the Feasibility Study.

14. **Comment: Page 3-5, section 3.2.5, 2nd paragraph, 3rd sentence.** The text indicates three sediment samples were analyzed for grain-size and bulk density, but Table 3-6 shows four

samples (PAI-01-SD-01-01 included). Additionally, Appendix A-5 shows four samples for geotechnical analysis, but one is not included in the text or table (01SD00201) and 01-SD-03-01-D is omitted, please clarify.

Response: The text and Table 3-6 will be revised to reflect that four samples from three locations were tested for particle size analysis.

15 **Comment: Page 3-5, sections 3.2.5 and 3.2.6, 2nd and 4th paragraphs**. Sediments and surface soils were not analyzed for redox potential. As redox state can greatly affect availability of contaminants bound to sediment and soil particles, it should be a part of the analytical procedures (EPA, 1989 sec. 9.2.1).

Response: Redox potential for solid matrices are difficult to measure reliably and obtain useful results. Therefore, redox potential measurements were not specified in the work plan for soils and sediments. Please note that the redox potential was measured for the surface water and groundwater samples.

16. **Comment: Figures 3-1, 3-2, 3-3, 4-1, 4-2, and 4-3.** These figures do not have an entry in the key for the fence line. While the fence line is drawn on the map there is no key entry for it and one should be included (EPA, 1989 sec. 2.4.1, 9.1).

Response: The figure does not reference a fence at the site. A two or three strand wire fence is located along the southern tree line of the site.

17. **Comment: Sections 3.2.4, 3.2.5, 3.2.6, and Figures 3-2 and 3-3.** It should be noted in the text that background and picnic area sampling locations are not shown on the referenced figures. An overall map showing the three sampling areas and how they relate to one another should be included.

Response: A reference to Appendix A-12 for background locations will be added to the text in these sections. A figure in Appendix A-12 shows the location of all the background sample locations. The locations for the picnic area sample would not fit on Figures 3-2 and 3-3. However, a new figure will be developed that shows the location of these samples. This figure will be added to Appendix A-12.

18. **Comment: Page 3-5, section 3.2.6, 1st paragraph.** It appears surface soil samples were collected primarily along the margins of the site. Please further justify the rationale for this

sampling approach. Additionally, please specify whether the sampling interval at each sampling location was in cover material, waste material, or both. Based on the boring logs, only three samples encountered waste material, and this was at the base of the sampling interval. Please clarify what these samples represent.

Response: The following will be added to the last paragraph of the section. "In accordance with the U.S. EPA's Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA 1993), these surface soil sample locations were biased toward potential contaminant migration pathways, with the understanding that a presumptive remedy would be used at this site to contain waste materials. The samples were collected to determine whether current site conditions represent a potential threat to human health or the environment, through direct contact or erosion pathways."

19 **Comment: Page 3-5, section 3.2.6, 3rd paragraph; Table 3-1, Page 3-18.** All surface soil samples were taken around the perimeter of the site and none were taken in the interior portion of the site. As explained in Section 2.3.2 of the Soil Screening Guidance: Users Guide (U.S.EPA, 1996), ideally the site should be divided into exposure areas (EA) and composite samples should be taken from each EA. The lack of samples from the middle of the site may underestimate the contamination of the site. If feasible, samples should be collected from the middle of the site to adequately characterize contamination, if any, in this area (i.e., Ahot spots@ or other contaminated areas may exist in the middle of the site). At a minimum, justification should be provided for sampling only around the perimeter of the site.

Response: The response to comment 18 will be added to the report.

20. **Comment: Page 3-6, section 3.2.7, 2nd paragraph, last sentence.** Monitoring well locations are shown on Figure 3-1 not Figure 3-2.

Response: The text will be changed as indicated.

21. **Comment: Page 3-27, Table 3-9.** Please footnote that these are the last measurements taken prior to sampling.

Response: Agreed. The following footnote will be added to the table.

"Results presented represent the last reading prior to sample collection. "

22. **Comment: Page 3-12, section 3.2.13, 1st paragraph, 4th sentence.** Laboratory analytical data sheets (form 1's) should be included within all decision documents, such as RI Reports, in addition to summary tables.

    Response: Electronic copies of the form 1's have been supplied to the EPA.

23. **Comment: Page 3-13, section 3.3, 1st paragraph, 3rd sentence.** Please clarify where the soil survey data is correlated to site specific lithologies. If the soil types at Site 1 were mapped, please provide a figure.

    Response: Since none of the material at Site 1 is native, a site specific soil survey was not conducted.

24. **Comment: Page 3-13, section 3.3, 3rd paragraph, 3rd sentence.** As previously noted, only 3 of 19 surface soil sample log sheets note observation of trash or debris (near the base of the sample interval). The prevalence of waste material in the surface interval of the site has not been demonstrated. Please elaborate on the waste materials noted during field reconnaissance and sampling to more fully describe site conditions.

    Response: In general, the investigation is based on an assumption that waste materials are present throughout the site. However, except for select areas where metal and glass fragments are present, the presence of waste material is not obvious throughout most of the Site. The waste materials may be covered with soil, or they may be present on the surface, but cannot be distinguished from soil.

25. **Comment: Page 3-14, section 3.3, 1st paragraph, last sentence.** Notations in the boring logs indicate the presence of plastic, wood, glass, and rock fragments/debris in the upper 6 feet of some borings (also a creosote odor was noted in SB-03). Are these materials interpreted as washout, or are these borings/wells within the limits of waste at this site.

    Response: Although the original intent was to select well locations outside of the waste area, the soft sediments in the marsh made this impractical. Therefore, some of the wells are located in possible areas of waste materials.

26. **Comment: Page 3-14, section 3.3, 1st paragraph, 3rd sentence.** If the statement "material was buried in pits" is based on interview or operational records, please cite the reference. Also, if this

is suspected to be the primary method of disposal at the site, should additional investigation (e.g., geophysics) be conducted to delimit the pits/waste areas.

Response: Although it is likely that materials may have been buried in pits, the practice is not substantiated by reports and will therefore be deleted from the report. Since the whole site is a landfill and will be addressed through the presumptive remedy, delineation of pits (if present) is not necessary.

27. **Comment: Page 3-14, section 3.3, 2nd paragraph.** The absence of subsurface data from the central portion of the site is a significant impairment to assessing the vertical limits of waste, the physical and chemical properties of the waste, and the stratigraphy and hydrogeology beneath the waste. Since this site encompasses a significant stratigraphic facie transition, stratigraphic projection from existing borings/wells may be of limited utility at this site.

Response: The vertical limit of waste will be based on historic photographs of the site coupled with boring data as needed during remediation in accordance with a presumptive remedy approach.

28. **Comment: Page 3-14, section 3.4, 2nd paragraph, 3rd sentence.** Identification of the Hawthorne Formation beneath the waste material, nor the presence of "phosphates" at the top of the Hawthorne Formation can be validated from the boring logs presented in Appendix A-2. Please clarify.

Response: The first sentence of paragraph 3 on p. 3-14 will be revised to read "The sand is underlain by a gray-green silty to clayey, fine sand which locally is believed to be the top of the Hawthorn Formation."

The Hawthorn is not thought to be very thick at this site. At Site 12 located nearby on Jericho Island, the Hawthorn was not encountered prior to reaching the confined aquifer. Archer Creek is thought to have eroded away a portion of the Hawthorn at this site, therefore explaining the lack of phosphates in the subsurface material. The Hawthorn (NEESA 1986) thought to be 20 to 30 feet thick, averaged approximately 6.5 feet thick at this site.

29. **Comment: Page 4-1, section 4.0, 3rd paragraph, 8th sentence.** Should this be rephrased to state that figures show results exceeding background or RBC's. Also, please tabulate and present the screening values used (background and RBC's) by media and source for each analyte (including Total PAHs).

Response: The description is accurate as presented. Since Section 4.0 relates to contamination, and therefore detections at concentrations less than background are not presented in these figures. As requested and was conducted for Site 2, relevant screening and background values will be added to the figures. The use of Total PAH screening values is being evaluated.

30. **Comment: Page 4-2, section 4.0, 2nd paragraph.** Please elaborate on how background samples with positive detections for organic compounds are qualified (i.e., are they rejected due to the presence of anthropogenic compounds). Also, why were "background values" for organic compounds presented in Table 4-1? Were these used as a screening criteria? Finally, please specify how the two picnic area "background" sample results were aggregated with the project data (i.e., included with the background data set or used separately for comparison of pesticide levels).

Response: Table 4-1 presents a summary of all detected analytes in the background data set. The organic results are presented for information only and were not used to screen data. However, during the detailed risk assessments, some of the organic detections in background data set were used qualitatively. The organics may be present in the background results because of anthropogenic, laboratory/sampling contamination, and/or natural sources.

The picnic area samples are not "background" and were never intended to represent background concentrations. Rather, they were collected to support an anthropogenic evaluation of "typical" pesticide use at the site. The picnic area was selected, because it is adjacent to a marsh and represents a likely area where pesticides would have been routinely used for insect control in the past. In addition, it is remote enough from the site, that disposal of solid wastes at the site would not impact these areas. As indicated in a previous response, a new figure will be prepared to show the location of these samples.

31. **Comment: Page 4-12, Table 4-2.** Please elaborate on and provide an explanation for the "Range of Non-detects" shown as NA.

Response: NA in this column will be modified with a footnote to indicate that: "A range non detect values was not determined for chemicals in which the chemical was detected in all samples tested."

32. **Comment: Page 4-6, section 4.1.3, 1st paragraph, 2nd sentence.** Should this be rephrased to state that figures show results exceeding background or RBC's.

Response: The description is accurate as presented. Since Section 4.0 relates to contamination, and therefore detections at concentrations less than background are not presented in these figures.

33. **Comment: Page 4-7, section 4.1.3, 2nd paragraph, 4th sentence.** Cobalt, Lead, and Nickel should be included in the series of inorganics detected above background levels.

Response: Agreed, since these chemicals were not detected in the background data set, any detection would exceed background.

34. **Comment: Page 4-7, section 4.1.3, 4th paragraph.** Please clarify whether the maximum levels in water samples refer to filtered, unfiltered, or both. Also, filtered samples should be presented for comparison purposes only.

Response: The sentence references both, although unfiltered results generally exceeded filtered results. The unfiltered results are generally used for human health evaluations, whereas the filtered results are used for ecological evaluations.

35. **Comment: Page 4-7, section 4.1.4, 1st paragraph, 2nd sentence.** Please clarify/rephrase this statement, it appears a line is missing.

Response: The sentence is complete, but will be reworded as follows.

"Detected chemicals that exceed background and human health or ecological screening values are presented on Figure 4-4. Human health screening values assume that sediment is the same as surface soils and consist of U.S. EPA Region 3 human health RBCs (1 x 10 -6 ILCR - Residential, HQ equal to 1). Ecological screening values are the EPA Region 4 sediment ecological screening values."

36. **Comment: Table 4-5, Figure 4-4, and Appendix C-2.** The maximum lead concentration tabulated and shown on the figure is 194 mg/kg at SD-009, but the appended summary analytical results show lead values of 201 mg/kg at SD-03 and 563 mg/kg at SD-A-01, please explain.

Response: The referenced lead result of 201 mg/kg in SD-03 is a field duplicate result. The original sample result is 138 mg/kg. For the summary statistic table, the average of the original

and duplicate result was used. This average is less than the maximum value of 194 mg/kg presented.

The following text will be added to the fourth paragraph of Section 4.0.

> "Figures display the average analytical result for those locations where a normal and duplicate sample was collected. Statistics provided in the tables of this section utilize these average values."

Sample SD-A-01 is a QA/QC sample and will be deleted from the appendix result sheet. It was not used in the summary statistics presented.

37. **Comment: Page 4-9, section 4.2.** Since the location of the former incinerator is not well established and the potential COC's and media for SWMU 41 are identical to those for Site 1, it is unclear why these four surface soil samples are not aggregated with the Site 1 data and evaluated together. Are separate actions anticipated for these sites? If not, consider combining these data for ease of evaluation.

Response: The reason for collecting samples at SWMU 41 was to determine whether the SMWU characteristics were different than that for Site 1. Based on a comparison of the chemical results, it was concluded that there is no significant difference between the two sites. For the human health and ecological risk assessments, the data was combined prior to calculating site risks.

38. **Comment: Page 4-9, section 4.2.1, 1st paragraph, 2nd sentence.** Should this be rephrased to state that figures show results exceeding background or RBC's.

Response: The description is accurate as presented. Section 4.0 relates to contamination, and therefore detections at concentrations less than background are not presented in these figures.

39. **Comment: Page 4-9, section 4.2.1, 3rd paragraph.** Clarify which four sample locations are attributed to SWMU 41. Based on Figure 4-1, samples SS-001, SS-002, SS-004, and SS-007 are the closest spatially, but SS-003 is referred to in the text.

Response: Samples with a PAI-41 are associated with two possible SMWU 41 locations. Samples with a PAI-01 are associated with Site 1 locations. The samples collected close to the

concrete pad were collected for different reasons. Regardless, the samples were collected to support a presumptive remedy.

40. **Comment: Section 4.0.** The nature (source) and extent (vertical) of potential contamination has not been fully delimited. The data presented in this RI provides an assessment of current exposure only. Future exposure cannot be reliably determined from the data presented. Additionally, without characterizing the nature and extent of waste material, a decision as to the most appropriate remedy (removal, capping, NFA) cannot be made.

Response: The field data was collected with an assumption of implementing the presumptive remedy. To further clarify this position, the following statement will be added to the executive summary under investigative summary and Section 3.2.

"This investigation was conducted to support a presumptive remedy for Site 1 that includes covering/capping of landfill contents, evaluation of contaminant migration into the surrounding environmental, and potential environmental impacts associated with this migration."

In addition, a reference to the presumptive remedy will be added to the conclusion and recommendation section for capping/covering options for this landfill.

41. **Comment: Page 5-1, section 5.1, 1st paragraph, 4th sentence.** The reference cited for determining BCF's for inorganic constituents is not the most current or complete source for these constituents.

Response: Table 5-2 will be revised to include the BCFs used in the ecological risk assessment presented in Section 7.0, which were obtained from U.S. EPA, 1997 *304(a) Toxic Substances Spreadsheet*, Region 4 Water Quality Standards Section, Atlanta, Georgia.

42. **Comment:** Pages 5-5 through 5-7, section 5.3. This section provides a generic description of migration processes for classes of site related chemicals. No site specific information or modeling was presented. The geotechnical data collected (i.e., TOC, grain-size, moisture content, density, etc.) could be used to define pathway-specific migration rates. Since source characterization data is limited, exposure point concentrations through time cannot be reliably developed. However, based on migration rates, inferences as to whether current conditions are likely to be reflective of future conditions can be made. Please provide site specific migration rates for Sites 1 and 41 COPC's, and discuss estimated future exposure concentrations.

Response: This section is intended to present only general chemical migration properties that can be used in the human health and ecological risk assessment models and calculations as needed. Detailed modeling as requested is generally inaccurate for all chemicals except VOCs and then only in well defined geological settings.

Based on the time period since the unit was last in operation, (approximately 35 years), and the continual infiltration, flushing, and biodegradation of contaminants since that time, it is very likely that the results observed in the site groundwater represent maximum conditions, however, modeling cannot be used to support this position.

43 **Comment: Page 6-11, section 6.2.3.5, 1st paragraph**. Ingestion of fish was rejected as a route of exposure due to the fact that the immediate area adjacent to the site was dry part of the time due to tides; therefore, fish would originate from outside the area. Although fish move with the tide so does the potentially contaminated water and sediment thus extending the exposure period. The Exposure Factors Handbook (U.S. EPA, 1997) states that, APollutants are carried in the surface waters, but also may be stored and accumulated in the sediments as a result of complex physical and chemical processes@. Due to the shifting aerobic/anaerobic cycle contaminants may be released from the sediments and into in-flowing waters and provide exposure to fish. Although finfish may only be in the area for a portion of the day, shellfish, which are a food source for finfish, may inhabit the area constantly. Therefore, contaminants may pass up the food chain, potentially to human receptors. Fish may also bioaccumulate contaminants in the sediment and water and present consumers with an elevated level of contamination. Tidal influence of the area immediately adjacent to the site is not sufficient justification for eliminating this exposure route. However, if there is reason to believe that fish from this area are not consumed, or other justification for elimination of this route can be documented, then fish consumption should be eliminated on that basis.

Response: The investigation was conducted to specifically evaluate the potential for migration of significant contamination from the site. Initially, the samples were collected as near the site as possible to maximize the potential contaminant concentrations. In general, the most significant chemical concentrations were measured near the site and most of the detected chemical concentrations decreased to below screening levels/background away from the site within the tidal zone.

Based on the physical characteristics of the site, fish cannot live continuously within several hundred feet of the site. Archers Creek in the northwest corner of the map and another a narrow

branch of a tidal stream branch located north of the site are the nearest surface water bodies during low tide.

We recognize the potential concern with this pathway and will add this scenario to the human health risk assessment. However, based on the relatively low chemical concentrations detected in surface water, the evaluation will compare the surface water data to ambient water quality criteria for fish consumption only and factor in site averages and home range considerations. If necessary, a conservative fish consumption model will be generated.

44. **Comment: Page 6-14, section 6.2.5, 3rd paragraph** discusses the use of a Toxicity Equivalence Factor (TEF) for carcinogenic PAH=s as adopted by U.S. EPA Region 4, but does not present the equation for arriving at the TEF used in the risk characterization. The equation should be presented in the text or in the appendix.

Response: A sample calculation will be included Appendix E.

45. **Comment: Page 6-16, sections 6.2.6.1 and 6.2.6.2, 1st paragraph.** The exposure frequency for soil (EF_{soil}) is assumed to be 125 days per year for both ingestion and dermal exposure to soil. U.S. EPA (1991) set the default value to worker as 250 days per year. A more in depth explanation should be given for the deviation from default values.

Response: EPA does not have a recommended default exposure frequency for construction workers. The default exposure frequency of 250 days/year is for commercial and industrial workers who work 5 days a week for 25 years. The EPA 1991 guidance does not list a default exposure frequency for construction workers, although Appendix B of the guidance states that for construction activities where an ingestion rate of 480 mg/day is used the exposure frequency would be generally less than one year. EPA's Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (EPA, 1993) recommends that a site-specific value be used for the exposure frequency for contact intensive scenarios.

46. **Comment: Table 6-10, Table 4.1(Appendix).** EF_{soil} is listed as 250 days/year on these tables; however, it is listed as 125 days/year in the text and in computations. The EF_{soil} should be consistent in the text, tables, and computations.

Response: The exposure frequency for the construction worker will be changed to 125 days/year in Table 6-10.

47. **Comment:** **Page 7-5, section 7.2.3, paragraph 1.** The text should be clarified so that it is clear that aquatic vegetation is included in Aquatic and semi-aquatic organisms. During the site visit, large areas around the edge of the marsh (where glass debris was visible) were sparsely vegetated indicating a potentially impacted vegetated community.

Response: The text will be revised as requested.

48. **Comment:** **Page 7-5, section 7.2.3, paragraph 2**. Direct contact should be included as a potential exposure route for terrestrial invertebrates and other burrowing species.

Response: The text will be revised as requested.

49. **Comment:** **Page 7-6, section 7.2.5.** Assessment and measurement endpoints should be selected only after the list of COCs have been agreed upon. Their selection is driven by the contaminants and exposure pathways present at a site. Until contaminants and pathways have been agreed upon by all parties, it is difficult to accurately select assessment and measurement endpoints. It is recommended that the selection of assessment endpoints be conducted by the ecological subgroup once problem formulation has been completed.

Response: Preliminary results of the screening ecological risk assessment for Site 1/SWMU 41 (including assessment and measurement endpoints and contaminants of potential concern [COPCs]) were presented to the Partnering Team on October 21, 1998. After additional samples had been collected and analyzed, further presentation and discussion of the in-process ecological risk assessment occurred at the Partnering Team meeting of October 5, 1999. These presentations and discussions were undertaken to gain concurrence by the Partnering Team regarding COPCs, exposure pathways, and endpoints. However, as suggested by the reviewer (agreement on COPCs and pathways, and selection of assessment endpoints by the ecological subgroup) can be re-evaluated a third time. Please note that the partnering team will be selecting the COPCs, and measurement/assessment endpoints based on the recommendation of the ecological subgroup.

50. **Comment:** **Page 7-7, section 7.3.1, paragraph 4**. The reference for the first sentence is a human health dermal risk assessment reference and should be corrected in the text. All screening values should be selected from EPA Region 4's ecological bulletins (EPA 1995, as updated on their webpage.)

Response: The reference for the ecological screening values is in error; the text will be revised as requested.

51. **Comment: Page 7-8, section 7.3.1, paragraph 1**. During the screening the most conservative screening value should be used. Since evidence exists that it may be unlikely that hexavalent chromium is present, this could be presented in the COPC refinement in Step 3.

Response: The text will be revised as requested.

52. **Comment: Page 7-8, section 7.3.2, paragraph 3**. Toxicity reference values should be reported using primary references together with a summary of test conditions that identify its applicability to the risk assessment process.

Response: Tables 7-1 and 7-2 will be revised to provide the requested information.

53. **Comment: Page 7-9, section 7.3.3, paragraph 1**. When food chain models are used to refine COPCs, it is imperative that only conservative assumptions are made. Therefore, the life history information to be included in the food chain models should be the lowest reported body weight, then highest reported ingestion rate, and the smallest reported home range.

Response: The Navy concurs with EPA guidance (EPA, 1997) that calls for the use of estimates of body weight and food ingestion rates to maximize the conservative nature of screening level risk assessments. In general, maximum food ingestion rates and minimum body weights were used to calculate daily doses. However, EPA's (1993) Wildlife Exposure Factors Handbook provides food ingestion rates as grams ingested per gram of body weight. In nearly all cases there are more body weight data than ingestion rate data, and often there are only one or two values for an ingestion rate. Arbitrary use of a maximum ingestion rate or a minimum body weight can result in doses that are less conservative than using averages. This result comes from using the minimum body weight to calculate ingestion. Therefore, professional interpretation of the data is sometimes required to select the most appropriate value. The wording in Section 7.3.3 did not clearly state this and will be revised.

Furthermore, the reviewer's comment addresses the use of food chain models to refine COPCs in Step 3 of the 8-step ecological risk assessment process. Section 3.2 of EPA (1997) states that Step 3 includes an assessment of doses and resulting hazard quotients that are calculated using more realistic assumptions. Therefore, it could be argued that doses initially calculated in Step 3 should not necessarily utilize the most conservative assumptions available. However, the Navy

concurs that the initial calculation of doses (via food chain modeling) and resulting hazard quotients should use conservative assumptions to the maximum practicable extent, whether the initial risk calculation is accomplished in Step 2 or Step 3. The requested approach will be incorporated in future risk assessments. (Note: A similar EPA comment and Navy response were previously made regarding the ecological risk assessment conducted for the Site 2/15 RI/RFI. The ecological risk assessment for Site 1 and SWMU 41 was drafted after the Site 2/15 comment was received. The requested approach was incorporated into the ecological risk assessment for Site 12/SWMU 10 (Jericho Island Disposal Area) and will be used in all future ecological risk assessments at MCRD Parris Island).

54. **Comment:** **Page 7-13, section 7.4.1, paragraph 3**. While the 0- to 1-foot surface soil rule generally is accepted for human health risk assessment this does not necessarily hold true for all sites in ecological risk assessments. This assumption could underestimate risk if the maximum concentrations are located below 1 foot deep, but have complete exposure pathways via burrowing animals. The text should indicate which depths reported the heaviest contamination and the rationale for not including deeper (possibly more contaminated) locations in the risk assessment.

Response: Tree roots extend deeper than one foot below the surface, and mammals such as moles, foxes, and skunks could burrow deeper than one foot. Other deep-burrowing terrestrial animals (e.g., armadillos, gopher tortoises, woodchucks) do not inhabit Site 1/SWMU 41. With the exception of moles, foxes, and skunks, most terrestrial animal species at the site would rarely (if ever) be exposed to soils deeper than one foot below the surface. Section 7.9 (Uncertainty Analysis) will be revised to address the uncertainties associated with not including sub-surface soil data in the ecological risk assessment. In addition, under the presumptive remedy, generally, two or more feet of cover material would be placed over wastes.

55. **Comment:** **Page 7-13, section 7.4.2, paragraph 4**. Since one of the assessment endpoints identified in Section 7.2.5 are benthic invertebrate communities and terrestrial and aquatic vegetation, it is not clear why these endpoints were not included in the evaluation. It is recommended that the ecological subgroup identify methods to evaluate risk to all agreed upon endpoints.

Response: The paragraph in question describes contaminant doses in the food chain model. Therefore, vegetation and benthic invertebrates were not discussed in that paragraph because potential risks to vegetation and benthic invertebrates are not investigated by a food chain model. As explained in the response to general comment # 7 and in Section 7.6 (pages 7-22 and 7-23) of

the RI/RFI, several factors were considered in a weight of evidence approach to assess potential risks posed by COPCs. These factors included habitat quality, toxicological evaluation of COPCs, frequency of detection, background concentrations, and comparisons of COPC concentrations to alternate guidelines.

56. **Comment:** **Page 7-14, section 7.4.2.1, paragraph 3**. It should be assumed that each predators diet is made up solely of the most contaminated food item. This helps to ensure that risks from exposure through the food web are not under estimated.

Response: A similar EPA comment was previously made regarding the ecological risk assessment conducted for the Site 2/15 RI/RFI. The Navy's response to that comment is repeated below:

"The current ecological risk assessment estimated the ingested doses to the hawk and fox by assuming that prey items consisted of equal amounts of shrews and mice. Although the incorporation of the requested revision would not significantly affect the results of the risk assessment, the Navy concurs that the requested approach would better maintain the conservative nature of the risk assessment. Thus, future ecological risk assessments will incorporate the requested approach."

The ecological risk assessment for Site 1 and SWMU 41 was drafted after the Site 2/15 comment was received. The requested approach was incorporated into the ecological risk assessment for Site 12/SWMU 10 (Jericho Island Disposal Area) and will be used in all future ecological risk assessments at MCRD Parris Island.

57. **Comment:** **Page 7-15, section 7.4.2.1, paragraph 2**. Reference EPA 1997d is not included in the reference list.

Response: The reference section will be revised to include the reference in question: U.S. Environmental Protection Agency, 1997, The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, Volume 1: National Sediment Quality Survey, Office of Science and Technology, Washington, D.C. EPA 823-R-07-006.

58. **Comment:** **Section 7.8**. It is recommended that this section be rewritten once the ecological subgroup completes its evaluation of this site.

Response: Section 7.8 was written in accordance with the guidance that was in effective at the time. Ultimately, the ecological subgroup prescription for PRG development and ecological risk assessment will be considered as we move forward. In the absence of specific comments, this section will remain as written.

59. **Comment: Section 8.0, subsection 1.0 and subsection 9.0, 2nd paragraph, 2nd bullet.** The statements that observed pesticide concentrations may be site related (i.e., from routine applications) needs to be further substantiated.

Response: The statement was presented to indicate that the pesticide detected in the area may - not be related to waste disposal practices. Spraying at MCRD Parris Island for control of insects has been a long standing practice and continues to this day. The text will be revised as follows. "Because of the base-wide application, pesticides may not be site related.

60. **Comment: Section 8.0, subsection 10.0.** The soil, in particularly soil waste, data is probably not sufficient to proceed to an FS/CMS. Under a presumptive remedy scenario of capping, decisions can be made regarding current exposure risks from surface soils only. However, the necessity for and long-term effectiveness of the selected remedy cannot be fully assessed.

Response: The Navy disagrees. There is sufficient information to document the need for the presumptive remedy at this site. Wastes were known to have been disposed at the site and can be observed at several locations. In addition, at locations where waste is exposed, elevated chemical concentrations represent a potential threat to the environment under both existing and potential future scenarios.

To help clarify the recommendation, the reference to the presumptive remedy will be added to the statement. Long term effectiveness issues can be addressed by proper design of the remedy.

61 **Comment: Section 8.** The baseline human health risk assessment did not contain a remedial goal options (RGOs) section as recommended by EPA Region 4 guidance (EPA, 1995). EPA Region 4 recommends that a range of RGOs be presented for the risk managers use as the last component of the risk assessment. RGOs should be calculated for each chemical of concern (COC) in each land use scenario that either exceeds a 1×10^{-4} cumulative cancer risk or exceeds a total noncarcinogenic hazard index of 1.

Response: The RGO section will be added to Section 6.0 as requested.

62. **Comment: Page 8-2, section 8.60, 6th paragraph.** The ICR and HI are not stated separately for adults and children who may potentially inhabit the site in the future. The estimated HI and the ICR across all media should be stated separately for adults (HI=1.22, ICR=2.8×10^{-4}) and children (HI=10.7, ICR=1.4×10^{-4}).

Response: Agreed. The text will be revised as requested.

63. **Comment: Appendix A-2.** Boring logs were only included for six of the ten borings installed in the copy of the report provided. Please verify that all of the boring logs are included in later revisions.

Response: All boring logs are presented in the Appendix. Six shallow monitoring wells were installed at the same location as an intermediate depth monitoring well. As a result, a separate boring log was not generated.

64. **Comment: Appendix A-3.** Construction logs were presented for eleven wells in the copy of the report provided. Please clarify which, if any, of these is the existing well.

Response: PAI-MW4(s) was a monitoring well installed prior to the current sample event and is only presented so that all of the well construction details for the site can be found in one location. The construction date for this well is located on the sheet as 2-23-88.

65. **Comment: Appendix A-5.** Please clarify the method used to calculate porosity from the geotechnical data collected. Also, the text should refer the reader to the analytical data for the total organic carbon results.

Response: There is no method number associated with porosity. The geotechnical laboratory calculated porosity by the following equation (Al-Khafaji and Andersland, 1992):

$$1 - \gamma_m/[\gamma_w + G_s(1+w)]$$

Where:

γ_m = Bulk unit weight of soil (calculated by ASTM method D2937)

γ_w = Bulk unit weight of water

G_s = Specific gravity of soil (calculated by ASTM method D854)

w = water content of soil (calculated by ASTM method D2216)

ASTM methods for bulk unit weight, specific gravity, and water content of soil will be added to the report.

A reference to TOC data is presented in Section 3.2.3.

66. **Comment:** **Appendix A-6.** On numerous sample log sheets the analyses requested have been scratched out or overwritten with marker. Log entry errors should be crossed-out with a single line, and initialed and dated.

Response: The referenced cross-outs with a marking pen were not log entry errors, but were markups of a standardized form which listed all possible analytes. Analytes that were not to be tested for (as per the work plan) were crossed out. This action aided the field personnel in filling the correct number of sample bottles. This action is similar to a check mark or circle of information. Underlying information is readable on the original forms.

67. **Comment:** **Appendix A-8.** On numerous sample log sheets the analyses requested have been scratched out or overwritten with marker. Log entry errors should be crossed-out with a single line, and initialed and dated.

Response: The referenced cross-outs with a marking pen were not log entry errors, but were markups of a standardized form which listed all possible analytes. Analytes that were not to be tested for (as per the work plan) were crossed out. This action aided the field personnel in filling the correct number of sample bottles. This action is similar to a check mark or circle of information. Underlying information is readable on the original forms.

68. **Comment:** **Appendix A-10.** On numerous sample log sheets the analyses requested have been scratched out or overwritten with marker. Log entry errors should be crossed-out with a single line, and initialed and dated.

Response: The referenced cross-outs with a marking pen were not log entry errors, but were markups of a standardized form which listed all possible analytes. Analytes that were not to be tested for (as per the work plan) were crossed out. This action aided the field personnel in filling the correct number of sample bottles. This action is similar to a check mark or circle of information. Underlying information is readable on the original forms.

69. **Comment:** **Appendix A-13.** Chain-of-custody forms have numerous quality assurance/quality control discrepancies, such as: the absence of received by signatures when custody was released by the samplers (presumably to an overnight shipper); incomplete data fields (such as station no.);

incomplete line-outs (corrections not initialed, blank rows left open); and, incomplete entries for trip blanks. Chain-of-custody forms should be reviewed for completeness in the future.

Response: The samples were released to Fed Ex. Fed ex records are available. Station numbers are not relevant to the current program and the station location is used as a complete description of the sample.

Regarding the cross outs, most of the cross outs on the chain of custody forms were initialed. For the few remaining cross outs and the unchecked blank columns, proper cross out procedures will be discussed with the field samplers.

70. **Comment: Appendix G.** The Introduction to this Appendix indicates that one "sediment/ash" sample, one sediment sample, and one groundwater sample were collected. The documentation of field sampling suggests that a third sediment sample was also collected at station SD-16. Please explain. Also, it is difficult to assess the representativeness of the samples collected as the locations are fairly distal from the main waste area, the samples were surface only (current exposure), and of the three station descriptions only one mentions the word ash. Since the existing data indicate that there are dioxins associated with this site (positive detections), additional justification of the appropriateness and representativeness of the data should be made.

Response: The text will be revised to indicate that 2 sediment samples were collected at the site and one sediment sample was collected at a background location (SD-16). The locations were selected during a partnering team meeting and one of the samples was collected of exposed waste, within the main waste area. As discussed during partnering team meetings, the Navy does not necessarily consider a positive detection to be an association.

As discussed in Appendix G, TCDD would not be expected to be present at the Site because of site related activities. Rather its presence is probable because of regional anthropogenic sources. However, as requested in a partnering team meeting, a limited number of samples were tested. These samples were biased toward areas of probable contamination (e.g. waste and nearby sediments). As discussed in the Appendix, these results confirm that the presence of TCDD is not related to waste disposal practices.

Typographical Errors:

1. **Comment: ES-4, 2nd paragraph, 1st sentence.** Add "aquifer" or "hydrogeologic unit" between "surficial" and "is".

Response: Agreed.

2. **Comment: Page 3-2, 2nd paragraph, 3rd sentence.** Change “slug test” to “slug testing”.

Response: Agreed.

References:

U.S. EPA, 1989, Risk Assessment Guidance for Superfund: Volume 1- Human Health Evaluation Manual, (RAGS), Interim Final, EPA/540/1-89/002.

U.S. EPA, 1991, Risk Assessment Guidance for Superfund: Volume 1- Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final, OSWER Directive No. 9285.6-03, March 25, 1991.

U.S. EPA 1995. Supplemental Guidance to RAGS: Region 4 Bulletins. Ecological Risk Assessment. Draft. (As updated on EPA Webpage as of 5/00).

U.S. EPA, 1996, Soil Screening Guidance: User=s Guide Second Edition. OSWER Publication 9355.4-23.

U.S. EPA, 1997a, EXPOSURE FACTORS HANDBOOK: Update to Exposure Factors Handbook EPA/600/8-89/043 - May 1989.

U.S. EPA 1997b, Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. June 5.

EPA (U.S. Environmental Protection Agency). 2000. Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders. Memorandum from Ted. W. Simon, Region 4 EPA Office of Technical Services, Atlanta, Georgia, June 23.

EPA (U.S. Environmental Protection Agency). 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, June 5, Edison, New Jersey.

EPA. 1993. Wildlife Exposure Factors Handbook: Volumes I and II. EPA/600/R-93/187. U.S. EPA Office of Research and Development, Washington, D.C.

Wellman, L. (U.S. Environmental Protection Agency, Waste Management Division, Atlanta, Georgia). 2000. Personal Communication with M.L. Whitten, April 13 (Tetra Tech NUS, Inc., Aiken, South Carolina).

RESPONSE TO SCDHEC COMMENTS
DRAFT REMEDIAL INVESTIGATION (RI)/RCRA FACILITIES INVESTIGATION (RFI) FOR SITE/SWMU 1 – INCINCERATOR LANDFILL, AND SWMU 41 – FORMER INCINERATOR

Comments by Jerry Stamps, Division of Hazardous and Infectious Waste Management
Dated September 27, 2000

1. **Comment:** General. If this investigation was conducted with the intent to implement the presumptive remedy for landfills, please indicate as such within the body of the report.

Response: The following statement will be added to Sections 1.3 and 3.0 and the executive summary.

"The sampling program was developed to support a presumptive remedy for the site that assumed waste materials would be encapsulated under a cover/cap and is consistent with U.S. EPA guidance entitled Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA, 1993) and Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills (Interim Guidance) (U.S. EPA, 1996a). "

2. **Comment:** General Figures. The yellow line in the figures appears to represent the boundary of the landfill; however, nothing in the legend identifies this line as such. Additionally, the figures should identify the fluctuations in surface water elevations resulting from tidal influences. This is particularly necessary for those figures presenting the surface water and sediment contamination.

Response: The yellow line is labeled in the figures as "APPROXIMATE HIGH WATER SHORELINE". However, as requested on previous documents, a legend will be added to the figure indicating that the green shading represents the forested/wooded areas, blue shading represents surface water, and brown shading represents highways.

The approximate location of water at low tide location will be added to figures. The low tide line is in the channel to the north of the site. All of the surface water and sediment locations are dry at low tide.

3. **Comment:** Section 2.7. This section includes an inadequate discussion of the site-specific ecology. At a minimum, this section should reference the Ecological Risk Assessment included in Section 7.

Response: A reference to Section 7.0 will be added to this section.

4. **Comment:** Section 3.1, 4th bullet, 6th bullet. This section should discuss the reasons for any deviations from the approved work plan rather than simply stating the deviations.

Response: The following statement will be added to the 4th bullet. "This concrete pad represents field conditions that provide direct evidence of the location of the former incinerator. Therefore, samples collected near this pad would be more representative of the SWMU than more randomly placed samples in the general area. "

The following statement will be added to the 6th bullet. "Because of a missed holding time," ....

5. **Comment:** Section 3.2.3. This section states that a creosote odor was observed at PAI-01-SB-02 and PAI-01-SB-03. Additionally, several samples had elevated PID readings. Please explain why these samples were not collected for laboratory analysis for the purposes of delineating nature and extent of contamination.

Response: The site was investigated assuming a presumptive remedy. Therefore sample collection was biased toward areas that do not contain visible waste and would not otherwise be addressed by a cover/cap. The samples contain waste and therefore would be addressed by the cover/cap.

6. **Comment:** Section 3.2.5, 1st paragraph, typographical error. The sediment sample locations are illustrated in Figure 3-2 rather than Figure 3-3. Please revise accordingly.

Response: Agreed.

7. **Comment:** Figure 3-3 and Section 3.2.5. It is difficult to decipher what areas were impacted by the debris such as glass and ash. Please clarify the figure.

Response: Figure 3-3 will be modified to show areas where glass and ash are visibly present. Typically, this type of figure is presented in the corrective measures study.

8. **Comment:** Section 3.2.5, last paragraph, typographical. It appears as though the term "representative concentration" should be "representative locations". Please revise accordingly.

Response: Agreed.

9. **Comment:** Section 3.2.6, 1st paragraph. Please incorporate a figure illustrating the location of the picnic area and associated sample locations relative to SWMU 1. Additionally, the first paragraph should clearly state that the samples collected from the picnic area were collected for background purposes.

Response: A figure showing the location of the picnic ground samples will be added to the appendix. The following sentence will be added to Section 3.2.6. Two surface soil samples were collected within the picnic area west of Site 1 "to determine potential levels of pesticides and PAHs that may be attributable to commercial applications of pesticides and other anthropogenic sources of pesticides and PAHs. These two samples are not part of the site background data set."

10. **Comment:** Section 3.2.12, Holding Times. Please explain why numerous holding times were exceeded.

Response: Holding times were exceeded for 24 sample - analytes. The analytes were salinity, TOC (surface water), TDS, and TSS in surface water and groundwater. The exact reason for the laboratory not achieving the holding time is variable, however, these parameters are not very sensitive to holding times (e.g. the salinity of sea water), and do not directly affect the risk assessments. As a result, the data was not rejected in the validation process. In addition, the salinity, TDS, and TSS results can be semi-quantitatively evaluated from field instrument results obtained during sample collection (e.g. salinity and turbidity). Also, these sample analytes represent less than 0.2% of the analytical data set.

11. **Comment:** Table 3-5. Please explain why sample PAI-01-SW-08-00 was not sampled for surface water quality parameters.

Response: PAI-01-SW-08-00 is not a sample, and reference to it will be deleted from Tables 3-1 and 3-5. During the original planning for the site, the designation SW08 was assigned to a sample location. During subsequent revisions, the SW08 sample was deleted from the field activities. Since renumbering all sample locations could result in quality problems with the field program, it was decided to maintain the previous sampling nomenclature for the rest of the locations.

12. **Comment:** Section 4.1.3. This section states that bis(2-ethylhexyl)phthalate was detected at concentrations exceeding the "background level"; however, there was no discussion of the levels

detected in the blank, if any. For the sake of comparison, please include a discussion of the detections of bis(2-ethylhexyl)phthalate in the blank.

Response: The sentence referencing bis (2-ethylhexyl)phthalate exceeding background will be deleted from this section. Organics detections are not compared to background concentrations in the early sections of the report, but are normally discussed in more detailed sections of the risk assessments.

13. **Comment:** Section 4.1.4, Figure 4-4. Please be advised that additional sediment samples may be necessary pending the outcome of the ecological subgroup.

Response: Acknowledged, once PRGs are developed for the site, supplemental delineation may be required prior to remediation.

COMMENTS BY DONALD C. HARGROVE, HYDROGEOLOGIST, DATED SEPTEMBER 8, 2000

1. **Comment:** The Division of Hydrogeology found this report technically inadequate. Comments were going to be written concerning field logs, monitoring well development and purging procedures, and Chain of Custody Forms. However, comments generated during this review mirror some of the comments by the EPA (letter: Pope to Cheney, dated 31 August, 2000). The Division does not wish to reiterate comments already generated by another reviewer, and therefor concurs with the EPA's comments. Responses to said comments will be reviewed upon their submittal.

Response: Acknowledged. See responses to EPA comments regarding field logs and chain of custody forms. The EPA did not comment on monitoring well development and purging procedures.

COMMENTS BY SUSAN K. BYRD, RISK ASSESSOR, DATED AUGUST 8, 2000

General Comments

1. **Comment:** Page 3-1 and 3-2, Section 3.1 - Deviations From the Work Plan: Explain in more detail the specific reasons for deviating from the work plan. For example, please provide details for why the two soil sample locations were moved at SWMU 41, and provide information why the sediment samples were not analyzed for hexavalent chromium.

Response: The following statement will be added to the 4th bullet. "This concrete pad represents field conditions that provide direct evidence of the location of the former incinerator."

The following statement will be added to the 6th bullet. "Because of a missed holding time," ....

2. **Comment:** Page 3-5, Section 3.2.6 - Surface Water Sampling: Please explain why dioxin samples were not collected during this investigation. SWMU 1 and 41 disposal histories indicate that dioxin samples are warranted. If samples were analyzed for dioxins, please discuss the results and sample locations.

Response: Based on the site history, environmentally significant concentrations of dioxin would not be expected to be present at this site. This determination was based on the type of waste burned (municipal) and the type of ash landfilled (bottom ash). Current research indicates that dioxins form during the combustion of chlorinated organics in the flyash. During the time period that the incinerator was in operation (pre 1959), chlorinated organics (either as liquid wastes or plastics) would not have been common in municipal type wastes. Therefore dioxin precursors would not have been present. The references to dioxin formation during combustion suggest that the dioxins are formed primarily in the flyash, not the bottom ash. This research was discussed with the partnering team. Based on the common confusion with dioxin formation, the team decided to collect a limited number of samples to document the absence of environmental significant levels of dioxins. Therefore, a work plan was developed.

The results of the investigation are provided in Appendix G of the Site 1 RI report, and TCDD equivalents were measured for waste, sediments, and groundwater as well as a remote background location. The TCDD concentrations found were similar to those measured in a background location and were less than or similar to the most stringent of human and ecological screening values. Therefore it was concluded that the TCDD detected were not of site origin and were not of environmental significance.

Specific Comments

1. **Comment:** Page 2-3, Section 2.7 – Ecology: As discussed in the teleconferencing call on July 31, 2000, the RFI report should be written as a stand alone document. In future documents, avoid referring the reader to previously written documents and summarize the pertinent information from the referenced document.

Response: MCRD Parris Island is a complex site with considerable historical information. The amount of historical information to be provided in current reports is subjective. If the requested information is needed by several groups and directly relevant, then it is included in the report. However, for information that is redundant or highly technical and is not directly relevant to the current investigation, it is more appropriate to reference other documents. This approach results in a more focused and efficient reporting of complex issues and results. As discussed, a reference to Section 7.0 will be provided in Section 2.7.

2. **Comment:** Page 3-4, Section 3.2.4 – Surface Water Sampling, Paragraph 2: The text states that elevated turbidity in the surface water samples was unavoidable due to the sampler walking to the sampling location. In order to decrease the amount of turbidity, always enter a sample location from downstream. Time should be allotted to allow for the turbidity to settle and migrate "downstream" prior to filling sample containers.

Response: The surface water at the site is nearly stagnant on the receding tide and very shallow (3 to 6 inches). Therefore, approaching the sample location from the downstream position would not reduce turbidity in the sample. Also, standing water is present at these locations for only 1 to 2 hours after high tide and the sampling proceedure requires approximately 30 minutes. Based on the fine grained nature of the sediments at this location and the long time required for sediment to flush or settle, there would not be sufficient water left at the site.

3. **Comment:** Page 6-11, Section 6.2.3.5, Ingestion of Fish: Since the extent of contamination has not been delineated in the surface water and the sediment in relation to the low tide line (not indicated on sample location maps), the rationale presented for excluding this pathway is not justified. If it is determined that contamination has not migrated from the site to the low tidal waters, then this rational is appropriate.

Response: The investigation was conducted to specifically evaluate the potential for migration of significant contamination from the site. Initially, the samples were collected as near the site as possible to maximize the potential contaminant concentrations. In general, the most significant

chemical concentrations were measured near the site and most of the detected chemical concentrations decreased to below screening levels/background away from the site within the tidal zone.

Based on the physical characteristics of the site, fish cannot live continuously within several hundred feet of the site. Archers Creek in the northwest corner of the map and another a narrow branch of a tidal stream branch located north of the site are the nearest surface water bodies during low tide.

We recognize the potential concern with this pathway and will add this scenario to the human health risk assessment. However, based on the relatively low chemical concentrations detected in surface water, the evaluation will compare the surface water data to ambient water quality criteria for fish consumption only and factor in site averages and home range considerations. If necessary, a conservative fish consumption model will be generated.

4. **Comment:** Page 7-8, Section 7.3.3.7: Response to comments from future reports as well as previous team meetings (April 20, 2000) indicate that smaller wading birds such as the green heron or the little blue heron would be used in ecological risk assessments due to smaller home ranges and greater food ingestion rates in relation to body weight. Since the smaller wading birds are better suited receptors for potential hazardous waste sites, please revise the section and calculations pertaining to the great blue heron.

Response: During the April 2000 team meeting, it was agreed to make this change for future reports. The Site 1 report was issued for review in March 2000. As discussed during the meeting, the impact of the change is very minor (less than 10%). However, for completeness, text will be added to the report to semi-quantitatively note this receptor and potential impacts on the food chain modeling and the green heron calculation will be added to the Appendix.

5. **Comment:** Page 7-26, Section 7.8.1 – Volatile Organic Compounds, Paragraph 2: The text recommend that acetone be dropped from further consideration since it is a common laboratory contaminant. Please include the levels of detections of acetone in the various blank samples in the body of the text of the report.

Response: The following will be added to Section 7.8.1.

"Acetone was detected in laboratory blank samples at concentrations up to 4.2 µg/l in water and 24 µg/kg in soils/sediments.

6. **Comment:** Page 7-27, Section 7.8.1 – Carbon disulfide: The text states that carbon disulfide may not be due to site-related contamination and should be dropped from further consideration. Since the waste disposal practices at the site are not known, and since no ESV is available for carbon disulfide, this compound should be retained unless additional information is provided for its exclusion.

Response: The following text will be added to this section. "Unlike most organic compounds on the TCL list, carbon disulfide is a naturally occurring compound in marsh sediments, therefore its presence in site sediments and associated groundwater would be expected. Carbon disulfide was detected in two of six background sediment samples at concentrations ranging from 2 to 7 µg/kg."

7. **Comment:** Page 7-30, Section 7.8.2 – PAH Compounds: The text states that various other "sources" may have influenced the PAH detections in sediment samples especially in the vicinity of SD-017-01. Sampling strategies should have been modified and additional "biased" samples should have been collected to control for other influences especially nearby drainage channels.

Response: Once PRGs are established, additional sampling may be considered to further delineate the PAHs in sediments prior to remediation. Additional sampling was not conducted at this time because the need for PAH-based remediation and potential cleanup levels were uncertain.

8. **Comment:** Page 7-47, Section 7.9.1 – Uncertainty: The text states that more than one source may be influencing the site. As stated in specific comment 7, without analytical data controlling for off-site sources, this is not a valid rationale. The samples should have been moved to more suitable locations to determine site influence or used as control samples for the off-site sources.

Response: The discussion is intended to address uncertainty in the results. This type of uncertainty can never be eliminated from an investigation and collecting more samples will not necessary reduce this uncertainty. The sample locations, initial and second round, were developed by the partnering team based on the results and site conditions. Anthropogenic sources of contamination can be further addressed during PRG development, if relevant.

NOAA Comments on Remedial Investigation (RI)/RCRA Facilities Investigation (RFI) for Site/SWMU 1 - Incinerator Landfill and SWMU 41 - Former Incinerator, Marine Corps Recruit Depot, Parris Island, South Carolina, Comments dated October 10, 2000

1a. **Comment:** The ecological risk assessment (ERA) is incomplete and inconsistent with EPA guidance. The first 2 steps of EPA's 8-Step ERA process was begun but not completed. A discrete Scientific-Management Decision Point for Step 2 (screening-level ERA) should be provided. This SMDP should summarize COPC identification (screening against maximum abiotic concentrations only) as well as other elements of the screening-level risk characterization. A clear ending to Step 2 will help focus subsequent activities under Step 3.

Response: Preliminary results of the screening level risk assessment, which consisted of Steps 1 and 2 of EPA's 8-step process, were presented to the partnering team in October 1998 and again in 1999. The partnering team concurred that a more thorough assessment was warranted, and that the Navy should proceed with the assessment; this decision represents the initial SMDP. Subsequently, a more thorough assessment is presented in Step 3A of the RI/RFI report. Comments, responses, and ultimate concurrence with the RI/RFI report will represent the next SMDP.

1b. **Comment:** Step 3, Problem Formulation, was begun but not completed. Notably absent are tables summarizing COPC refinement. When reporting COPC refinement, please provide media-specific tables with the following information.

a. Maximum, mean and range of site concentrations
b. Frequency of detection expressed not as a % but as # exceeded/total # of samples
c. Range of detection limits
d. Range of organic carbon content and grain size (sediment results)
e. EPA Region 4 screening value
f. Max. HQ based on maximum concentration and Region 4 screening value
g. Frequency of exceeding Region 4 screening value (again, not as a %)
h. Column(s) considering background concentrations (especially for inorganics)
i. Decision and rationale for including or excluding each analyte as a COPC. A brief text narrative may be required to clearly present each rationale.

Once the above tables have been prepared and distributed, conduct a Step 3-Problem Formulation meeting with the newly formed Parris Island ERA subgroup. Until that time, ERA conclusions and recommendations in the Executive Summary and Chapter 8.0 are premature

(e.g., recommendation to proceed directly to FS). Also, delete statement in the Executive Summary and Chapter 8.0 suggesting pesticides at Site 1 are not site-related until the data are rigorously evaluated for that possibility.

Response: Most of the requested information is presented in the RI report, although not in one table. However, as requested, TtNUS will summarize and submit the requested information in tables (added as Appendix F-7) to aid NOAA in completing their review of the RI report.

The ERA conclusions and recommendations presented in the executive summary and Section 8.0 are based on the belief that sufficient information is present to proceed to a Corrective Measures Study to address the primary site problems, i.e. the landfill wastes and contaminated sediments, similar to that conducted for Site 3.

The reference to pesticides not being related to site is a mis-statement. The correct statement is "Because of the common application of pesticides at the base, the pesticides may or may not be from site related waste disposal practices."

1c. **Comment:** The heavy emphasis on detailed food web modeling for ten different receptors are unnecessary for the Preliminary Effects Evaluation (§7.3) and Exposure Estimate (§7.4) and inconsistent with EPA regional and national guidance. Screening-level evaluations of higher trophic level risks should be confined to simple, conservative food web models. Likewise, inclusion of Measurement Endpoints (§7.2.5) at this early stage in the ERA is not consistent with EPA guidance.

Response: The risk assessment was performed in accordance with guidance in effect at the time, the approved work plan, and modifications agreed to during the partnering teams. The reviewer's comment reflects recently amended guidance from U.S. EPA Region IV (June 23, 2000) regarding the implementation of EPA's (1997) *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Under the amended guidance (EPA, 2000), most topics currently presented in Sections 7.3.2 through 7.5 (e.g., food chain modeling methodology) would instead be presented in Step 3 of the risk assessment process. However, the ecological risk assessment for Site 1 and SWMU 41 was conducted prior to dissemination of EPA's amended guidance. According to Lynn Wellman (2000) of U.S. EPA Region IV, reorganization of risk assessments already in process will not be required. The Navy will organize future ecological risk assessments as requested and this change will be discussed in the RI report.

2. **Comment:** Detection limits in sediment, surface water and ground water routinely exceed ecological screening values. For example, detection limits for mercury in ground water exceed the screening value by an order of magnitude. Sediment mercury detection limits routinely exceed the EPA screening value. PAH detection limits almost always exceed the sediment screening value. This may be related to creosote noted in the soil borings (p 3-3) and landfill debris (p 3-14). The Master WP (Table D-2) suggests SW 846-8310 would be used to achieve the necessary detection limits for PAHs. Was this method used? Detection limits for the bioaccumulative compound, PCP, are also very elevated in sediments (2-6 mg/kg) relative to the detection limit suggested in the Master WP (0.33 mg/kg). These routine violations of DQOs result in detection frequencies that are misleadingly low (Tables 7-4, 7-5, 7-8). Moreover, they underestimate the quantitative projections of ecological risks.

Response: The detection limits presented and the analytical methods used for this investigation represent the best reliable techniques available and were conducted in accordance with the approved work plan. For example, PAHs were analyzed in sediments using SW846-8310 - see Page D-103 as referenced.

The concern with the detection limits appears to focus on the use of the reported practical quantitation limits (PQLs) versus method detection limits (MDLs) (for organic compounds). The detection limits presented in the report for organics are the PQLs. The PQL represents concentrations at which most laboratories are able to routinely achieve and reliably report non detected values. For reporting purposes, the detection limit presented in the report is also adjusted for moisture content and dilutions (if employed). For sediment samples, which normally have a high moisture content, corrections factors of 1.5 to 5.0 are common. However offsetting these adjustments, the laboratory is contractually required to report detected values to the MDL, which represents the minimum concentration that the laboratory can detect a compound. The MDLs are normally a factor of 5 to 10 less than the PQL.

For example, the PQL for PCP is 0.8 mg/kg (the master work plan incorrectly reported the PQL as 0.33 mg/kg), therefore the resolution in the master work plan should have referenced best available technology. However, the laboratory method detection limits (MDLs) on a wet weight basis for PCPs in these samples ranged from 0.05 to 0.17 mg/kg (depending on the instrument)

This same discussion applies to mercury and the other organic results, including PAHs. MDLs for organic compounds are typically a factor of 5 to 10 times less than the reporting limit, and mercury MDLs for the study ranged from 0.031 to 0.13 ug/l for water and 0.006 to 0.02 mg/kg for soils/sediments. The MDLs are analyte and instrument specific and can vary over time. Also,

positive detections and reported concentrations are not very accurate in this range and a "J" qualifier is added (indicating an estimated value). Therefore, laboratories do not normally report to the MDL level.

For samples in which the chemical was not detected in any sample, there are two considerations. The first consideration is that the actual detection limit (MDL) for a chemical in a medium is less than the reliable detection limit presented in the report (PQL), generally by a factor of 5 to 10. Therefore, potential exceedances are not common. The second consideration is that the best reliable analytical methods were used in this study. To attempt to prove the absence of chemicals at concentrations below detectable limits is not feasible.

3a. **Comment:** More fully evaluate the ground water to surface water exposure pathway. Ground water is very shallow at this site (2'-3' BGS). It is likely that ground water is discharging at the surface water/sediment interface. This line of speculation is supported by elevated surface water/sediment concentrations that are spatially related to some elevated ground water analytes (e.g., see mercury and copper). The fate and transport section of this RI report should more fully explore this pathway.

Response: We concur, the groundwater to surface water scenario and risk are discussed in the report and further consideration of groundwater impacts on surface water and sediment will be evaluated in the feasibility study. This approach is a recommendation for the FS.

3b. **Comment:** Figures showing the direction of modeled ground water flow are normally provided in a RI report. Is there an explanation for their omission? Finally, the subject document does not report ground water results for upgradient or background monitoring wells. These analytical data would elucidate the ground water to surface water exposure pathway and facilitate the ecological risk assessment.

Response: The site hydrogeology is presented in Section 3.4 of the report and indicates that groundwater flows radially from the center of the site. Also, because of the monitoring wells are placed in a circle around the site, water level data cannot be used to generate a map as suggested.

Monitoring well PAI-MW04S can potentially be used as an upgradient/background well. Arsenic and zinc were detected in this well. If either of these chemicals become risk drivers, then PRG development in the FS will account for them.

4. Other Comments

4a. **Comment:** In the environment, PAHs exist and exert their toxicity as mixtures. It is for this reason that EPA Headquarters is developing ecological sediment guidelines based on the mixture of PAHs rather than individual compounds. To help simplify and clarify the Parris Island COPC screening/refinement process, consider using a "Total PAH" expression and use the EPA Region 4 screening value for Total PAHs.

Response: Concur. Sediment values for total PAHs were calculated and assessed (see Table 7-18, and Section 7.8.2). However, total PAHs were not shown in Table 7-5; this table will be revised.

4b. **Comment:** The cumulative toxicity discussion begun in §7.8.5 is excellent. Consider using ER-M quotients to help bolster this discussion. ER-M quotients permit one to quantitatively compare benthic toxicity risks among sample locations on an equal (i.e., normalized) basis. If mean quotients are calculated, consider guidance offered by Long et al. atwww.response.restoration.noaa.gov/cpr/sediment/SQGs.html (especially Table 4).

Response: Future ecological risk assessments at MCRD Parris Island will incorporate the use of ER-M quotients to the maximum possible extent.

4c. **Comment:** Sediment grain size/organic carbon information is inadequate. Grain size is reported for only 3 of the 14 sediment samples. These limited data indicate sediments sampled are approximately 60% sand+gravel (Table 4-6). This suggests sediment samples may not have been collected from depositional areas (per EPA Region 4 guidance). No grain size or organic carbon data is reported for the six reference/background samples. Table 4-6 is mistitled; delete reference to the Causeway Landfill.

Response: The number of samples collected for grain size and organic content analysis was in accordance with the approved work plan. The rationale for collecting this number of samples was to provide a general characterization of the sediments in the area. Since the area is a large flat tidal marsh, significant variations in these parameters would not be anticipated. The data collected was consistent with this expected uniformity. The work plan discussed the sampling methodology and indicated that in a given area, a sample would be biased toward depositional areas. Since the marsh surrounding Site 1 is largely uniform and flat, this bias was not a factor in selecting sample locations.

Also, as previously discussed, the predominant particle size for native materials in the area would lie in the sand particle range with some silts and clays. Therefore, the relatively high concentration of sand noted in the sediment matrix would be expected for this area and would be consistent with potential depositional areas for waste migration from the site.

Table 4-6 will be retitled.

4d. **Comment:** Section 7.2.4 indicates Ca, Mg, K, Na were deleted prior to screening. This is contrary to EPA Regional guidance. Include these analytes in the screen. Then evaluate their ecological risks during COPC refinement using the spatial distributions of analyte concentrations, background levels and known/suspected toxic levels.

Response: The essential elements Ca, Mg, K, and Na are normally excluded as ecological COPCs prior to the initial screening for the reasons provided in Section 7.2.4. The Navy is not aware of EPA Region IV guidance to the contrary, and the exclusion of these elements was not commented upon by EPA Region IV.

4e. **Comment:** The “tag” maps in Chapter 4 mislead the reader by omitting many exceedences of ecological screening values reported in Tables 7-4, 7-5, 7-6, 7-7, 7-8.

Response: The tags maps are presented in Section 4.0 - Nature and Extent of Contamination. Chemicals detected at concentrations below background are not contamination. Therefore, the alleged omission is simply a screen against background (inorganic only) contaminants. The ERA process is presented in Section 7.0 and follows appropriate guidance for ecological risk assessments. Specifically, background concentrations were not considered in Step 2 of the ERA process, but were considered (primarily for inorganics) in Step 3 of the ERA process.

4f. **Comment:** Include descriptions and a location map for the six background samples (Table 4-1).

Response: The location of the background sample locations is presented in Appendix A.

4g. **Comment:** The Theoretical Bioaccumulation Potential (TBP) model can be used to estimate bioaccumulation of neutral, non-polar compounds directly from sediment. However, this exposure model does not account for routes involving the ingestion of contaminated prey and/or chemicals that may biomagnify. It is inappropriate, therefore, to use TBP when these conditions may exist (e.g., §7.4.3.2).

Response: Concur; the use of the TBP model to predict concentrations of organochlorine pesticides in red drum was in error. Section 7.4.3.2 and Table 7-15 will be revised to show only predicted pesticide concentrations in mummichog tissue.

REFERENCES

EPA (U.S. Environmental Protection Agency). 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, June 5, Edison, New Jersey.

EPA (U.S. Environmental Protection Agency). 2000. Amended Guidance on Ecological RisK Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders. Memorandum from Ted. W. Simon, Region 4 EPA Office of Technical Services, Atlanta, Georgia, June 23.

Wellman, L.. (U.S. Environmental Protection Agency, Region 4, Waste Management Division, Atlanta, Georgia). 2000. Personal Communication with M.L. Whitten, April 13 (Tetra Tech NUS, Inc., Aiken, South Carolina).

EXECUTIVE SUMMARY

PURPOSE AND OBJECTIVES OF REPORT

This Remedial Investigation (RI)/RCRA Facility Investigation (RFI) report summarizes the 1998 and 1999 field activities and results for the Incinerator Landfill (Site 1/Solid Waste Management Unit [SWMU] 1) and the Former Incinerator (SWMU 41), located at the Marine Corps Recruit Depot (MCRD) Parris Island, South Carolina. The report encompasses the RI/RFI activities and also references previous investigations, as relevant. The historical activities include an Initial Assessment Study in 1986, a RI Verification Step in 1990, and an Interim RCRA Facility Assessment in 1990.

The RI/RFI sampling program was developed to support a presumptive remedy for the site that assumes waste materials would be encapsulated under a cover/cap. The sampling approach is consistent with United States Environmental Protection Agency (U.S. EPA) guidance entitled Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA, 1993a) and Application of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Municipal Landfill Presumptive Remedy to Military Landfills (Interim Guidance) (U.S. EPA, 1996e). This RI/RFI report describes the collection of soil, sediment, surface water, and groundwater samples in accordance with the RI/RFI Work Plan, evaluates the analytical data, assesses human health and ecological risks, and provides recommendations.

HISTORICAL INFORMATION

MCRD Parris Island is located along the southern coast of South Carolina, approximately 1 mile south of the city of Port Royal and 3 miles south of the city of Beaufort within Beaufort County. MCRD Parris Island covers approximately 8,047 acres that consist of dry land, salt marshes, saltwater creeks, and ponds. MCRD Parris Island is the reception and recruit training facility for the Marine Corps for enlisted men from states east of the Mississippi River and for enlisted women nationwide.

Site/SWMU 1 is located on the northeastern tip of Horse Island at MCRD Parris Island. The landfill extends approximately 670 feet into the marsh toward Archers Creek and is approximately 400 feet in width. The landfill occupies approximately 4 acres and is covered primarily with mature pine trees. The former incinerator (SWMU 41) was either located adjacent to or within the boundaries of Site/SWMU 1 and consisted of a coal-fired brick chamber approximately 43 feet long, 34 feet tall, and 20 feet wide. Emissions were vented through a hole in the top of the chamber. A ramp was situated along one of the unit's sides to provide access to the top of the incinerator. Trucks carried wastes up the ramp and discharged them into the hole.

From 1921 to 1965, Site/SWMU 1 served as the disposal site for combustion residues from the incinerator. The majority of wastes disposed in the landfill during this time were nonhazardous, combustible domestic wastes (ash residues) and other noncombustible wastes (e.g., cans, bottles, and construction debris). Additionally, hazardous wastes generated from the MCRD from 1921 to 1959 were treated in the incinerator and disposed in the landfill. Paint thinners (mineral spirits), diesel fuels, kerosene, and strippers (methylene chloride) were also poured onto the landfill and burned (NEESA, 1986). No auxiliary fuels were used for open burning.

SWMU 41 remained in operation until 1959. Site/SWMU 1 continued to be used for disposal of combustible trash and noncombustible waste until 1965. No records exist documenting how noncombustible waste was disposed of during this period. Since 1965, no significant disposal or intrusive activity has taken place within the boundaries of Site/SWMU 1 or SWMU 41. A thin layer of cover soil appears to have been placed over the fill material at the site and the site is currently well vegetated.

The RI/RFI field investigation was conducted from May to September 1998 and in April 1999. The objectives of this investigation were to characterize the nature and extent of potential contaminant migration from past landfilling operations at Site/SWMU 1 and past incineration activities at SWMU 41. At Site/SWMU 1, the 1998 investigation included sampling of soils, surface water, and sediment, as well as an overall investigation of site groundwater. At SWMU 41, the 1998 investigation included sampling of surface soil. Background conditions were also established for both sites. A supplemental RI/RFI sampling event was conducted in April 1999 where additional sediment and surface soil samples were collected. Both human health and ecological risk assessments are included in this report to support site decisions.

Data collected during the investigation have been entered into a database. The database was used in this report to support the risk assessments, including the comparison of analytical results to state and federal standards and to background levels. Data evaluation and recommendations for Site/SWMU 1 and SWMU 41 are included herein. Data validation on these data consisted of either a data review or a full data validation. The full data validation was performed on approximately 10 percent of the data packages received from a laboratory. All analytes were covered by at least one full data validation. A data review was performed on the remaining data packages for the purposes of identifying false positive and negative results.

INVESTIGATION SUMMARY

Investigation activities were conducted from May to September 1998 and in April 1999. During the 1998 RI/RFI investigation, groundwater, surface soils, sediment, and surface water samples were collected and

analyzed for Target Compound List (TCL)/Target Analyte List (TAL) and other selected parameters (e.g. geotechnical properties). Select groundwater samples were analyzed for Appendix IX constituents. 1998 field activities at Site/SWMU 1 include the following:

- 10 groundwater monitoring wells were installed and developed (5 shallow and 5 deep)
- 11 groundwater samples were collected (one from each new well and one existing well) using low flow sampling techniques
- a tidal influence study was conducted using the monitoring wells and surface water bodies
- slug tests were conducted on each well to determine hydraulic parameters
- 11 surface water samples were collected
- 12 sediment samples were collected
- 13 surface soil samples were collected
- sample locations were surveyed to establish horizontal and vertical control

In 1998, four surface soil samples were also collected at SWMU 41.

In April 1999, five additional sediment samples were collected to better define detections observed in the 1998 sediment samples. Additionally, in April 1999 two surface soil samples were collected at a picnic area near Site/SWMU 1 to determine whether pesticides or PAHs may be present in the area form non-site sources (e.g., pesticide applications or road run-off). In October 1999, two sediment locations and one monitoring well at Site 1 and one background sediment sample location were sampled and analyzed for TCDD and related isomers.

SITE GEOLOGY/HYDROGEOLOGY RESULTS

Surface soils collected from the interior of the landfill during the 1998 field event consisted of fine to medium sands with varying amounts of silt and clay. Surface debris consisting of glass and metal was observed during the field event. This material was observed in several surface soil locations at depths of 1 foot or less.

The site-specific subsurface geology at the unit has been affected by human activities. Material was buried in pits in the landfill, creating topographic high and low areas within the facility limits. In the soil boring locations along the edge of the landfill boundary, landfilled debris consisted of creosote-soaked poles, glass fragments, and construction debris, which included concrete and brick fragments. Generally, the shallow subsurface geology of the study area consists of a heterogeneous mixture of tidal- and storm-deposited silt, clay, and sand, with clays being prevalent to a depth of approximately 28 feet below

ground surface (bgs). Beneath the tidal sands, silts, and clays, the sediment consists of fine to coarse sands with varying clay content to depths of 34 to 36 feet bgs.

In general, a surficial groundwater table (less than 2.5 feet bgs) exists at the site where the new monitoring wells were installed. Based on the depth of the confining unit (Hawthorn Formation), which was consistently identified at approximately 36 feet bgs, the thickness of the surficial aquifer is 33.5 feet. Locally, shallow groundwater is expected to flow from the middle of the landfill facility toward the topographic low areas that serve as groundwater discharge points. The geometric average hydraulic conductivity for the six shallow surficial aquifer wells and the five deep surficial aquifer wells was calculated to be approximately 2.52 feet per day [8.89×10^{-4} centimeters per second (cm/sec)] and 4.51 feet per day (1.59×10^{-3} cm/sec), respectively. The values for the shallow and deep wells are within the typical range of hydraulic conductivity for the material encountered.

The upper surficial aquifer is generally divided from the lower Floridan Aquifer by the Hawthorn Formation, which acts as a confining unit. The Hawthorn Formation is a phosphatic sand and clay unit with a reported thickness of approximately 2 to 40 feet in the study area. The results of a falling head permeability test performed on an undisturbed sample (gray-green silty to clayey, fine sand) at a depth of 39 to 41 feet bgs indicate the material encountered has a vertical hydraulic conductivity of 8.4×10^{-8} cm/sec. Based on the results of the falling head permeability test, the material likely acts as a confining unit. At soil boring PAI-01-SB-05 [well cluster PAI-01-MW-13(S)/14(D)], the confining unit is underlain to a depth of at least 50 feet bgs by fine to coarse sand that gets tighter and dryer with depth. Assuming this sand unit exists across site, the confining unit is approximately 6 feet thick.

The Floridan Aquifer, which underlies the site, extends continuously from South Carolina into Florida. Groundwater of this aquifer occurs mainly under artesian conditions at MCRD Parris Island. The Floridan aquifer is the most important source of groundwater in the Low Country area, and wells generally less than 250 feet deep tap this aquifer system. The aquifer is the only source of potable groundwater west, north, and east of MCRD Parris Island.

NATURE AND EXTENT OF CONTAMINATION

Surface soils were found to contain polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and several metals including lead, arsenic, aluminum, iron, mercury, vanadium, and zinc at concentrations greater than present in background soils and in exceedance of the most stringent human health risk-based concentrations (RBCs) (residential) or the most stringent ecological screening values. The highest levels of metals were generally associated with areas with little or no cover soil. As discussed in Appendix H, the observed pesticide concentrations in soil are consistent with surface application; consequently, pesticides may not be site related.

Arsenic, iron, lead, manganese, thallium, chloroform, and naphthalene were detected in the site groundwater at concentrations that exceed the most stringent human health criteria (drinking water standards). The presence of a salt water marsh surrounding the site and the measured salinity in the groundwater limits the use of site groundwater as a potable water supply. Naphthalene, copper, lead, mercury, and zinc were present in groundwater at concentrations that could exceed the most stringent ecological screening values for surface water if groundwater to surface water attenuation factors were not present.

Bis(2-ethylhexyl)phthalate, chrysene, pentachlorophenol, arsenic, iron, manganese, and mercury were detected in surface water at concentrations in excess of background and the most stringent human health RBCs. Pentachlorophenol, copper, lead, mercury, silver, and zinc were detected in surface water at concentrations in excess of background and the most stringent ecological screening values.

Sediments were found to contain PAHs, pesticides, arsenic, cadmium, copper, iron, lead, mercury, and silver at concentrations greater than present in background sediments and in exceedance of the most stringent human health RBCs (residential) or the most stringent ecological screening values. As discussed in Appendix H, the observed pesticide concentrations in soil are consistent with surface application; consequently, pesticides may not be site related.

TCDD and related isomers, measured as TCDD toxicity equivalent concentrations (TEQ) were found in both sediment and groundwater at the site, but at concentrations below the most stringent risk-based human health and drinking water criteria. The detected TEQ at the site were at concentrations similar to the most stringent ecological criteria for mammals and significantly less than the most stringent criteria for fish and avian receptors. As a result, significant impact to site ecological receptors would not be anticipated. The concentration of TEQ in site sediments is also similar to that found in a background sample location. As a result, the presence of TEQ is likely to be present from a regional source and is not related to Site 1 waste disposal activities.

HUMAN HEALTH RISK ASSESSMENT SUMMARY

The human health risk assessment considered site media exposure to construction workers, maintenance workers, adolescent and adult recreational users, and potential future residents. The estimated incremental lifetime cancer risk (ILCR) to construction workers exceeded $1x10^{-6}$, but was less than $1x10^{-4}$. This risk is within the acceptable U.S. EPA target risk range. The noncarcinogenic risk estimate for the construction worker was slightly greater than 1.0 (2.2), indicating that toxic effects are possible. However, the only chemical with a hazard quotient greater than 1.0 was iron.

The estimated ILCR to maintenance workers exceeded $1x10^{-6}$, but was less than $1x10^{-4}$. This risk is within the acceptable U.S. EPA target risk range. The noncarcinogenic risk estimate for the maintenance worker was less than 1.0, indicating that toxic effects are not anticipated.

For surface water with the exception of bioaccumulation through fish, the estimated ILCR to the adolescent recreational user exceeded $1x10^{-4}$ for surface water (at $1.2x10^{-4}$). This risk is greater than the U.S. EPA target risk range. Bis(2-ethylhexyl) phthalate and pentachlorophenol were the major contributors to this cancer risk estimate. For soils and sediments, the estimated incremental cancer risk to adolescent recreational user exceeded $1x10^{-6}$, but was less than $1x10^{-4}$. This risk is within the acceptable U.S. EPA target risk range. The noncarcinogenic risk estimate for the adolescent recreational user indicates that toxic effects are not anticipated.

The estimated incremental cancer risk to the adult recreational user with the exception of exposure through fish ingestion exceeded $1x10^{-6}$, but was less than $1x10^{-4}$. This risk is within the acceptable U.S. EPA target risk range. The noncarcinogenic risk estimate for the adult recreational user indicates that toxic effects are not anticipated.

The human health risk assessment also considered environmental exposure from the adult recreational user via recreational fishing at the site. Chemical concentrations in fish tissue were estimated through theoretical equilibrium partitioning of surface water contaminants to fish. This approach is expected to be very conservative for this site. The estimated chemical concentrations in fish tissue were then used to calculate risks to human health under a frequent consumer (daily fish consumption– default) and occasional consumer consumption (once per week) of fish from the site. Under the most likely scenario (average concentrations and occasional fish consumption), the ILCR estimate ($4.1x10^{-5}$) was within the acceptable U.S. EPA risk range of $1x10^{-4}$ to $1x10^{-6}$. The estimated noncarcinogenic risk (2.2) slightly exceeded 1.0 indicating that toxic effects are possible. Under more stringent scenarios (frequent fish consumer and/or maximum concentrations), incremental cancers risks exceeded $1x10^{-4}$ and non carcinogenic risks were greater than 1.0. These risk estimates are higher than acceptable U.S. EPA risk criteria. Pentachlorophenol and arsenic were the main contributors to carcinogenic risk. Pentachlorophenol, dibenzofuran, arsenic, iron, and manganese were the main contributors to noncarcinogenic risk.

The estimated ILCR to a hypothetical future child, adult, and lifelong resident exceeded $1x10^{-4}$ based on exposure to surface water. The ILCR for exposure to surface water was estimated to be $1x10^{-4}$ for the child resident, 2.5 $x10^{-4}$ for the adult resident, and $3.6x10^{-4}$ for the lifelong resident. Bis(2-ethylhexyl) phthalate and pentachlorophenol in surface water were the major contributors to this cancer risk estimate. The total ILCR across all media (surface water, soil, and sediment) was estimated to be $1.4x10^{-4}$ for the

child resident, 2.8 $x10^{-4}$ for the adult resident, and $4.2x10^{-4}$ for the lifelong resident. These risk estimates are greater than the U.S. EPA target risk range. The noncarcinogenic risk estimates for a hypothetical future child (11) and adult (1.3) were greater than 1.0, indicating that toxic effects are possible.

ECOLOGICAL RISK ASSESSMENT SUMMARY

The initial ecological risk screening determined that the maximum concentrations of pentachlorophenol and several metals, pesticides, phthalates, and PAHs at the site exceed U.S. EPA Region 4 screening values, indicating a potential risk to ecological receptors. In addition, several other chemicals were identified as chemicals of potential concern (COPCs) because of the lack of screening criteria.

The food chain modeling evaluated 11 representative receptors and found that the majority of the initial COPCs do not represent a threat to site receptors even under a worst case scenario (organisms constantly exposed to maximum concentrations). Chemicals that pose potential risks under this scenario consist of PCBs, pesticides, phthalates, and several metals.

The food chain modeling found that under more realistic conditions which consider mean chemical concentrations, the list of chemicals in which hazard quotients (HQ) for NOAELs exceed 1.0 were reduced to the following:

- DDT(maximum HQ is 66)
- DDE (maximum HQ is 177)
- DDD (maximum HQ is 30)
- aluminum (maximum HQ is 1,130)
- antimony (maximum HQ is 27)
- arsenic (maximum HQ is 10.6)
- barium (maximum HQ is 6.7)
- cadmium (maximum HQ is 3.4)
- iron (maximum HQ is 116)
- lead (maximum HQ is 195)
- mercury (maximum HQ is 41)
- thallium (maximum HQ is 10.1)
- vanadium (maximum HQ is 27.5)
- zinc (maximum HQ is 28)

In evaluating this data the following factors should be considered.

- Except for aluminum, arsenic, thallium, and vanadium, the maximum hazard quotients were all associated with terrestrial receptors and surface soils.

- The majority of the pesticides detected at Site/SWMU 1 were similar to typical concentrations found at the base.

CONCLUSIONS/RECOMMENDATIONS

Soil testing at SWMU 41 did not find any evidence that contamination at the two suspected locations of the former incinerator is unique from that found at Site/SWMU 1. As a result, SWMU 41 will be addressed as part of Site/SWMU 1. In addition, the one suspected location south of the Site/SWMU 1 did not exhibit any evidence of contamination, indicating that either incineration activities never occurred in this area or that potential impacts from the historical operation have been remediated.

The surface soil data are adequate to proceed to a feasibility study/corrective measures study to support a presumptive remedy at Site 1. Options for evaluation under the presumptive remedy include covering/capping of landfill contents. Protection of ecological receptors (direct contact and erosion into the sediment) is the primary concern.

The groundwater data are adequate to proceed to a feasibility study/corrective measures study to evaluate options for managing contaminated groundwater. Based on the low level of contamination, the location of the site relative to a salt water marsh, and the permeability of underlying soils, remedial options will focus on reducing infiltration and tidal effects.

Because of the transient nature of surface water, water quality concerns would be better addressed through management of sediment, soil, and groundwater.

The sediment data are adequate to proceed to a feasibility study/corrective measures study.

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

Tetra Tech NUS, Inc. (TtNUS) prepared this remedial investigation (RI)/RCRA facility investigation (RFI) report to summarize field activities conducted at the Incinerator Landfill [Site 1/Solid Waste Management Unit (SWMU) 1] and the Former Incinerator (SWMU 41), located at the Marine Corps Recruit Depot (MCRD) Parris Island, South Carolina. This report was prepared for the United States Navy (Navy) Southern Division (SOUTHDIV) Naval Facilities Engineering Command (NAVFAC) under Contract Task Order (CTO) 0020, for the Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract Number N62467-94-D-0888.

1.2 REGULATORY SETTING

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act of 1986 (SARA) established a program for the cleanup of hazardous waste disposal and spill sites nationwide. This program contains provisions for the cleanup of contamination from past hazardous waste operations and past hazardous material spills and is the framework for Installation Restoration (IR) programs at Navy and Marine Corps installations. The Resource Conservation and Recovery Act (RCRA), as amended, also establishes a cleanup program that provides for current and future hazardous waste management practices, as well as cleanup of past disposal sites at permitted or interim status Navy/Marine Corps installations. SOUTHDIVNAVFAC has the responsibility for implementing the Navy's IR Program at MCRD Parris Island.

Because of the past hazardous waste activities conducted at the MCRD Parris Island, South Carolina, the MCRD meets criteria for conducting IR activities under the CERCLA regulatory framework. To date, the MCRD has completed steps equivalent to the preliminary assessment/site inspection phases of the CERCLA remedial action process at Site/SWMU 1. The MCRD also meets the criteria for conducting IR activities under the authority of RCRA because, in the late 1980s, the MCRD submitted a RCRA Part A application. Per RCRA, this action required the MCRD to conduct corrective action for the release of hazardous waste or hazardous constituents from SWMUs. As part of this requirement, an Interim RCRA Facility Assessment (RFA) was conducted in 1990 where both the incinerator landfill and the former incinerator were addressed as SWMUs. Since this time, the MCRD has withdrawn its Part A application.

Because of the circumstances surrounding the MCRD's IR program history, discussions have been held among representatives from the U.S. Marine Corps, U.S. Navy, South Carolina Department of Health and Environmental Control (SCDHEC), and the U.S. Environmental Protection Agency (U.S. EPA), Region 4 to

determine the appropriate regulatory framework for conducting IR activities at the MCRD. From these discussions, it has been decided that this report will encompass both CERCLA and RCRA requirements and the title, RI/RFI, reflects this decision. For ease of reading and clarity, the incinerator landfill (Site/SWMU 1) will be referred to as Site 1 for the remainder of this document. The former incinerator will be referred to as SWMU 41.

In 1996, the partnering team for MCRD Parris Island was established. The original members of the team consisted of the Navy, Marine Corps – MCRD Parris Island, U.S. EPA, and SCDHEC. In 1997, representatives of National Oceanic and Atmospheric Administration (NOAA), South Carolina Department of Natural Resources (SCDNR), and U.S. Fish and Wildlife Service joined the team as natural resource trustees. The partnering team was developed to facilitate the development, review and approval of work plans, reports (RI/RFI and FS/CMS), and decision documents [proposed plan and records of decision (ROD)].

1.3 SCOPE OF RFI/RI

The initial RI/RFI field investigation was conducted from May 1998 to September 1998. The objectives of this investigation were to characterize the nature and extent of potential contaminant migration from past landfilling operations at Site 1 and past incineration activities at SWMU 41. At Site 1, this investigation included sampling of soils, surface water, and sediment, as well as an overall investigation of site groundwater. At SWMU 41, the investigation included sampling of surface soil. Background conditions were also established for both sites. A supplemental RI/RFI sampling event was conducted in April 1999 where additional sediment samples were collected. Both human health and ecological risk assessments are included in this report to support site decisions.

The RI/RFI sampling program was developed to support a presumptive remedy for the site that assumes waste materials would be encapsulated under a cover/cap. The sampling approach is consistent with U.S. EPA guidance entitled Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA, 1993a) and Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills (Interim Guidance) (U.S. EPA, 1996e)

Data collected during the investigation have been entered into a database. The database was used in this report to support the risk assessments, including the comparison of analytical results to state and federal standards and to background levels. Data evaluation and recommendations for Site 1 and SWMU 41 are included herein. Data validation on these data consisted of either a data review or a full data validation. The full data validation was performed on approximately 10 percent of the data packages received from a laboratory. All analytes were covered by at least one full data validation. A data review was performed on the remaining data packages for the purposes of identifying false positive and negative results.

1.4 HISTORICAL INFORMATION

1.4.1 Facility Background

MCRD Parris Island is located along the southern coast of South Carolina, approximately 1 mile south of the city of Port Royal and 3 miles south of the city of Beaufort within Beaufort County. MCRD Parris Island covers approximately 8,047 acres that consist of dry land, salt marshes, saltwater creeks, and ponds, as shown in Figure 1-1. MCRD Parris Island is the reception and recruit training facility for the Marine Corps for enlisted men from states east of the Mississippi River and for enlisted women nationwide.

1.4.2 Site 1 and SWMU 41 Background and History

Site 1 is located on the northeastern tip of Horse Island at MCRD Parris Island, as shown in Figure 1-1. The landfill extends approximately 670 feet into the marsh toward Archers Creek and is approximately 400 feet in width. The landfill occupies approximately 4 acres and is currently covered primarily with mature pine trees, as illustrated in Figure 1-2.

Historical records indicate that SWMU 41 was located in one of two possible locations, as indicated in Figure 1-2. The former incinerator consisted of a coal-fired brick chamber approximately 43 feet long, 34 feet tall, and 20 feet wide. Emissions were vented through a hole in the top of the chamber. A ramp was situated along one of the unit's sides to provide access to the top of the incinerator. Trucks carried wastes up the ramp and discharged them into the hole.

From 1921 to 1965, Site 1 served as the disposal site for combustion residues from the incinerator. The majority of wastes disposed in the landfill during this time were nonhazardous, combustible domestic wastes (ash residues) and other noncombustible wastes (e.g., cans, bottles, and construction debris). Additionally, hazardous wastes generated from the MCRD from 1921 to 1959 were reportedly treated in the incinerator and disposed in the landfill. Paint thinners (mineral spirits), diesel fuels, kerosene, and strippers (methylene chloride) were also reportedly poured onto the landfill and burned (NEESA, 1986). No auxiliary fuels were used for open burning.

Wastes were initially piled on the land or placed in trenches into the marsh, extending the edge of the landfill farther into the marsh. Fill dirt was also used to build up the land at the edge of the marsh. The landfill progressively extended farther into the marsh as wastes were dumped on the edge of the fill.

SWMU 41 remained in operation until 1959. Site 1 continued to be used for disposal of combustible trash and noncombustible waste until 1965. No records exist documenting how noncombustible waste was

disposed of during this period. Since 1965, no significant disposal or intrusive activity has taken place within the boundaries of Site 1 or SWMU 41. A thin layer of cover soil appears to have been placed over the fill material at the site and the site is a currently well vegetated.

1.4.3 Previous Site 1 and SWMU 41 Investigations

Several investigations conducted at MCRD Parris Island have included Site 1 and SWMU 41. Based on the results of past investigations, it was determined that further evaluation was needed and a recommendation was made to conduct an RI/RFI at both Site 1 and SWMU 41. A summary of these earlier investigations is as follows.

Initial Assessment Study

In 1986, NEESA conducted an initial assessment study (IAS) (NEESA, 1986) under the Naval Assessment and Control of Installation Pollutants (NACIP) Program. The IAS is equivalent to the preliminary assessment phase of the CERCLA process. The purpose of the IAS (Phase I of the NACIP Program) was to identify potentially contaminated sites at MCRD Parris Island that may pose a threat to human health or the environment. Because of the potential for contaminant migration and for adverse impacts on human health and the environment, the IAS recommended that NACIP Phase II (Verification Step) actions be conducted at Site 1. These recommended actions included the installation and sampling of one monitoring well and four piezometers. Sampling of sediment and surface water locations along the edge of the landfill was also recommended.

The IAS did not distinguish the former incinerator as a site separate from the incinerator landfill. No recommendations were made specific to the former incinerator.

Verification Step

Based on the recommendations of the IAS, McClelland Consultants conducted a remedial investigation verification step (VS) at Site 1 (McClelland, 1990). The VS is equivalent to the site inspection phase of the CERCLA process. McClelland installed one monitoring well south of Site 1. Three well points were also installed (two along the western edge of the landfill in the marsh and one within the eastern edge of the landfill). McClelland collected groundwater samples from the monitoring well and well points and collected three sediment samples along the landfill/marsh interface near the location of the well points. The former incinerator was not distinguished as a unique site in the VS; however, a southern monitoring well was installed approximately 150 feet northwest of one of the suspected locations of the former incinerator.

The groundwater samples were analyzed for Priority Pollutant List volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and dissolved metals (arsenic, barium, beryllium, cadmium, chromium, lead, mercury, selenium, and silver). The sediments were analyzed for Priority Pollutant VOCs, SVOCs, and metals and extended procedure (EP) toxic metals (arsenic, cadmium, chromium, lead, and mercury).

No organic compounds were detected in the groundwater samples; however only one groundwater sample was located within the landfill boundary. All groundwater samples contained dissolved lead at concentrations (0.017, 0.015, 0.017, and 0.101 mg/L) that exceeded or were equal to the current U.S. EPA Safe Drinking Water Act Action Level of 0.015 mg/L. The detection of 0.101 mg/L was located within the landfill boundary. All lead detections in groundwater also exceeded the state chronic water quality standard for protection of saltwater aquatic life (0.050 mg/L).

Chloroform was identified in two sediment samples at concentrations of 352 µg/kg and 215 µg/kg. Benzene was detected in one sediment sample at a concentration of 16 µg/kg. Chromium, lead, arsenic, barium, and cadmium were also detected in the sediment samples.

The VS recommended the following:

- Based on the presence of chloroform in sediment and the density and possible mobility of this compound, evaluate the depth and lateral extent of chloroform in subsurface soils and determine whether chloroform is present in the surficial aquifer.

- Evaluate the nature and extent of heavy metals (lead and chromium).

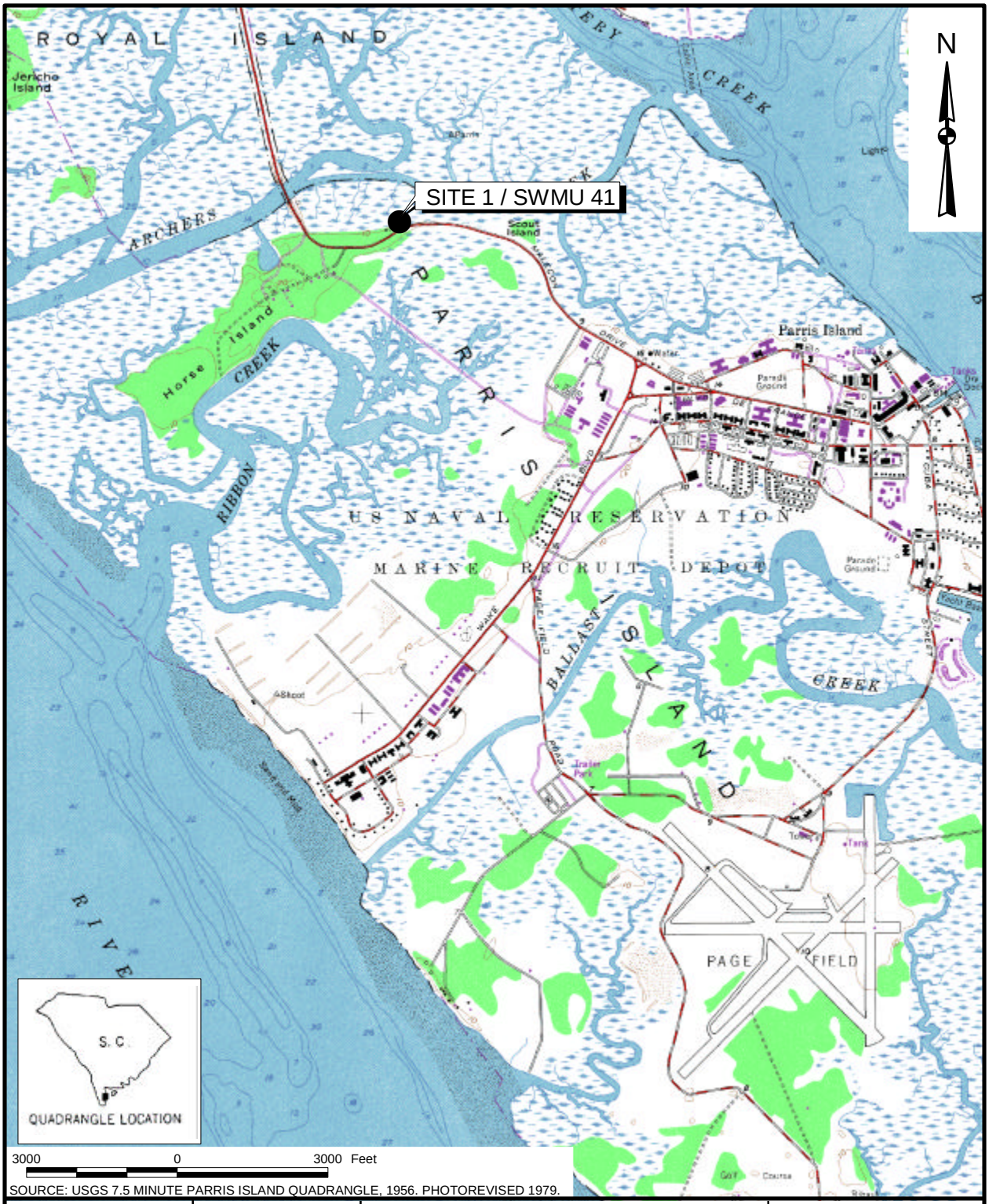
Interim RCRA Facility Assessment

Per the requirements of the MCRD's application for a RCRA permit, an Interim RFA was performed from January 1990 to March 1990. The recommendations of the RFA report were based on a review of the file material available at U.S. EPA regional and state offices and on observations made during a visual site inspection. The file review included a review of RCRA, CERCLA, National Pollution Discharge Elimination System (NPDES), and air files available at EPA Region 4, Atlanta, Georgia, and the SCDHEC, Columbia, South Carolina.

Based on the results of the VS, the RFA report (Kearney, 1990) recommended that an RFI be conducted at Site 1. For SWMU 41, the RFA recommended no further action because there was no evidence of release and the incinerator unit was not in operation.

1.5 REPORT ORGANIZATION

This report is divided into eight sections. Section 1.0, Introduction, provides historic information about MCRD Parris Island and Site 1 and SWMU 41 in particular. Section 2.0, Environmental Setting, provides geological and geographical information about MCRD Parris Island and the surrounding areas. Section 3.0, Investigation Summary, summarizes the sampling program and presents the Site 1 and SWMU 41 geology and hydrogeology based on the field results. Section 4.0, Nature and Extent of Contamination, addresses the nature and extent of site contamination for all media investigated. Section 5.0, Contaminant Fate and Transport, is a reference-like section describing the chemical and physical properties of the analytes positively detected at Site 1 and SWMU 41. Section 6.0, Human Health Risk Assessment, and Section 7.0, Ecological Risk Assessment, present the methodology and results of the human health and ecological risk assessments, respectively. Section 8.0, Conclusions and Recommendations, focuses on the magnitude of site-related risks and remedies, if any, to address those risks. Appendices A through F provide support documentation for the field investigation and supplemental information for the evaluation of results.



SOURCE: USGS 7.5 MINUTE PARRIS ISLAND QUADRANGLE, 1956. PHOTOREVISED 1979.

DRAWN BY MJJ	DATE 09Oct99	DEPOT LOCATION MAP MCRD, PARRIS ISLAND, SOUTH CAROLINA	CONTRACT NUMBER 7803
CHECKED BY	DATE		APPROVED BY DATE
COST/SCHEDULE-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-1 / REV 0

P:\GIS\MCRD_ParrisIsland\parris.apr 09Oct99 MJJ Depot Location Map

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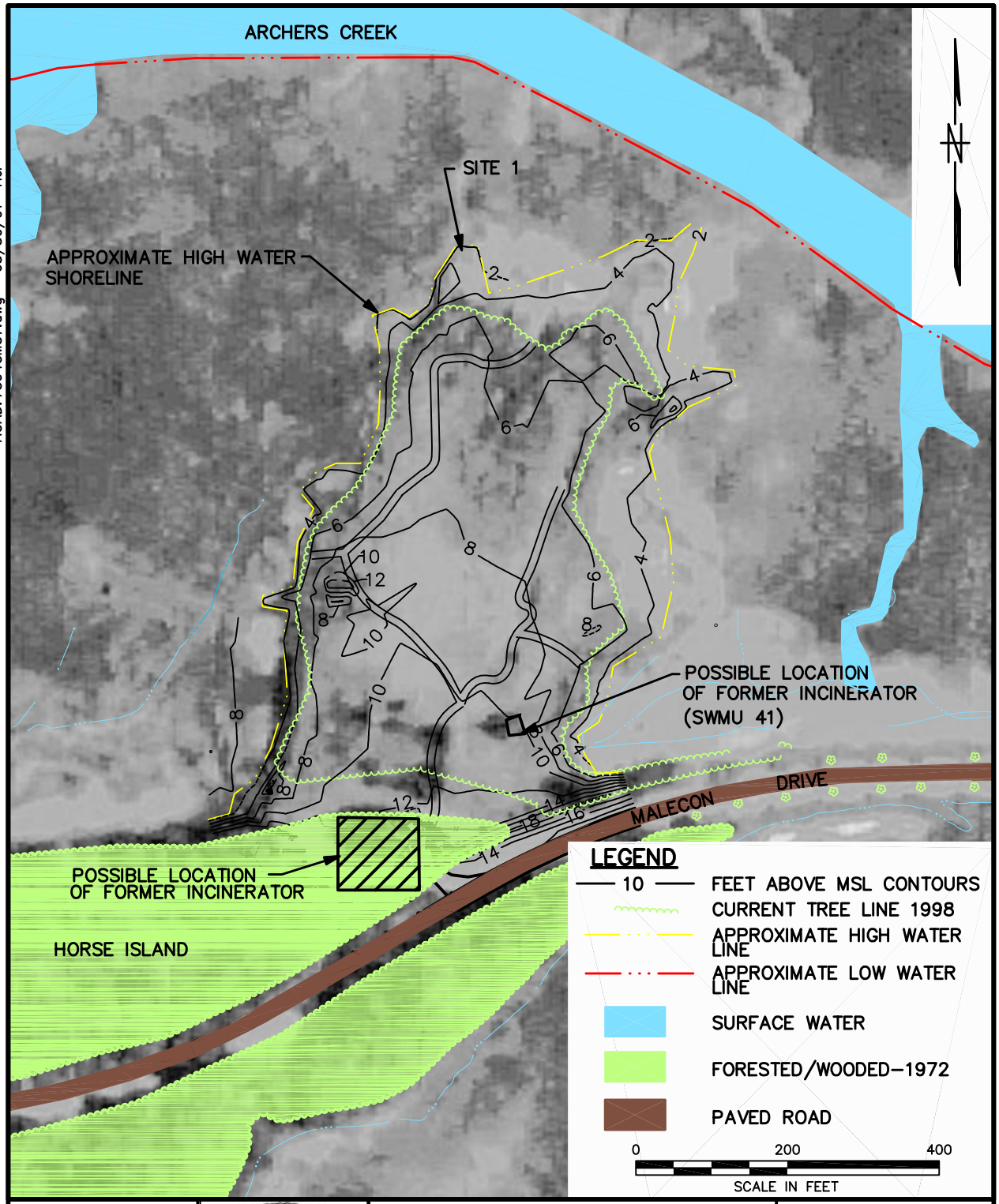

DRAWN BY HJP DATE 9/30/99		SITE LAYOUT SITE 1 – INCINERATOR LANDFILL AND SWMU 41 – FORMER INCINERATOR MCRD PARRIS ISLAND, SOUTH CAROLINA	CONTRACT NO. 7394
CHECKED BY DATE			APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-2 / REV. 0

FORM CADD NO. SDIV_AV.DWG - REV 0 - 1/20/98

2.0 ENVIRONMENTAL SETTING

This section contains general information relative to the environmental setting common to all the sites currently under investigation at MCRD Parris Island. A comprehensive discussion of the environmental setting at the MCRD can be found in the Master Work Plan (B&R Environmental 1998a) or the IAS (NEESA, 1986).

2.1 CLIMATE

MCRD Parris Island is in the southernmost region of South Carolina, where the climate is milder than elsewhere in the state. This low-lying coastal area has numerous islands, inlets, streams, and marshes and a temperature regime that clearly reflects the influences of its maritime and southerly location. The climate is subtropical, with long and hot summers followed by short and mild winters. Precipitation is abundant, averaging about 49 inches per year and remaining within the range of 40 to 58 inches during most years. Precipitation in the amount of 0.1 inch or more falls on an average of about 77 days per year. The annual distribution shows a major monthly maximum of about 7 inches in July and a major monthly minimum of about 2 inches in November. The period from April through October, which includes the growing season for most crops in this area, receives an average of about 34 inches of rain, about 70 percent of the annual total.

2.2 TOPOGRAPHY

MCRD Parris Island lies in the Lower Coastal Plain physiographic province. Elevations range from sea level to 22 feet above mean sea level (msl), with the elevation at Site 1 ranging from sea level to 12 feet above msl. The Depot consists of Parris Island (the largest and most developed island), seven smaller, named islands, many small unnamed islands, salt marshes, and related tidal creeks. Because of the low elevation, most of the Depot is within the 100-year flood plain. The majority of the area of Parris Island north of Ballast Creek, the east-central area of Page Field, and the central part of Horse Island are the only surfaces above the 100-year flood plain (NEESA, 1986).

The Depot covers 8,047 acres: 1,502 acres are devoted to forest management; 744 acres are grass and facilities; 4,344 acres are saltwater marsh; and the remainder consists of creeks, ponds, and causeways. Dry land makes up 3,274 acres (NEESA, 1986).

2.3 SURFACE WATER DRAINAGE

Drainage off the land surface is to the nearest surface water body. Three generally east-west creeks drain much of the Depot. Archers Creek is at the northern boundary of the Depot and connects Battery

Creek to the north with the Broad River to the west of Parris Island (see Figure 1-1). Surface water at Site 1 drains into Archers Creek. Ribbon Creek drains the area between Horse and Parris Islands and flows westward into the Broad River. Ballast Creek enters the Beaufort River and drains central Parris Island. Smaller unnamed creeks drain the areas west and east of Page Field.

The Beaufort and Broad Rivers meet at the southern end of Parris Island to form Port Royal Sound, which extends about 4 miles southeastward to the Atlantic Ocean.

2.4 SOILS

Soils at MCRD Parris Island have been mapped by the U.S. Soil Conservation Service as both individual soils and groupings of soils (units). The Depot has been mapped as having 15 individual soil types, but only eight types are present beneath the identified sites. Three soil units have been mapped for the Depot (the Wando-Seabrook-Seewee, Coosaw-Williman-Ridgeland, Bohicket-Capers-Handsboro Soil Unit). A further discussion of the soils and soil units identified at the MCRD can be found in the Master Work Plan for MCRD Parris Island (B&R Environmental, 1998a) or the IAS (NEESA, 1986).

2.5 GEOLOGY

Four geological units are present in the Beaufort-Jasper County Area. These units from the oldest (Eocene age) to the youngest (Pleistocene age) are the Santee Limestone, Cooper Marl, Hawthorn Formation, and Pleistocene sands and clays. A further discussion of the descriptive and structural geology of the Beaufort-Jasper County area can be found in the Master Work Plan for MCRD Parris Island (B&R Environmental, 1998a) or the IAS (NEESA, 1986). The geology of Site 1 and SWMU 41 is further discussed in Section 3.3.

2.6 HYDROGEOLOGY

Two primary aquifers are present within the Beaufort-Jasper County Area: the surficial aquifer and the Floridan Aquifer. These aquifers are generally separated by the Hawthorn Formation and Cooper Marl, which act as confining units to the underlying Floridan Aquifer.

In the MCRD Parris Island area, the shallow, unconfined aquifer generally consists of permeable, fine to medium, Pleistocene age sands. Surface relief is relatively low. The area is drained by fresh and brackish water streams inland and by tidal streams along the coast. The water table in the MCRD Parris Island area usually ranges from 0 to 10 feet below ground surface (bgs) and is most commonly found at a depth of 3 feet bgs. Water-table fluctuations are a function of recharge, evaporation, and transpiration and have been observed to be as great as 6.5 feet at some locations (Glowacz, and others, 1980). Water

table elevations were measured to fluctuate by up to 1.75 feet during a tidal study conducted at Site 1. The direction of groundwater flow in the upper portion of the shallow surficial aquifer is generally toward the nearest surface water body, such as a pond, river, tidal creek, or the ocean.

In the Beaufort-Jasper County Area, the Floridan Aquifer system occurs near land surface, and confining beds vary from essentially 0 to more than 150 feet in thickness. Groundwater in the Floridan aquifer occurs in solutionally enlarged openings or cavities in the limestone. In general, groundwater occurs in a series of broadly defined water-bearing (permeable) zones that serve as aquifers and are separated by less permeable rocks. Two hydrogeologic zones within the Floridan aquifer lie beneath the MCRD Parris Island area. These two hydrogeologic units consist of a 200-foot-thick Upper Hydrogeologic Unit that contains an upper permeable zone and an 800-foot-thick Lower Hydrogeologic Unit that has a somewhat lower permeability compared to the Upper Unit.

A further discussion of the hydrogeological characteristics of the Beaufort-Jasper County area can be found in the Master Work Plan for MCRD Parris Island (B&R Environmental, 1998a). The hydrogeology of Site 1 is detailed in Section 3.4.

2.7 ECOLOGY

Discussions on the ecoystems present and threatened and endangered plants and animals that occur or potentially occur on MCRD Parris Island can be found in the Master Work Plan for MCRD Parris Island (B&R Environmental, 1998a) or the IAS (NEESA, 1986). A discussion of the site-specific ecology is provided in Section 7.2.

3.0 INVESTIGATION SUMMARY

The initial field investigation for Site/SWMU 1 (Site 1) and SWMU 41 was performed from May through September 1998. During this investigation, monitoring wells were installed, groundwater, soil, sediment, and surface water samples were collected, a tidal study was performed, aquifer tests were conducted, and background conditions were assessed. Based on a review of the 1998 sample results with the partnering team, additional sediment sampling further from the landfill was conducted in April 1999. Information collected during the investigation was used to supplement existing geologic and hydrogeologic information at Site 1 and SWMU 41. The following sections discuss deviations from the work plan, the field activities conducted, and the site-specific geologic and hydrogeologic setting at Site 1 and SWMU 41. A summary of the 1998 and 1999 RFI/RI sampling activities is provided in Tables 3-1 to 3-10. The site layout for Site 1 and SWMU 41 is shown in Figure 1-2.

3.1 DEVIATIONS FROM THE WORK PLAN

Several deviations to the approved work plan for Site 1 and SWMU 41 (B&R Environmental, 1998b) were made during the field effort:

- The method of well installation was changed from the approved work plan method of mud rotary drilling to the use of 4-1/4-inch inner-diameter (ID) hollow-stem augers after consultation with SCDHEC.

- Because of the shallow depth of groundwater at the well locations (less than 1 foot bgs at time of drilling) at Site 1, it was not possible to install the well screen across the water table (as originally planned) and have an appropriate bentonite seal. Therefore, the well screens of the shallow wells were installed below the water table at an appropriate depth to allow for the installation of a bentonite seal and surface seal.

- Vadose zone subsurface soil samples were not collected due to the shallowness of the groundwater.

- Two of the four soil sample locations (PAI-41-SS-03, PAI-41-SS-04) at SWMU 41 were moved from the proposed work plan locations (B&R Environmental, 1998b) to low-lying areas adjacent to a concrete pad within the landfill unit. This concrete pad represents field conditions that provide direct evidence of the former incinerator. Therefore, samples collected near this pad would be more representative of the SWMU than more randomly placed samples in the general area.

- Due to the shallowness of the surface water at the proposed locations, Secchi Disk readings were not obtained.

- Because of a missed holding time, sediment sample PAI-01-SD-01-01 was not analyzed for hexavalent chromium as proposed in the work plan (B&R Environmental, 1998b).

3.2 FIELD INVESTIGATION

The following sections discuss the activities conducted during the field investigation at Site 1 and SWMU 41. First, a history of investigative activities at Site 1 and SWMU 41 is presented. Next, the specific field activities conducted during the investigation are discussed, including monitoring well installation; subsurface soil, surface water, sediment, surface soil, and groundwater sampling; the performance of slug testing and a tidal influence study; and investigation-derived waste (IDW) management. Lastly, a discussion of quality assurance/quality control samples and sample analysis is presented.

The RI/RFI sampling program was developed to support a presumptive remedy for the site that assumes waste materials would be encapsulated under a cover/cap. The sampling approach is consistent with U.S. EPA guidance entitled Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA, 1993a) and Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills (Interim Guidance) (U.S. EPA, 1996a).

3.2.1 Sampling History

Previous MCRD Parris Island investigations that have included Site 1 consist of an initial assessment study (NEESA, 1986) and subsequent verification step (McClelland, 1990) to identify potentially contaminated sites at MCRD Parris Island that may pose a threat to human health or the environment. Also, an Interim RFA (Kearny, 1990) was performed per RCRA permitting requirements and addressed both Site 1 and SWMU 41. A description of these investigations is provided in Section 1.4.3.

3.2.2 Monitoring Well Installation

One monitoring well PAI1-MW4(S) was installed during a previous investigation (McClelland, 1990) at Site 1. Ten monitoring wells were installed during the 1998 RFI/RI field investigation at the locations indicated on Figure 3-1. Of the 10 new wells, five shallow surficial aquifer wells were installed to depths less than 15 feet bgs and five deep surficial aquifer wells were installed to depths ranging from 30 to 38 feet bgs. The well permit authorization is provided in Appendix A.

The monitoring wells were installed through the ID of 8-inch outside-diameter augers to help ensure a proper sand pack. The wells were installed in accordance with SCDHEC regulations. The surficial aquifer monitoring wells were constructed with 10-foot screen sections with 0.010-inch slot openings and No. 1 sand due to the fines encountered at shallow depths. The deep surficial wells were constructed using 5-foot screen sections with 0.020-inch slot screens and No. 2 sand. Boring logs and monitoring well construction sheets were completed for each soil boring and monitoring well location. Copies of these forms are provided in Appendix A.

A licensed South Carolina driller employed by Parratt Wolff, Inc., of Hillsborough, North Carolina, installed the monitoring wells. All monitoring wells were developed after construction using a surge block and a submersible pump. Well development logs were completed during development and are provided in Appendix A. Construction details of the monitoring wells are provided in Table 3-2.

As indicated in Table 3-2, five wells [PAI-01-MW-05(S), PAI-01-MW-07(S), PAI-01-MW-09(S), PAI-01-MW-11(S), and PAI-01-MW-13(S)] were installed as shallow monitoring wells and screened in the upper part of the surficial aquifer. The well screens were installed with the intent to straddle the water table. However, because of the shallow depth of groundwater and the need for an adequately installed subsurface seal, the water level in these monitoring wells occurs above the top of the well screen.

Development of the groundwater monitoring wells was performed using a surge block and electric pump with discharge tubing. The surge block was used to sweep the screen interval (and filter pack) several times throughout the development process. The well water was pumped into 55-gallon drums and labeled as IDW. Water was collected for monitoring in a stainless steel beaker and a Horiba U-10 was used to measure field parameters consisting of temperature, specific conductance, pH, salinity, dissolved oxygen, and turbidity. At least three times the calculated well volume of water was removed during development. If potable water was used to fill the augers during drilling to prevent sand from flowing into the augers or to remove a sand bridge during installation of the sand pack, the amount of water used (measured in five-gallon buckets) was noted in the field book and five times the water added was removed prior to removing the minimum of three well volumes. Readings were collected until the field parameters, with the exception of dissolved oxygen, stabilized and the required removal volume of water for each well was removed.

A target turbidity of 10 NTUs was used in an attempt to reduce the turbidity as much as possible during the development phase. Time pumped, volume of water pumped, and the turbidity of the water were used to determine whether to suspend development once stabilization had been achieved.

3.2.3 Subsurface Soil Sampling

Subsurface soil samples (Figure 3-1) were collected from each of the five soil boring locations used for the monitoring well clusters using split-spoon-sampling techniques. One subsurface sample was collected from the screened area of each of the deep surficial wells for ecological and geotechnical evaluation, including natural moisture content (ASTM D2216), grain size analysis (ASTM D421/422), Atterberg Limits (ASTM D4318), bulk density (ASTM D2937), and specific gravity (ASTM D854). Porosity was calculated from bulk density, specific gravity, and moisture content results. A subsurface sample was collected from soil boring locations PAI-01-SB-02, PAI-01-SB-03, and PAI-01-SB-05 at a depth of 4 to 6 feet bgs for analysis for total organic carbon (TOC), natural moisture content, grain size analysis, Atterberg Limits, porosity, bulk density, and specific gravity. The results of the ecological/geotechnical sampling are presented in Appendix A. All split-spoon samples collected were screened in the field using a photoionization detector (PID). Several samples had elevated PID readings; however, there were no visual signs of contamination. A creosote odor was observed in borings PAI-01-SB-02 and PAI-01-SB-03. A Shelby Tube sample (PAI-01-SB-03-41) was collected from boring PAI-01-SB-03 to obtain vertical hydraulic conductivity information of the Hawthorn Formation at the site. Copies of the soil samples log sheets are provided in Appendix A. A summary of the subsurface soil samples collected is presented in Table 3-3.

3.2.4 Surface Water Sampling

Eleven surface water samples (PAI-01-SW-01-00 through PAI-01-SW-07-00 and PAI-01-SW-09-00 through PAI-01-SW-12-00) were collected during the field investigation for Site 1. Eight samples were collected along the tidal flats along Site 1. Three samples were collected from Pinckney Island, located across Port Royal Sound southwest of Parris Island. All surface water samples were collected during the receding tide. The samples were obtained by dipping the appropriate containers in the surface water. The samples were analyzed for TOC, pH, hardness ($CaCO_3$), Target Compound List (TCL) VOCs, SVOCs, pesticides, PCBs, Target Analyte List (TAL) metals (totals and dissolved), and cyanide. The analytical parameters performed on the samples are summarized in Table 3-4. Surface water quality parameters (collected during sampling) are listed in Table 3-5, and the Parris Island surface water locations are shown on Figure 3-2.

Three of the surface water samples (PAI-01-SW-01-00, PAI-01-SW-02-00, and PAI-01-SW-11-00) were also analyzed for hexavalent chromium. The three hexavalent chromium samples were collected from across the site at representative locations. The purpose of this supplemental analysis was to support risk assessment by determining the speciation of total chromium. Surface water sampling was performed in accordance with the RFI/RI work plan (B&R Environmental, 1998b), except Secchi Disk readings were

not obtained due to the shallowness of the surface water. Copies of the surface water sample log sheets are provided in Appendix A.

The surface water quality parameters indicate that, at the time of sampling, the water temperature ranged from 28.0^{o} to 33.8^{o} C. The specific conductance remained fairly constant, varying only between 36.5 to 43.1 mS/cm. Dissolved oxygen varied from 4.32 to 11.4 mg/L. Salinity remained fairly constant, ranging only from 2.29 to 2.83 percent. Turbidity of the samples varied widely from 0 to greater than 999 nephelometric turbidity units (NTUs). The elevated turbidity can be attributed to shallow surface water and the unavoidable disturbance of the sediment while the sampler walked to the sample location. Surface water quality parameter data were not qualified. The human health and ecological risks assessments generally factor in uncertainties in the data especially for a transient media such as surface water. Since surface water was not identified as a primary risk driver, there was no need to qualify the data.

As presented in Section 7.2.1 of the work plan, surface water samples were collected during a receding tide to conservatively bias sample results to evaluate potential contaminant migration from the site. Normally, surface water samples can also be collected at mid tide and low tide to eliminate some of the bias. However, based on the site conditions, surface water at the site is normally only 4 to 12 inches high at high tide, and at mid tide and low tide, standing water is not present within several hundred feet of the site and therefore samples could not be collected under these conditions.

Based on the shallow depth of surface water at the site, stratification of surface water was not observed and therefore individual samples collected.

3.2.5 Sediment Sampling

Initially, 12 sediment samples and one duplicate sample were collected from 11 locations during the 1998 field investigation. Three of these samples (PAI-01-SD-05-01, PAI-01-SD-06-01, and PAI-01-SD-07-01) were collected as background samples from Pickney Island, which is located across Port Royal Sound southwest of MCRD Parris Island. The remaining samples were collected along the tidal flats at Site 1. In April 1999, field personnel collected five additional sediment samples (plus one duplicate sample) to further delineate the extent of impacted sediment. Furthermore, in October 1999, TtNUS collected three sediment samples and one duplicate sample to determine whether significant concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related isomers were present at Site 1 due to past waste disposal and incineration activities. One of these samples (PAI-10-SD-16A-02) was collected from a background location in the western portion of the Depot and the other samples were collected from Site 1. Site 1 sediment sample locations are shown on Figure 3-2 and background locations are shown in Appendix A. Sediment sampling was performed in accordance with the RFI/RI work plan

(B&R Environmental, 1998b). A pre-cleaned plastic or stainless-steel trowel was used to collect the sample to the appropriate depth. The sample material for all the analytical parameters, except TCL VOCs, was placed directly in the appropriate containers and then on ice. The volatiles were collected using Encore® samplers. Soil was collected in the samplers, and the samplers were capped and placed on ice. Copies of the sediment sample log sheets are provided in Appendix A.

Sediment samples PAI-01-SD-13-01 (plus a duplicate) through PAI-01-SD-17-01 were collected 200 feet from the edge of the landfill. To evaluate the potential wastes that were present below the surface, test holes were dug to a depth of 18 inches at 50-foot intervals from the Site outward and observed for ash/garbage. See the sediment sample log sheets for details. Surface material consisting of construction debris, including concrete, brick fragments, pieces of metal, and cresole-treated poles, was observed on the surface around the site. Glass and possibly ash were observed in the areas directly adjacent to the landfill.

Surface debris (construction debris) was observed at distances of less than 50 feet from the landfill proper at all locations. Sediment was collected from just outside these areas during the 1998 investigation. Construction debris was observed on the surface just under 150 feet from the landfill in the area of sediment sample PAI-01-SD-17-01. No ash/garbage/debris was observed at depth in the sediments.

All the sediment samples collected during the 1998 field investigation were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (Total), cyanide, TOC, and pH. In addition, samples PAI-01-SD-02-01 and PAI-01-SD-11-01 were analyzed for hexavalent chromium and were collected from across the site at representative locations. Samples PAI-01-SD-01-01; PAI-01-SD-02-02, PAI-01-SD-03-01, and PAI-01-SD-03-01-D were also tested for grain-size analysis and bulk density. Sediment samples PAI-01-SD-13-01, PAI-01-SD-14-01, PAI-01-SD-15-01, PAI-01-SD-16-01, and PAI-01-SD-17-01 were analyzed for polynuclear aromatic hydrocarbons (PAHs), TAL metals (total), and TCL pesticides. Sediment samples PAI-01-SD-02A-02, PAI-01-SD-11-02, PAI-01-SD-DU11-02, and PAI-01-SD-16A-02 were analyzed for TCDD and related isomers. The analytical parameters performed on the samples are summarized in Table 3-6. The results of the ecological/geotechnical sampling are presented in Appendix A.

3.2.6 Surface Soil Sampling

A total of 19 surface soil samples were collected during the field investigation. Fourteen surface soil samples were collected within the boundaries of Site 1 and SWMU 41. Two surface soil samples were collected within the picnic area west of Site 1 to determine potential levels of pesticides and PAHs that may be attributable to commercial applications of pesticides and other anthropogenic sources of

pesticides and PAHs. These two samples are not part of the background data set. Three background surface soil samples were collected from Pinckney Island. Surface soil sample locations are shown on Figure 3-3. The analytical parameters performed on the samples are summarized in Table 3-7. Background sample locations, picnic area sample locations, and sample log sheets for soils are presented in Appendix A. The samples were collected at a depth of 0 to 1 foot bgs. Surface materials consisting of grasses and other organic material were removed prior to obtaining the sample. A pre-cleaned plastic or stainless-steel trowel was used to collect the sample to a depth of 1 foot. The sample material for all the analytical parameters except for TCL VOCs was placed directly in the appropriate containers and then on ice. The volatiles were collected using Encore® samplers. Soil was collected in the samplers, and the samplers were capped and placed on ice.

All the surface soil samples from Site 1, SWMU 41, and Pinckney Island were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (total), and cyanide. In addition, PAI-01-SS-07-01, PAI-01-SS-09-01, and PAI-01-SS-10-01 were analyzed for TOC and pH. Samples PAI-01-SS-08-01, PAI-01-SS-09-01, and PAI-01-SS-014-01 were also analyzed for hexavalent chromium. The three hexavalent chromium samples were collected from across the site at representative locations. Sample PAI-01-SS-07-01 was analyzed for grain size (ASTM D421/422), bulk density (ASTM D2937), and specific gravity (ASTM D854), and sample PAI-01-SS-10-01 was analyzed for natural moisture content (ASTM D2216), Atterberg Limits (ASTM 4318), grain size, bulk density, and specific gravity. Porosity was calculated from bulk density, specific gravity, and moisture content results. The results of the ecological/geotechnical sampling are presented in Appendix A. Surface soil samples PAI-01-SS-15-01 and PAI-01-SS-16-01 were analyzed for TCL PAHs and pesticides. Surface soil sampling was performed in accordance with the RFI/RI work plan (B&R Environmental, 1998b). In accordance with the U.S. EPA's Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA 1993), these surface soil sample locations were biased toward potential contaminant migration pathways, with the understanding that a presumptive remedy would be used at this site to contain waste materials. The samples were collected to determine whether current site conditions represent a potential threat to human health or the environment, through direct contact or erosion pathways.

3.2.7 Groundwater Sampling

Groundwater sampling was performed using a peristaltic pump and pre-cleaned disposable tubing. The tubing was lowered in the well to approximately the midpoint of the well screen. The wells were then purged in accordance with the low-flow sampling techniques specified in the approved work plan (B&R Environmental, 1998b). Water-level data and water-quality parameters, such as temperature, pH, specific conductance, turbidity, dissolved oxygen, and salinity, were collected during purging of the monitoring wells and recorded on Low-Flow Purge Data Sheets and Groundwater Sample Log Sheets (included in Appendix A). The groundwater sample from each well, except TCL VOCs, was collected by

reducing the flow to minimize volatilization of the sample and collecting the sample in the appropriate containers directly from the tubing after it passed through the peristaltic pump. The TCL VOC samples were obtained by removing the tubing from the well and allowing the water in the tubing to flow under gravity backward through the tubing and collected in the appropriate containers.

All the groundwater samples collected, with the exception of PAI-01-GW-10-01[1], were analyzed for TOC, hardness, TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (total), TAL metals (dissolved), and cyanide. All samples were analyzed for total dissolved solids (TDS), total suspended solids (TSS), chloride, fluoride, nitrate/nitrite, and sulfate. Groundwater sample PAI-01-GW-10-01 was also analyzed for hexavalent chromium and for RCRA Appendix IX organics (including volatile organics, semivolatile organics, pesticides/PCBs, and chlorinated solvents) and RCRA Appendix IX inorganics and cyanide. Appendix IX analysis was conducted at this groundwater monitoring well to satisfy SCHEC requirements under the state RCRA program. In October 1999, groundwater sample PAI-01-GW-09CS1-02 and its duplicate sample were also sampled for TCDD and related isomers. The groundwater analytical parameters are summarized in Table 3-8. The groundwater quality information (including dissolved oxygen, salinity, temperature, pH, and turbidity) was also collected and is summarized in Table 3-9. The depth-to-water measurements shown on Table 3-10 were collected prior to the performance of the tidal study for Site 1 and SWMU 41. The groundwater sample locations are indicated on Figure 3-1.

As shown in Table 3-9, the pH of the groundwater at Site 1 varied between 5.89 (PAI-01-GW-06-01) to 7.88 (PAI-01-GW-07-01). The temperature readings were relatively stable throughout Site 1. The specific conductance varied from 0.465 mS/cm (PAI1-GW4-01) to 57.8 mS/cm (PAI-01-GW-09-01). Salinity readings ranged from 0.01 to 3.41 percent. The salinity readings indicate that, of all the groundwater samples, only PAI1-GW4-01 is considered to be fresh (fresh water is less than 0.048 percent as identified by SCDHEC, 1998). The groundwater samples from wells installed in the shallow surficial aquifer, with the exception of PAI1-GW4-01, generally exhibited higher salinity readings than the wells installed in the deeper portion of the surficial aquifer. Dissolved oxygen readings varied (0.71-2.93 mg/L) throughout Site 1. Groundwater samples from the deeper portion of the surficial aquifer typically had a higher dissolved oxygen level than the shallower wells. The exception was sample PAI1-GW4-01 from well PAI1-MW4(S) that had a dissolved oxygen level of 2.93 mg/L. The wells were purged in an effort to reduce the turbidity to less than the benchmark of 5 NTUs.

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[1] Sample identification number PAI-01-GW-10-01 indicates that the sample was collected from monitoring well PAI-01-MW-10(D).

3.2.8 Slug Tests

Slug tests were performed on the one existing monitoring well and the 10 new monitoring wells. Rising and falling head slug tests were performed at each of the monitoring wells. The procedure for performing the rising-head slug test consisted of injecting a slug of known volume below the water level within the well. After the water level re-stabilized, the slug was suddenly removed to create a drop of water level within the well. A 20 pounds per square inch (psi) pressure transducer and a data logger were used to record the rate of water-level recovery. The procedure for performing the falling-head slug test consisted of rapidly injecting a slug of known volume into the well below the water surface, so that the water level within the well rose. The subsequent rate of water level recovery to the original static water level (time versus recovery) was measured. The data were analyzed using the Hvorslev Method (Hvorslev, 1951). Slug test results are discussed in Section 3.4.

3.2.9 Tidal Influence Study

A tidal influence study was performed in September 1998. The results of this study indicate that the wells installed at Site 1, with the exception of PAI1-MW4(S), are tidally influenced. The tidal fluctuations that were observed in the deep surficial monitoring wells varied from 0.5 foot in well PAI-01-MW-14(D) to 1.75 feet in well PAI-01-MW-06(D). The shallow surficial monitoring wells, with the exception of PAI1-MW4(S), exhibited tidal fluctuations of 0.1 foot in well PAI-01-MW-09(S) to 1.47 feet in well PAI-01-MW-13(S). Well PAI1-MW4(S) did not exhibit tidal influence and, based on the fresh water (salinity <0.048%) observed during purging of the well prior to sampling, the well is influenced only by groundwater.

3.2.10 Surveying

All monitoring well, soil boring, sediment, surface water, and surface soil sample locations were surveyed for horizontal and vertical control by Donaldson, Garrett & Associates, Inc., of Macon, Georgia (South Carolina licensed), in accordance with the RFI/RI work plan (B&R Environmental, 1998b). Additional points were surveyed, such as the corners of a concrete pad located within Site 1 and SWMU 41, to update the existing site figures. A permanent concrete monument was installed at Site 1 and SWMU 41 to establish site control. The concrete monument has a plaque containing the northing, easting, and ground surface elevation at that point. The northing and easting coordinates are tied into the South Carolina State Plane Coordinate System, North American Datum 1983 (NAD83).

3.2.11 Investigation-Derived Waste (IDW)

During the investigation, 55-gallon drums of water (decontamination, development, and purge waters) and soil IDW were generated and stored within the Depot's waste storage facility pending final disposition

of the IDW. All IDW was handled in accordance with the Master Work Plan (B&R Environmental, 1998a) and the Work Plan for Site 1 and SWMU 41 (B&R Environmental, 1998b).

A composite sample was collected from the drummed decontamination waters and analyzed for TCL VOCs, SVOCs, PCBs, pesticides and TAL inorganics. Additionally, a composite sample was collected from the drummed soils and analyzed for the previously mentioned parameters plus Toxicity Characteristic Leaching Procedure (TCLP) inorganics. Analytical results from groundwater samples collected during the field investigation were used to characterize development and purge waters.

The soil IDW was characterized as nonhazardous; however, two PAHs and one inorganic compound were detected in the soil IDW composite sample in excess of U.S. EPA Region 3 Risk-Based Concentrations (RBCs) for residential dermal contact (U.S. EPA, 1999a). Benzo(a)pyrene exceeded its RBC of 87 µg/kg with a concentration of 360 J µg/kg, and dibenzo(a,h)anthracene was detected in excess of its RBC of 87 µg/kg with a concentration of 130 J µg/kg. Arsenic was also detected above its RBC of 0.43 mg/kg with a concentration of 6.6 mg/kg.

Per concurrence with SCDHEC, soil IDW was spread back at Site 1 near the location of surface soil sample PAI-01-SS-08-01. Although the soil IDW exceeds three residential RBCs for dermal contact, this action was accepted for several reasons. The RBC exceedances are relatively minor (a factor of 1 to 3 above the criteria and only for two PAHs) and fall below the industrial dermal contact value of 780 µg/kg for both PAHs. Access to the site is currently limited, and these soils would be addressed in the future with the site. Additionally, the detection of arsenic falls with the range of background (1.2 to 12 mg/kg) observed for soils and sediment. The drummed Site 1 soils are not inherently wastelike but rather consist of soils/sediments. Lastly, the location of surface soil sample PAI-01-SS-08-01 represents an area where PAHs, pesticides, and 13 metals exceed human health or ecological screening values. As a result, placement of these soils at this location will reduce potential impacts to receptors.

Decontamination, development, and purge waters were also found to be nonhazardous. All liquid IDW was discharged to the Depot's wastewater treatment facility for treatment. Fenn-Vac, the IDW subcontractor, conducted the discharge of waters and the spreading of soils in February 1999.

3.2.12 Quality Assurance/Quality Control (QA/QC) Samples

Quality assurance (QA) objectives are evaluated by assessing the PARCC parameters, as defined in the Master Quality Assurance Plan (QAP). The PARCC parameters are precision, accuracy, representativeness, comparability, and completeness. QA/QC samples were collected to provide information pertaining to these key quality characteristics. The QA/QC sample results from this investigation are summarized in the following subsections.

The following QA/QC samples were collected during this investigation: 10 trip blanks, 4 equipment rinse blanks (these samples are limited, because disposable sampling equipment was used), and 9 duplicate samples from surface water, sediment, and surface soil.

QA/QC sample log sheets and sample chain-of-custody (COCs) forms are provided in Appendix A. Appendix D contains the data validation summaries and detailed PARCC discussion can also be found in Appendix A.

Precision

Precision is a measure of the degree to which two or more measurements are in agreement. Field sampling precision was assessed through the collection and analysis of field duplicate samples. The precision of the laboratory's analytical program was assessed through the calculation of relative percent difference (RPD) for the matrix spike/matrix spike duplicate (MS/MSD) samples. According to the QAP, field duplicate results are considered to be precise if the RPD is less than 50 percent for solid samples and less than 30 percent for aqueous samples. Laboratory duplicates for solid and aqueous matrices are considered to be precise if the RPD is less than 35 percent and 20 percent, respectively. No results were qualified for RPD noncompliance. Based on the validation results, the data appear to be precise.

Accuracy

Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy in the field is assessed through the use of field equipment rinsate blanks, trip blanks, and source water blanks and also through adherence to sample handling, preservation, and holding times. Laboratory accuracy is assessed through the analysis of matrix spike, standard reference materials, and the determination of percent recoveries. Spike recoveries (e.g., blank, surrogate, and matrix spikes) are compared to acceptance limits statistically derived by the laboratory in accordance with established practices identified in the analytical method followed and further defined in the laboratory QAP.

Percent Recovery

Groundwater sample results (PAI-GW-07-01, PAI-GW-07-01-F, PAI-GW-08-01, PAI-GW-08-01-F, PAI-GW-10-01, and PAI-GW-10-01-F) were qualified as estimated, J, due to matrix spike recovery <75% for lead, mercury, selenium, and thallium. No results for sediment samples were qualified due to matrix spike noncompliance.

Groundwater sample results (PAI-GW-07-01, PAI-GW-08-01, and PAI-GW-10-01) were qualified as estimated, J, due to matrix spike recovery >125% for sulfate. No results for sediment samples were qualified due to matrix spike noncompliance.

The continuing calibration verification (CCV) percent recovery for lead was less than the 90 percent quality control limit. Therefore, the positive results for lead in sample PAI-01-SD-02-02 was qualified as "J" or estimated.

Surrogate recoveries in soil sample PAI-01-SD-13-01-D were below quality control limits. As a result the non-detected base/neutral SVOC results were rejected and qualified as "UR."

Heptachlor epoxide, detected in sample PAI-01-SD-17-01, and b-BHC, detected in sample PAI-01-SS-05-01, were rejected (qualified as "R") due to a percent difference between columns that exceeded 100 percent.

Holding Times

Results for salinity exceeded the specified holding time by 61 days in surface water samples PAI-01-SW-05-00, PAI-01-SW-06-00, and PAI-01-SW-07-00. Positive results were qualified as estimated, J.

Results for total organic carbon (TOC) exceeded the specified holding time by four days in surface water samples PAI-01-SW-03-00, PAI-01-SW-04-00, and PAI-01-SW-09-00. Positive results were qualified as estimated, J.

Results for total dissolved solids (TDSs) and total suspended solids (TSSs) exceeded the specified holding time by 12 days and 3 days, respectively. Positive results in samples PAI-01-GW-04-01, PAI-01-GW-05-01, PAI-01-GW-06-01, PAI-01-GW-09-01, PAI-01-GW-11-01, PAI-01-GW-11-01-D, PAI-01-GW-12-01, PAI-01-GW-13-01, and PAI-01-GW-14-01 were qualified as estimated, J.

Due to poor surrogate recovery the semivolatile fraction of PAI-01-GW-05-01 was re-analyzed 6 days beyond the 40 day analysis holding time. Rather than reject the data, the reviewer elected to use the results from the re-analysis, since this resulted in qualification of the data as estimated, J and UJ.

Samples PAI-01-SS-05-01, PAI-01-SS-06-01, and PAI-01-SS-07-01 were re-analyzed at a dilution for 4,4'-DDE and 4,4'-DDT. The re-analysis occurred 57 to 58 days after sample extraction. Positive results for these compounds were qualified as estimated, J.

Laboratory and Field Blanks

Several VOCs and SVOCs were found in the field/trip blanks. One VOC was found in the laboratory blank. Various inorganics were found in the laboratory/preparation blank. Positive sample results less than 5 times the maximum blank concentration (or 10 times for typical laboratory contaminants) were qualified as "U" or non-detect due to blank contamination. Details are presented in Appendix D.

Representativeness

Representativeness was qualified through the field sampling procedures and evaluation of laboratory analytical data. The site data accurately and precisely depict the actual characteristics of the environmental conditions that exist at SWMUs 1 and 41. EPA-approved work plans and standardized sampling, handling, analytical, and reported procedures were followed to ensure that the final data accurately represent actual site conditions. Validated results support this finding.

Comparability

Comparability, the confidence of comparing one data set to another, was satisfied through the strict adherence of field sampling and laboratory analysis to their respective SOPs. Both programs (field and laboratory) adhered to their respective SOPs and were reviewed by third parties. Also, the majority of sampling for this investigation occurred during the spring/summer 1998 and 1999. In addition, standardized sampling and analysis methods and data reporting formats (including use of consistent units of measure and reporting of solid matrix sample results on a dry-weight basis) were used. As a result, data collected for this site are comparable and usable.

Completeness

Completeness is the percentage of analyses with valid results as compared to the total number of analyses for each analytical method in a given matrix. For this project, 90 percent completeness is acceptable for meeting the data completeness objective. The amount of rejected data was approximately 1 percent. As a result, the amount of usable and valid data available was 98.9 percent, which meets the project objective for completeness. Appendix D presents the details of the validation reports.

Detection Limits

Sample PAI-01-SD-003-01 was re-analyzed at a 20X dilution factor due to the presence of benzo(b)fluoranthene and fluoranthene above the instrument's linear calibration range. Results from the dilution were transposed over the original sample results and reported for these compounds only.

The semivolatile fraction of samples PAI-01-SD-001, PAI-01-SD-017, PAI-01-SS-016, and PAI-01-SS-015 were analyzed and reported at dilution factors ranging from 2X to 50X due to the presence of target compounds present in the samples. This accounts for the elevated reporting limits for these samples.

The pesticide fraction of samples PAI-01-SD-001, PAI-01-SD-013, and PAI-01-SD-013-D were analyzed and reported at a 2.5X dilution factor due to matrix interference. This accounts for the elevated reporting limits for these samples.

Samples PAI-01-SS-005-01, PAI-01-SS-006-01, and PAI-01-SS-007-01 were re-analyzed at a 10X, 5X, and 50X dilution factor, respectively, due to the presence of 4,4'-DDE and 4,4'-DDT above the instrument's linear calibration range. Results from the dilution were transposed over the original sample results and reported for these compounds only.

Samples PAI-01-SD-001, PAI-01-SD-013, and PAI-01-SD-013-D contained less than 30% solids. This accounts for the elevated reporting limits for these samples.

3.2.13 Sample Analysis

Chemical analysis of environmental samples was conducted at three laboratories. Soils, sediment, and surface water samples were analyzed for chemical parameters at RECRA Environmental, Inc. in Chicago, Illinois. Groundwater samples were analyzed by Laucks Testings Laboratory of Seattle, Washington. Both laboratories are certified in South Carolina. Results are presented in Appendix C. All analytical results are presented in the appendix, including positive detections and detection limits for non-detected parameters. The appendix is divided into background results and Site 1 sample results. In addition, Appendix C is divided into soils, sediments, surface water, and groundwater data.

Kiber Environmental Services of Norcross, Georgia performed the geotechnical analysis. Results are presented in Appendix A.

3.3 SITE-SPECIFIC GEOLOGY

The site-specific geology at Site 1 and SWMU 41 was interpreted by classifying subsurface materials collected during drilling activities in 1998. A cross-section along the perimeter of Site 1 and SWMU 41 was developed from the data collected during the field investigation. Information from a previously installed monitoring well and the Soil Survey of Beaufort County, South Carolina (U.S. Department of Agriculture, 1980) was used for correlation of soil types.

The Soil Survey of Beaufort County indicates that the Wando-Seabrook-Seewee Soil Unit is present on Horse Island, where Site 1 and SWMU 41 are located. This soil unit constitutes about 31 percent of Beaufort County. The unit is about 24 percent Wando soils, 18 percent Seabrook soils, 11 percent Seewee soil, and 47 percent minor soils. Wando soils are in the higher areas of the soil unit and are excessively drained. Seabrook soils are in intermediate areas and are moderately well drained. Seewee soils are commonly in slightly lower areas than Seabrook soils and are somewhat poorly drained. All of these soils are sandy throughout and differ primarily in drainage. It is believed that none of the material at Site 1 is native; consequently, a site specific soil survey was not conducted.

The minor soils in this soil unit are the somewhat poorly drained Ridgeland soils, the poorly drained Baratari soils, and the very poorly drained Polawana and Rosedhu soils. There is rapid leaching in all these soils. All soils in this unit, except the excessively drained Wando soils, have a seasonally high water table.

Surface soils collected from the interior of the landfill during the 1998 field event consisted of fine to medium sands with varying amounts of silt and clay, as confirmed by the results of two surface soil samples analyzed for ecological/geotechnical parameters. Surface debris consisting of glass and metal was observed during the field event. This same material was observed in several surface soil locations at depths of 1 foot or less. A large amount of wood fragments was encountered within the soil boring samples, along with paper and plastics that could have been deposited by tides and/or storm surges and therefore may not be associated with the incinerator/landfill activity. In general, the investigation is based on an assumption that waste materials are present throughout the site. However, except for select areas where metal and glass fragments are present, the presence of waste material is not obvious throughout most of the site. The waste materials may be covered with soil or they may be present on the surface, in the form of ash commingled with the surface soil.

Subsurface materials at Site 1 and SWMU 41 were classified from the performance of five soil test borings (one per well cluster) drilled during the TtNUS field investigation and from existing well data. The borings were sampled continuously to the termination of the borings using split-spoon sampling techniques. The site-specific geology at the unit has been affected by human activities. Material was buried in the landfill, creating topographic high and low areas within the facility limits. In the soil boring locations along the edge of the landfill boundary, landfilled debris consisted of creosote-soaked poles, glass fragments, and construction debris, which included concrete and brick fragments.

Figures 3-4 and 3-5 show the cross-sectional transects, A-A' and B-B', that were developed from soil boring data collected during the current investigation. The locations of these cross-sections are shown on Figure 3-1. The boundaries between fill material and natural material is blurred at the well locations.

Debris washed to shore over the years has mixed with landfilled material in the surficial silty sands and soft tidal silts and clays, making the distinction difficult. Generally, the shallow subsurface geology of the study area consists of a heterogeneous mixture of tidal- and storm-deposited silt, clay, and sand, with clays being prevalent to a depth of approximately 28 feet bgs. Beneath the tidal sands, silts, and clays, the sediment consists of fine to coarse sands with varying clay content to depths of 34 to 36 feet bgs. Subsurface soil and sediment samples analyzed for ecological/geotechnical parameters confirm the geology encountered. Details of the results of the ecological/geotechnical sampling are presented in Appendix A.

The sand is underlain by a gray-green silty to clayey, fine sand which locally is believed to be the top of the Hawthorn Formation. Based on the results of a falling head permeability test performed on an undisturbed sample collected within this unit from sample location PAI-01-SB-03-41, the material likely acts as a confining unit. At soil boring PAI-01-SB-05 [well cluster PAI-01-MW-13(S)/14(D)], the confining unit is underlain to a depth of at least 50 feet bgs by fine to coarse sand that gets tighter and dryer with depth. Assuming this sand unit exists across site, the confining unit is approximately 6 feet thick.

3.4 SITE-SPECIFIC HYDROGEOLOGY

The hydrogeologic conditions at Site 1 and SWMU 41 were interpreted from data obtained during the subsurface investigation activities at the site, groundwater-level measurements collected, and from slug tests performed during the 1998 investigation.

In general, a surficial groundwater table (less than 2.5 feet bgs) exists at the site where the new monitoring wells were installed. The depth to groundwater in the previously installed well, PAI1-MW4(S) that is upgradient of the new wells and at a higher ground elevation was approximately 8.5 feet bgs. Based on the depth of the confining unit (Hawthorn Formation), which was consistently identified at approximately 36 feet bgs, the thickness of the surficial aquifer is 33.5 feet. Recharge of the shallow aquifer beneath the facility is likely to occur primarily through infiltration of precipitation. Locally, shallow groundwater is expected to flow from the middle of the landfill facility toward the topographic low areas that serve as groundwater discharge points. Site 1 and SWMU 41 are located within the 100-year flood plain. This was determined by reviewing the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (1986). Based on the groundwater elevation data collected during this field event, the vertical gradient within the surficial aquifer is downward.

Rising-head and falling-head slug tests were performed at all newly installed monitoring wells and the existing well at Site 1 and SWMU 41. The geometric average hydraulic conductivity for the six shallow surficial aquifer wells was calculated to be approximately 2.52 feet per day (8.89×10^{-4} cm/sec), which is within the typical range of hydraulic conductivity for clayey, silty sands (Fetter, 1980). The geometric

average hydraulic conductivity for the five deep surficial aquifer wells was calculated to be approximately 4.51 feet per day (1.59 x 10^{-3} cm/sec), which is within the typical range of hydraulic conductivity for well-sorted sands to silty sands and fine sands (Fetter, 1980). Hydraulic conductivity curves and calculations based on the slug tests are included in Appendix B. The results of a falling head permeability test performed on an undisturbed sample collected from boring location PAI-01-SB-03 at a depth of 39 to 41 feet bgs indicate the material encountered has a vertical hydraulic conductivity of 8.4 x 10^{-8} cm/sec and is consistent with clays (Fetter, 1980).

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TABLE 3-1

SAMPLING RATIONALE
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample Location	Sampling Rationale
Groundwater	
PAI1-MW4 (S)	Collected to provide analytical data upgradient of the landfill.
PAI-01-MW-05 (S) through PAI-01-MW-14 (D)	Collected to provide analytical data downgradient (along the perimeter) of the landfill.
Surface Water	
PAI-01-SW-01	Collected to assess whether site-related chemicals are present in the intertidal area between the treeline and the landfill boundary.
PAI-01-SW-02	Collected to assess whether site-related chemicals are present in the intertidal area between the treeline and the landfill boundary.
PAI-01-SW-03	Collected to assess whether site-related chemicals are present in the intertidal area between the treeline and the landfill boundary.
PAI-01-SW-04	Collected to assess whether site-related chemicals are present in the intertidal area between the treeline and the landfill boundary.
PAI-01-SW-05, PAI-01-SW-06, and PAI-01-SW-07	Collected at Pinckney Island to provide background data.
PAI-01-SW-09	Collected to assess whether site-related chemicals have migrated outside the landfill boundary.
PAI-01-SW-10	Collected to assess whether site-related chemicals have migrated to Archers Creek.
PAI-01-SW-11	Collected to assess whether site-related chemicals have migrated outside the landfill boundary.
PAI-01-SW-12	Collected to assess whether site-related chemicals are present in the intertidal area between the treeline and the landfill boundary.
Sediment	
PAI-01-SD-01	Collected to assess whether site-related chemicals are present in the intertidal area between the treeline and the landfill boundary.
PAI-01-SD-02	Collected to assess whether site-related chemicals are present in the intertidal area between the treeline and the landfill boundary. Two samples were collected: one at a shallow depth to reflect recent migration of landfill material and one at a deeper depth to reflect historical migration.
PAI-01-SD-03	Collected to assess whether site-related chemicals are present in the intertidal area between the treeline and the landfill boundary.
PAI-01-SD-02A	Collected from exposed ash material adjacent to PAI-01-SD-02 and analyzed for TCDD and related isomers.
PAI-01-SD-04	Collected to assess whether site-related chemicals are present in the intertidal area between the treeline and the landfill boundary.
PAI-01-SD-05, PAI-01-SD-06, and PAI-01-SD-07	Collected at Pinckney Island to provide background data.
PAI-01-SD-08	A sample location was not associated with this sample ID per the work plan (B&R Environmental, 1998b).

TABLE 3-1

SAMPLING RATIONALE
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample Location	Sampling Rationale
PAI-01-SD-09	Collected to assess whether site-related chemicals have migrated outside the landfill boundary.
PAI-01-SD-10	Collected to assess whether site-related chemicals have migrated to Archers Creek.
PAI-01-SD-11	1998 sample collected to assess whether site-related chemicals have migrated outside the landfill boundary. 1999 sample collected to determine whether TCDD and related isomers were present due to past waste disposal activity.
PAI-01-SD-12	Collected to assess whether site-related chemicals are present in the intertidal area between the treeline and the landfill boundary.
PAI-01-SD-13 to PAI-01-SD-17	Collected to further delineate the extent of chemicals of potential concern in sediment.
PAI-10-SD-16A-02	Collected in a background sample location 4 miles from the site.
Surface Soil	
PAI-01-SS-01, PAI-01-SS-02, and PAI-01-SS-03	Collected at Pinckney Island to provide background data.
PAI-01-SS-04	A sample location was not associated with this sample ID per the work plan (B&R Environmental, 1998b).
PAI-01-SS-05	Sample located in a depression/low-lying area. Collected to assess potential accumulation of landfill-related contaminants.
PAI-01-SS-06	Sample collected in a large depression containing litter/garbage.
PAI-01-SS-07	Sample collected near one of the suspected locations of the former incinerator unit.
PAI-01-SS-08	Sample collected in a large gully approximately 5 to 6 feet deep.
PAI-01-SS-09	Sample located in a depression/low-lying area. Collected to assess potential accumulation of landfill-related contaminants.
PAI-01-SS-10	Sample located in a depression. Collected to assess potential accumulation of landfill-related contaminants.
PAI-01-SS-11	Sample location along a surface water runoff flow path. Collected to assess potential accumulation of landfill-related contaminants.
PAI-01-SS-12	Sample located in a depression/low-lying area. Collected to assess potential accumulation of landfill-related contaminants.
PAI-01-SS-13	Sample located in a depression/low-lying area. Collected to assess potential accumulation of landfill-related contaminants.
PAI-01-SS-14	Sample location along a surface water runoff flow path. Collected to assess potential accumulation of landfill-related contaminants.
PAI-01-SS-15 and PAI-01-SS-16	To determine whether pesticides or PAHs may be present in the area form non-site sources (e.g., pesticide applications or road run-off. Collected west of Site 1 near the picnic area).
PAI-41-SS-01	Sample collected near one of the suspected locations of the former

TABLE 3-1

SAMPLING RATIONALE
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample Location	Sampling Rationale
	incinerator unit.
PAI-41-SS-02	Sample collected near one of the suspected locations of the former incinerator unit.
PAI-41-SS-03	Sample collected near one of the suspected locations of the former incinerator unit.
PAI-41-SS-04	Sample collected near one of the suspected locations of the former incinerator unit.
Subsurface Soil	
PAI-01-SB-01 through PAI-01-SB-05	Samples collected during monitoring well installations to provide data in the event that groundwater modeling is conducted.

TABLE 3-2

MONITORING WELL CONSTRUCTION DETAILS
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Well Number	Installation Date	Ground Elevation (ft. msl)	Measuring Point Elevation (TPVC) (ft. msl)	Total Depth (feet bgs)	Depth to Water (feet TPVC)	Screened Interval (feet bgs)
PAI1-MW4 (S)	1988	11.5	14.99	14.3*	12.01	5-15
PAI-01-MW-05 (S)	1998	3.4	6.33	13.7	3.55	3.5 – 13.5
PAI-01-MW-06 (D)	1998	3.4	6.04	36.2	3.90	31 – 36
PAI-01-MW-07 (S)	1998	3.2	6.26	13.2	3.19	3 – 13
PAI-01-MW-08 (D)	1998	3.4	6.78	36.5	4.76	31.3 – 36.3
PAI-01-MW-09 (S)	1998	3.6	6.76	13.2	3.56	3 – 13
PAI-01-MW-10 (D)	1998	3.5	6.47	36	5.41	31 – 36
PAI-01-MW-11 (S)	1998	3.3	6.08	13.5	2.88	3.5-13.5
PAI-01-MW-12 (D)	1998	3.3	6.33	38	4.81	33 – 38
PAI-01-MW-13 (S)	1998	3.4	6.45	13.5	3.70	3.2 – 13.2
PAI-01-MW-14 (D)	1998	3.5	6.35	36	3.65	31 – 36

PAI-01-MW-05 (S) - well installed in shallow surficial aquifer
PAI-01-MW-06 (D) - well installed in deep surficial aquifer
Depths to groundwater measured June 12, 1998
TPVC - Top of PVC casing
bgs - below ground surface
ft. msl - feet above mean sea level
* Formation sand is present in the bottom of well.

TABLE 3-3

**SUMMARY OF SUBSURFACE SOIL SAMPLES COLLECTED
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA**

Sample ID	Date Collected	Medium	Depth Collected (ft bgs)	Analysis
PAI-01-SB-01-36*	1998	Subsurface soil	36-38	(2), (4)
PAI-01-SB-02-04* PAI-01-SB-02-36*	1998 1998	Subsurface soil Subsurface soil	4-6 36-38	(1), (2), (4) (2), (4)
PAI-01-SB-03-04* PAI-01-SB-03-36* PAI-01-SB-03-41	1998 1998 1998	Subsurface soil Subsurface soil Subsurface soil	4-6 36-38 39-41	(1), (2), (4) (2), (4) (3)
PAI-01-SB-04-38*	1998	Subsurface soil	38-40	(2), (4)
PAI-01-SB-05-36 PAI-01-SB-05-04*	1998 1998	Subsurface soil Subsurface soil	34-36 4-6	(2), (4) (1), (2), (4)

* denotes top of sample interval
1 TOC, pH
2 Natural moisture content, grain-size analysis and Atterberg Limits
3 Shelby Tube (for Vertical Conductivity)
4 Porosity, grain-size analysis, bulk density, and specific gravity

TABLE 3-4

**SUMMARY OF SURFACE WATER SAMPLES COLLECTED
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA**

Sample ID	Date Collected	Medium	Depth Collected (Feet)	Analysis
PAI-01-SW-01-00	1998	Surface water	Surface	(1), (2), (3), (4)
PAI-01-SW-01-00-D	1998	Surface water	Surface	(1), (2), (3), (4)
PAI-01-SW-02-00	1998	Surface water	Surface	(1), (2), (3), (4)
PAI-01-SW-02-00-D	1998	Surface water	Surface	(1), (2), (3), (4)
PAI-01-SW-03-00	1998	Surface water	Surface	(1), (3), (4)
PAI-01-SW-04-00	1998	Surface water	Surface	(1), (3), (4)
PAI-01-SW-05-00	1998	Surface water	Surface	(1), (3), (4)
PAI-01-SW-06-00	1998	Surface water	Surface	(1), (3), (4)
PAI-01-SW-07-00	1998	Surface water	Surface	(1), (3), (4)
PAI-01-SW-09-00	1998	Surface water	Surface	(1), (3), (4)
PAI-01-SW-10-00	1998	Surface water	Surface	(1), (3), (4)
PAI-01-SW-11-00	1998	Surface water	Surface	(1), (2), (3), (4)
PAI-01-SW-12-00	1998	Surface water	Surface	(1), (3), (4)

PAI-01-SW-02-00-D - duplicate sample
TCL - Target Compound List
TOC - Total Organic Carbon
TAL - Target Analyte List
PCBs - Polychlorinated biphenyls

1 TOC, pH, hardness ($CaCO_3$)
2 Hexavalent Chromium
3 TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (Totals), TAL metals (Dissolved) cyanide
4 Dissolved oxygen, salinity, temperature, pH, and turbidity

TABLE 3-5

**SUMMARY OF SURFACE WATER QUALITY PARAMETERS
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA**

Sample Number	Temperature (°C)	pH	Specific Conductance (mS/cm)	Dissolved Oxygen (mg/L)	Salinity (%)	Turbidity (NTU)	Secchi Disk (FT)
PAI-01-SW-01-00	33.4	7.47	39.5	4.71	2.54	>999	(1)
PAI-01-SW-01-00-D	33.4	7.47	39.5	4.71	2.54	>999	(1)
PAI-01-SW-02-00	30.7	7.55	41.2	4.80	2.66	0	(1)
PAI-01-SW-02-00-D	30.7	7.55	41.2	4.80	2.66	0	(1)
PAI-01-SW-03-00	30.7	6.84	39.2	6.27	2.57	2	(1)
PAI-01-SW-04-00	31.1	5.92	39.2	6.28	2.48	15	(1)
PAI-01-SW-05-00	28.0	7.70	39.0	10.3	2.50	8	(1)
PAI-01-SW-06-00	29.0	7.70	38.0	9.10	2.50	36	(1)
PAI-01-SW-07-00	31.0	6.80	38.0	11.4	2.40	18	(1)
PAI-01-SW-09-00	29.8	7.43	37.8	7.10	2.37	0	(1)
PAI-01-SW-10-00	31.8	7.09	36.7	4.90	2.29	886	(1)
PAI-01-SW-11-00	33.8	7.40	43.1	8.49	2.83	81	(1)
PAI-01-SW-12-00	29.7	6.27	36.5	4.32	2.32	10	(1)

1 Surface water too shallow to obtain Secchi Disk readings.
mS/cm - milliSiemens per centimeter
mg/L - milligram per Liter
NTU - Nephlometric Turbidity Units

TABLE 3-6

**SUMMARY OF SEDIMENT SAMPLES COLLECTED
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA**

Sample ID	Date Collected	Medium	Depth Collected (Feet)	Analysis
PAI-01-SD-01-01	1999	Sediment	0-0.5	(1), (3), (4)
PAI-01-SD-02-01 PAI-01-SD-02-02	1998 1998	Sediment Sediment	0-0.5 0.5-1	(1), (2), (3) (1), (2), (4)
PAI-01-SD-03-01 PAI-01-SD-03-01-D	1998 1998	Sediment Sediment	0-0.5 0-0.5	(1), (2), (4) (1), (2), (4)
PAI-01-SD-04-01	1998	Sediment	0-0.5	(1), (2)
PAI-01-SD-05-01	1998	Sediment	0-0.5	(1), (2)
PAI-01-SD-06-01	1998	Sediment	0-0.5	(1), (2)
PAI-01-SD-07-01	1998	Sediment	0-0.5	(1), (2)
PAI-01-SD-09-01	1998	Sediment	0-0.5	(1), (2)
PAI-01-SD-10-01	1998	Sediment	0-0.5	(1), (2)
PAI-01-SD-11-01	1998	Sediment	0-0.5	(1), (2), (3)
PAI-01-SD-12-01	1998	Sediment	0-0.5	(1), (2)
PAI-01-SD-13-01 PAI-01-SD-13-01-D	1999 1999	Sediment Sediment	0-0.5 0-0.5	(5) (5)
PAI-01-SD-14-01	1999	Sediment	0-0.5	(5)
PAI-01-SD-15-01	1999	Sediment	0-0.5	(5)
PAI-01-SD-16-01	1999	Sediment	0-0.5	(5)
PAI-01-SD-17-01	1999	Sediment	0-0.5	(5)
PAI-01-SD-02A-02	1999	Sediment/Ash	0-0.5	(6)
PAI-01-SD-11-02	1999	Sediment	0-0.5	(6)
PAI-01-SD-DU11-02	1999	Sediment	0-0.5	(6)

PAI-01-SD-03-01-D - duplicate sample
TCL - Target Compound List
TOC - Total Organic Carbon
TAL - Target Analyte List
PCBs - Polychlorinated biphenyls
PAHs - Polynuclear Aromatic Hydrocarbons

1 TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (Total), cyanide
2 TOC, pH
3 Hexavalent chromium
4 Grain–size analysis and bulk density
5 TAL Metals (total), TCL pesticides and PAHs
6 TCDD and related isomers

TABLE 3-7

**SUMMARY OF SURFACE SOIL SAMPLES COLLECTED
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA**

Sample ID	Date Collected	Medium	Depth Collected (Feet)	Analysis
PAI-01-SS-01-01	1998	Soil	0-1	(1)
PAI-01-SS-02-01	1998	Soil	0-1	(1)
PAI-01-SS-03-01	1998	Soil	0-1	(1)
PAI-01-SS-05-01	1998	Soil	0-1	(1)
PAI-01-SS-06-01	1998	Soil	0-1	(1)
PAI-01-SS-07-01	1998	Soil	0-1	(1), (2), (5)
PAI-01-SS-08-01	1998	Soil	0-1	(1), (3)
PAI-01-SS-09-01	1998	Soil	0-1	(1), (2), (3)
PAI-01-SS-10-01	1998	Soil	0-1	(1), (2), (4), (5)
PAI-01-SS-11-01	1998	Soil	0-1	(1)
PAI-01-SS-12-01	1998	Soil	0-1	(1)
PAI-01-SS-13-01	1998	Soil	0-1	(1)
PAI-01-SS-14-01-D	1998	Soil	0-1	(1)
PAI-01-SS-14-01	1998	Soil	0-1	(1), (3)
PAI-01-SS-15-01	1999	Soil	0-1	(6)
PAI-01-SS-16-01	1999	Soil	0-1	(6)

Sample ID	Date Collected	Medium	Depth Collected (Feet)	Analysis
PAI-41-SS-01-01	1998	Soil	0-1	(1)
PAI-41-SS-02-01	1998	Soil	0-1	(1)
PAI-41-SS-03-01	1998	Soil	0-1	(1)
PAI-41-SS-04-01	1998	Soil	0-1	(1)

PAI-01-SS-14-01-D -duplicate sample
TCL - Target Compound List
TOC - Total Organic Carbon
TAL - Target Analyte List
PCBs - Polychlorinated biphenyls
PAHs - Polynuclear aromatic hydrocarbon

1 TCL VOCs, SVOCs, pesticides, PCBs, TAL metals (Total), cyanide
2 TOC, pH
3 Hexavalent chromium
4 Natural moisture content, grain-size analysis and Atterberg Limits
5 Porosity, grain-size analysis, bulk density, and specific gravity
6 TCL pesticides and PAHs

TABLE 3-8

**SUMMARY OF GROUNDWATER SAMPLES COLLECTED
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA**

Sample ID	Date Collected	Medium	Depth Collected (Feet)	Analysis
PAI1-GW4-01	1998	Groundwater	Shallow surficial	(1), (3), (5), (6)
PAI-01-GW-05-01	1998	Groundwater	Deep surficial	(1), (3), (5), (6)
PAI-01-GW-06-01	1998	Groundwater	Deep surficial	(1), (3), (5), (6)
PAI-01-GW-07-01	1998	Groundwater	Shallow surficial	(1), (3), (2), (5), (6)
PAI-01-GW-08-01	1998	Groundwater	Deep surficial	(1), (3), (5), (6)
PAI-01-GW-09-01	1998	Groundwater	Shallow surficial	(1), (3), (5), (6)
PAI-01-GW-10-01	1998	Groundwater	Deep surficial	(2), (4), (5), (6)
PAI-01-GW-11-01	1998	Groundwater	Shallow surficial	(1), (2), (3), (5), (6)
PAI-01-GW-11-01-D	1998	Groundwater	Groundwater	(1), (2), (3), (5), (6)
PAI-01-GW-12-01	1998	Groundwater	Deep surficial	(1), (3), (5), (6)
PAI-01-GW-13-01	1998	Groundwater	Shallow surficial	(1), (3), (5), (6)
PAI-01-GW-14-01	1998	Groundwater	Deep surficial	(1), (3), (5), (6)

PAI-01-GW-11-01-D - duplicate sample
TCL - Target Compound List
TAL - Target Analyte List
TOC - Total Organic Carbon
PCBs - Polychlorinated biphenyl
TSS - Total suspended solids
TDS - Total dissolved solids

1 TOC, pH, hardness ($CaCO_3$)
2 Hexavalent chromium
3 TCL volatiles, semivolatiles, pesticides, PCBs, TAL metals (Totals), TAL metals (Dissolved) cyanide
4 RCRA Appendix IX Organics (including volatile organics, semivolatile organics, pesticides/PCBs, pesticides and chlorinated herbicides), RCRA Appendix IX inorganics, cyanide
5 TDS, TSS, chloride, fluoride nitrate/nitrite, sulfate
6 Dissolved oxygen, salinity, temperature, pH, and turbidity

TABLE 3-9

**SUMMARY OF GROUNDWATER QUALITY PARAMETERS
COLLECTED DURING PURGING
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA**

Sample Number	Temperature[1] (°C)	pH[1]	Specific Conductance[1] (mS/cm)	Dissolved Oxygen[1] (mg/L)	Salinity[1] (%)	Turbidity[1] (NTU)
PAI1-GW4-01	21.3	7.26	0.465	2.93	0.01	0
PAI-01-GW-05-01	26.0	7.81	31.0	0.75	1.94	0
PAI-01-GW-06-01	25.6	5.89	19.7	1.87	1.18	0
PAI-01-GW-07-01	23.0	7.88	30.1	0.98	1.88	0
PAI-01-GW-08-01	23.8	6.82	19.8	2.42	1.19	5
PAI-01-GW-09-01	24.8	7.02	57.8	1.19	3.41	0
PAI-01-GW-10-01	26.3	6.70	26.7	1.24	1.65	3
PAI-01-GW-11-01	26.9	6.94	48.7	0.71	3.20	0
PAI-01-GW-11-01-D	26.9	6.94	48.7	0.71	3.20	0
PAI-01-GW-12-01	23.7	6.81	35.6	0.98	2.26	0
PAI-01-GW-13-01	27.7	6.77	33.7	1.36	2.13	0
PAI-01-GW-14-01	24.2	6.52	10.6	2.01	0.59	0

PAI-01-GW-11-01-D - duplicate sample
mS/cm - milliSiemens per centimeter
mg/L - milligram per Liter
NTU - Nephlometric Turbidity Units
1 Results presented represent the last reading prior to sample collection

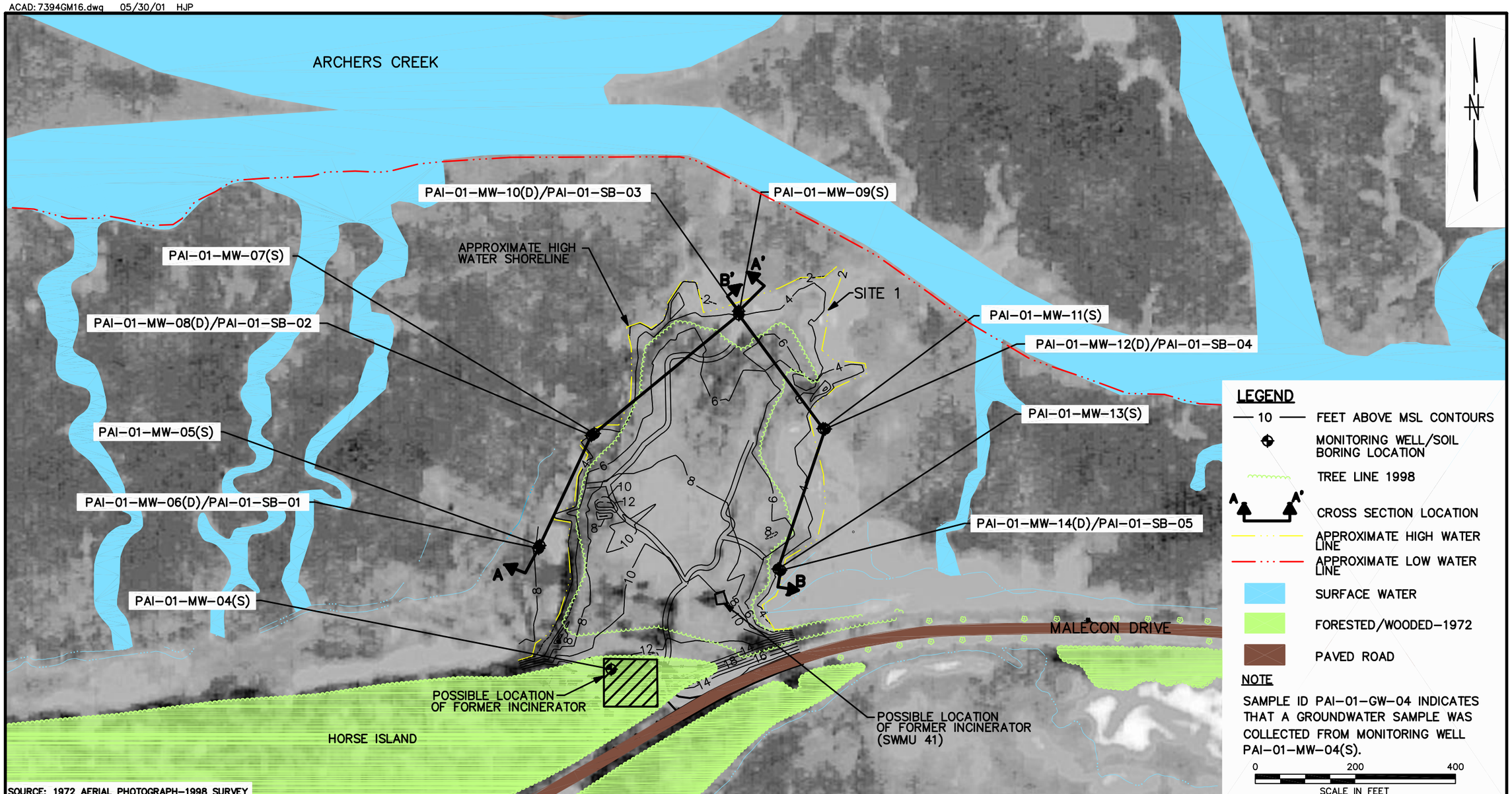
TABLE 3-10

WATER LEVEL MEASUREMENTS
SITE 1/SWMU 41 - INCINERATOR LANDFILL/FORMER INCINERATOR UNIT
MCRD PARRIS ISLAND, SOUTH CAROLINA

Monitoring Well Number	Date Measured	Measuring Point Elevation (ft. msl)	Depth to Water (ft. from TPVC)	Groundwater Elevation (ft. msl)
PAI1-MW4(S)	06/12/98	14.99	12.01	2.98
PAI-01-MW-05(S)	06/12/98	6.33	3.55	2.78
PAI-01-MW-06(D)	06/12/98	6.04	3.90	2.14
PAI-01-MW-07(S)	06/12/98	6.26	3.19	3.07
PAI-01-MW-08(D)	06/12/98	6.78	4.76	2.02
PAI-01-MW-09(S)	06/12/98	6.76	3.56	3.20
PAI-01-MW-10(D)	06/12/98	6.47	5.41	1.06
PAI-01-MW-11(S)	06/12/98	6.08	2.88	3.20
PAI-01-MW-12(D)	06/12/98	6.33	4.81	1.52
PAI-01-MW-13(S)	06/12/98	6.45	3.70	2.75
PAI-01-MW-14(D)	06/12/98	6.35	3.65	2.70

(S) - well installed in shallow surficial aquifer
(D) - well installed in deep surficial aquifer
ft msl - feet above mean sea level
TPVC - top of polyvinyl chloride (PVC)

ACAD: 7394GM16.dwg 05/30/01 HJP



SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

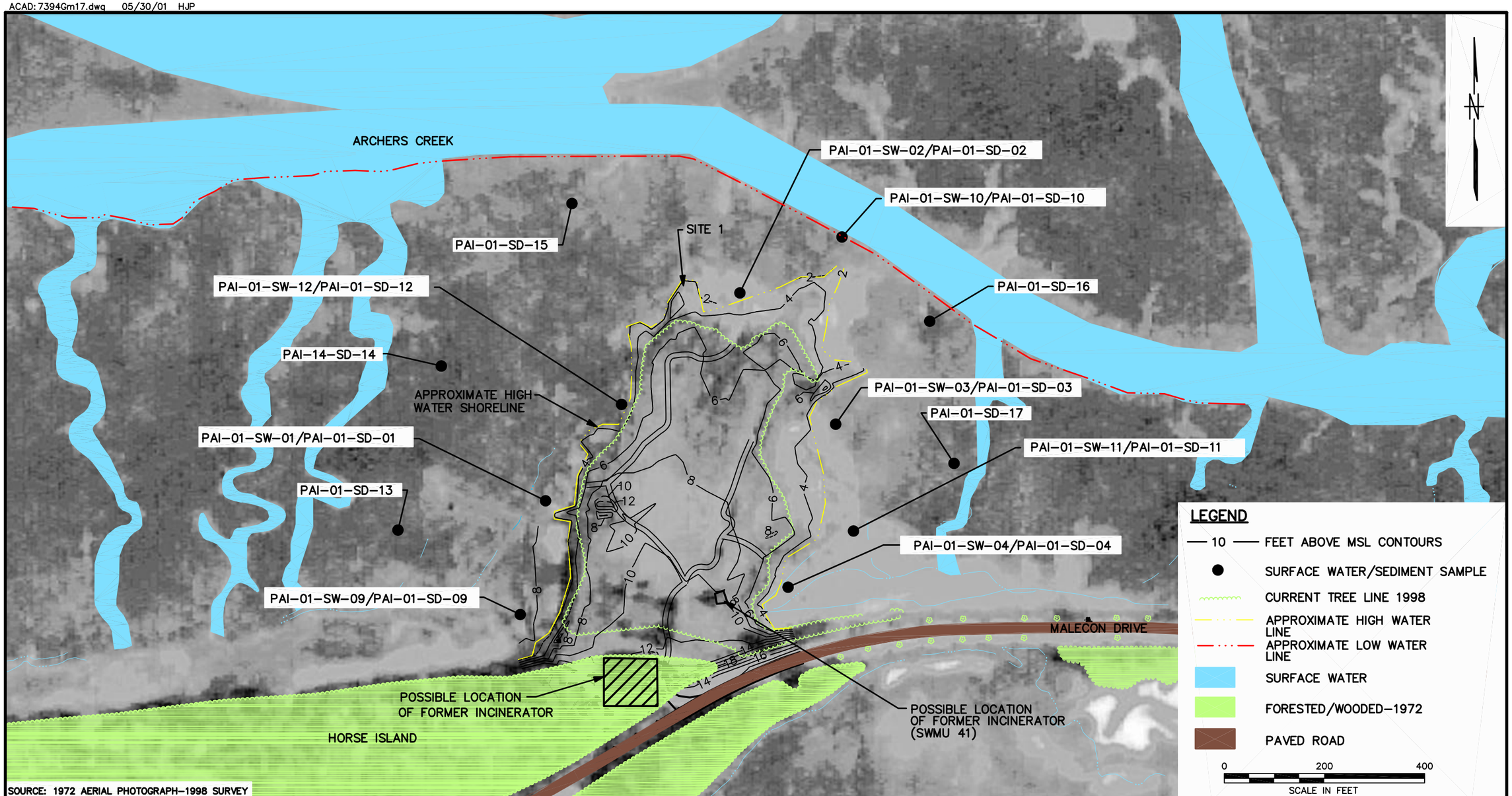
DRAWN BY HJP DATE 9/30/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

MONITORING WELL AND SOIL BORING SAMPLE LOCATION MAP
SITE 1-INCINERATOR LANDFILL AND SWMU 41-FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3-1
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 7394Gm17.dwg 05/30/01 HJP



SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

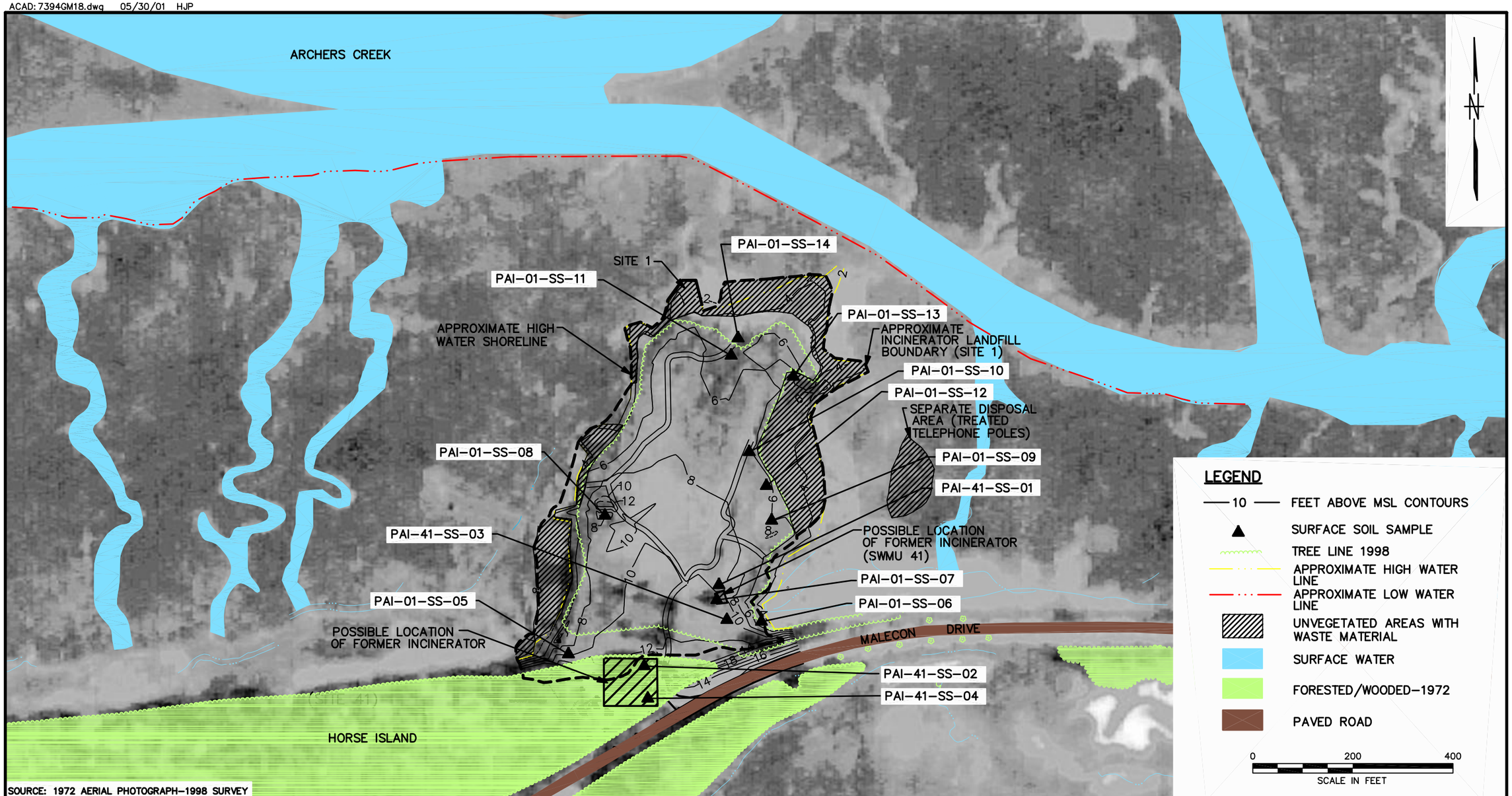
DRAWN BY HJP DATE 9/30/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SURFACE WATER AND SEDIMENT SAMPLE LOCATION MAP
SITE 1-INCINERATOR LANDFILL AND SWMU 41-FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3-2
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 7394GM18.dwg 05/30/01 HJP



SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 9/30/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SURFACE SOIL SAMPLE LOCATION MAP
SITE 1-INCINERATOR LANDFILL AND
SWMU 41-FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3-3
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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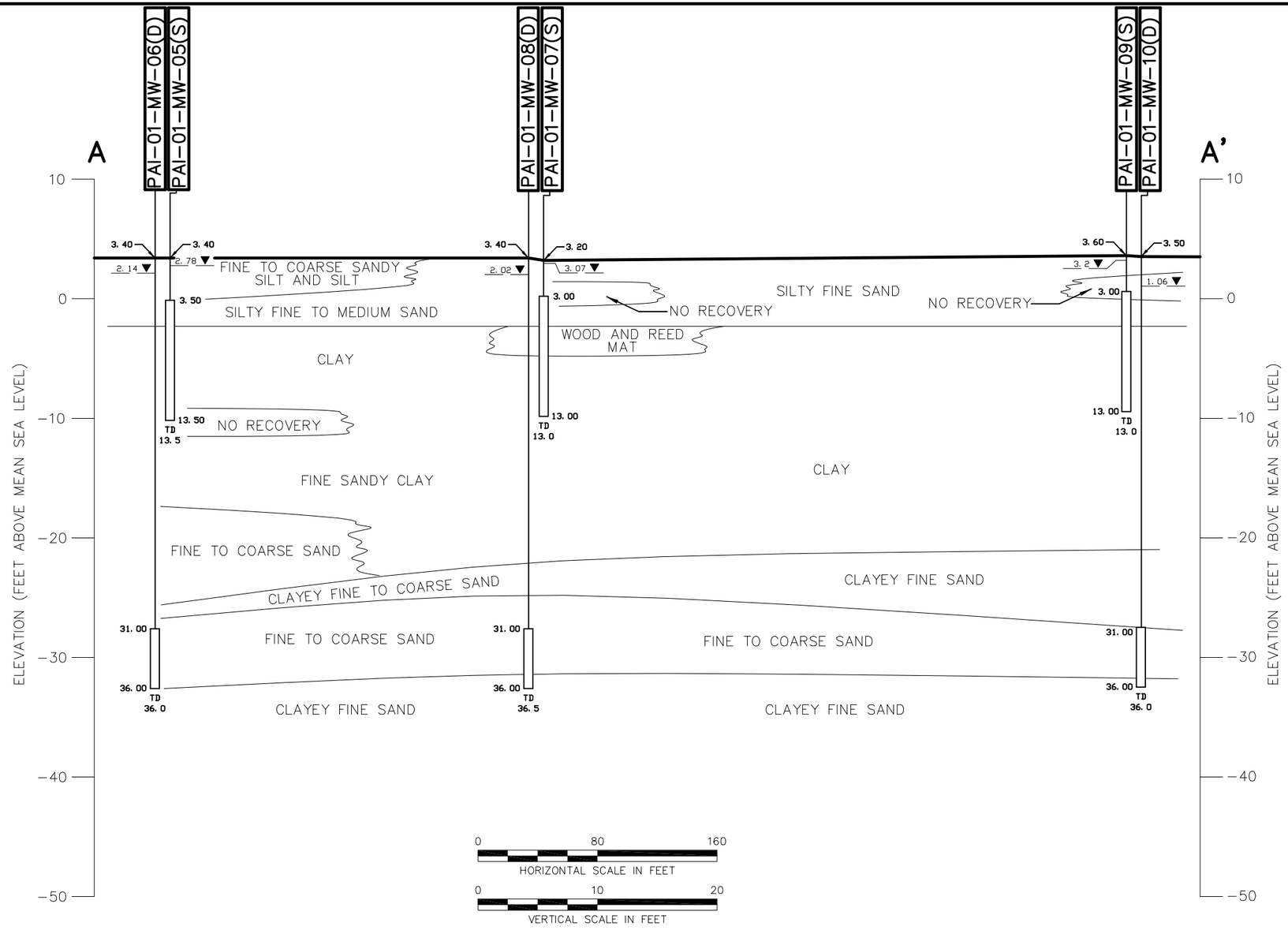

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 12/28/98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

CROSS SECTION A-A'
SITE - 1 INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
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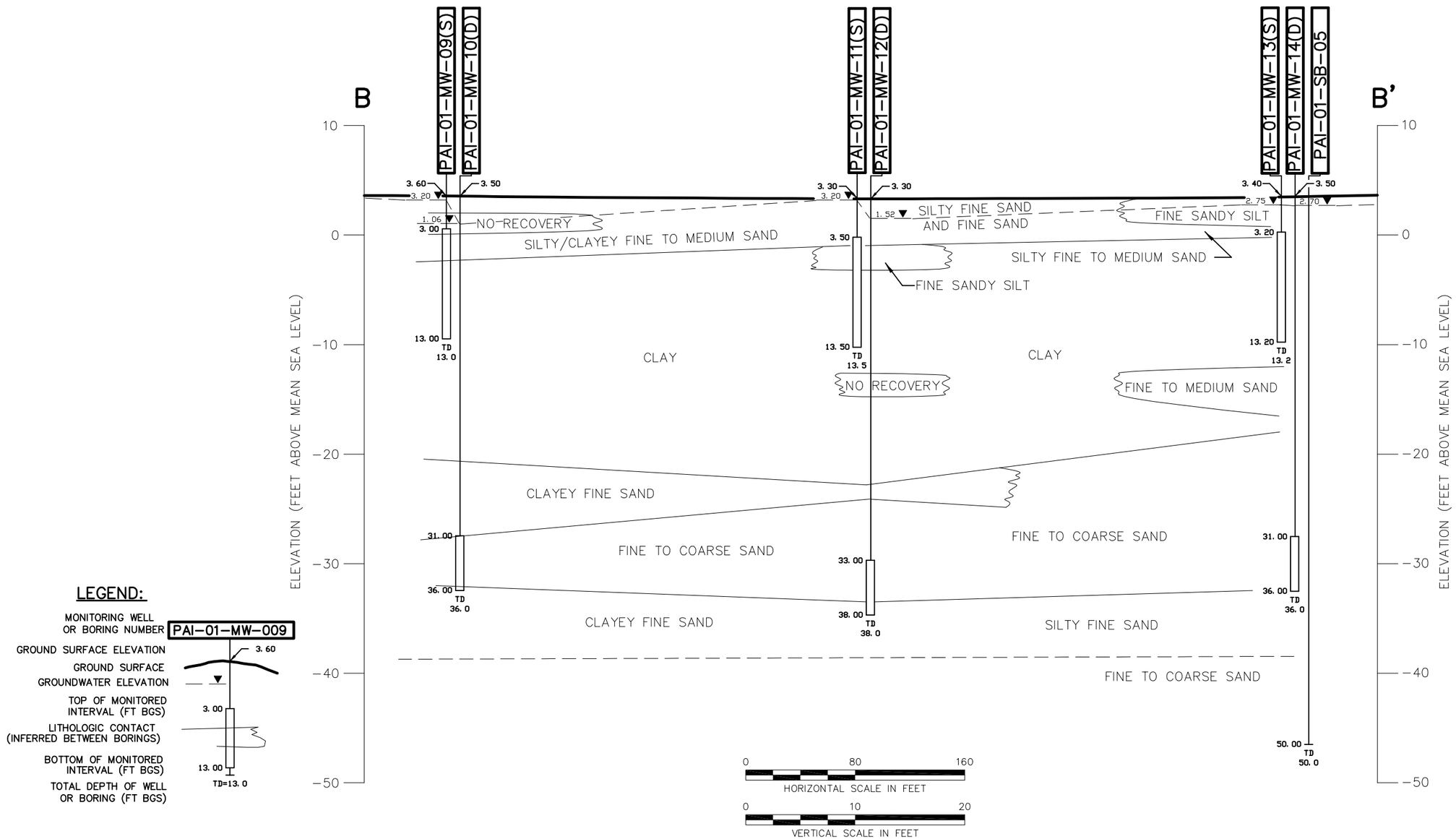
DRAWING NO. FIGURE 3-4
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 7394GX09.dwg 10/01/99 HJP



LEGEND:

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DATE: HJP 12/28/98

CHECKED BY DATE

COST/SCHED-AREA

SCALE: AS NOTED

CROSS SECTION B-B'
SITE 1 - INCINERATOR LANDFILL AND
SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394

APPROVED BY DATE

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DRAWING NO. FIGURE 3-5

REV. 0

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4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents the analytical results of the 1998 field investigation sampling conducted at Site/SWMU 1 (Site 1) and SWMU 41. Site 1 is the Incinerator Landfill, and SWMU 41 is the Former Incinerator. Site 1 received combustion residue from the former incinerator. It was operated from 1921 to 1965. The landfill served as the disposal area for the following wastes from the MCRD:

- combustible domestic wastes
- noncombustible domestic wastes
- construction debris
- heat treated hazardous wastes
- mineral spirits
- diesel fuels
- kerosene
- strippers (methylene chloride)

The former landfill occupies approximately 4 acres and is currently covered by a mature pine stand. No significant disposal activities have occurred at Site 1 since 1965.

The former incinerator at SWMU 41 consisted of a brick chamber that was approximately 43 feet long, 34 feet tall, and 20 feet wide. Trucks carried wastes, mostly nonhazardous combustible domestic wastes, up a ramp to the top of the chamber and discharged them into the hole. Emissions were then vented through a hole at the top of the chamber. Additionally, some hazardous wastes generated from the MCRD from 1921 to 1959 were treated in the incinerator.

Samples were collected from Site 1 and SWMU 41 in the summer and fall of 1998. Additional surface soil and sediment samples were collected in the spring of 1999. A summary of the analytical program is provided in Section 3.0. During the field investigation sampling at Site 1, 13 surface soil samples (three of which were only analyzed for miscellaneous parameters), 12 filtered and non-filtered groundwater samples (including one duplicate), 10 filtered and non-filtered surface water samples (including one duplicate), and 16 sediment samples (including two duplicates) were collected and analyzed. At SWMU 41, four surface soil samples were also collected and analyzed. This section presents all detected results in summary table. A complete set of analytical results is presented in Appendix C. The figures in Section 4 show the results that exceed background levels and human health risk-based concentrations (RBCs) or ecological screening values. Figures display the original and duplicate analytical result for those locations where a normal and duplicate sample was collected. Statistics provided in the tables of this section utilize

the average of the original and duplicate sample result. Detailed discussions of the comparison of analytical results to U.S. EPA human health and ecological criteria are provided in the human health and ecological risk assessments in Sections 6 and 7, respectively.

Inorganic background levels are based on samples collected from areas that are remote from the investigate sites and other waste management activities at Parris Island. For each background area, sample locations were visually located in the field to confirm the absence of waste management activities and represent a range of undisturbed soils and sediment types. The two locations selected for background samples consist of Pinckney Island and an undeveloped area on the southern portion of Parris Island. See Appendix A for sample locations. Six background samples were collected for all media of concern, except groundwater. Positive detections were noted for most inorganic parameters. The background values presented in Table 4-1 are based on U.S. EPA Region 4 protocol and equal two times the mean value. A complete set of analytical results is presented in Appendix C.

Data were validated in accordance with U.S. EPA National Functional Guidance for Organic and Inorganic Data Review (U.S. EPA, 1994a,b).

The analytical results for the sampled media are summarized in the following sections.

4.1 SITE 1

Samples were collected from Site 1 during the field investigation sampling in 1998 and 1999. A summary of the analytical program for samples collected from Site 1 is provided in Section 3.0. During the field investigation sampling, 13 surface soil samples, 12 filtered and non-filtered groundwater samples (including one duplicate), 10 filtered and non-filtered surface water samples (including one duplicate), and 16 sediment samples (including two duplicates) were collected and analyzed.

4.1.1 Surface Soil

Summary statistics of all positive results for the 1998/99 surface soil sampling at Site 1 are provided in Table 4-2. Positive detections of organics and inorganics for surface soil at Site 1 that exceed background and U.S. EPA Region 3 human health RBCs [1 x 10^{-6} incremental lifetime cancer risk (ILCR) - Residential, HQ >1.0] or U.S. EPA Region 4 ecological criteria are shown on Figure 4-1 and are discussed below.

Organic compounds detected in surface soil at Site 1 include the VOC toluene and the SVOCs 1,2,4-trichlorobenzene, 2-methylnapthalene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl) phthalate,

butylbenzyl phthalate, carbazole, chrysene, dibenzofuran, di-n-butyl phthalate, di-n-octyl phthalate, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. Detected pesticides and PCBs include 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC (Lindane), alpha-chlordane, gamma-chlordane, endrin ketone, and Aroclor 1260.

Toluene was only detected in 1 out of 10 samples. The detected maximum was relatively low, 0.003 mg/kg, and was less than the human health RBCs or ecological screening values.

The following PAHs were detected in all 10 samples: benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and fluoranthene. Their maximum levels were detected at the same sample location, PAI-01-SS-07 (southeastern portion of site). Benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene were detected at a frequency of 7, 8, or 9 out of 10. All other PAHs were detected in five or fewer samples. The range of maximum detections for the more frequently detected SVOCs was 0.011 mg/kg to 0.63 mg/kg (fluoranthene). Benzo(a)pyrene equivalents [B(a)P] and total PAH concentrations exceeded the human health and ecological screening value at several locations (Figure 4-1).

Four phthalates [bis(2-ethylhexyl) phthalate, butylbenzyl phthalate, di-n-butyl phthalate, and di-n-octyl phthalate] and 1,2,4-trichlorobenzene were also detected in the surface soil. Although di-n-octyl phthalate was only detected at one location (PAI-01-SS-12), it had the highest maximum concentration of the SVOCs (6.4 mg/kg).

Two of the pesticides, 4,4'-DDE and 4,4'-DDT, were detected in all the sample locations. 4,4'-DDD was detected in 8 of the 10 samples. The maximum levels ranged from 0.18 mg/kg (4,4'-DDD) to 4.4 mg/kg (4,4'-DDT at location PAI-01-SS-07). The other pesticides and Aroclor 1260 were detected in three or fewer detects out of 10. These pesticide levels ranged from 0.004 mg/kg to 0.075 mg/kg (gamma-BHC). The maximum levels of all pesticides, except gamma-chlordane, were detected at sample location PAI-01-SS-07. Aroclor 1260 was detected at a maximum level of 0.08 mg/kg (PAI-01-SS-09). Pesticide and PCB levels were generally low, with only 4,4'-DDE and 4,4'-DDT exceeding human health RBCs. 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-BHC, beta-BHC, gamma-BHC, and Aroclor 1260 exceeded ecological screenings values at one or more sites (Figure 4-1).

Inorganics were also detected throughout the surface soil samples collected at Site 1. They included the following metals: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, cyanide (total), iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Essential nutrients like calcium, magnesium, potassium, and sodium were also detected.

The following metals (excluding essential nutrients) were detected in all samples: aluminum, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, vanadium, and zinc. Antimony was detected in (9 out of 10) samples. The metals selenium (5 out of 10), silver (5 out of 10), and cyanide (2 out of 10) were detected at lower frequencies.

Iron was detected at levels ranging between 2,560 mg/kg and 147,000 mg/kg. The maximum level is two orders of magnitude greater than background (3,920 mg/kg). Aluminum and lead were detected at maximum levels of 8610 mg/kg and 8380 mg/kg, respectively. Aluminum only slightly exceeded the background level; however, the maximum detection of lead is much greater than the background level of 13 mg/kg. The maximum detections of manganese (1280 mg/kg) and zinc (497 mg/kg) also exceeded the background level.

The range of maximum levels for the other frequently detected metals (i.e., antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, mercury, nickel, and vanadium) was 1.1 mg/kg (mercury) to 178 mg/kg (barium). Selenium, silver, and cyanide were detected at a range of 0.73 mg/kg (selenium) to 2.4 mg/kg (silver).

Maximum detections for aluminum, barium, cadmium, chromium, cobalt, copper, cyanide, iron, manganese, nickel, and zinc were found at sampling location PAI-01-SS-08-01. The maximum detections for antimony, arsenic, lead, silver, and vanadium were found at sampling location PAI-01-SS-09-01. Mercury had maximum detection at location PAI-01-SS-07. Sample locations PAI-01-SS-07 and PAI-01-SS-09 are in the eastern portion of the site. Sample PAI-01-SS-08-01 is located on the western side of the site. All the detected metals exceeded the background level. Cyanide and cobalt were the only metals that did not exceed the human health RBCs or ecological screening values (Figure 4-1).

The pH of the surface soil was generally neutral, ranging from 6.3 to 7.7 at sampling location PAI-01-SB-05. Total organic carbon concentrations ranged from a low of 0.98 mg/kg to a high of 2.5 mg/kg.

4.1.2 Groundwater

Summary statistics of positive results for the 1998 groundwater sampling at Site 1 are provided in Table 4-3. Positive detections of organics and inorganics for groundwater at Site 1 that exceed human health potable water use (EPA Region 3 human health RBCs [1×10^{-6} ILCR - potable water use, HQ >1.0]) or EPA Region 4 surface water (brackish) ecological criteria are shown on Figure 4-2 and are discussed below.

Organic compounds detected in groundwater at Site 1 included the following VOCs: acetone, 2-butanone, carbon disulfide, chloroform, ethylbenzene, toluene, and m,p-xylenes. Detected SVOCs included 1,2-dichlorobenzene, 2-methylnaphthalene, 2-methylphenol, 2,4-dimethylphenol, acenapthene, anthracene, bis(2-ethylhexyl) phthalate, carbazole, di-n-butyl phthalate, di-n-octyl phthalate, diethyl phthalate, dibenzofuran, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene. Pesticides or PCBs were not detected in the groundwater samples.

Carbon disulfide (6 out of 11) and acetone (4 out of 11) were detected the most in comparison to the other organics. Acetone was detected at a maximum level of 13 µg/L, and carbon disulfide was detected at 16 µg/L. Chloroform (3 out of 11), toluene (3 out of 11), and m,p-xylene (2 out of 11) were detected at lower frequencies. The maximum concentrations of toluene and m,p-xylene were both 2 µg/L. 2-Butanone and ethylbenzene were detected once each, at levels of 3.4 µg/L and 0.2 µg/L, respectively. Chloroform, detected at a maximum concentration of 0.9 µg/L, exceeded the human health screening value at three locations (Figure 4-2). In general, VOCs were detected at relatively low levels.

Of the PAHs, naphthalene and phenanthrene were detected in 4 of 11 samples, and the remaining PAHs were detected only once or twice. The PAH concentrations ranged from 1 µg/L to 57 µg/L (naphthalene at location PAI-01-GW-10). The phthalate compounds were generally detected at higher frequencies: di-n-butyl phthalate (7 out of 11), diethyl phthalate (4 out of 11), bis(2-ethylhexyl) phthalate (3 out of 11), and di-n-octyl phthalate (1 out of 11). These concentrations ranged from 1 µg/L to 7 µg/L (di-n-butyl phthalate at location PAI1-GW4-001). SVOC levels were relatively low, with only naphthalene exceeding its human health and ecological screening values (Figure 4-2).

TCDD toxicity equivalent concentrations (TEQs) were found to be below the most stringent drinking water criteria. Further details are provided in Appendix G.

Inorganics detected in the filtered and non-filtered groundwater samples collected at Site 1 include aluminum, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, thallium, vanadium, and zinc. Essential nutrients like calcium, magnesium, potassium, and sodium were also detected.

Barium, chromium, lead, and zinc were detected in most of the samples (10 or 11 out of 11). The maximum levels of these inorganics ranged from 16.9 µg/L (zinc) to 1,030 µg/L (barium). Chromium was detected at 18.4 µg/L, and lead was detected at a maximum level of 34.7 µg/L. Arsenic (6 out of 11), iron (7 out of 11), manganese (7 out of 11), and vanadium (8 out of 11) were detected at slightly lower frequencies. These metals were detected at concentrations that ranged from 4.4 µg/L (arsenic) to 12,700 µg/L (iron). Copper (7.8 µg/L), beryllium (0.7 µg/L), and aluminum (3,970 µg/L) were detected at

frequencies of 5 or 6 out of 11. Arsenic, iron, lead, and manganese exceeded the human health RBCs in the non-filtered groundwater samples (Figure 4-2).

Filtered results for some of the inorganics, including barium (1,230 µg/L), chromium (26.9 µg/L), iron (13,300 µg/L), lead (36.4 µg/L), and zinc, were detected at levels greater than the non-filtered results. The detected maximum of the filtered zinc sample was 102 µg/L, compared to a non-filtered concentration of 16.2 µg/L, a difference of an order of magnitude. The remaining metals (excluding essential nutrients) were detected at maximum levels ranging from 0.3 µg/L (beryllium) to 1,300 µg/L (manganese). Arsenic, copper, iron, lead, manganese, mercury, and zinc were detected at levels exceeding the human health RBCs or ecological screening values (Figure 4-2).

Tests were also conducted for several miscellaneous parameters. Chloride concentrations ranged from 28 mg/L to 20,000 mg/L (at location PAI-01-GW-09), and fluoride ranged in concentration from 11 mg/L to 155 mg/L. Hardness was reported as $CaCO_3$, with detected levels of 200 mg/L to 6,300 mg/L. The nitrogen concentrations varied between 0.01 mg/L to 0.06 mg/L. Sulfate levels ranged from 24 mg/L to 1,500 mg/L; sulfide was detected at 16 mg/L. The maximum detected total dissolved solid level was 35,000 mg/L. The detected total suspended solid concentrations ranged from 17 mg/L to 270 mg/L. Total organic carbon concentrations ranged from 4 mg/L to 45 mg/L.

4.1.3 Surface Water

Summary statistics of positive results for the 1998 surface water sampling at Site 1 are provided in Table 4-4. Positive detections of organics and inorganics for surface water at Site 1 that exceed background and human health EPA water quality standards (EPAWQs) for consumption of surface water and organisms or EPA Region 4 surface water (brackish) ecological criteria are shown on Figure 4-3 and are discussed below.

Organic compounds detected in surface water at Site 1 included acetone, pentachlorophenol, phenol, the phthalate bis(2-ethylhexyl) phthalate, and the following detected PAHs: 2-methylnaphthalene, chrysene, dibenzofuran, and fluoranthene. Pesticides or PCBs were not detected in surface water.

Detection frequencies of the organics were generally low, with bis(2-ethylhexyl) phthalate (detected at three of the eight sample locations) having the most detections. All other organics were detected in one or two of the samples. Pentachlorophenol was detected only once, at a maximum level of 110 µg/L at sample location PAI-01-SW-03. Maximum concentrations of the other organics ranged between 0.22 µg/L (fluoranthene) to 56 µg/L [bis(2-ethylhexyl) phthalate]. Bis(2-ethylhexyl) phthalate, chrysene, and pentachlorophenol levels exceeded the EPAWQs for human health (Figure 4-3).

The following inorganics were detected in the surface water at Site 1: aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver, vanadium, and zinc. Essential nutrients like calcium, magnesium, potassium, and sodium were also detected.

In the unfiltered samples, iron was detected at a maximum concentration of 15,600 µg/L. Aluminum was detected at a maximum level of 13,435 µg/L. The range of detections for the other metals was 0.12 µg/L (mercury) to 124 µg/L (manganese). Aluminum, arsenic, cobalt, copper, iron, lead, manganese, nickel, vanadium, and zinc were detected at maximum levels greater than the background concentrations. Arsenic, copper, iron, lead, manganese, and silver levels exceeded the human health EPAWQs and ecological screening values (Figure 4-3).

Filtered results point out that barium (263 µg/L) and zinc (96.4 µg/L) were detected at higher maximum concentrations than the unfiltered samples and exceeded the background levels. The range of the other detected metals was 2.08 µg/L (antimony) to 43.8 µg/L (manganese). Zinc was the only filtered metal to exceed the ecological screening value (Figure 4-3).

Most of the maximum inorganic levels were detected in samples PA-01-SW-01, PAI-01-SW-10, and PAI-01-SW-12. Samples PAI-01-SW-01 and PAI-01-SW-12 are located on the western side of the site. Sample PAI-01-SW-10 is located north along the shoreline of Archer's Creek (see Figure 4-3).

Hardness values ranged from 3,430 mg/L to 4,360 mg/L (as $CaCO_3$). The pH was slightly basic, ranging from 7.2 to 8.3. Salinity was measured at all nine sampling locations, ranging in concentration from 18.7 mg/L to 23.4 mg/L (PAI-01-SW-11). Total organic carbon concentrations ranged from 2.55 mg/L to 9.1 mg/L.

4.1.4 Sediment

Summary statistics of positive results for the 1998 and 1999 sediment sampling at Site 1 are provided in Table 4-5. Detected chemicals that exceed background and human health or ecological screening values are presented on Figure 4-4. Human health screening values assume that sediment is the same as surface soils and consist of U.S. EPA Region 3 human health RBCs (1 x 10 -6 ILCR - Residential, HQ equal to 1). Ecological screening values are the U.S. EPA Region 4 sediment ecological screening values.

Organic compounds detected in sediment at Site 1 included the following VOCs: acetone, carbon disulfide, and toluene. The detected PAHs included acenaphthylene, anthracene, benz(a)anthracene, benzo(a)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene, carbazole, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. The

following pesticides were also detected: 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-BHC, alpha-chlordane, beta-BHC, delta-BHC, gamma-BHC (lindane), and gamma-chlordane. No PCBs were detected in the sediment.

Toluene and carbon disulfide were detected in six of nine samples. Acetone was detected in three out of nine samples. The detected levels were low and ranged from 0.007J mg/kg (toluene) to 0.063 mg/kg (acetone). Carbon disulfide was detected at a maximum level of 0.024J mg/kg at sample location PAI-01-SD-01.

Benzo(b)fluoranthene was detected the most in comparison to the other PAHs (frequency of 10 out of 14). With the exception of acenaphthylene (1 out of 14), dibenz(a,h)anthracene (1 out of 14), and carbazole (3 out of 9), the other PAHs were detected in at least 6 out of 14 samples. Maximum PAH concentrations ranged from 0.16J mg/kg (fluorene) to 5.4J mg/kg (pyrene). Total PAH concentration exceeded ecological screening criteria at four sampling locations (Figure 4-4). Benzo(a)pyrene equivalent concentration also exceeded human health screening criteria at four locations.

Most of the maximum concentrations were detected in sample PAI-01-SD-17 (the extreme eastern portion of the site).

The pesticides 4,4'-DDE (0.12J mg/kg), 4,4'-DDD (0.26J mg/kg), and 4,4'-DDT (0.27J mg/kg) were detected in 4 to 6 of 14 samples. The other pesticides were detected in only 1 of 14 samples. The maximum concentrations of the other pesticides ranged between 0.002J mg/kg (gamma-BHC) and 0.13 mg/kg (gamma-chlordane). These levels are relatively low. However, as shown in Figure 4-4, levels of some pesticides exceeded the ecological screening values.

TCDD and related isomers, measured as TEQ, were found in sediment at concentrations below the most stringent risk-based human health criteria. The detected TEQ were at concentrations slightly above the most stringent criteria for mammals, but less than the ecological screening criteria for fish and avian receptors. However, TEQ is similar to that found in a background sample location. As a result, the presence of TEQ is likely present from a regional source and is not related to Site 1 waste disposal activity. Further detail is provided in Appendix G.

The following inorganics were detected in the sediment at Site 1: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver, thallium, vanadium, and zinc. Essential nutrients like calcium, magnesium, potassium, and sodium were also detected.

The following metals were detected in all samples (14 out of 14 samples): aluminum, barium, chromium, iron, lead, manganese, vanadium, and zinc. The maximum levels of these metals ranged from 34.4 mg/kg (chromium) to 24,000 mg/kg (iron). Cadmium (0.79 mg/kg) and thallium (0.93 mg/kg) were detected in just 1 of 14 samples. The other metals were detected at various frequencies, with maximum levels ranging from 0.67 mg/kg (mercury) to 95.3 mg/kg (copper). Aluminum and chromium were detected at maximum concentrations below the background levels. All other metals were detected at concentrations exceeding the background levels. Arsenic, cadmium, copper, iron, lead, mercury, and silver concentrations exceeded the human health RBCs or ecological screening value at various sampling locations (Figure 4-4).

Maximum inorganic detections occurred primarily at sample locations PAI-01-SD-09, PAI-01-SD-10, and PAI-01-SD-13. Sample PAI-01-SD-01 and PAI-01-SD-13 are located on the western side of the site, and PAI-01-SD-09 is located farther south. Sample PAI-01-SD-10 is located north of the site along Archers Creek (see Figure 4-4).

The acid volatile sulfide concentration in the sediment was 5.7 mg/kg. The simultaneously extracted metals lead, nickel, and zinc had concentrations of 0.014 mg/kg, 0.008 mg/kg, and 0.75 mg/kg, respectively. The pH of the sediment ranged from neutral to a slightly basic 8.3 at location PAI-01-SD-02. Total organic carbon ranged from 1.4% to 4.2%, and sediment grain size and TOC data for 1998 samples are presented in Table 4-6.

4.2 SWMU 41

Samples were collected from SWMU 41 during the field investigation sampling in 1998. A summary of the analytical program for samples collected from SWMU 41 is provided in Section 3.0. During the field investigation sampling, four surface soil samples were collected and analyzed. The analytical results for the sampled medium are summarized in the following section.

4.2.1 Surface Soil

Summary statistics of positive results for the 1998 surface soil sampling at SWMU 41 are provided in Table 4-7. Positive detections of organics and inorganics for surface soil at SWMU 41 that exceeded background and EPA Region III RBC-residential human health or EPA Region 4 ecological criteria are shown on Figure 4-1 and are discussed below.

Organic compounds detected in surface soil at SWMU 41 include acetone, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, 4,4'-DDE, and 4,4'-DDT.

Acetone was detected once, at a level of 0.730 mg/kg (sample PAI-41-SS-02). Benzo(b)fluoranthene, fluoranthene, and phenanthrene were detected in all four samples. Maximum PAH levels ranged from 0.012 mg/kg to 0.200 mg/kg (fluoranthene at sample location PAI-41-SS-03). Higher levels of PAHs were primarily detected in sample PAI-41-SS-03, where total PAHs exceeded the ecological screening value (Figure 4-1).

The maximum detected levels of 4,4'-DDE and 4,4'-DDT ranged between 0.043 mg/kg to 0.065 mg/kg. The higher concentrations of 4,4'-DDE and 4,4'-DDT were detected in sample PAI-41-SS-01. These pesticides were detected in two of the four samples and exceeded the ecological screening values.

The following inorganics were detected in the surface soil at SWMU 41: aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, and zinc. Essential nutrients like calcium, magnesium, potassium, and sodium were also detected.

Detected metals were found in nearly all the samples. Aluminum levels ranged from 3,130 mg/kg to 6,290 mg/kg. Iron levels ranged from 2,150 mg/kg to 15,500 mg/kg. Barium (151 mg/kg), copper (114 mg/kg), lead (161 mg/kg), manganese (95.7 mg/kg), and zinc (158 mg/kg) were detected at relatively similar maximum levels. Arsenic (6.3 mg/kg), chromium (13.4 mg/kg), cobalt (4.3 mg/kg), nickel (13.9 mg/kg), and vanadium (11 mg/kg) were detected at lower levels. The remaining metals were detected at maximum levels only slightly greater than or less than 1 mg/kg: beryllium (0.51 mg/kg), cadmium (1.1 mg/kg), mercury (0.18 mg/kg), silver (0.89 mg/kg), and selenium (1.1 mg/kg).

Aluminum and manganese levels did not exceed background concentrations. The other metals were detected at levels greater than background levels. Arsenic was the only metal to exceed the human health RBC. Copper, iron, mercury, lead, selenium, vanadium, and zinc were detected at levels exceeding the ecological screening values (Figure 4-1).

Most of the maximum concentrations were detected in sample PAI-41-SS-03. This sample is located in the southern portion of the site (see Figure 4-1). Sample PAI-41-SS-04-01 was collected within the possible location of the former incinerator, and no elevated levels of organics or inorganics were noted.

TABLE 4-1

SUMMARY OF DETECTED BACKGROUND CONCENTRATIONS
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Surface Soil	Sediment	Surface Water Filtered	Surface Water Unfiltered
Organics	**(mg/kg)**	**(mg/kg)**	**(mg/l)**	**(mg/l)**
4-Methyl-2-pentanone	7.3	26		
2-Butanone		22		
Acetone	267			
Chloromethane				0.68
Carbon Disulfide		9.2		
Toluene	5.7	9.7		
Xylenes				1
Bis(2-Ethylhexyl)phthalate		421		45
Fluorene	646			
Indeno(1,2,3-cd)pyrene		518		2.6
Beta-BHC		7.1		
Inorganics	**(mg/kg)**	**(mg/kg)**	**(mg/l)**	**(mg/l)**
Aluminum	7270	24200		3100
Arsenic	1.4	12	4.3	5.1
Barium	24	28	256	38
Beryllium	0.095	0.98		
Cadmium		0.28		
Calcium	766	4000	650000	637000
Chromium	6.2	35.2	20	22.5
Cobalt	0.36	2.6		
Copper	1.5	10	13	7
Iron	3920	21500	48	2090
Lead	12.5	21	11	
Magnesium	515	6400	1900000	1900000
Manganese	129	186	18	53
Mercury	0.11	0.09		
Nickel	1.8	6		
Potassium	313	3200	890000	830000
Selenium	0.29			
Sodium	241	19000	15900000	16000000
Thallium	0.098	0.41		
Vanadium	9.5	50	15	18
Zinc	9.7	45	66	11

Background concentration is calculated as 2 times the average background concentration.

For chemicals in which at least one detection was noted, the average was calculated using 1/2 the detection limit for non detected chemicals.

Blank: Indicates that the chemical was not detected in any sample, and therefore an average could not be calculated.

Chemicals not detected in the background data set were not presented in this table. They include antimony, silver, and most organic compounds.

TABLE 4-2

SUMMARY STATISTICS - SURFACE SOIL
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Positive Detect	Average of Positive Detects	Average All	Background Level	Maximum Level Exceed Background
Volatile Organics (mg/kg)								
Toluene	1/10	0.003	0.006 - 0.009	PAI-01-SS-05-01	0.003	0.0035	NA	NA
Semivolatile Organics (mg/kg)								
1,2,4-Trichlorobenzene	1/10	0.14	0.34 - 0.53	PAI-01-SS-07-01	0.14	0.19	NA	NA
2-Methylnaphthalene	1/10	0.13	0.34 - 0.53	PAI-01-SS-07-01	0.13	0.19	NA	NA
Anthracene	5/10	0.012 - 0.035	0.0085 - 0.088	PAI-01-SS-09-01	0.022	0.015	NA	NA
Benzo(a)anthracene	10/10	0.011 - 0.28	NA(1)	PAI-01-SS-07-01	0.099	0.091	NA	NA
Benzo(a)pyrene	10/10	0.02 - 0.31	NA(1)	PAI-01-SS-07-01	0.12	0.11	NA	NA
Benzo(b)fluoranthene	10/10	0.02 - 0.51	NA(1)	PAI-01-SS-07-01	0.14	0.13	NA	NA
Benzo(g,h,i)perylene	7/10	0.038 - 0.21	0.034 - 0.081	PAI-01-SS-07-01	0.12	0.077	NA	NA
Benzo(k)fluoranthene	10/10	0.011 - 0.16	NA(1)	PAI-01-SS-07-01	0.054	0.046	NA	NA
Bis(2-Ethylhexyl)phthalate	4/10	0.06 - 5.6	0.36 - 0.53	PAI-01-SS-12-01	1.45	0.71	NA	NA
Butylbenzyl Phthalate	1/10	2	0.34 - 0.53	PAI-01-SS-12-01	2	0.38	NA	NA
Carbazole	5/10	0.26 - 0.49	0.36 - 0.4	PAI-01-SS-14-01-AVG	0.40	0.30	NA	NA
Chrysene	10/10	0.019 - 0.33	NA(1)	PAI-01-SS-07-01	0.12	0.11	NA	NA
Di-n-butyl phthalate	1/10	0.072	0.34 - 0.53	PAI-01-SS-12-01	0.072	0.18	NA	NA
Di-n-octyl phthalate	1/10	6.4	0.34 - 0.53	PAI-01-SS-12-01	6.4	0.82	NA	NA
Dibenzofuran	3/10	0.17 - 0.2	0.34 - 0.53	PAI-01-SS-14-01-AVG	0.18	0.20	NA	NA
Fluoranthene	10/10	0.033 - 0.63	NA(1)	PAI-01-SS-07-01	0.20	0.18	NA	NA
Fluorene	1/10	0.095	0.042 - 0.44	PAI-01-SS-05-01	0.095	0.054	NA	NA
Indeno(1,2,3-cd)pyrene	8/10	0.18 - 0.23	0.025 - 0.047	PAI-01-SS-07-01	0.092	0.079	NA	NA
Phenanthrene	9/10	0.021 - 0.18	0.037	PAI-01-SS-06-01	0.10	0.089	NA	NA
Pyrene	9/10	0.030 - 0.51	0.094	PAI-01-SS-07-01	0.17	0.14	NA	NA
Pesticides/PCBs (mg/kg)								
4,4'-DDD	8/10	0.0021 - 0.18	0.0094 - 0.01	PAI-01-SS-07-01	0.043	0.030	NA	NA
4,4'-DDE	10/10	0.0038 - 4.2	NA(1)	PAI-01-SS-07-01	0.45	0.45	NA	NA
4,4'-DDT	10/10	0.0021 - 4.4	NA(1)	PAI-01-SS-07-01	0.44	0.44	NA	NA
Alpha-Chlordane	2/10	0.0095 - 0.018	0.0009 - 0.005	PAI-01-SS-07-01	0.014	0.004	NA	NA
Aroclor-1260	3/10	0.021 - 0.08	0.0094 - 0.088	PAI-01-SS-09-01	0.046	0.023	NA	NA
Endrin Ketone	1/10	0.012	0.0017 - 0.01	PAI-01-SS-07-01	0.012	0.0033	NA	NA
Gamma-Chlordane	1/10	0.006	0.0009 - 0.005	PAI-01-SS-09-01	0.007	0.0021	NA	NA
alpha-BHC	2/10	0.0037 - 0.042	0.0009 - 0.005	PAI-01-SS-07-01	0.023	0.0048	NA	NA
beta-BHC	2/9	0.0089 - 0.033	0.0009 - 0.005	PAI-01-SS-07-01	0.021	0.0049	NA	NA
delta-BHC	1/10	0.045	0.0009 - 0.005	PAI-01-SS-07-01	0.045	0.0049	NA	NA
gamma-BHC (Lindane)	1/10	0.075	0.0009 - 0.005	PAI-01-SS-07-01	0.075	0.0074	NA	NA

TABLE 4-2

SUMMARY STATISTICS - SURFACE SOIL
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Positive Detect	Average of Positive Detects	Average All	Background Level	Maximum Level Exceed Background
Inorganics (mg/kg)								
Aluminum	10/10	3880 - 8610	NA(1)	PAI-01-SS-08-01	6085.5	6085.5	7270	Yes
Antimony	9/10	0.1875 - 90.6	0.15	PAI-01-SS-09-01	10.84	9.76	ND	Yes
Arsenic	10/10	0.58 - 24.9	NA(1)	PAI-01-SS-09-01	5.237	5.24	1.4	Yes
Barium	10/10	15.2 - 178	NA(1)	PAI-01-SS-08-01	74.45	74.45	24	Yes
Cadmium	10/10	0.1 - 5.4	NA(1)	PAI-01-SS-08-01	1.13	1.13	ND	Yes
Calcium	10/10	420 - 13100	NA(1)	PAI-01-SS-05-01	3440.65	3440.65	766	Yes
Chromium	10/10	7 - 53.2	NA(1)	PAI-01-SS-08-01	16.57	16.57	6.2	Yes
Cobalt	10/10	0.33 - 13.7	NA(1)	PAI-01-SS-08-01	2.86	2.86	0.36	Yes
Copper	10/10	6.5 - 131	NA(1)	PAI-01-SS-08-01	48.26	48.26	1.5	Yes
Cyanide	2/10	0.73 - 0.86	0.42 - 0.61	PAI-01-SS-08-01	0.795	0.36	ND	Yes
Iron	10/10	2560 - 147000	NA(1)	PAI-01-SS-08-01	24992.5	24992.50	3920	Yes
Lead	10/10	58.4 - 8380	NA(1)	PAI-01-SS-09-01	1129.9	1129.90	12.5	Yes
Magnesium	10/10	233 - 1280	NA(1)	PAI-01-SS-06-01	695.5	695.50	515	Yes
Manganese	10/10	17.4 - 752	NA(1)	PAI-01-SS-08-01	149.95	149.95	129	Yes
Mercury	10/10	0.04 - 1.1	NA(1)	PAI-01-SS-07-01	0.25	0.25	0.11	Yes
Nickel	10/10	1.8 - 47.8	NA(1)	PAI-01-SS-08-01	9.63	9.63	1.8	Yes
Potassium	10/10	190 - 692	NA(1)	PAI-01-SS-05-01	473.45	473.45	313	Yes
Selenium	5/10	0.18 - 0.73	0.17 - 0.2	PAI-01-SS-05-01	0.36	0.22	0.29	Yes
Silver	5/10	0.48 - 2.4	0.06 - 0.44	PAI-01-SS-09-01	1.39	0.74	ND	Yes
Sodium	10/10	68 - 3530	NA(1)	PAI-01-SS-06-01	1288.4	1288.40	241	Yes
Vanadium	10/10	5.7 - 47.4	NA(1)	PAI-01-SS-09-01	14.25	14.25	9.5	Yes
Zinc	10/10	45.65 - 497	NA(1)	PAI-01-SS-08-01	220.17	220.17	9.7	Yes
Miscellaneous Parameters (mg/kg)								
Ph	5/5	6.3 - 7.7	NA(1)	PAI-01-SB-05-04	7.16	7.16	NA	NA
Total Organic Carbon (%)	5/5	0.98 - 2.5	NA(1)	-01-SB-05-04/PAI-01-SB-03	1.90	1.90	NA	NA

NA = Not Applicable
ND = Not Detected
1 A range of non detect values was not determined for chemicals in which the chemical was detected in all samples tested.

TABLE 4-3

SUMMARY STATISTICS - GROUNDWATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Detect	Average of Positive Detects	Average All
Volatile Organics (ug/L)						
2-Butanone	1/1	3.4	0	PAI-01-GW-10-01	3.4	3.4
Acetone	4/4	1.4 - 13	0	PAI-01-GW-14-01	6.5	6.5
Carbon Disulfide	6/11	0.7 - 16	1	PAI-01-GW-14-01	5.9	3.5
Chloroform	3/11	0.3 - 0.9	1	PAI-01-GW-14-01	0.53	0.51
Ethylbenzene	1/11	0.2	1	PAI-01-GW-10-01	0.20	0.47
Toluene	3/11	0.5 - 2	1	PAI-01-GW-07-01	1	0.64
Xylenes, Total	2/11	1.4 - 2	1	PAI-01-GW-09-01	1.7	0.72
Semivolatile Organics (ug/L)						
1,2-Dichlorobenzene	1/11	3	5 - 6	PAI-01-GW-05-01	3	2.6
2,4-Dimethylphenol	2/11	2 - 5	5 - 6	PAI-01-GW-09-01	3.5	2.8
2-Methylnaphthalene	1/11	7	5 - 6	PAI-01-GW-10-01	7	3.0
2-Methylphenol	1/11	1	5 - 6	PAI-01-GW-10-01	1	2.5
Acenaphthene	2/11	1 - 7	5 - 6	PAI-01-GW-10-01	4	2.9
Anthracene	2/11	1	5 - 6	PAI-01-GW-10-01/PAI-01-GW-13-01	1	2.4
Bis(2-Ethylhexyl)phthalate	3/11	1	5 - 10	PAI-01-GW-08-01/PAI-01-GW-10-01/GW-07-01	1	2.5
Carbazole	1/10	2	5 - 6	PAI-01-GW-13-01	2	2.6
Di-n-butyl phthalate	7/11	1	5 - 6	PAI-01-GW-12-01/12-01/10-01/09-01/-06-01/11-01-AVG/07-01	1	1.6
Di-n-octyl phthalate	1/11	7	5 - 6	PAI1-GW4-01	7	3.0
Dibenzofuran	2/11	1 - 3	5 - 6	PAI-01-GW-10-01	2	2.5
Diethyl Phthalate	4/11	1	5 - 6	PAI-01-GW-10-01/06-01/-08-01/-09-01	1	2.0
Fluoranthene	2/11	1	5 - 6	PAI-01-GW-13-01/-10-01	1	2.4
Fluorene	2/11	1 - 6	5 - 6	PAI-01-GW-10-01	3.5	2.8
Naphthalene	4/11	1 - 57	5 - 6	PAI-01-GW-10-01	16	7.6
Phenanthrene	4/11	1 - 8	5 - 6	PAI-01-GW-10-01	2.8	2.7
Pyrene	2/11	1	5 - 6	PAI-01-GW-10-01/-13-01	1	2.4
Inorganics (ug/L)						
Aluminum	5/10	23.3 - 3970	22 - 27	PAI1-GW4-01	850	431
Arsenic	6/11	1.15 - 4.4	1.1 - 2.2	PAI-01-GW-09-01	2.3	1.7
Barium	11/11	16.2 - 1030	NA	PAI-01-GW-07-01	424	424
Beryllium	5/11	0.2 - 0.7	0.2 - 0.7	PAI-01-GW-09-01	0.36	0.25
Calcium	10/10	67200 - 494000	NA	PAI-01-GW-09-01	239430	239430
Chromium	9/11	6.4 - 18.4	6.4	PAI-01-GW-09-01	13	11
Copper	4/11	2.55 - 7.8	2.1 - 3.7	PAI-01-GW-05-01	4.8	2.6
Iron	7/10	259 - 12700	8.6 - 84.6	PAI-01-GW-06-01	4311	3023
Lead	10/11	0.5 - 34.7	0.9	PAI-01-GW-09-01	13	11
Magnesium	10/10	9650 - 1180000	NA	PAI-01-GW-09-01	627615	627615
Manganese	7/10	40.3 - 1320	13.7 - 96.6	PAI-01-GW-05-01	306	224
Potassium	10/10	6980 - 477000	NA	PAI-01-GW-09-01	242198	242198
Sodium	10/10	19400 - 10100000	NA	PAI-01-GW-09-01	5476940	5476940

TABLE 4-3

SUMMARY STATISTICS - GROUNDWATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Detect	Average of Positive Detects	Average All
Vanadium	8/11	3.1 - 32.6	6.3 - 8.8	PAI-01-GW-09-01	9.6	8.0
Zinc	10/11	4.6 - 16.9	4.3	PAI-01-GW-05-01	9.8	9.1
Inorganics, Filtered (ug/L)						
Aluminum, Filtered	1/11	44.4	22 - 27	PAI1-GW4-01-F	44	15
Arsenic, Filtered	4/11	1.3 - 4	1.1 - 2.2	PAI-01-GW-09-01-F	2.6	1.4
Barium, Filtered	11/11	252 - 1230	NA	PAI-01-GW-10-01-F	630	630
Beryllium, Filtered	6/11	0.15 - 0.3	0.2 - 0.5	PAI-01-GW-05-01-F	0.21	0.19
Cadmium, Filtered	4/11	1.7 - 2.7	1.4 - 2	PAI-01-GW-12-01-F	2.2	1.4
Calcium, Filtered	11/11	62400 - 462000	NA	PAI-01-GW-09-01-F	240373	240373
Chromium, Filtered	8/11	7.1 - 26.9	6.4	PAI-01-GW-09-01-F	15	11
Copper, Filtered	4/11	3.05 - 4.6	2.1 - 2.6	PAI-01-GW-09-01-F	3.5	2.0
Iron, Filtered	7/11	114 - 13300	10.7 - 112	PAI-01-GW-06-01-F	3677	2348
Lead, Filtered	10/11	0.9 - 36.4	0.9	PAI-01-GW-09-01-F	12	11
Magnesium, Filtered	11/11	9430 - 1140000	NA	PAI-01-GW-09-01-F	638312	638312
Manganese, Filtered	9/11	14 - 1300	72.7 - 89.4	PAI-01-GW-05-01-F	247	210
Mercury, Filtered	1/11	0.23	0.2	PAI-01-GW-05-01-F	0.23	0.11
Potassium, Filtered	11/11	6740 - 440000	NA	PAI-01-GW-09-01-F	238613	238613
Sodium, Filtered	11/11	23000 - 9940000	NA	PAI-01-GW-09-01-F	5459818	5459818
Thallium, Filtered	1/11	3.1	2 - 20	PAI-01-GW-08-01-F	3.1	4.6
Vanadium, Filtered	7/11	2.8 - 27.8	2.6 - 9.8	PAI-01-GW-09-01-F	9.4	7.2
Zinc, Filtered	11/11	16.7 - 112	NA	PAI-01-GW-06-01-F	55	55
Miscellaneous Parameters (mg/L)						
Chloride	11/11	28 - 20000	NA	PAI-01-GW-09-01	10493	10493
Fluoride	5/11	11 - 155	2 - 20	PAI-01-GW-11-01-AVG	47.2	26
Hardness As Caco3	10/10	200 - 6300	NA	PAI-01-GW-09-01	3444	3444
Nitrate/nitrite, As Nitrogen	8/11	0.01 - 0.06	0.01 - 0.03	PAI1-GW4-01	0.033	0.027
Sulfate	11/11	24 - 1500	NA	PAI-01-GW-06-01	728	728
Sulfide	1/1	16	NA	PAI-01-GW-10-01	16	16
Total Dissolved Solids	11/11	290 - 35000	NA	PAI-01-GW-09-01	17908	17908
Total Organic Carbon	11/11	4 - 45	NA	PAI-01-GW-09-01	15	15
Total Suspended Solids	11/11	17 - 270	NA	PAI-01-GW-10-01	79	79
Miscellaneous Parameters (pg/L)						
2,3,7,8 TCDD Equivalents	1/1	0.0105	NA	PAI-01-GW-09(S)-02	0.0105	0.0105

NA = Not Applicable

TABLE 4-4

SUMMARY STATISTICS - SURFACE WATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Detect	Average of Positive	Average All	Background	Maximum Level Exceed Background
Volatile Organics (ug/L)								
Acetone	1/2	7	2	PAI-01-SW-09-00	7	4	NA	NA
Semivolatile Organics (ug/L)								
2-Methylnaphthalene	1/8	10	10 - 11.5	PAI-01-SW-03-00	10	5.8	NA	NA
Bis(2-Ethylhexyl)phthalate	3/8	14 - 56	10 - 11.5	PAI-01-SW-03-00	31	15	45	Yes
Chrysene	1/8	0.1	0.12 - 0.24	PAI-01-SW-10-00	0.1	0.075	NA	NA
Dibenzofuran	1/8	10	10 - 11.5	PAI-01-SW-03-00	10	5.8	NA	NA
Fluoranthene	1/8	0.082	0.12 - 0.27	PAI-01-SW-04-00	0.082	0.082	NA	NA
Pentachlorophenol	1/8	110	48 - 57	PAI-01-SW-03-00	110	36	NA	NA
Phenol	1/8	3	10 - 11.5	PAI-01-SW-11-00	3	4.9	NA	NA
Inorganics (ug/L)								
Aluminum	6/8	434 - 13435	262 - 309	PAI-01-SW-01-00-AVG	5062	3832	3113	Yes
Arsenic	1/8	13.9	2 - 8.3	PAI-01-SW-10-00	14	3.0	5.1	Yes
Barium	8/8	12.6 - 37.15	0	PAI-01-SW-01-00-AVG	20	20	38	No
Cadmium	2/8	0.305 - 0.42	0.3	PAI-01-SW-01-00-AVG	0.36	0.20	ND	Yes
Calcium	8/8	228000 - 290000	0	PAI-01-SW-12-00	257438	257438	637000	No
Chromium	2/8	14.1 - 19.2	0.7 - 0.8	PAI-01-SW-10-00	17	4.4	23	No
Cobalt	2/8	1.755 - 2.9	0.4 - 0.6	PAI-01-SW-10-00	2.3	1	ND	Yes
Copper	2/8	13.6 - 62.95	1.4 - 9	PAI-01-SW-01-00-AVG	38	11	7.0	Yes
Iron	8/8	175 - 15600	0	PAI-01-SW-10-00	3405	3405	2091	Yes
Lead	2/8	20.9 - 77.5	1 - 17	PAI-01-SW-01-00-AVG	49	15	ND	Yes
Magnesium	8/8	693000 - 883000	0	PAI-01-SW-12-00	783438	783438	1918667	No
Manganese	8/8	21.65 - 124	0	PAI-01-SW-10-00	58	58	53	Yes
Mercury	2/8	0.09 - 0.12	0.1 - 0.12	PAI-01-SW-10-00	0.11	0.065	ND	Yes
Nickel	2/8	3.85 - 5	0.6 - 1	PAI-01-SW-10-00	4.4	1.4	ND	Yes
Potassium	8/8	342500 - 492000	0	PAI-01-SW-12-00	435438	435438	831333	No
Silver	1/8	0.89	0.6 - 0.7	PAI-01-SW-11-00	0.89	0.39	ND	Yes
Sodium	8/8	5710000 - 7440000	0	PAI-01-SW-01-00-AVG	6541250	6541250	16226667	No
Vanadium	2/8	24.2 - 36.1	0.5 - 4.1	PAI-01-SW-10-00	30	8.1	18	Yes
Zinc	4/8	7.3 - 51.025	5 - 28.25	PAI-01-SW-01-00-AVG	29	18	11	Yes
Inorganics, Filtered (ug/L)								
Antimony, Filtered	1/8	2.075	1.7 - 2.2	PAI-01-SW-01-00-F-AVG	2.1	1.1	ND	Yes
Barium, Filtered	8/8	34.9 - 263	0	PAI-01-SW-12-00-F	189	189	256	Yes

TABLE 4-4

SUMMARY STATISTICS - SURFACE WATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Detect	Average of Positive	Average All	Background	Maximum Level Exceed Background
Calcium, Filtered	8/8	225000 - 287000	0	PAI-01-SW-12-00-F	252563	252563	650,000	No
Magnesium, Filtered	8/8	702500 - 873000	0	PAI-01-SW-12-00-F	769063	769063	1,900,000	No
Manganese, Filtered	7/8	11 - 43.8	14.05	PAI-01-SW-01-00-F-AVG	33	30	18	Yes
Potassium, Filtered	8/8	333000 - 487000	0	PAI-01-SW-03-00-F	441875	441875	890,000	No
Sodium, Filtered	8/8	5860000 - 7595000	0	PAI-01-SW-01-00-F-AVG	6503750	6503750	15,900,000	No
Zinc, Filtered	6/8	51.4 - 96.4	14.45 - 36.7	PAI-01-SW-12-00-F	66	53	66	Yes
Miscellaneous Parameters (mg/L)								
Hardness As Caco3	8/8	3430- 4360	0	PAI-01-SW-12-00	3870	3870	NA	NA
pH	8/8	7.2 - 8.3	0	PAI-01-SW-10-00	7.7	7.7	NA	NA
Salinity	8/8	18.7 - 23.4	0	PAI-01-SW-11-00	21	21	NA	NA
Total Organic Carbon	8/8	2.55 - 9.1	0	PAI-01-SW-04-00	4.5	4.5	NA	NA

NA = Not Applicable
ND = Not Detected

TABLE 4-5

SUMMARY STATISTICS - SEDIMENT
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Detect	Average of Positive Detects	Average All	Background Level	Maximum Level Exceed Background
Volatile Organics (mg/kg)								
Acetone	3/3	0.016 - 0.063	NA	PAI-01-SD-09-01	0.037	0.037	NA	NA
Carbon Disulfide	6/9	0.002 - 0.024	0.008 - 1.2	PAI-01-SD-01	0.013	0.077	NA	NA
Toluene	6/9	0.003 - 0.007	0.019 - 1.2	PAI-01-SD-09-01	0.0051	0.073	NA	NA
Semivolatile Organics (mg/kg)								
Acenaphthylene	1/14	0.38	0.071 - 3.6	PAI-01-SD-02-01	0.38	0.35	NA	NA
Anthracene	6/14	0.011 - 0.77	0.0028 - 0.85	PAI-01-SD-01	0.26	0.14	NA	NA
Benzo(a)anthracene	8/14	0.03 - 2.2	0.0071 - 0.85	PAI-01-SD017	0.56	0.35	NA	NA
Benzo(a)pyrene	9/14	0.0078 - 1.7	0.0071 - 0.85	PAI-01-SD-17	0.45	0.32	NA	NA
Benzo(b)fluoranthene	10/14	0.0081 - 1.8	0.0028 - 0.85	PAI-01-SD-17	0.40	0.32	NA	NA
Benzo(g,h,i)perylene	7/14	0.03 - 0.99	0.011 - 0.85	PAI-01-SD-17	0.32	0.20	NA	NA
Benzo(k)fluoranthene	9/14	0.0031 - 0.85	0.0028 - 0.85	PAI-01-SD-17	0.18	0.15	NA	NA
Carbazole	3/9	0.086 - 0.58	0.47 - 1.2	PAI-01-SD-02-01	0.31	0.38	NA	NA
Chrysene	9/14	0.013 - 2.3	0.0071 - 0.85	PAI-01-SD-17	0.56	0.39	NA	NA
Dibenzo(a,h)anthracene	1/14	1.6	0.011 - 0.85	PAI-01-SD-17	1.60	0.22	NA	NA
Fluoranthene	9/14	0.025 - 6.6	0.0071 - 0.85	PAI-01-SD-17	1.36	0.90	NA	NA
Fluorene	1/14	0.16	0.014 - 0.85	PAI-01-SD-03-01-AVG	0.16	0.11	NA	NA
Indeno(1,2,3-cd)pyrene	8/14	0.03 - 1.1	0.0071 - 0.85	PAI-01-SD-17	0.33	0.22	NA	NA
Phenanthrene	8/14	0.025 - 2.6	0.0057 - 0.85	PAI-01-SD-01	0.66	0.41	NA	NA
Pyrene	7/14	0.064 - 5.4	0.014 - 0.85	PAI-01-SD-17	1.46	0.77	NA	NA
Pesticides/PCBs (mg/kg)								
4,4'-DDD	4/14	0.0036 - 0.26	0.0057 - 0.032	PAI-01-SD-09-01	0.073	0.026	NA	NA
4,4'-DDE	6/14	0.0055 - 0.12	0.0057 - 0.032	PAI-01-SD-09-01	0.033	0.018	NA	NA
4,4'-DDT	4/13	0.0032 - 0.27	0.0046 - 0.032	PAI-01-SD-09-01	0.073	0.026	NA	NA
Alpha-Chlordane	1/8	0.052	0.0023 - 0.0074	PAI-01-SD-09-01	0.052	0.0083	NA	NA
Gamma-Chlordane	1/14	0.13	0.0023 - 0.0155	PAI-01-SD-09-01	0.13	0.012	NA	NA
alpha-BHC	1/14	0.0027	0.0023 - 0.0155	PAI-01-SD-02-01	0.0027	0.0030	NA	NA
beta-BHC	1/14	0.0054	0.0023 - 0.0155	PAI-01-SD-02-01	0.0054	0.0032	NA	NA
delta-BHC	1/14	0.0027	0.0023 - 0.0155	PAI-01-SD-02-01	0.0027	0.0030	NA	NA
gamma-BHC (Lindane)	1/14	0.0021	0.0023 - 0.0155	PAI-01-SD-02-01	0.0021	0.0029	NA	NA
Inorganics (mg/kg)								
Aluminum	14/14	2110 - 23400	NA	PAI-01-SD-02-02	10179	10179	24200	No
Antimony	4/14	0.55 - 1.3	0.39 - 6	PAI-01-SD-001	0.8	0.70	ND	Yes
Arsenic	13/14	1.2 - 15.6	0.27	PAI-01-SD-10-01	6.7	6.2	12	Yes
Barium	14/14	5.7 - 88.5	NA	PAI-01-SD-09-01	24	24	28	Yes
Beryllium	3/14	0.7075 - 1.2	0.17 - 0.95	PAI-01-SD-10-01	1.00	0.39	0.97	Yes

TABLE 4-5

SUMMARY STATISTICS - SEDIMENT
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Detect	Average of Positive Detects	Average All	Background Level	Maximum Level Exceed Background
Cadmium	1/14	0.79	0.04 - 0.09	PAI-01-SD-02-02	0.79	0.08	0.28	Yes
Calcium	14/14	387 - 14500	NA	PAI-01-SD-09-01	2640	2640	4000	Yes
Chromium	14/14	7.1 - 34.4	NA	PAI-01-SD-10-01	21	21	35.2	No
Cobalt	13/14	0.19 - 3.9	5.7	PAI-01-SD-10-01	1.9	2.0	2.6	Yes
Copper	13/14	5.5 - 95.3	3.3	PAI-01-SD-01	29	27	10	Yes
Iron	14/14	1930 - 24000	NA	PAI-01-SD-02-02	13221	13221	21450	Yes
Lead	14/14	6.6 - 194	NA	PAI-01-SD-09-01	48	48	21	Yes
Magnesium	14/14	597 - 7355	NA	PAI-01-SD-13-AVG	3698	3698	6400	Yes
Manganese	14/14	12.3 - 190	NA	PAI-01-SD-13-AVG	93	93	186	Yes
Mercury	2/14	0.16 - 0.67	0.07 - 0.28	PAI-01-SD-09-01	0.42	0.13	0.09	Yes
Nickel	12/14	1.4 - 7.9	0.75 - 11.3	PAI-01-SD-001	4.6	4.4	6	Yes
Potassium	14/14	331 - 4475	NA	PAI-01-SD-013-AVG	2201	2201	3200	Yes
Silver	2/14	0.36 - 2.4	0.06 - 1.1	PAI-01-SD-09-01	1.4	0.29	ND	Yes
Sodium	14/14	2620 - 25550	NA	PAI-01-SD-13-AVG	12686	12686	19000	Yes
Thallium	1/14	0.925	0.38 - 1.1	PAI-01-SD-13-AVG	0.93	0.35	0.41	Yes
Vanadium	14/14	4.3 - 50.65	NA	PAI-01-SD-13-AVG	27	27	50	Yes
Zinc	14/14	10.5 - 124	NA	PAI-01-SD-09-01	45	45	45	Yes
Miscellaneous Parameters (mg/kg)								
Acid Volatile Sulfide	1/1	5.7	NA	PAI-01-SD-02-02	5.7	5.7	NA	NA
Lead Avs/sem	1/1	0.014	NA	PAI-01-SD-02-02	0.014	0.014	NA	NA
Nickel Avs/sem	1/1	0.008	NA	PAI-01-SD-02-02	0.008	0.008	NA	NA
Ph	9/9	7 - 8.3	NA	PAI-01-SD-02-02	7.5	7.5	NA	NA
Total Organic Carbon	1/1	29400	NA	PAI-01-SD-01	29400	29400	NA	NA
Total Organic Carbon (%)	8/8	1.4 - 4.2	NA	PAI-01-SD-10-01	2.5	2.5	NA	NA
Zinc Avs/sem	1/1	0.75	NA	PAI-01-SD-02-02	0.75	0.75	NA	NA
Miscellaneous Parameters (pg/g)								
TCDD Equivalents[(1)]	2/2	1.7-2	NA	PAI-01-SD-02A-02	1.8	1.8	NA	NA

NA = Not Applicable
ND = Not Detected
1 Minimum and maximum concentrations are toxic equivalent (TEQ) concentrations for mammalian wildlife calculated using methods recommended by the World Health Organization (Van den Berg et al, 1998) and U.S. EPA's Interim Report on Data Methods for Assessment of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Risks. TEQs are based on positive detections of polychlorinated dibenzo-p-dioxins. Mammal TEQ concentrations were greater than fish and avian wildlife TEQ concentrations and thus, the mammal TEQ concentration represents the most conservative of the three values.

TABLE 4-6

SEDIMENT GRAIN SIZE AND TOC
SITE 1 – INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample ID	TOC %	Grain Size			
		% Gravel	% Sand	% Silt	% Clay
PAI-01-SD-01	0.8				
PAI-01-SD-02-01	1.4	0.2	58.2	23.4	17.9
PAI-01-SD-02-02	2.1	0.5	67.3	17.1	15.2
PAI-01-SD-03-01	2.5	0.1	61.2	19.9	18.8
PAI-01-SD-03-01-D	4.3	NA	NA	NA	NA
PAI-01-SD-04-01	2.3	NA	NA	NA	NA
PAI-01-SD-09-01	3.6	NA	NA	NA	NA
PAI-01-SD-10-01	4.2	NA	NA	NA	NA
PAI-01-SD-11-01	1.5	NA	NA	NA	NA
PAI-01-SD-12-01	1.4	NA	NA	NA	NA

NA – Not Analyzed

TABLE 4-7

SUMMARY STATISTICS - SURFACE SOIL
SITE 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Parameter	Frequency of Detection	Range of Positive Detects	Range of Nondetects	Location of Maximum Detect	Average of Positive Detects	Average All	Background Level
Volatile Organics (mg/kg)							
Acetone	1/1	0.73	NA	PAI-41-SS-02-01	0.73	0.73	NA
Semivolatile Organics (mg/kg)							
Benzo(a)anthracene	2/4	0.024 - 0.063	0.021 - 0.022	PAI-41-SS-03-01	0.044	0.027	NA
Benzo(a)pyrene	2/4	0.032 - 0.037	0.021 - 0.022	PAI-41-SS-03-01	0.035	0.023	NA
Benzo(b)fluoranthene	4/4	0.01 - 0.068	NA	PAI-41-SS-03-01	0.034	0.034	NA
Benzo(g,h,i)perylene	1/4	0.07	0.034 - 0.07	PAI-41-SS-03-01	0.070	0.035	NA
Benzo(k)fluoranthene	1/4	0.019	0.0086 - 0.018	PAI-41-SS-01-01	0.019	0.009	NA
Chrysene	1/4	0.012	0.022 - 0.044	PAI-41-SS-04-01	0.012	0.017	NA
Fluoranthene	4/4	0.026 - 0.2	NA	PAI-41-SS-03-01	0.079	0.079	NA
Fluorene	1/4	0.028	0.043 - 0.087	PAI-41-SS-03-01	0.028	0.029	NA
Indeno(1,2,3-cd)pyrene	1/4	0.026	0.021 - 0.044	PAI-41-SS-01-01	0.026	0.017	NA
Phenanthrene	4/4	0.03 - 0.19	NA	PAI-41-SS-03-01	0.080	0.080	NA
Pyrene	1/4	0.12	0.043 - 0.087	PAI-41-SS-03-01	0.12	0.052	NA
Pesticides/PCBs (mg/kg)							
4,4'-DDE	2/4	0.034 - 0.043	0.085 - 0.18	PAI-41-SS-01-01	0.039	0.052	NA
4,4'-DDT	2/4	0.012 - 0.065	0.085 - 0.18	PAI-41-SS-01-01	0.039	0.052	NA
Inorganics (mg/kg)							
Aluminum	4/4	3130 - 6290	NA	PAI-41-SS-04-01	4623	4623	7270
Arsenic	4/4	0.48 - 6.3	NA	PAI-41-SS-03-01	2.1	2.1	1.4
Barium	4/4	20.7 - 151	NA	PAI-41-SS-03-01	61	61	24
Beryllium	3/4	0.05 - 0.51	0.14	PAI-41-SS-03-01	0.23	0.19	0.095
Cadmium	3/4	0.11 - 1.1	0.13	PAI-41-SS-03-01	0.51	0.40	NA
Calcium	4/4	384 - 1830	NA	PAI-41-SS-03-01	1369	1369	766
Chromium	4/4	4.8 - 13.4	NA	PAI-41-SS-03-01	8.2	8.2	6.2
Cobalt	4/4	0.36 - 4.3	NA	PAI-41-SS-03-01	1.4	1.4	0.36
Copper	4/4	4.8 - 114	NA	PAI-41-SS-03-01	35	35	1.5
Iron	4/4	2150 - 15500	NA	PAI-41-SS-03-01	5970	5970	3920
Lead	4/4	26.4 - 161	NA	PAI-41-SS-01-01	94	94	12.5
Magnesium	4/4	187 - 604	NA	PAI-41-SS-03-01	341	341	515
Manganese	4/4	28.3 - 95.7	NA	PAI-41-SS-03-01	57	57	129
Mercury	4/4	0.04 - 0.18	NA	PAI-41-SS-03-01	0.11	0.11	0.11
Nickel	4/4	1.1 - 13.9	NA	PAI-41-SS-03-01	4.8	4.8	1.8
Potassium	4/4	148 - 1170	NA	PAI-41-SS-03-01	443	443	313
Selenium	4/4	0.22 - 1.1	NA	PAI-41-SS-03-01	0.45	0.45	0.29
Silver	2/4	0.18 - 0.89	0.05 - 0.25	PAI-41-SS-03-01	0.54	0.31	NA
Sodium	4/4	263 - 425	NA	PAI-41-SS-03-01	364	364	241
Vanadium	4/4	4.8 - 11	NA	PAI-41-SS-03-01	7.0	7.0	9.5
Zinc	4/4	27.8 - 158	NA	PAI-41-SS-03-01	70	70	9.70

NA = Not Applicable

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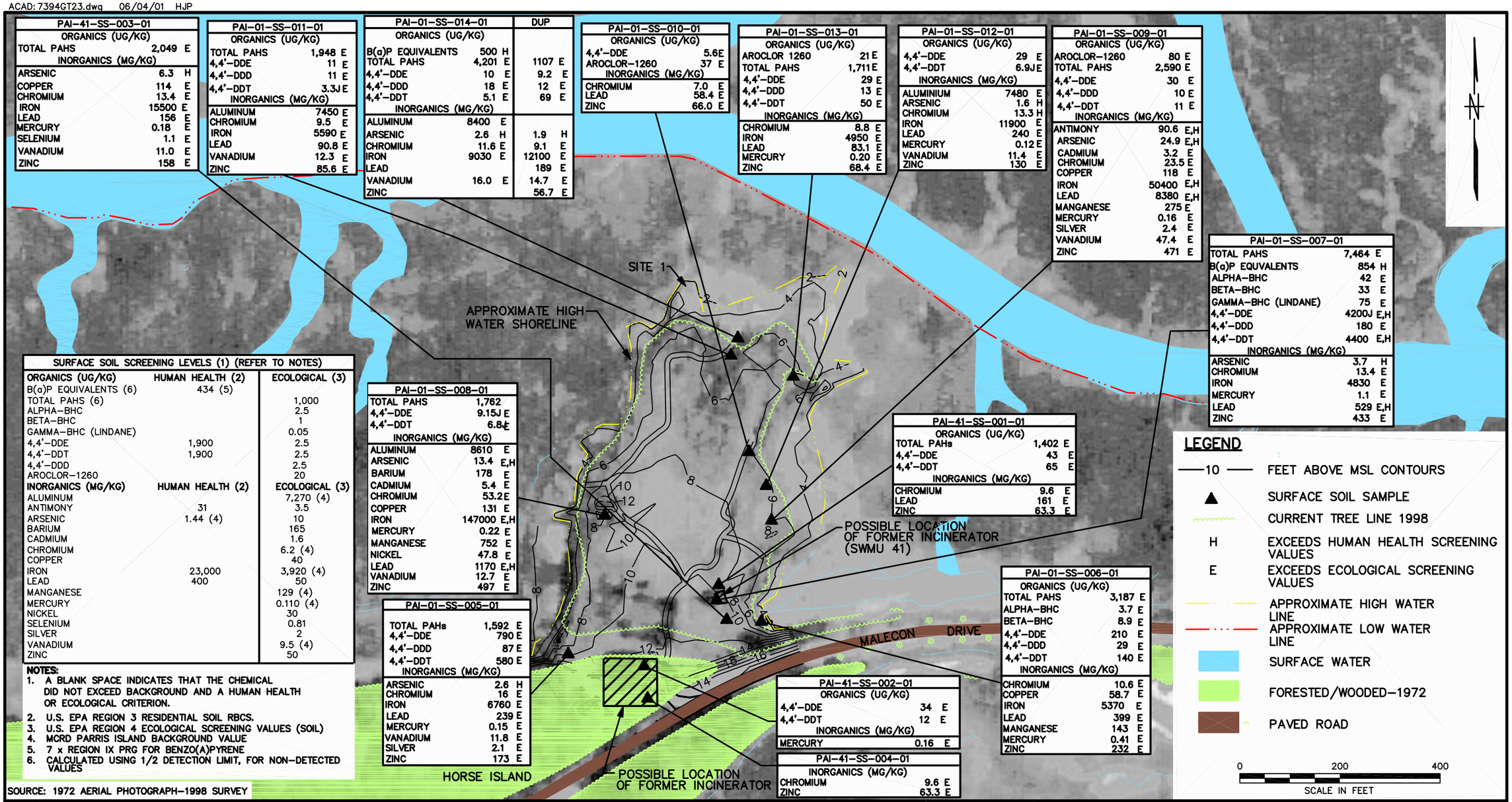

PAI-41-SS-003-01

ORGANICS (UG/KG)		
TOTAL PAHS	2,049	E
INORGANICS (MG/KG)		
ARSENIC	6.3	H
COPPER	114	E
CHROMIUM	13.4	E
IRON	15500	E
LEAD	156	E
MERCURY	0.18	E
SELENIUM	1.1	E
VANADIUM	11.0	E
ZINC	158	E

PAI-01-SS-011-01

ORGANICS (UG/KG)		
TOTAL PAHS	1,948	E
4,4'-DDE	11	E
4,4'-DDD	11	E
4,4'-DDT	3.3J	E
INORGANICS (MG/KG)		
ALUMINUM	7450	E
CHROMIUM	9.5	E
IRON	5590	E
LEAD	90.8	E
VANADIUM	12.3	E
ZINC	85.6	E

PAI-01-SS-014-01 / DUP

ORGANICS (UG/KG)				
B(a)P EQUIVALENTS	500	H		
TOTAL PAHS	4,201	E	1107	E
4,4'-DDE	10	E	9.2	E
4,4'-DDD	18	E	12	E
4,4'-DDT	5.1	E	69	E
INORGANICS (MG/KG)				
ALUMINUM	8400	E		
ARSENIC	2.6	H	1.9	H
CHROMIUM	11.6	E	9.1	E
IRON	9030	E	12100	E
LEAD			189	E
VANADIUM	16.0	E	14.7	E
ZINC			56.7	E

PAI-01-SS-010-01

ORGANICS (UG/KG)		
4,4'-DDE	5.6	E
AROCLOR-1260	37	E
INORGANICS (MG/KG)		
CHROMIUM	7.0	E
LEAD	58.4	E
ZINC	66.0	E

PAI-01-SS-013-01

ORGANICS (UG/KG)		
AROCLOR 1260	21	E
TOTAL PAHS	1,711	E
4,4'-DDE	29	E
4,4'-DDD	13	E
4,4'-DDT	50	E
INORGANICS (MG/KG)		
CHROMIUM	8.8	E
IRON	4950	E
LEAD	83.1	E
MERCURY	0.20	E
ZINC	68.4	E

PAI-01-SS-012-01

ORGANICS (UG/KG)		
4,4'-DDE	29	E
4,4'-DDT	6.9J	E
INORGANICS (MG/KG)		
ALUMINIUM	7480	E
ARSENIC	1.6	H
CHROMIUM	13.3	H
IRON	11900	E
LEAD	240	E
MERCURY	0.12	E
VANADIUM	11.4	E
ZINC	130	E

PAI-01-SS-009-01

ORGANICS (UG/KG)		
AROCLOR-1260	80	E
TOTAL PAHS	2,590	E
4,4'-DDE	30	E
4,4'-DDD	10	E
4,4'-DDT	11	E
INORGANICS (MG/KG)		
ANTIMONY	90.6	E,H
ARSENIC	24.9	E,H
CADMIUM	3.2	E
CHROMIUM	23.5	E
COPPER	118	E
IRON	50400	E,H
LEAD	8380	E,H
MANGANESE	275	E
MERCURY	0.16	E
SILVER	2.4	E
VANADIUM	47.4	E
ZINC	471	E

PAI-01-SS-007-01

TOTAL PAHS	7,464	E
B(a)P EQUVALENTS	854	H
ALPHA-BHC	42	E
BETA-BHC	33	E
GAMMA-BHC (LINDANE)	75	E
4,4'-DDE	4200J	E,H
4,4'-DDD	180	E
4,4'-DDT	4400	E,H
INORGANICS (MG/KG)		
ARSENIC	3.7	H
CHROMIUM	13.4	E
IRON	4830	E
MERCURY	1.1	E
LEAD	529	E,H
ZINC	433	E

SURFACE SOIL SCREENING LEVELS (1) (REFER TO NOTES)

ORGANICS (UG/KG)	HUMAN HEALTH (2)	ECOLOGICAL (3)
B(a)P EQUIVALENTS (6)	434 (5)	
TOTAL PAHS (6)		1,000
ALPHA-BHC		2.5
BETA-BHC		1
GAMMA-BHC (LINDANE)		0.05
4,4'-DDE	1,900	2.5
4,4'-DDT	1,900	2.5
4,4'-DDD		2.5
AROCLOR-1260		20
INORGANICS (MG/KG)	**HUMAN HEALTH (2)**	**ECOLOGICAL (3)**
ALUMINUM		7,270 (4)
ANTIMONY	31	3.5
ARSENIC	1.44 (4)	10
BARIUM		165
CADMIUM		1.6
CHROMIUM		6.2 (4)
COPPER		40
IRON	23,000	3,920 (4)
LEAD	400	50
MANGANESE		129 (4)
MERCURY		0.110 (4)
NICKEL		30
SELENIUM		0.81
SILVER		2
VANADIUM		9.5 (4)
ZINC		50

NOTES:

1. A BLANK SPACE INDICATES THAT THE CHEMICAL DID NOT EXCEED BACKGROUND AND A HUMAN HEALTH OR ECOLOGICAL CRITERION.
2. U.S. EPA REGION 3 RESIDENTIAL SOIL RBCS.
3. U.S. EPA REGION 4 ECOLOGICAL SCREENING VALUES (SOIL)
4. MCRD PARRIS ISLAND BACKGROUND VALUE
5. 7 x REGION IX PRG FOR BENZO(A)PYRENE
6. CALCULATED USING 1/2 DETECTION LIMIT, FOR NON-DETECTED VALUES

PAI-01-SS-008-01

TOTAL PAHS	1,762	
4,4'-DDE	9.15J	E
4,4'-DDT	6.8J	E
INORGANICS (MG/KG)		
ALUMINUM	8610	E
ARSENIC	13.4	E,H
BARIUM	178	E
CADMIUM	5.4	E
CHROMIUM	53.2	E
COPPER	131	E
IRON	147000	E,H
MERCURY	0.22	E
MANGANESE	752	E
NICKEL	47.8	E
LEAD	1170	E,H
VANADIUM	12.7	E
ZINC	497	E

PAI-41-SS-001-01

ORGANICS (UG/KG)		
TOTAL PAHs	1,402	E
4,4'-DDE	43	E
4,4'-DDT	65	E
INORGANICS (MG/KG)		
CHROMIUM	9.6	E
LEAD	161	E
ZINC	63.3	E

PAI-01-SS-005-01

TOTAL PAHs	1,592	E
4,4'-DDE	790	E
4,4'-DDD	87	E
4,4'-DDT	580	E
INORGANICS (MG/KG)		
ARSENIC	2.6	H
CHROMIUM	16	E
IRON	6760	E
LEAD	239	E
MERCURY	0.15	E
VANADIUM	11.8	E
SILVER	2.1	E
ZINC	173	E

PAI-01-SS-006-01

ORGANICS (UG/KG)		
TOTAL PAHS	3,187	E
ALPHA-BHC	3.7	E
BETA-BHC	8.9	E
4,4'-DDE	210	E
4,4'-DDD	29	E
4,4'-DDT	140	E
INORGANICS (MG/KG)		
CHROMIUM	10.6	E
COPPER	58.7	E
IRON	5370	E
LEAD	399	E
MANGANESE	143	E
MERCURY	0.41	E
ZINC	232	E

PAI-41-SS-002-01

ORGANICS (UG/KG)		
4,4'-DDE	34	E
4,4'-DDT	12	E
INORGANICS (MG/KG)		
MERCURY	0.16	E

PAI-41-SS-004-01

INORGANICS (MG/KG)		
CHROMIUM	9.6	E
ZINC	63.3	E

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 9/8/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

DEPARTMENT OF THE NAVY · NAVAL FACILITIES ENGINEERING COMMAND

SURFACE SOIL RESULTS THAT EXCEED BACKGROUND, HUMAN HEALTH AND/OR ECOLOGICAL SCREENING VALUES SITE 1-INCINERATOR LANDFILL AND SWMU 41-FORMER INCINERATOR MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-1
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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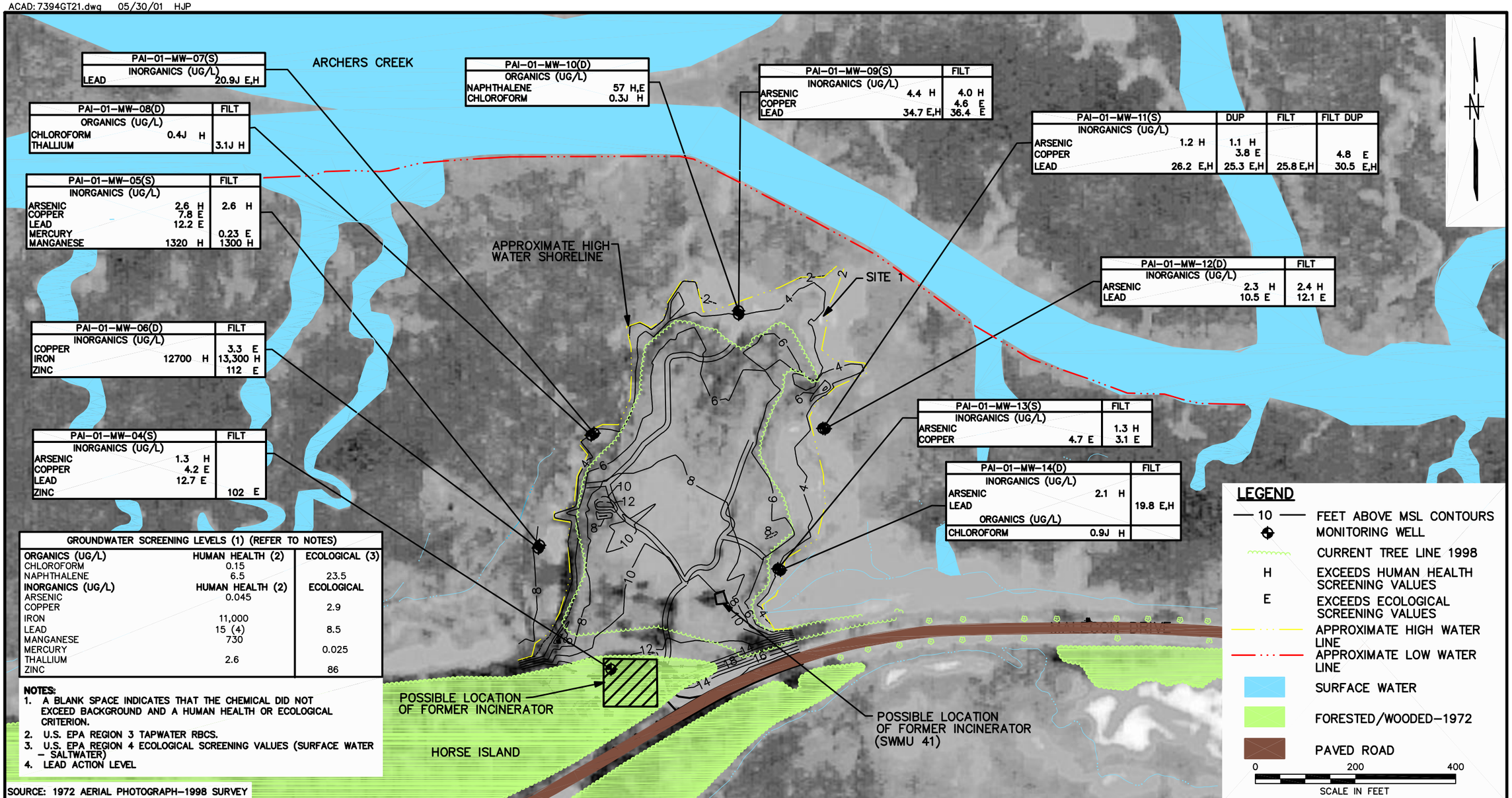


PAI-01-MW-07(S)	
INORGANICS (UG/L)	
LEAD	20.9J E,H

PAI-01-MW-08(D)	FILT
ORGANICS (UG/L)	
CHLOROFORM 0.4J H	
THALLIUM	3.1J H

PAI-01-MW-05(S)	FILT
INORGANICS (UG/L)	
ARSENIC 2.6 H	2.6 H
COPPER 7.8 E	
LEAD 12.2 E	
MERCURY	0.23 E
MANGANESE 1320 H	1300 H

PAI-01-MW-06(D)	FILT
INORGANICS (UG/L)	
COPPER	3.3 E
IRON 12700 H	13,300 H
ZINC	112 E

PAI-01-MW-04(S)	FILT
INORGANICS (UG/L)	
ARSENIC 1.3 H	
COPPER 4.2 E	
LEAD 12.7 E	
ZINC	102 E

PAI-01-MW-10(D)	
ORGANICS (UG/L)	
NAPHTHALENE	57 H,E
CHLOROFORM	0.3J H

PAI-01-MW-09(S)	FILT
INORGANICS (UG/L)	
ARSENIC 4.4 H	4.0 H
COPPER	4.6 E
LEAD 34.7 E,H	36.4 E

PAI-01-MW-11(S)	DUP	FILT	FILT DUP
INORGANICS (UG/L)			
ARSENIC 1.2 H	1.1 H		
COPPER	3.8 E		4.8 E
LEAD 26.2 E,H	25.3 E,H	25.8 E,H	30.5 E,H

PAI-01-MW-12(D)	FILT
INORGANICS (UG/L)	
ARSENIC 2.3 H	2.4 H
LEAD 10.5 E	12.1 E

PAI-01-MW-13(S)	FILT
INORGANICS (UG/L)	
ARSENIC	1.3 H
COPPER 4.7 E	3.1 E

PAI-01-MW-14(D)	FILT
INORGANICS (UG/L)	
ARSENIC 2.1 H	
LEAD	19.8 E,H
ORGANICS (UG/L)	
CHLOROFORM 0.9J H	

GROUNDWATER SCREENING LEVELS (1) (REFER TO NOTES)

ORGANICS (UG/L)	HUMAN HEALTH (2)	ECOLOGICAL (3)
CHLOROFORM	0.15	
NAPHTHALENE	6.5	23.5
INORGANICS (UG/L)	**HUMAN HEALTH (2)**	**ECOLOGICAL**
ARSENIC	0.045	
COPPER		2.9
IRON	11,000	
LEAD	15 (4)	8.5
MANGANESE	730	
MERCURY		0.025
THALLIUM	2.6	
ZINC		86

NOTES:
1. A BLANK SPACE INDICATES THAT THE CHEMICAL DID NOT EXCEED BACKGROUND AND A HUMAN HEALTH OR ECOLOGICAL CRITERION.
2. U.S. EPA REGION 3 TAPWATER RBCS.
3. U.S. EPA REGION 4 ECOLOGICAL SCREENING VALUES (SURFACE WATER – SALTWATER)
4. LEAD ACTION LEVEL

SOURCE: 1972 AERIAL PHOTOGRAPH–1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

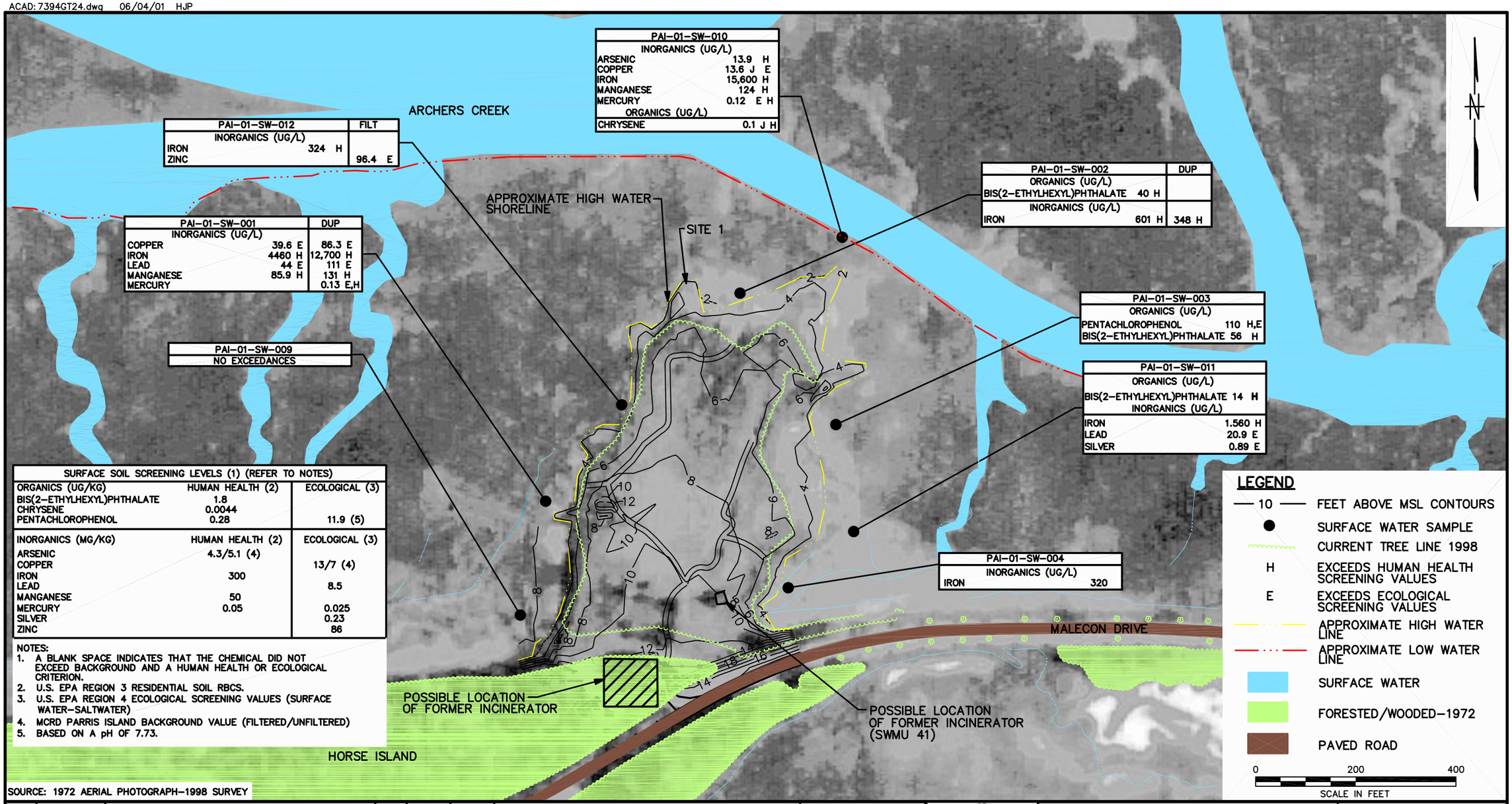
DRAWN BY HJP DATE 9/8/99
CHECKED BY DATE
COST/SCHED–AREA
SCALE AS NOTED

GROUNDWATER SAMPLE RESULTS THAT EXCEED HUMAN HEALTH OR ECOLOGICAL SCREENING VALUES
SITE 1–INCINERATOR LANDFILL AND SWMU 41–FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4–2
REV. 0

FORM CADD NO. SDIV_BH.DWG – REV 0 – 1/20/98

ACAD: 7394GT24.dwg 06/04/01 HJP



SURFACE SOIL SCREENING LEVELS (1) (REFER TO NOTES)		
ORGANICS (UG/KG)	HUMAN HEALTH (2)	ECOLOGICAL (3)
BIS(2-ETHYLHEXYL)PHTHALATE	1.8	
CHRYSENE	0.0044	
PENTACHLOROPHENOL	0.28	11.9 (5)
INORGANICS (MG/KG)	HUMAN HEALTH (2)	ECOLOGICAL (3)
ARSENIC	4.3/5.1 (4)	
COPPER		13/7 (4)
IRON	300	
LEAD		8.5
MANGANESE	50	
MERCURY	0.05	0.025
SILVER		0.23
ZINC		86

NOTES:
1. A BLANK SPACE INDICATES THAT THE CHEMICAL DID NOT EXCEED BACKGROUND AND A HUMAN HEALTH OR ECOLOGICAL CRITERION.
2. U.S. EPA REGION 3 RESIDENTIAL SOIL RBCS.
3. U.S. EPA REGION 4 ECOLOGICAL SCREENING VALUES (SURFACE WATER-SALTWATER)
4. MCRD PARRIS ISLAND BACKGROUND VALUE (FILTERED/UNFILTERED)
5. BASED ON A pH OF 7.73.

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

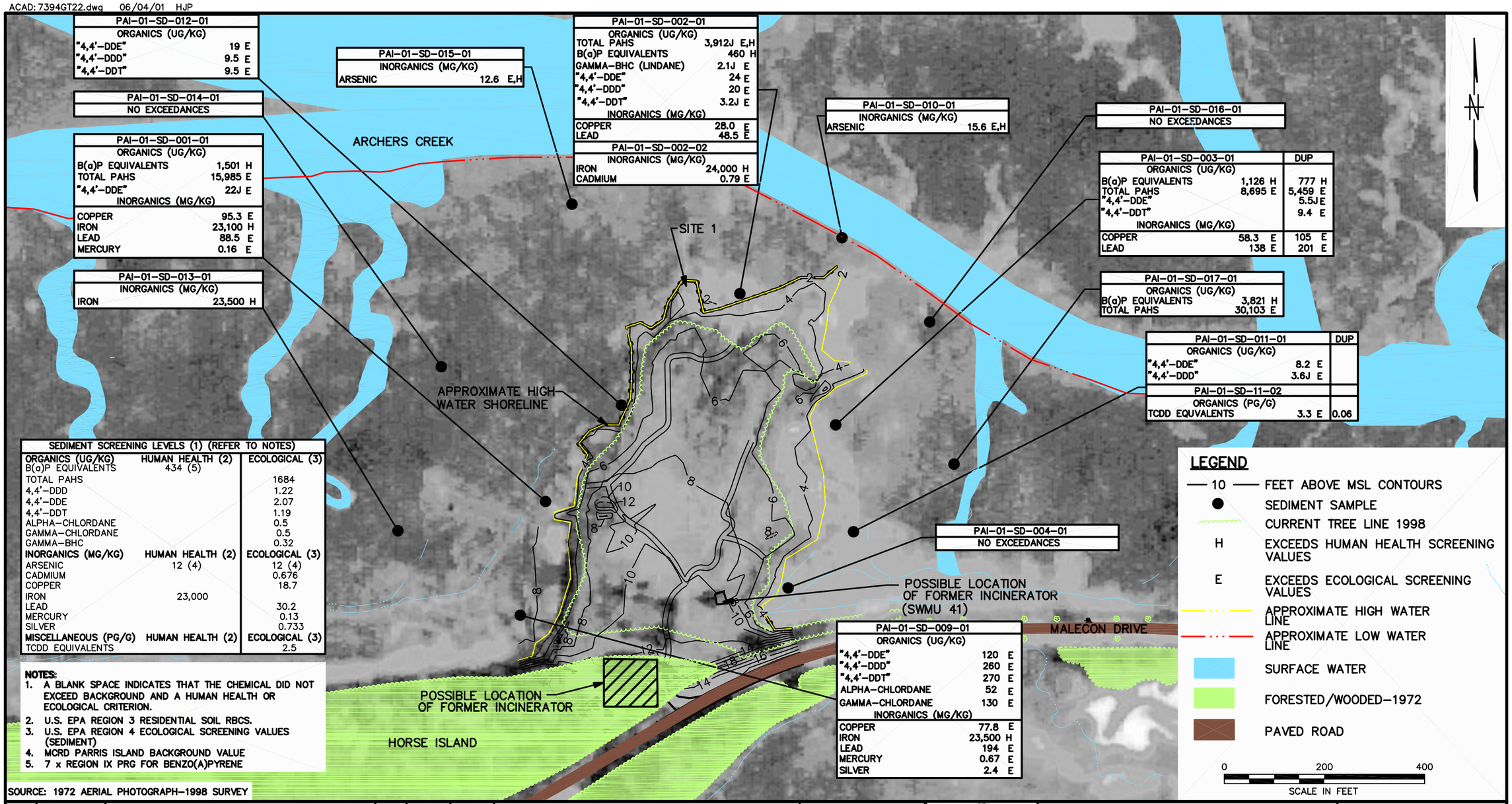
DRAWN BY HJP DATE 9/8/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SURFACE WATER RESULTS THAT EXCEED BACKGROUND, HUMAN HEALTH AND/OR ECOLOGICAL SCREENING VALUES
SITE 1-INCINERATOR LANDFILL AND SWMU 41-FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-3
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 7394GT22.dwg 06/04/01 HJP



SEDIMENT SCREENING LEVELS (1) (REFER TO NOTES)		
ORGANICS (UG/KG)	**HUMAN HEALTH (2)**	**ECOLOGICAL (3)**
B(a)P EQUIVALENTS	434 (5)	
TOTAL PAHS		1684
4,4'-DDD		1.22
4,4'-DDE		2.07
4,4'-DDT		1.19
ALPHA-CHLORDANE		0.5
GAMMA-CHLORDANE		0.5
GAMMA-BHC		0.32
INORGANICS (MG/KG)	**HUMAN HEALTH (2)**	**ECOLOGICAL (3)**
ARSENIC	12 (4)	12 (4)
CADMIUM		0.676
COPPER		18.7
IRON	23,000	
LEAD		30.2
MERCURY		0.13
SILVER		0.733
MISCELLANEOUS (PG/G)	**HUMAN HEALTH (2)**	**ECOLOGICAL (3)**
TCDD EQUIVALENTS		2.5

NOTES:
1. A BLANK SPACE INDICATES THAT THE CHEMICAL DID NOT EXCEED BACKGROUND AND A HUMAN HEALTH OR ECOLOGICAL CRITERION.
2. U.S. EPA REGION 3 RESIDENTIAL SOIL RBCS.
3. U.S. EPA REGION 4 ECOLOGICAL SCREENING VALUES (SEDIMENT)
4. MCRD PARRIS ISLAND BACKGROUND VALUE
5. 7 x REGION IX PRG FOR BENZO(A)PYRENE

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 9/8/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SEDIMENT SAMPLE RESULTS THAT EXCEED BACKGROUND, HUMAN HEALTH AND/OR ECOLOGICAL SCREENING VALUES
SITE 1-INCINERATOR LANDFILL AND SWMU 41-FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-4
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

5.0 CHEMICAL FATE AND TRANSPORT ANALYSIS

This section contains information on contaminant fate and transport and the chemical properties affecting contaminant migration Site/SWMU 1 (Site 1) and SWMU 41. Section 5.1 contains a discussion of the chemical and physical properties of the analytes detected in all media. Section 5.2 presents brief discussions of contaminant persistence, and Section 5.3 presents a summary of contaminant migration.

This section is intended to present only general chemical migration properties that can be used in the human health and ecological risk assessment models and calculations as needed. Detailed modeling is generally inaccurate for all chemicals except VOCs and then only in well defined geological settings.

Based on the time period since the unit was last in operation, (approximately 35 years), and the continual infiltration, flushing, and biodegradation of contaminants since that time, it is very likely that the results observed in the site groundwater represent maximum conditions, however, modeling cannot be used to support this position.

5.1 CHEMICAL AND PHYSICAL PROPERTIES

Chemical and physical properties of the compounds detected on site are presented and discussed in this section. These parameters are used to estimate the environmental behavior of site chemicals. Physical and chemical properties of the organic chemicals detected at MCRD Parris Island Site 1 and SWMU 41 are provided in Table 5-1. Physical and chemical properties for inorganics are provided in Table 5-2.

Empirically determined literature values of the water solubility, octanol/water partition coefficient, organic carbon partition coefficient, vapor pressure, Henry's Law constant, bioconcentration factor, and specific gravity are presented, when available. Calculated values, which were obtained using approximation methods, are presented when literature values are not available.

5.2 CHEMICAL PERSISTENCE

The persistence of various classes of chemicals is discussed in this section. Several transformation mechanisms affect chemical persistence, such as hydrolysis, biodegradation, photolysis, and oxidation/reduction reactions. The following general classes of compounds are discussed:

- Ketones
- Monocyclic aromatics
- Miscellaneous VOCs

- PAHs
- Phthalate esters
- Miscellaneous SVOCs
- Pesticides
- PCBs
- Metals

5.2.1 Ketones

Ketones are highly volatile and soluble, and these two processes dominate the fate of these compounds in the environment. Hydrolysis is generally not a significant fate process for this class of chemicals, nor is bioconcentration significant, based on the low octanol water partition coefficients (K_{ow}s) (Howard, 1990).

Acetone is completely miscible in water and is unlikely to adsorb to soil or sediments or bioaccumulate. It has a high vapor pressure and, once released to the air, photolysis and reaction with hydroxyl radicals result in an average half-life of 22 days (Howard, 1990).

2-Butanone will partially evaporate into the atmosphere if released to the soil and may also leach into the groundwater. Once in the groundwater, 2-butanone may slowly degrade. In surface water, 2-butanone has a half-life of approximately 3 to 12 days. Hydrolysis, photolysis, bioconcentration, and adsorption are not significant fate processes for this chemical (Howard, 1990).

5.2.2 Monocyclic Aromatics

Monocyclic aromatic compounds such as toluene, styrene, and xylenes are not considered to be persistent in the environment, particularly in comparison to chemicals such as PCBs and pesticides. Monocyclic aromatics are subject to degradation via the action of both soil and aquatic microorganisms. The biodegradation of these compounds in the soil matrix is dependent on the abundance of microflora, macronutrient availability, soil reaction (pH), temperature, etc.

Although these compounds are amenable to microbial degradation, it is not anticipated that degradation will occur at an appreciable rate, although macronutrient availability is not known. In the event that these compounds discharge to surface water bodies, volatilization and biodegradation may occur relatively rapidly. For example, a reported biodegradation rate constant for benzene is 0.11 day^{-1} in aquatic systems (Lyman et al., 1990). This corresponds to an aquatic half-life of approximately 6 days. Other monocyclic aromatics are subject to similar degradation processes in aquatic environments (U.S. EPA, December 1982). However, chlorinated monocyclic aromatics such as chlorobenzene are not expected to be as susceptible to microbial degradation. For example, a reported first-order biodegradation rate

constant for chlorobenzene is 0.0045 day^{-1} in aquatic systems (Lyman et al., 1990), which corresponds to an aquatic half-life of approximately 150 days.

Benzene in groundwater is significantly reduced by the action of aerobic bacteria. A biodegradation rate of 0.95 percent/day has been reported (Chiang et al., 1989). The amount of benzene, toluene, and xylenes in the groundwater was reported to be directly proportional to the availability of dissolved oxygen.

Additional environmental degradation processes, such as hydrolysis and photolysis, are considered to be insignificant fate mechanisms for monocyclic aromatics in aquatic systems (U.S. EPA, December 1982). However, some monocyclic aromatics, such as benzene and toluene, have been shown to undergo clay-, mineral-, and soil-catalyzed oxidation (Dragun, 1988).

Miscellaneous VOCs

Chloroform, 1,2-dichlorobenzene, and ethylbenzene were also detected. These VOCs tend to volatilize and degrade in the atmosphere via reaction with photochemically produced hydroxyl radicals. 1,2-Dichlorobenzene will adsorb more readily to soils than chloroform or ethylbenzene. Chloroform and ethylbenzene tend to leach into the underlying groundwater. In water, 1,2-dichlorobenzene will adsorb to sediment and bioconcentrate in aquatic organisms. Chloroform and ethylbenzene do not readily bioconcentrate in aquatic organisms.

5.2.3 Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs have very low solubilities, vapor pressures, and Henry's Law constants and high organic carbon partition coefficients (K_{oc}s) and K_{ow}s. The low-molecular-weight PAHs (e.g., acenaphthene, anthracene, fluorene, phenanthrene) may volatilize from surface waters, and the high-molecular-weight PAHs [e.g., benz(a)pyrene, benzo(a)anthracene, chrysene, etc.] are less likely to volatilize. PAHs in soil are much more likely to bind to soil and be transported via mass transport mechanisms than to go into solution.

Bioconcentration of PAHs in aquatic organisms is greater for the higher-molecular-weight compounds than the lower-molecular-weight compounds. PAHs can be bioaccumulated from water, sediments, or lower organisms in the food chain.

Land-spreading applications have indicated that PAHs are highly amenable to microbial degradation in soil. Temperature, pH, oxygen concentrations, initial chemical concentrations, and moisture influence the rate of degradation. Photolysis, hydrolysis, and oxidation are not important fate processes for the degradation of PAHs in soil (ATSDR, 1997).

The most important fates of PAHs in water are photo-oxidation, chemical oxidation, and biodegradation. PAHs do not contain functional groups that are susceptible to hydrolytic action; therefore, hydrolysis is considered to be an insignificant degradation mechanism. Water depth, turbidity, and temperature influence the rate of photodegradation. Benzo(a)pyrene, chrysene, fluorene, and pyrene are reported to be resistant to photodegradation. PAHs may also be oxidized by chlorination and ozonation and may be metabolized by microbes under oxygenated conditions (ATSDR, 1997).

5.2.4 Phthalate Esters

Phthalate esters are considered to be relatively persistent chemicals in the environment. Although numerous studies have demonstrated that phthalate esters undergo biodegradation, it appears that this is a slow process in both soils and surface waters. Certain microorganisms have been shown to excrete products that increase the solubility of phthalate esters and enhance their biodegradation (Gibbons and Alexander, 1989).

Biodegradation of bis(2-ethylhexyl) phthalate and other phthalates in water is an important fate mechanism, with a half-life of 2 to 3 weeks reported for bis(2-ethylhexyl) phthalate (Howard, 1989). Bioaccumulation is also a significant fate process. Hydrolysis of phthalate esters is very slow, with calculated half-lives of 3 years (dimethyl phthalate) to 2000 years [bis(2-ethylhexyl) phthalate] (U.S. EPA, December 1979). Similarly, photolysis and volatilization are considered to be insignificant degradation mechanisms (U.S. EPA, 1979; Howard, 1989). Diethyl phthalate and di-n-octyl phthalate were also detected. These compounds will adsorb to particulates and sediment. Di-n-octyl phthalate will also bioconcentrate in aquatic organisms.

5.2.5 Pesticides

Whether pesticides are sprayed, dusted, or applied directly to the soil, the soil is the ultimate sink for these chemicals. Runoff may carry pesticides to adjacent surface water bodies. Bioconcentration of pesticides in the food chain is another important fate mechanism. Hydrolysis, oxidation, and photolysis are not generally important fate mechanisms for pesticides in soil or water. Hydrolysis half-lives for several pesticides is reported in periods of months to years (U.S. EPA, 1979).

4,4'-DDT and its metabolites are considered to be persistent chemicals. They undergo extensive adsorption to soil and are not highly soluble. Biodegradation may occur under both aerobic and anaerobic conditions in the presence of certain soil microorganisms. Under aerobic conditions, DDT may be transformed to DDE, and under anaerobic conditions, DDD may result. These compounds are, however, somewhat volatile, with a reported half-life of 100 days for DDT. These compounds are highly lipophilic and therefore readily bioaccumulate (ATSDR, 1997). DDT is no longer in production in the United States.

α-BHC, β-BHC, δ-BHC, and γ-BHC (lindane) were detected. Lindane is not expected to volatilize or hydrolyze in water. When released to soil, it is slow to volatilize and does not readily leach to groundwater. Lindane binds tightly to soil particles. It can biodegrade more readily under aerobic conditions than anaerobic conditions. It will degrade in the atmosphere via reaction with hydroxyl radicals. Lindane bioconcentrates slightly in aquatic organisms.

5.2.6 Polychlorinated Biphenyls (PCBs)

PCBs are considered to be very persistent organic chemicals. Biodegradation is the only process known to transform PCBs under environmental conditions, and only the lighter compounds are measurably biodegraded (U.S. EPA, 1979). Although some microorganisms (e.g., Phanaerochaete chrysosporium) may biodegrade PCBs, such fungi may not exist in local soil. There is experimental evidence to suggest that heavier PCBs (five or more chlorine atoms per molecule) can undergo photolytic degradation, but there are no data to suggest that this process operates under environmental conditions (U.S. EPA, 1979). Base-, acid-, and neutral-promoted hydrolysis are considered to be inconsequential degradation mechanisms for PCBs (U.S. EPA, 1982).

5.2.7 Metals

Metals are highly persistent environmental contaminants. They do not biodegrade, photolyze, hydrolyze, etc. The major fate mechanisms for metals are adsorption to the soil matrix (as compared to being part of the soil structure) and bioaccumulation.

The mobility of metals is influenced primarily by their physical and chemical properties in combination with the physical and chemical characteristics of the soil matrix. Factors that assist in predicting the mobility of inorganic species are the soil/pore water pH, soil/pore water Eh, and cation exchange capacity. The mobility of metals generally increases with decreasing soil pH and cation exchange capacity.

5.3 CHEMICAL MIGRATION

This section presents a brief overview of contaminant fate and transport issues for several major chemical classes detected at Site 1 and SWMU 41.

5.3.1 Volatile Organic Compounds

Volatile organic chemicals are typically considered to be fairly soluble and have a low capacity for retention by soil organic carbon; therefore, these are the organic compounds most frequently detected in groundwater. These types of chemicals may migrate through the soil column after being released by a

spill event or by subsurface waste burial as infiltrating precipitation solubilizes them. Some fraction of these chemicals is retained by the soil, but most will continue migrating downward to the water table. At that time, migration occurs primarily laterally with the hydraulic gradient. Again, some portion of the chemical may be retained by the saturated soil.

Several of these compounds have specific gravities less than that of water (e.g., benzene, toluene). These compounds are typically found in fuels, and if a large enough fuel spill occurs, these compounds may move through the soil column as a bulk liquid, until they reach the water table. There, instead of going into solution, the majority of the release may remain as a discrete fuel layer on the water table surface, with some of the material going into solution at the water/fuel interface.

Similarly, compounds with specific gravities greater than that of water (e.g., dichlorobenzene) are often used in various industrial applications such as degreasing. If a large enough spill of these solvents occurs, these chemicals may also migrate as a bulk liquid but will not stop at the water table (i.e., these chemicals will mix/sink into the aquifer).

5.3.2 Polycyclic Aromatic Hydrocarbons

PAHs are generally considered to be fairly immobile chemicals in the environment. They are large molecules with high organic carbon partition coefficients and low solubilities when compared to the volatile organics. These compounds, when found in the soil, generally do not migrate vertically to a great extent. Instead, they are more likely to adhere to soil particles and be removed from the site via surface runoff and erosional processes.

5.3.3 Pesticides

Pesticides were used at this installation. Many of the detected compounds are no longer licensed for general sale and use in the United States. Therefore, it is assumed that much of what was detected in the soil and sediments is representative of past application for insect control.

Like the PAHs, pesticides as a class of compounds are not considered to be very mobile in the environment. These chemicals, upon application or disposal, tend to remain affixed to soil particles. Migration of pesticides occurs primarily by erosion via the action of wind or water.

5.3.4 Inorganics

Because metals are frequently incorporated into the soil matrix and remain bound to particulate matter, they also migrate from the source areas via bulk movement processes (erosion). The larger particles

(greater than 0.45 microns, which are removed via the filtration step prior to water analysis) are not generally considered to be mobile in groundwater. The metals detected in unfiltered groundwater samples are often representative of suspended soil material in the samples.

There are some instances, however, where these metals are found at such concentrations or in such form as to be able to migrate in solution. It is possible that industrial activities could saturate all available exchange sites in soil and hence a metal may be mobilized. Metals are also more mobile under acidic conditions, which may exist in areas where plating-type activities have occurred. Finally, a metal solution may be utilized in some industrial applications. In these cases, it is possible for metals to migrate vertically through the soil column and reach the groundwater.

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TABLE 5-1

FATE AND TRANSPORT PHYSICAL AND CHEMICAL CHARACTERISTICS FOR ORGANICS
SITE 1, INCINERATOR LANDFILL, AND SWMU 41, FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Specific Gravity (@ 20/4°C)[1]	Vapor Pressure (mm Hg @ 20°C)[1]	Solubility (mg/L @ 20°C)[1]	Octanol/ Water Partition Coefficient[1]	Organic Carbon Partition Coefficient[2]	Henry's Law Constant (atm-m3/mole)[1]	Bioconcentration Factor (mg/L/mg/kg)[2]
KETONES							
Acetone	0.7899	2.66E+02 (25°C)	Miscible	5.75E-01	7.8E+03[3]	4.276E-05 (25°C)	3.81E-01[4]
2-Butanone	0.8054	1.0E+02 (25°C)	2.75E+05	1.82E+00	4.44E+0[5]	4.66E-05 (25°C)	9.3E-01[4]
MONOCYCLIC AROMATICS							
2,4-Dimethylphenol	1.036	6.095	6,200	2.00E+02	425	6.3E-07	1.18
2-Methylphenol	1.0273	2.4E-01 (25°C)	3.1E+04 (40°C)	8.91E+01	9.12E+01[3]	8.41E-07	1.8E+01[4]
4-Methylphenol	1.0178	1.1E-01 (25°C)	2.4E+04 (40°C)	8.32E+01	9.0E-01[6]	3.92E-07	1.7E+01[4]
Pentachlorophenol	1.978 (22/4°C)	1.10E-04	1.40E+01	1.02E+05	5.92E+02[3]	2.80E-06	1.60E+04
Phenol	1.0576	3.5E-01 (25°C)	8E+04 (25°C)	2.88E+01	2.88E+01[3]	1.3E-06 (25°C)	9.40E+00
Toluene	0.8669	2.8E+01 (25°C)	5.15E+02	4.90E+02	1.82E+02[3]	5.92E-03 (25°C)	1.48E+02
1,2,4-Trichlorobenzene	1.574	0.29	48.8	1.05E+04	670	1.42E-03	2,800
Xylenes (Total)	0.86104 - 0.8801	1E+01 (27.3 - 32.1°C)	1.6E+02 - 1.75E+02[7]	5.89E+02 - 1.58E+03	3.63E+02 - 4.07E+02[3]	4.184E-03 - 6.662E-03 (25°C)	7.5E+01 - 1.59E+02[4]
VOLATILE ORGANICS							
Carbon disulfide	1.2632	2.98E+02	2.90E+03	1.45E+02	4.57E+01[3]	1.921E-02 (25°C)	2.6E+01[4]
Chloroform	1.5	1.51E+02	8.2E+03	9.33E+02	31	2.87E-03	3.75
1,2-Dichlorobenzene	1.31	1.47	156	2.40E+03	1,700	1.2E-03	56
Ethylbenzene	0.867	9.53	161	1.41E+03	1,100	8.44E-03	37.5
POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs)							
Acenaphthene	1.0242 (90/4°C)	1E+01 (131°C)	3.42E+0 (25°C)	8.32E+03	7.08E+03[3]	2.41E-04 (25°C)	1.80E+03
Anthracene	1.283 (25/4°C)	1.95E-04 (25°C)	1.29E+0 (25°C)	2.82E+04	2.95E+04[3]	8.6E-05 (25°C)	4.70E+03
Benzo(a)anthracene	1.274	5.00E-09	1E-02 (24°C)	4.07E+05	3.98E+05[3]	6.60E-07	5.30E+04
Benzo(b)fluoranthene	NA	5.00E-07	1.2E-03 (25°C)	3.72E+06	1.23E+06[3]	1.20E-05	1.40E+05
Benzo(k)fluoranthene	NA	9.59E-11	5.5E-04 (25°C)	6.92E+06	1.23E+06[3]	1.04E-03	1.40E+05
Benzo(g,h,i)perylene	NA	1.00E-10	2.6E-04 (25°C)	1.70E+07	1.60E+06	1.4E-07 (25°C)	3.50E+05
Benzo(a)pyrene	1.351	5.00E-09	3.8E-03 (25°C)	9.55E+05	1.02E+06[3]	4.9E-07 (25°C)	1.40E+05
Carbazole	1.1 (18°C/4°C)	4.0E+02 (323°C)	NA	1.95E+03[8]	3.39E+03[3]	NA	1.86E+02[4]
Chrysene	1.274 (20°C)	6.3E-09 (25°C)	6E-03 (25°C)	4.07E+05	3.98E+05[3]	1.05E-06 (25°C)	5.30E+04
Dibenzo(a,h)anthracene	1.282	1.00E-10	5E-04 (25°C)	9.33E+05	3.80E+06[3]	7.3E-08 (25°C)	6.90E+05
Dibenzofuran	4.22	2.48E-03	3.11	1.32E+04	-	2.13E-04	3.13
Fluoranthene	1.252	5.0E-06 (25°C)	2.65E-01 (25°C)	2.14E+05	1.07E+05[3]	6.5E-06 (25°C)	1.20E+04
Fluorene	1.202	1E+01 (146°C)	1.9E+0 (25°C)	1.51E+04	1.38E+04[3]	1.17E-04 (25°C)	3.80E+03
Indeno(1,2,3-cd)pyrene	NA	1E-010 (25°C)	6.20E-02	4.57E+07	3.47E+06[3]	6.95E-08 (25°C)	3.50E+05
2-Methylnaphthalene	1.0058	1E+01 (105°C)	2.6E+01 (25°C)	7.24E+03	7.27E+02[5]	4.99E-04 (25°C)	5.1E+02[4]
Naphthalene	1.162	8.2E-02 (25°C)	3E+01 (25°C)	2.34E+03	2.00E+03[3]	4.83E-04 (25°C)	4.20E+02
Phenanthrene	0.980 (4°C)	1E+0 (118.2°C)	8.16E-01 (21°C)	2.88E+04	1.40E+04	3.93E-05 (25°C)	4.70E+03

TABLE 5-1

FATE AND TRANSPORT PHYSICAL AND CHEMICAL CHARACTERISTICS FOR ORGANICS
SITE 1, INCINERATOR LANDFILL, AND SWMU 41, FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Specific Gravity (@ 20/4°C)[1]	Vapor Pressure (mm Hg @ 20°C)[1]	Solubility (mg/L @ 20°C)[1]	Octanol/ Water Partition Coefficient[1]	Organic Carbon Partition Coefficient[2]	Henry's Law Constant (atm-m3/mole)[1]	Bioconcentration Factor (mg/L/mg/kg)[2]
Pyrene	1.271 (23/4°C)	2.5E+0 (200°C)	1.6E-01 (26°C)	1.51E+05	1.05E+05[3]	5.1E-06 (25°C)	1.20E+04
PHTHALATE ESTERS							
Bis(2-ethylhexyl) phthalate	0.99 (20/20°C)	1.2E+0 (200°C)	4E-01 (25°C)	2.00E+05	1.51E+07[3]	3.00E-07	2.30E+08
Butylbenzyl pthalate	NA	8.6E-06	2.69	8.123E+04	68-350	1.3E-06	663
Di-n-butyl phthalate	1.047 (20/20°C)	1E-01 (115°C)	4E+02 (25°C)	1.58E+05	3.39E+04[3]	2.8E-07 (25°C)	4.70E+04
Diethyl phthalate	1.12	1.65E-03	1,080	2.95E+02	142	4.8E-06	117
Di-n-octyl phthalate	6.978	6.45E-06	0.3	1.3E+05	10,000-100,000	1.1E-05	100-10,000
PESTICIDES							
Alpha-BHC	NA	1.6E-04	7.8	7.94E+03	1,080	7.85E-06	500
Beta-BHC	NA	2.8E-07	0.24	7.94E+03	3,800	4.47E-07	NA
Delta-BHC	NA	1.5E-05	31.4	1.3E+04	6,600	2.07E-07	NA
Gamma-BHC (Lindane)	NA	4.5E-05	2	6.31E+03	6,463	1.06E-06	183 (shrimp)
Chlordane	1.61 (25°C)	1E-05 (25°C)	5.60E-02	6.03E+02	1.20E+05[8]	4.79E-05 (25°C)	4.00E+04
4,4'-DDD	1.476	1E-06 (30°C)	1.6E-01 (24°C)	9.77E+05	1.00E+06[3]	2.16E-05	1.80E+05
4,4'-DDE	NA	6.50E-06	4.00E-02	4.90E+05	4.47E+06[3]	2.34E-05	8.90E+05
4,4'-DDT	1.5 (15/4°C)	1.50E-07	3.1E-03 (25°C)	1.55E+06	2.63E+06[3]	3.89E-05 (25°C)	8.00E+06
Endrin Ketone	NA	3E-06	0.25 UG/L	3.63E+04	34,000	7.52E-06	1,355-16,000
PCBs							
Aroclor 1260	1.58 (25°C)[2]	4.05E-05[2]	2.7E-03[2]	1.4E+7[2]	6.70E+06	7.4E-01[2]	1.30E+06

1 U.S. EPA, 1992c, Handbook of RCRA Groundwater Monitoring Constituents: Chemical and Physical Properties.
2 U.S. EPA, December 1982, Aquatic Fate Process Data for Organic Priority Pollutants.
3 U.S. EPA, July 1996, Soil Screening Guidance.
4 Lyman et al., 1990, Eq. 5-2.
5 Lyman et al., 1990; Equation 4-5
6 Howard, 1989, Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume 1.
7 ATSDR, October 1989, Toxicity Profile for Xylenes.
8 Verschueren, 1983, Handbook of Environmental Data of Organic Chemicals.

NA - Not Available
Note: Values for endrin were substituted for endrin ketone

TABLE 5-2

FATE AND TRANSPORT PHYSICAL AND CHEMICAL CONSTANTS FOR INORGANICS
SITE 1, LANDFILL INCINERATOR, AND SWMU 41, FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Molecular Weight (g/mol)[1]	Specific Gravity (20/4 C)[1]	Vapor Pressure (25 C) (mm Hg)[1]	Solubility (25 C) (mg/L)[1]	Henry's Law Constant (25 C) (atm-m^3/mol)[1]	Bioconcentration Factor (L/kg)[2]
Inorganics						
Aluminum	26.98[3]	2.708 (20 C)[3]	NA	NA	NA	95[4]
Antimony	121.75	6.684 (25 C)	1 (886 C)	insoluble	NA	NA
Arsenic	74.9216	5.727 (14 C)	1 (372 C)	insoluble	NA	44
Barium	137.33	3.51 (20 C)	10 (1049 C)	hydrolyzes	NA	4[5]
Beryllium	9.01218	1.85 (20 C)	1 (1520 C)	insoluble	NA	19
Cadmium	112.41	8.642 (UT)	NA	insoluble	NA	64
Chromium	51.996	7.2 (28 C)	1 (1616 C)	insoluble	NA	NA
Cobalt	58.9332	8.9 (UT)	30 (2375 C)	insoluble	NA	50[4]
Copper	63.546	8.92 (UT)	1 (1628 C)	insoluble	NA	36
Cyanide	26.018	0.6884 g/cm^3	630	soluble	0.051	NA
Lead	207.2	11.2960 (16 C)	1 (970 C)	insoluble	NA	49
Manganese	54.938[4]	7.2[4]	NA	decomposes[4]	NA	373[4]
Mercury	200.59	13.5939	100 (260 C)	0.056	1.14E-02 (UT)	3760[5]
Nickel	58.69	8.9 (UT)	1 (1800 C)	insoluble	NA	NA
Selenium	78.96	4.81 (20/4+1 C)	NA	NA	NA	NA
Silver	107.8682	10.5 (20 C)	1 (1310 C)	insoluble	NA	0.5
Thallium	204.383	11.85 (UT)	1 (825 C)	insoluble	NA	119
Tin	118.69	5.75 - 7.28	1 (1492 C)	insoluble	NA	NA
Vanadium	50.9415	5.96 (UT)	NA	insoluble	NA	0.01[5]
Zinc	65.38	7.14 (UT)	1 (487 C)	insoluble	NA	47

1 Handbook of RCRA Ground-Water Monitoring Constituents: Chemical and Physical Properties, September 1992.
2 The Condensed Chemical Dictionary, Van Nostrand Reinhold Company, New York, 1971.
3 Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites, Clement Associates, September 1985.
4 Jorgensen, 1991.
5 Barnthouse, et al., 1998.

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The baseline human health risk assessment contained in this section was performed to characterize and quantify potential health risks at Site/SWMU 1 (Site 1), the Incinerator Landfill, and SWMU 41, the Former Incinerator, in the absence of remedial action. The results of the baseline risk assessment are also used to focus the evaluation of remedial action alternatives, if action is required. The baseline risk assessment consists of five major components:

- Data evaluation
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis

Methods for selection of chemicals of potential concern (COPCs) to be evaluated quantitatively in the baseline human health risk assessment, as well as those chemicals identified as COPCs for Site 1 and SWMU 41, are described in Section 6.1, Data Evaluation. The data evaluation section is primarily concerned with the selection of COPCs that are representative of the type and magnitude of potential human health effects. The COPC screening process involves the comparison of maximum site concentrations to risk-based screening levels and other health-based standards. Recent and historical data available for the site are considered during the selection process. A brief discussion of data usability is also provided.

Section 6.2, Exposure Assessment, identifies potential receptor populations and exposure pathways by which receptors may come in contact with contaminants at the site. Potential exposure routes under current and future land uses are developed from information on source area, chemical concentrations, chemical release mechanisms, patterns of human activity, and other pertinent information. A concise conceptual site model illustrates the potential receptors and exposure pathways evaluated in the baseline risk assessment. The exposure assessment also includes the calculation of quantitative estimates of chemical intake for each identified receptor, pathway, and route of exposure under the reasonable maximum exposure (RME) scenario. Equations and relevant exposure input parameters used in estimating chemical intakes are provided.

Section 6.3, Toxicity Assessment, presents the chemical-specific toxicity criteria for the identified COPCs that are used in the quantification of potential human health risks. These toxicity criteria, when integrated with the estimated chemical intakes developed in the exposure assessment, provide the basis for quantifying potential human health risks.

Methods used for characterizing risks associated with noncarcinogenic and carcinogenic effects for exposure to COPCs are provided in Section 6.4, Risk Characterization. Actual numerical results of the baseline human health risk assessment for Site 1 and SWMU 41 are summarized.

Because the quantitative risk estimates developed in the risk characterization are based on a number of assumptions (concerning exposure, land use, toxicity, etc.), various uncertainties are associated with the risk assessment process. A brief discussion of the uncertainties associated with the risk evaluation for Site 1 and SWMU 41 is contained in Section 6.5, Uncertainty Analysis.

To assess potential public health risks, four major aspects of chemical contamination and exposure must be considered: (1) contaminants with toxic characteristics must be found in environmental media; (2) the contaminants must be released by either natural processes or by human action; (3) potential exposure points must exist; and (4) human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure; without one of the factors listed above, there is no risk.

An illustration of the baseline human health risk assessment process is provided in Figure 6-1.

The baseline human health risk assessment for Site 1 and SWMU 41 was conducted using the most recent guidance from the U.S. EPA (U.S. EPA, 1989, 1992a, 1993, 1998a, 1998b, 1999a), including Regional supplemental guidance (U.S. EPA Region 4, 1995a). To maintain consistency among risk assessments performed at various sites at the Base, methodologies presented in the Master Workplan for MCRD, Parris Island, South Carolina (B&R Environmental, 1998a) were also used to develop the baseline risk assessment for this site.

6.1 DATA EVALUATION

Data evaluation is a site-specific task that uses a variety of information to determine which of the detected chemicals at a site are most likely to present a risk to potential human receptors. The end result of this qualitative selection process is a list of COPCs for each environmental medium under consideration. Section 6.1.1 provides a brief summary of data usability, as it pertains to the baseline human health risk assessment. The selection of COPCs for the site is contained in Section 6.1.2.

6.1.1 Data Usability

This section addresses the usability of data collected as part of the 1998 RI/RFI field investigation. The use of approved work plans for the 1998 RI/RFI promotes quality by identifying appropriate sample locations, analytical parameters, analytical methods, and data quality objectives (DQOs). The results of

measures (field and laboratory quality control, data validation, etc.) taken to ensure the quality of data collected during the 1998 RI/RFI field investigation are summarized in Appendix D of this report.

All sample data collected for Site 1 and SWMU 41 were used to assess potential human health risks. The qualification of data during the formal data validation process is not expected to compromise the results of the baseline human health risk assessment. Analytical data qualified as estimated were utilized, even though the reported positive concentrations or sample-specific quantitation limits may be somewhat imprecise. The use of estimated data adds to the uncertainty associated with the risk assessment; however, the associated uncertainty is expected to be negligible compared to the other uncertainties inherent in the risk evaluation process (i.e., uncertainties with land uses, exposure scenarios, toxicological criteria, etc.).

6.1.2 Selection of COPCs

The overall goal of the baseline human health risk assessment is to quantify risks associated with those chemicals that represent a potentially significant human health hazard on the basis of toxicity, environmental concentration, and mobility. U.S. EPA guidance (U.S. EPA, 1989; and U.S. EPA, Region 4, 1995a) recommends focusing the baseline risk assessment by quantifying risk only for a select list of COPCs at a site. These chemicals, which are a subset of all detected chemicals in a given medium, are defined as those chemicals likely to dominate the overall potential risks for a site.

For the purposes of this baseline risk assessment, COPCs for a particular medium are limited to those chemicals that exceed a selection criterion. The maximum concentration of a chemical detected in soil, sediment, and groundwater was compared to the RBCs for that chemical. RBCs have been determined for cancer risk levels of 1×10^{-6} and noncancer (hazard quotient) levels of 1.0 and are presented in the most recent version of the U.S. EPA Region III Risk-Based Concentration Table (U.S. EPA, 1999a). The values in the RBC table were divided by 10 for noncarcinogens to screen to the more conservative hazard quotient of 0.1. Chemicals detected in groundwater were retained as COPCs if the maximum concentration detected exceeded the RBC for tap water. The maximum concentrations of chemicals detected in soil or sediment were compared to Region 3 residential RBCs for soil ingestion. U.S. EPA soil screening levels for transfer to air or groundwater were used to evaluate the inhalation pathway and the potential for chemicals to migrate from soil to groundwater (U.S. EPA, 1996a). Chemicals with concentrations exceeding these RBCs will be retained as COPCs.

Concentrations (maximum) of chemicals detected in surface water were compared to the National Recommended Water Quality Standard (WQS) for human health (consumption of water and organisms) (U.S. EPA, 1999b) and the chemicals were retained as COPCs whenever the standards were exceeded.

If WQSs were not available for detected chemicals, comparisons were made to the U.S. EPA Region 3 tap water RBCs.

Fish tissue samples were not collected as part of the current site investigation. Chemical concentrations in fish tissue will be estimated using bioconcentration factors and surface water concentrations. The estimated fish tissue concentrations will be compared to the U.S. EPA Region III RBCs for the ingestion of fish and USDFA action levels.

Inorganic COPCs were also selected based on a comparison of site-specific chemical concentrations to background chemical concentrations. Comparisons were made between the maximum concentration of the site-specific chemical and twice the mean of the background chemical concentration. If the maximum detected concentration was less than twice the mean of the background chemical concentrations, then that chemical was not retained as a COPC.

Samples were analyzed for both total chromium and hexavalent chromium. Consequently, criteria for trivalent chromium will be used to evaluate concentrations of total chromium.

The initial list of COPCs for an area under investigation will include any chemical detected at least once in validated environmental samples from the area. Essential human nutrients (magnesium, potassium, calcium, and sodium) present at relatively low concentrations will be eliminated from the initial list of COPCs. They can be eliminated because they are only toxic at high doses.

Maximum detected concentrations (in a single sample) in each sample medium for Site 1 and SWMU 41 were compared to the risk-based and health-based screening criteria. If the maximum concentration exceeded any of the screening criteria, that chemical was retained as a COPC for all significant exposures involving that medium. For example, if arsenic was retained for soil, this chemical was evaluated as a COPC for both ingestion and dermal exposure routes. If none of the chemicals detected in a medium exceeded criteria, that medium was dropped from further consideration and the potential risks associated with exposure to that medium are regarded as relatively insignificant.

Table 6-1 summarizes the screening criteria used in the selection of COPCs. A medium-specific discussion of the specific criteria used for COPC selection and the results for the selection process are provided in the remainder of this section. A copy of all the screening criteria is included in Appendix E.

6.1.2.1 Surface Soil

Site 1

Ten surface soil samples were collected at Site 1 and analyzed for VOCs, SVOCs, pesticides/PCBs, and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-2. The following chemicals were detected at maximum concentrations in surface soil that exceeded the risk-based COPC screening levels.

- SVOCs - benzo(a)pyrene
- Pesticides/PCBs - 4,4'-DDE, 4,4'-DDT
- Inorganics - aluminum, antimony, arsenic, cadmium, iron, lead, and manganese

In accordance with U.S. EPA Region 4 guidance, since one carcinogenic PAH [benzo(a)pyrene] had a maximum concentration exceeding the screening criteria, all carcinogenic PAHs will be retained as COPCs for surface soil.

Concentrations of all chemicals detected in surface soil were less than the U.S. EPA soil screening levels (SSLs) for soil to air (Table 6-2); therefore, exposures through inhalation of fugitive dust will not be retained for evaluation in the risk assessment.

Maximum detected concentrations in surface soil were also compared to U.S. EPA soil screening levels for migration to groundwater, as summarized in Table 6-2. Maximum concentrations of alpha-BHC, beta-BHC, gamma-BHC, antimony, and chromium exceeded the SSLs, indicating the potential for these chemicals to migrate to groundwater and potentially impact the quality of groundwater. It should be noted that alpha-BHC, beta-BHC, gamma-BHC were not detected in groundwater samples collected at Site 1.

SWMU 41

Four surface soil samples were collected at SWMU 41 and analyzed for VOCs, SVOCs, pesticides/PCBs, and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-3. The following chemicals were detected at maximum concentrations in surface soil that exceeded the risk-based COPC screening levels.

- Inorganics - arsenic and iron

Concentrations of all chemicals detected in surface soil were less than the U.S. EPA SSLs for soil to air (Table 6-3); therefore, exposures through inhalation of fugitive dust will not be retained for evaluation in the risk assessment.

Maximum detected concentrations in surface soil were also compared to U.S. EPA SSLs for migration to groundwater, as summarized in Table 6-3. Concentrations of all chemicals detected in surface soil were less than the U.S. EPA SSLs for migration to groundwater.

Since SWMU 41 is located within Site 1, the surface soil sampling results for Site 1 and SWMU 41 will be combined and evaluated as one area in the human health risk assessment.

6.1.2.2 Groundwater

Site 1

Eleven groundwater samples were collected at Site 1 and analyzed for VOCs, SVOCs, pesticides/PCBs, TCDD and related isomers and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-4. The following chemicals were detected at maximum concentrations in groundwater that exceeded the risk-based COPC screening levels.

- VOCs - chloroform
- SVOCs - dibenzofuran, naphthalene, and phenanthrene
- Inorganics - aluminum, arsenic, barium, iron, lead, manganese, and vanadium

SWMU 41

No groundwater samples were collected at SWMU 41.

6.1.2.3 Surface Water

Site 1

Eight surface water samples were collected at Site 1 and analyzed for VOCs, SVOCs, pesticides/PCBs, and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-5. The following chemicals were detected at maximum concentrations in surface water that exceeded the risk-based COPC screening levels.

- SVOCs - bis(2-ethylhexyl) phthalate, chrysene, dibenzofuran, and pentachlorophenol

- Inorganics - aluminum, arsenic, iron, lead, manganese, mercury, and vanadium

In accordance with U.S. EPA Region 4 guidance, since one carcinogenic PAH (chrysene) had a maximum concentration exceeding the screening criteria, all carcinogenic PAHs will be retained as COPCs for surface water.

Surface water quality parameter data were not qualified. The human health and ecological risks assessments generally factor in uncertainties in the data especially for a transient media such as surface water. Since surface water was not identified as a primary risk driver, there was no need to qualify the data.

SWMU 41

No surface water samples were collected at SWMU 41.

6.1.2.4 Sediment

Site 1

Fourteen sediment samples were collected at Site 1 and analyzed for VOCs, SVOCs, pesticides/PCBs, TCDD and related isomers and inorganics. A comparison of the maximum detected concentrations to the risk-based screening levels is presented in Table 6-6. The following chemicals were detected at maximum concentrations in sediment that exceeded the risk-based COPC screening levels.

- SVOCs - benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
- Inorganics - arsenic, iron, manganese, and thallium.

In accordance with U.S. EPA Region 4 guidance, since several carcinogenic PAHs have maximum concentrations exceeding the screening criteria, all carcinogenic PAHs will be retained as COPCs for sediment.

SWMU 41

No sediment samples were collected at SWMU 41.

6.1.2.5 Fish Tissue

No fish tissue samples were collected at the site; therefore, the concentration of chemicals in fish tissue were estimated suing bioconcentration factors and the maximum detected concentration in surface water. A comparison of the estimated fish tissue concentrations with U.S. EPA Region III RBCs is presented in Table 6-6b. The following chemicals had estimated concentrations in fish tissue that exceeded the risk-based COPC screening levels.

- SVOCs [bis(2-ethylhexyl)phthalate, dibenzofuran, and pentachlorophenol]
- Inorganics (aluminum, arsenic, iron, lead, manganese, and mercury)

Table 6-7 summarizes the chemicals retained as COPCs for surface soil, groundwater, surface water, sediment, and fish.

6.2 EXPOSURE ASSESSMENT

The exposure assessment defines and evaluates the exposures experienced by likely receptor populations at a site. In order to have an exposure, several factors must be present: (1) a source and mechanism of release; (2) a route of contaminant transport through an environmental medium; (3) a contact point for a human receptor; and (4) an exposure route at the point of contact. All four components must be present for the exposures to occur.

The exposure assessment presented in this section of the report consists of several subsections that characterize the physical site setting and the potential receptors of concern, identify the potential contaminant migration and exposure pathways, define the contaminant concentrations at the point of exposure, and present the equations used to quantify exposure in terms of contaminant intake (dose). As previously discussed, since SWMU 41 is located within Site 1, the surface soil sampling results for Site 1 and SWMU 41 will be combined and evaluated as one area in the human health risk assessment. Appendix E of this report contains sample calculations for the quantification of contaminant intakes, as well as the chemical-specific intakes for Site 1 and SWMU 41.

6.2.1 <u>Exposure Setting</u>

There is no development in close proximity to MCRD Parris Island, because it is an island. The surrounding areas are estuarine, however, and support considerable commercial and recreational fishing, boating, and water recreation. The mainland closest to Parris Island is developed as a residential area. Hilton Head, a major recreational area, is located approximately 3 miles southwest of Parris Island, across Port Royal Sound.

Because it is an island, MCRD Parris Island has a single point of access for vehicular traffic. Military police stationed at the entrance currently monitor incoming traffic, stopping those without official stickers.

Site 1 is located on the northeastern tip of Horse Island at MCRD Parris Island. The landfill extends approximately 670 feet into the marsh toward Archers Creek and is approximately 400 feet in width. The landfill occupies approximately 4 acres and is covered primarily with mature pine trees.

6.2.2 Conceptual Site Model

This section discusses the conceptual site model for Site 1 and SWMU 41. A conceptual site model facilitates consistent and comprehensive evaluation of the potential risks to human health by creating a framework for identifying the pathways by which human receptors may come in contact with contaminated media resulting from the source area. A conceptual site model depicts the relationships between the following elements, which are necessary for defining complete exposure pathways:

- Site sources of contamination
- COPCs in environmental media
- Contaminant release mechanisms
- Contaminant transport pathways
- Exposure mechanisms and exposure routes
- Potential receptors

The conceptual site model for Site 1 and SWMU 41 is provided in Figure 6-2. The potential sources of contamination at Site 1 and SWMU 41 are the wastes disposed within the landfill. Contaminants may be released from the landfill by mechanisms such as storm water runoff and subsequent erosion of surface soil; leaching of COPCs from soil via infiltrating water to subsurface soil and subsequent migration through the subsurface soil to the water table; wind erosion of surface soil (fugitive dust); and the volatilization of chemicals from soil (volatile emissions).

Storms generate runoff, which is directed toward the surrounding surface water. Initially, this water may move across the site as sheet flow, which can entrain loose soil material. This soil is moved from the site as a sediment and will be deposited where the flow velocity diminishes below that needed to carry a particular grain size.

Soluble chemicals may also migrate downward through the soil column via infiltrating precipitation. The migration of these chemicals may be somewhat impeded by the chemical's tendency to bind to soil

organic material. However, these soluble chemicals may eventually reach the water table. Once in the groundwater, these chemicals continue to migrate via dispersion and advection.

Chemicals adsorbed to surface soil may also be released from a site via wind erosion of loose soil material. These particulates are carried downwind and potentially off site if the grain size is small enough and the wind velocity is great enough. Additionally, chemicals may also be released from soil via volatilization.

Once released from the source, contaminants are transported in media such as soil, groundwater, surface water, sediment, or air. Potential receptors may be exposed either directly or indirectly to contaminants in these media by a variety of exposure mechanisms, such as direct contact and immersion. Typically, several exposure routes (ingestion, dermal contact, inhalation, etc.) are associated with a particular exposure mechanism.

The conceptual site model presented in Figure 6-2 also indicates those exposure routes that are carried through the quantitative risk assessment for each potential receptor. An objective of the development of the conceptual site model, as well as the baseline human health risk assessment, is to focus attention on those pathways that contribute the most to the potential impacts on human health and the environment and to provide the rationale for eliminating other exposure pathways that are considered to be minor components of the overall risk.

6.2.3 Potential Exposure Pathways

Potential receptors can come into contact with contaminants in a variety of ways, which are generally the result of interactions between a receptor's behavior or lifestyle and an exposure medium. This assessment defines an exposure route as a stylized description of the behavior that brings a receptor into contact with a contaminated medium.

6.2.3.1 Air

This pathway is based on the scenario that a receptor is immersed in air that contains suspended particulates and/or volatile organic vapors originating from the source area. Subsequent exposure of the receptor occurs upon inhalation of the ambient air.

A qualitative comparison of maximum detected concentrations in surface soil at Site 1 and SWMU 41 to U.S. EPA SSLs, based on intermedium transfer (from soil to air), was performed to determine if additional quantitative analysis of this potential exposure pathway was warranted. The SSLs are based on residential land use and lifetime exposure scenarios and are, therefore, conservative values for potential

receptors under current and future land use conditions. Exposures to fugitive dust and volatile organic compounds released from soil were found to be relatively insignificant, based on the qualitative screening. This screening is summarized in Tables 6-2 and 6-3. Maximum detections of all chemicals in surface soil were less than the SSLs; therefore, exposure via the inhalation pathway is considered to be minimal and was not considered for further evaluation.

6.2.3.2 Direct Contact with Soil and Sediment

Potential receptors may come into direct contact with surface soil and sediment, which may be affected by the release of chemicals from the source area. During the receptor's period of contact, the individual may be exposed via incidental ingestion of a surface soil and sediment or via dermal absorption of contaminants from surface soil and sediment.

Dermal contact with chemicals detected in the site surface soil and sediment may or may not result in a significant exposure. In general, inorganics, which were detected frequently in the soil/sediment samples and were selected as COPCs, tend to strongly adhere to organic matter. For these chemicals to be percutaneously absorbed, they must first desorb from soil and diffuse through the skin. Various factors affect the rate of dermal absorption, including the amount of soil on the skin surface, soil characteristics (moisture, pH, organic carbon content, etc.), skin characteristics (thickness, temperature, hydration, etc.), volatilization losses, and chemical-specific properties. Dermal exposures to chemicals in soil and sediment are evaluated quantitatively in the baseline risk assessment.

6.2.3.3 Direct Contact with Groundwater

Human receptors using groundwater as a potable water supply may be exposed to groundwater via ingestion, dermal contact, and inhalation. Groundwater at the site is not suitable for use as a potable water supply because of high salinity. This scenario is based on the high TDS of the groundwater, the current and future use of the site as a landfill, and the relative absence of toxic constituents. First, the TDS of the groundwater averages greater than 10,000 mg/L. The high TDS results from the surrounding salt water marsh and a limited precipitation unfiltration area. Attempts to pump water from this area would be more likely to draw from the abundant supply of salt water from either side of the site than from accumulated precipitated unfiltration. Secondly the causeway is a landfill. Under future scenarios considered for the causeway, restrictions would be placed to prevent the installation of wells for this purpose. Finally, with the exception of lead in 5 of 11 wells, manganese in 7 of 11 wells and thallium in one well, Federal and State MCLs are not exceeded in the site groundwater. Construction workers may have dermal contact with groundwater if excavation occurs below the water table.

6.2.3.4 Direct Contact with Surface Water

Receptors may come into direct contact with surface water in the marshy areas of the site. These surface waters may contain contaminants in a dissolved phase. Individuals may be exposed via dermal contact and/or incidental ingestion.

6.2.3.5 Ingestion of Fish

Individuals may fish at Site 1. Receptors ingesting fish caught in the area may be exposed to COPCs that have bioaccumulated in fish tissue.

6.2.4 Potential Receptors

Potential receptors were identified for both current and future land use conditions. The receptors were identified by analyzing the interaction of current land use practices and the identified sources of contamination. Future site use is expected to remain the same as current use (i.e., industrial). These receptors are as follows:

- Individuals (**construction workers**) who may contact surface and subsurface soils while excavating will be evaluated for exposure to surface soil and surface water/sediment. Dermal exposure to shallow groundwater may also be possible for this receptor. It will be assumed that the construction worker is exposed to surface soil 6 months over a 1-year period and would be engaged in activities where he could be exposed to groundwater, surface water, and sediment 1 month out of the year.

- **Maintenance workers** may be exposed to site media while performing maintenance activities (e.g., mowing, landscaping), site inspections, or daily duties. The maintenance worker is assumed to be a different receptor than the military personnel receptor. The maintenance worker is assumed to be a long-term employee at the site who is engaged exclusively in maintenance activities, and the military personnel is assumed to be an instructor or a trainee. Although it is possible for military personnel to perform maintenance activities, the exposure duration for military personnel (3 to 6 years) is less than the exposure duration for the maintenance worker (25 years); therefore, the maintenance worker is a more conservative scenario. The maintenance worker will be evaluated for exposure to surface soil and sediment only. Exposure to groundwater will not be evaluated for these receptors because shallow groundwater at Site 1 and SWMU 41 is not used as a potable water supply under current conditions. It will be assumed that the maintenance worker is engaged in activities at the site where he may be exposed to surface soil 1 day a week and exposed to sediment 1/2 day a week.

- **Hypothetical Future On-Site Residents** are evaluated as potential receptors. Future on-site residents are assumed to be exposed to soil on a daily basis and less frequently to surface water and sediment. Future child and adult residents are not receptors under current or expected future land use and are included only to provide an indication of potential risks if the base were to close and then be developed for residential use. Although military personnel reside at the base under current conditions, the residential scenario is not applicable for these receptors since they do not reside in the areas of investigation and they are assigned to the base for a relatively short period of time (e.g., 3 to 6 years). Future residents are not assumed to be exposed to groundwater because groundwater at the site is not suitable for use as a potable water supply due to high salinity.

- Access to the site is restricted; consequently, there are no off-site recreational users at Site 1 and SWMU 41. At present, the site is not used for recreational activities, although recreational use of the site may occur in the future. On-site **adolescent or adult recreational users** consist of military personnel and their families who are stationed at the base. On-site recreational users are assumed to be exposed to soil, surface water, and sediment on an infrequent basis. On-site recreational users are also assumed to fish at the site.

A summary of the rationale used for the selection or elimination of a potential receptor group is provided in Table 6-8. Trespassers are not considered to be a potential receptor group because access to the site is restricted. In addition, if an individual did manage to trespass on the site, his exposures would be similar to those of the on-site recreational user.

Cancer risks and hazard indices for construction workers and maintenance workers were within the U.S. EPA acceptable levels. As a result, potential risks to other receptor groups with lower exposure frequencies (e.g., recreation users), would also be within acceptable levels.

6.2.5 Exposure Point Concentrations

According to U.S. EPA guidance (1989, 1992b), risk assessments are conducted using a representative exposure point concentration for each COPC. The exposure point concentration is typically defined as the upper 95 percent confidence limit (UCL), which is based on the distribution of a data set. However, when small data sets (i.e., less than 11 samples) are available for a site and/or medium, the 95 percent UCL is not considered to be a good estimate of the sample mean and, in those cases, the maximum detected concentration is used as the exposure point concentration. It should be noted that a sample and its duplicate sample were averaged prior to the determination of the exposure point concentration.

For normally distributed data, the calculation of the exposure point concentration (UCL) is a two-step process. First the standard deviation of the sample set must be determined, as follows:

$$S = \left[\frac{\Sigma(X_i - \overline{X})^2}{(n-1)} \right]^{1/2}$$

where:	S	=	standard deviation
	X_i	=	individual sample value
	n	=	number of samples
	$\overline{X}$	=	mean sample value

The one-sided UCL on the mean is then calculated as follows:

$$UCL = \overline{X} + t\left(\frac{S}{n^{1/2}}\right)$$

where:	UCL	=	95% Upper confidence limit of the mean
	$\overline{X}$	=	Arithmetic average
	t	=	One-sided t distribution factor ($t_{0.95}$)
	S	=	standard deviation
	n	=	number of samples

For log-normally distributed data sets, the exposure concentration is calculated using the following equation:

$$UCL = \exp\left(\overline{X} + 0.5\,S^2 + \frac{HS}{(n-1)^{1/2}}\right)$$

where:	UCL	=	95% Upper confidence limit of the mean
	exp	=	Constant (base of the natural log, e)
	$\overline{X}$	=	Mean of the transformed data
	S	=	standard deviation of the transformed data
	H	=	H-statistic (from Gilbert, 1987; $H_{0.95}$)
	n	=	Number of samples

This equation uses individual sample results that have been transformed using the natural logarithm function. If the data set has an undefined distribution, then the maximum detected concentration was used as the exposure point concentration.

U.S. EPA Region 4 has adopted a Toxicity Equivalence Factor (TEF) approach to evaluate potentially carcinogenic PAHs. These TEFs are based on the relative potency of each compound relative to that of benzo(a)pyrene. TEFs for the individual carcinogenic PAHs are as follows:

Compound	TEF
Benzo(a)pyrene	1.0
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1

The TEFs are used to convert each individual carcinogenic PAH concentration into an equivalent concentration of benzo(a)pyrene. Using individual benzo(a)pyrene equivalent concentrations, an exposure point concentration for carcinogenic PAHs is derived. Sample calculations for the derivation of benzo(a)pyrene equivalent concentration are included in Appendix E.1.

Exposure point concentrations for COPCs for surface soil, surface water, sediment, and fish tissue are summarized in Tables 6-9a and 6-9b. Only nine surface water samples were collected; consequently, the maximum detected concentration in surface water was used as the exposure point concentration.

6.2.6 Quantification of Exposure

Estimates of exposure are based on the contaminant concentrations at the exposure points and on scenario-specific assumptions and intake parameters. The models and equations used to quantify intakes are described in this section and have been obtained from a variety of U.S. EPA guidance documents, which are cited in the specific intake estimation sections that follow.

Exposure model parameters for all receptors are presented in Tables 6-10 to 6-27. The parameters are based on those presented in the Master Workplan for MCRD, Parris Island, South Carolina (Brown & Root Environmental, 1998a) and standard U.S. EPA Region 4 default values. Rationale is provided below for those parameters that are non-standard values or values other than those presented in the Master Work Plan. The parameters are used in the equations presented in this section, along with the exposure point

concentrations previously defined to estimate contaminant intakes, which will be used to determine potential risks. Individual chemical intakes for each receptor/exposure route combination are presented in Appendix E.

6.2.6.1 Incidental Ingestion of Soil/Sediment

Direct physical contact with soil (and sediment) may result in the incidental ingestion of chemicals by construction workers, maintenance workers, on-site recreational users, and on-site residents. Exposure associated with the oral route is estimated in the following manner (U.S. EPA, 1989):

$$\text{Intake}_{si} = \frac{(C_{si})(IR_s)(FI)(EF)(ED)(CF)}{(BW)(AT)}$$

where:

Intake_i	=	intake of contaminant "i" from soil or sediment (mg/kg/day)
C_{si}	=	concentration of contaminant "i" in soil or sediment (mg/kg)
IR	=	incidental ingestion rate (mg/day)
FI	=	fraction ingested from contaminated source (decimal fraction)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF	=	conversion factor (10^{-6} kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

EPA does not recommend a default exposure frequency or exposure duration for construction workers. Since Site 1 and SWMU 41 are relatively small in size, it was assumed that a construction worker would be engaged in construction-related activities 125 days per year (EF_{Soil}) over a 1-year period (ED). It was further assumed that a construction worker would be exposed to sediment for one work month or 21 days per year ($EF_{Sediment}$) while at the site. For maintenance workers, it was assumed that they would be at the site for 1 day a week or 50 days per year (EF_{Soil}). It was also assumed that, while at the site, the maintenance worker would be exposed to sediment for 1/2 day a week or 25 days per year ($EF_{Sediment}$). An exposure frequency of 45 days a year will be used for on-site recreational users and on-site residents exposed to sediment. This value is based on EPA Region 4's default value for recreational swimming. All other exposure parameters for incidental ingestion of soil and sediment are standard U.S. EPA default values.

6.2.6.2 Dermal Contact with Soil/Sediment

During direct contact, construction workers, maintenance workers, on-site recreational users, and on-site residents may get contaminated soil and sediment on their skin. Dermal absorption from potentially contaminated soil and sediment is calculated using the following equation:

$$\text{Intake}_{si} = \frac{(C_{si})(SA)(AF)(ABS)(CF)(EF)(ED)}{(BW)(AT)}$$

where:

Intake_{si}	=	amount of chemical "i" absorbed during contact with soil or sediment (mg/kg/day)
C_{si}	=	concentration of chemical "i" in soil or sediment (mg/kg)
SA	=	skin surface area available for contact (cm^2/day)
AF	=	skin adherence factor (mg/cm^2)
ABS	=	absorption factor (decimal fraction)
CF	=	conversion factor (10^{-6} kg/mg)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days); for noncarcinogens, AT = ED x 365 days/year; for carcinogens, AT = 70 years x 365 days/year

The same exposure frequencies and durations used in the estimation of incidental ingestion intakes of soil/sediment are used to estimate exposure via dermal contact. Current guidance (U.S. EPA, 1992a) is used to develop the following default assumptions concerning the amount of skin surface area available for contact for a receptor: For construction workers and maintenance workers, the exposed skin surface area was assumed to be 4,100 cm^2. This value represents the hands, forearms, and head being exposed to soil (U.S. EPA, 1992a). It was assumed that 25 percent of the total body surface area (U.S. EPA, 1992a) was available for exposure by the adolescent recreational user (3820 cm^2), adult recreational user 5700 cm^2), child resident (2000 cm^2), and adult resident (5700 cm^2). Soil/sediment skin adherence factors used in the risk assessment were 0.5 mg/cm^2 for the construction worker; 0.2 mg/cm^2 for the maintenance worker, adolescent recreational user, adult recreational user, and child resident; and 0.07 for the adult resident (U.S. EPA, 1998b). Absorption factors of 0.13 and 0.03 were used to assess dermal exposure to benzo(a)pyrene and arsenic, respectively (U.S. EPA, 1998b). Region 4 default values of 0.01 for organics and 0.001 for inorganics were for those chemicals for which chemical-specific absorption factors were not available (U.S. EPA Region 4, 1995a).

6.2.6.3 Incidental Ingestion of Surface Water

Construction workers, recreational users, and on-site residents may incidentally ingest surface water while at the site. Intakes associated with incidental ingestion of surface water are evaluated using the following equations (U.S. EPA, 1989):

$$\text{Intake}_{swi} = \frac{(C_w)(CR)(ET)(EF)(ED)}{(BW)(AT)}$$

where:

Intake_{swi}	=	intake of chemical "i" from water (mg/kg/day)
C_{sw}	=	concentration of chemical "i" in water (mg/L)
IR_w	=	ingestion rate for groundwater (L/day)
CR	=	contact rate for surface water (L/hour)
ET	=	exposure time for surface water (hours/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

It is assumed that construction workers, on-site recreational users, and on-site residents may incidentally ingest (CR) 0.01 L/hr (similar to wading) while at the site (U.S. EPA, 1995a). It was assumed that exposure frequencies for surface water would be the same as those for exposure to sediments. The exposure time (ET) for construction workers is 8 hours per day, the length of a typical work day. The exposure time for on-site recreational users and on-site residents exposed to surface water was 2.6 hours, which is the U.S. EPA-recommended default value for swimming (U.S. EPA, 1989). It was assumed that all other exposure parameters for incidental ingestion of surface water are standard U.S. EPA default values.

6.2.6.4 Dermal Contact with Groundwater/Surface Water

Construction workers may contact groundwater during construction activities if excavation occurs below the water table. In addition, construction workers, on-site recreational users, and on-site residents may come into contact with surface water. The following equation is used to assess exposures resulting from dermal contact with water (U.S. EPA, 1998b):

$$DAD_{wi} = \frac{(DA_{event})(EV)(ED)(EF)(A)}{(BW)(AT)}$$

where:

DAD_{wi}	=	dermally absorbed dose of chemical "i" from water (mg/kg/day)
DA_{event}	=	absorbed dose per event (mg/cm^2/event)
EV	=	event frequency (events/day)
ED	=	exposure duration (years)
EF	=	exposure frequency (days/year)
A	=	skin surface area available for contact (cm^2)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

The absorbed dose per event (DA_{event}) is estimated using a nonsteady-state approach for organic compounds and a more traditional steady-state approach for inorganics. For organics, the following equations apply (U.S. EPA, 1998b):

$$\text{If } t_{event} < t^*, \text{ then: } DA_{event} = (2K_p)(C_{sw})(CF)\left(\sqrt{\frac{6\,\tau\, t_{event}}{\pi}}\right)$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = (K_p)(C_{sw})(CF)\left(\frac{t_{event}}{1+B} + 2\,\tau\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right)$$

where:

t_{event}	=	duration of event (hour/event)
t^*	=	time it takes to reach steady-state conditions (hours)
K_p	=	permeability coefficient from water through skin (cm/hour)
C_{sw}	=	concentration of chemical "i" in water (mg/L)
τ	=	lag time (hour)
π	=	constant (unitless; equal to 3.141592654)
CF	=	conversion factor (10^{-3} L/cm^3)
B	=	partitioning constant derived by Bunge Model (dimensionless)

For organic COPCs for groundwater and surface, values for the chemical-specific parameters (t_{event}, t^*, K_p, τ, and B) are obtained from the current dermal guidance (U.S. EPA, 1998b).

The following nonsteady-state equation is used to estimate DA_{event} for inorganics:

$$DA_{event} = (K_p)(C_{sw})(t_{event})$$

The recommended default value of 0.001 cm/hour was used for the inorganic selected as COPCs.

Current guidance (U.S. EPA, 1992a) was used to develop the following default assumptions concerning the amount of skin surface area available for contact. The exposed skin surface area for construction workers was assumed to be 2,490 cm^2. This value represents the hands and forearms being exposed to groundwater/surface water (U.S. EPA, 1992a). It was assumed that exposure frequencies for groundwater/surface water would be the same as those for exposure for sediments. The exposure time (ET) for construction workers is 8 hours per day, the length of a typical work day. The exposure time for on-site recreational users and on-site residents exposed to surface water is 2.6 hours, which is the U.S. EPA-recommended default value for swimming (U.S. EPA, 1989). It was assumed that 25 percent of the total body surface area (U.S. EPA, 1992a) was available for exposure to surface water by the adolescent recreational user (3820 cm^2), adult recreational user (5700 cm^2), child resident (2000 cm^2), and adult resident (5700 cm^2). All other exposure parameters for dermal contact with groundwater and surface water are standard U.S. EPA default values.

6.2.6.5 Ingestion of Fish

Recreational users who consume fin and shall fish caught in the area may be exposed to COPCs in fish tissue. Intakes associated with ingestion of fish are evaluated using the following equation (U.S. EPA, 1989):

$$Intake_{fishi} = \frac{(C_{fishi})(IR)(FI)(EF)(ED)}{(BW)(AT)}$$

where:

$Intake_{fishi}$	=	intake of contaminant "i" from ingestion of fish (mg/kg/day)
C_{fishi}	=	concentration of contaminant "i" in fish tissue (mg/kg)
IR	=	fish ingestion rate (kg/day or kg/meals)
FI	=	fraction ingested from contaminated source (decimal fraction)
EF	=	exposure frequency (days/year or meals/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;

for carcinogens, AT = 70 years x 365 days/year

Two scenarios will be evaluated for the recreational user. The first scenario will use U.S. EPA standard default values, which assume that an individual ingests 0.054 kg-fish per meal (IR) for 350 meals per year (EF) over a 30 year period (ED). The second scenario will be based on site-specific considerations. It will be assumed that the recreational user fishes at the site 45 days per year, which is approximately 1 day a week. It will also be assumed that the fish a recreational user catches at the site supplies one meal a week, for a total of 45 meals per year (EF). The U.S. EPA Region IV suggested default value of 0.145 kg-fish/meal for site-specific evaluations will be used for the fish ingestion rate (IR). It will be assumed that the recreational user is military personnel stationed at the base who spend two 3-year tours of duty or 6 years (ED) at the site. All other exposure parameters for ingestion of fish tissue are standard U.S. EPA default values.

6.2.6.6 Exposure to Lead

The equations and methodology presented in the previous section cannot be used to evaluate exposure to lead because of the absence of published dose-response parameters for this chemical. Exposure to lead can be evaluated using the U.S. EPA Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead, version 0.99D (U.S. EPA, 1994a). This model is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure. Exposures to lead by nonresidential adults are evaluated by use of a slope-factor approach developed by the U.S. EPA Technical Review Workgroup for Lead (U.S. EPA, 1996c). The approach focuses on estimating fetal blood-lead concentrations in women exposed to lead-contaminated soils.

Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood-lead levels. The threshold for toxic effects to children from this chemical is believed to be in the range of 10 µg/dL to 15 µg/dL. Blood-lead levels greater than 10 µg/dL are considered to be a "concern."

In general, the IEUBK Model and Technical Review Work Group Model for lead were used to address exposure to lead when groundwater and surface water concentrations exceed the 15 µg/L Federal Action Level promulgated under the Safe Drinking Water Act and when detected soil concentrations exceeded the OSWER soil screening level of 400 mg/kg for residential land use (U.S. EPA, 1994c). Exposure concentrations, as well as default parameters for some input parameters, were used in the evaluation. The input parameters used and the results of lead models, estimated blood-lead levels, and probability density histograms are presented in the site-specific appendices.

6.3 TOXICITY ASSESSMENT

The toxicity assessment examines information concerning the potential human health effects associated with exposure to COPCs. The goal of the toxicity assessment is to provide, for each COPC, a quantitative estimate of the relationship between the magnitude and type of exposure and the severity or probability of human health effects. The toxicity values presented in this section are integrated with the outputs of the exposure assessment to characterize the potential for the occurrence of adverse health effects.

The toxicological evaluation involves a critical review and interpretation of toxicity data from epidemiological, clinical, animal, and in vitro studies. This review of the data ideally determines both the nature of the health effects associated with a particular chemical and the probability that a given quantity of a chemical could result in the referenced effect. This analysis defines the relationship between the dose received and the incidence of an adverse effect for the COPC.

The entire toxicological database is used to guide the derivation of cancer slope factors (CSFs) for carcinogenic effects and reference doses (RfDs) for noncarcinogenic effects. These data may include epidemiological studies, long-term animal bioassays, short-term tests, and comparisons of molecular structure. Data from these sources are reviewed to determine if a chemical is likely to be toxic to humans. Because of the lack of available human studies, however, the majority of toxicity data used to derive CSFs and RfDs come from animal studies.

For noncarcinogenic effects, the most appropriate animal model (i.e., the species most biologically similar to the human) is identified. Pharmacokinetic data often enter into this determination. In the absence of sufficient data to identify the most appropriate animal model, the most sensitive species is chosen. The RfD is generally derived from the most comprehensive toxicology study that characterizes the dose-response relationship for the critical effect of the chemical. Preference is given to studies using the exposure route of concern; in the absence of such data, however, an RfD for one route of exposure may be extrapolated from data from a study that used a different route of exposure. Such extrapolation must take into account pharmacokinetic and toxicological differences between the routes of exposure. Uncertainty factors are applied to the highest no-observed-adverse-effect-level (NOAEL) to adjust for inter- and intraspecies variation, deficiencies in the toxicological database, and use of subchronic rather than chronic animal studies. Additional uncertainty factors may be applied to estimate a NOAEL from a lowest-observed-adverse-effect-level (LOAEL) if the key study failed to determine a NOAEL.

CSFs for weights-of-evidence of Group A or B chemicals are generally derived from positive cancer studies that adequately identify the target organ in the test animal data and characterize the dose-response relationship. CSFs are derived for Group C compounds for which the data are sufficient but are

not derived for Group D or E chemicals. No consideration is given to similarity in the animal and human target organ(s) because a chemical capable of inducing cancer in any animal tissue is considered potentially carcinogenic to humans. Preference is given to studies using the route of exposure of concern, in which normal physiologic function was not impaired and in which exposure occurred during most of the animal's lifetime. Exposure and pharmacokinetic considerations are used to estimate equivalent human doses for computation of the CSF. When a number of studies of similar quality are available, the data may be combined in the derivation of the CSF.

Toxicological profiles for each of the COPCs are presented in Appendix E.5. These profiles present a summary of the available literature on carcinogenic and noncarcinogenic effects associated with human exposure to the chemical.

6.3.1 Carcinogenic Effects

The toxicity information considered in the assessment of potential carcinogenic risks includes a weight-of-evidence classification and a slope factor. The weight-of-evidence classification qualitatively describes the likelihood that a chemical is a human carcinogen and is based on an evaluation of the available data from human and animal studies. A chemical may be placed in one of three groups in U.S. EPA's classification system to denote its potential for carcinogenic effects:

- Group A - known human carcinogen
- Group B1 or B2 - probable human carcinogen
- Group C - possible human carcinogen

Chemicals that cannot be classified as a human carcinogen because of a lack of data are placed in Group D, and those for which there is evidence of noncarcinogenicity in humans are in Group E.

The CSF is the toxicity value used to quantitatively express the carcinogenic hazard of cancer-causing chemicals. It is defined as the upper-bound estimate of the probability of cancer incidence per unit dose averaged over a lifetime. Slope factors are derived from studies of carcinogenicity in humans and/or laboratory animals and are typically calculated for compounds in Groups A, B1, and B2, although some Group C carcinogens also have slope factors and some B2 carcinogens have none (e.g., lead). Slope factors are specific to a chemical and route of exposure and are expressed in units of $(mg/kg/day)^{-1}$ for both oral and inhalation routes. Inhalation cancer toxicity values are usually expressed as inhalation unit risks in units of reciprocal $\mu g/m^3$ ($1/\mu g/m^3$). Because cancer risk characterization requires an estimate of reciprocal dose in units of 1/mg/kg/day, the inhalation unit risk must be converted to the mathematical equivalent of an inhalation cancer slope factor or risk per unit dose (mg/kg/day). This is done by assuming that humans weigh 70 kg and inhale 20 m^3 of air per day [i.e., the inhalation unit risk ($1/\mu g/m^3$)

is divided by 20 m^3, multiplied by 70 kg, and multiplied by 1,000 µg/mg to yield the mathematical equivalent of an inhalation slope factor (1/mg/kg/day)].

CSFs for COPCs at Site 1 and SWMU 41 are presented in Table 6-28. The primary sources of information for these values are U.S. EPA's Integrated Risk Information System (IRIS) (U.S. EPA, 1999c). The U.S. EPA intends that IRIS supersede all other sources of toxicity information for risk assessment. If values are not available in IRIS, the annual Health Effects Assessment Summary Tables (HEAST) (U.S. EPA, 1997a) are consulted. U.S. EPA Region 3 Risk-Based Concentration Tables (April 12, 1999) are also used as a quick tabulated reference for available CSFs. If no CSF is available from any of these sources, carcinogenic risks are not quantified and potential exposures are addressed in Section 6.5, Uncertainty Analysis.

CSFs also exist for several (but not all) Class C compounds, which are identified as "possible" human carcinogens. These compounds typically exhibit inadequate evidence of carcinogenicity in humans and limited evidence in animals. In this human health risk assessment, Class C compounds are evaluated the same as Class A, B1, and B2 compounds. The uncertainty associated with this approach is discussed in Section 6.5.

Dermal CSFs are derived from the corresponding oral values. Regional guidance (U.S. EPA, Region 4, 1995, 1996b) is used as a basis for determining the dermal CSFs. In the derivation of a dermal CSF, the oral CSF is divided by the gastrointestinal absorption efficiency to determine a CSF based on an absorbed dose rather than an administered dose, as follows:

$$CSF_{dermal} = (CSF_{oral}) \ / \ (ABS_{GI})$$

The oral CSF is divided by the absorption efficiency because CSFs are expressed as reciprocal doses. Dermal CSFs and the absorption efficiencies used in their determination are also included in Table 6-28.

As discussed in Section 6.2.6, U.S. EPA Region 4 has adopted a Toxicity Equivalence Factor (TEF) approach to evaluate potentially carcinogenic PAHs. These TEFs are based on the relative potency of each compound relative to that of benzo(a)pyrene. U.S. EPA Region 4 also requires that dermal exposures to PAHs be evaluated using the TEF approach. Consequently, the oral and dermal CSFs for benzo(a)pyrene are used to evaluate exposures to all carcinogenic PAHs in terms of benzo(a)pyrene equivalents.

6.3.2 Noncarcinogenic Effects

For noncarcinogens, it is assumed that there exists a dose below which no adverse health effects will be seen. Below this "threshold" dose, exposure to a chemical can be tolerated without adverse effects. For

noncarcinogens, a range of exposure exists that can be tolerated. Toxic effects are manifested only when physiologic protective mechanisms are overcome by exposures to a chemical above its threshold level. Maternal and developmental endpoints are considered systemic toxicity.

The potential for noncarcinogenic health effects resulting from exposure to chemicals is assessed by comparing an exposure estimate (intake or dose) to an RfD. The RfD is expressed in units of mg/kg/day and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern. An RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs. Separate RfDs are presented for ingestion and inhalation pathways. In particular, reference concentrations (RfCs) in units of mg/m^3 are typically presented for the inhalation pathway. Because characterization of noncarcinogenic effects requires an estimate of dose in units of mg/kg/day, the inhalation RfC must be converted to an inhalation RfD. This is done by assuming that humans weigh 70 kg and inhale 20 m^3 of air per day [i.e., the inhalation RfC (mg/m^3) is multiplied by 20 m^3/day and divided by 70 kg to yield an inhalation RfD (mg/kg/day)].

To derive an RfD, U.S. EPA reviews all relevant human and animal studies for each compound and selects the study (studies) pertinent to the derivation of the specific RfD. Each study is evaluated to determine the NOAEL or, if the data are inadequate for such a determination, the LOAEL. The NOAEL corresponds to the dose (in mg/kg/day) that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect." To derive an RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure that the RfD will be protective of human health. Uncertainty factors are applied to account for (1) extrapolation of data from laboratory animals to humans (interspecies extrapolation), (2) variation in human sensitivity to the toxic effects of a compound (intraspecies differences), (3) derivation of a chronic RfD based on a subchronic rather than a chronic study, and/or (4) derivation of an RfD from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 1 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For most compounds, the modifying factor is 1.

A dermal RfD is developed from an oral RfD by multiplying by the gastrointestinal tract absorption factor as follows:

$$RfD_{dermal} = (RfD_{oral})(ABS_{GI})$$

The resulting dermal RfD is, therefore, based on absorbed dose, which is what is calculated by the dermal exposure algorithms.

RfDs for the COPCs at Site 1 and SWMU 41 are presented in Table 6-29. The primary source of these values is the IRIS database (U.S. EPA, 1999c), followed by other U.S. EPA sources described for the carcinogens. Table 6-29 also includes the primary target organs affected by a particular chemical. This information may be used in the risk characterization section to segregate risks by target organ effects, unless the total Hazard Index is below unity. This ensures that "risks" are not overestimated when different compounds affect different target organs.

6.4 RISK CHARACTERIZATION

This section provides a characterization of the potential human health risks associated with the potential exposure to COPCs at Site 1 and SWMU 41. Section 6.4.1 outlines the methods used to quantitatively estimate the type and magnitude of potential risks for human receptors. A summary of the risk characterization for Site 1 and SWMU 41 is provided in Section 6.4.2.

6.4.1 Methodology for Estimation of Quantitative Risks

Potential human health risks resulting from exposure to COPCs are estimated using algorithms established by U.S. EPA (U.S. EPA, 1989). The methods described by U.S. EPA are protective of human health and are likely to overestimate (rather than underestimate) risk. The methodology uses specific algorithms to calculate risk as a function of chemical concentration, human exposure parameters, and toxicity.

Risks from hazardous chemicals are calculated for either carcinogenic or noncarcinogenic effects. Some carcinogenic chemicals may also exhibit noncarcinogenic effects. Potential impacts are then characterized for both types of health effects.

6.4.1.1 Carcinogenic Effects

Risks attributable to exposure to carcinogens COPCs are estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. At low doses, the incremental lifetime cancer risk (ILCR) is determined as follows (U.S. EPA, 1989):

$$ILCR_i = (Intake_i)(CSF_i)$$

where: $ILCR_i$ = Incremental Lifetime Cancer Risk for chemical "i", expressed as a unitless probability

$Intake_i$ = Intake of chemical "i" (mg/kg/day)

CSF_i = Cancer slope factor of chemical "i" (kg/day/mg)

Estimated ILCRs are compared to the U.S. EPA target risk range, 10^{-4} to 10^{-6}. Risks below 1 x 10^{-6} (1/1,000,000, or a risk less than 1 in 1 million) are generally considered to be “acceptable” by the U.S. EPA, and risks greater than 1 x 10^{-4} (1 in 10,000) are generally considered to be “unacceptable” by the agency. Depending on the risk management goals for the site, risks within 10^{-4} to 10^{-6} are also typically regarded as “acceptable."

When carcinogenic risks exceed 1 x 10^{-2} using the above methodology, U.S. EPA (1989) specifies that the one-hit model be used, as follows:

$$ILCR_i = 1 - \exp(-Intake_i)(CSF_i)$$

Risks are estimated for all carcinogenic compounds regardless of the class designation (A, B, or C).

6.4.1.2 Noncarcinogenic Effects

The hazards associated with the effects of noncarcinogenic COPCs are evaluated by comparing an exposure level or intake to an RfD. The ratio of the intake to the RfD is called the hazard quotient (HQ) and is defined as follows (U.S. EPA, 1989):

$$HQ_i = \frac{Intake}{RfD_i}$$

where: HQ_i = Hazard Quotient for chemical "i" (unitless)
$Intake_i$ = Intake of chemical "i" (mg/kg/day)
RfD_i = Reference Dose of chemical "i" (mg/kg/day)

A hazard index (HI) is generated by summing the individual HQs for all the COPCs. If the HI exceeds unity, there exists a potential for noncarcinogenic (toxic) effects to occur. When the HI exceeds unity, it is necessary to segregate the HQs by target organ effects since the HQs for all noncarcinogens are not considered to be truly additive unless similar target organs are affected.

The estimation of noncarcinogenic effects (i.e., the calculation of HQs/HIs) should not be construed as a probability in the manner of the ILCR, but rather a numerical indicator of the extent to which a predicted intake exceeds, or is less than, an RfD.

6.4.2 Results of the Risk Characterization

This section contains a summary of the results of the risk characterization for Site 1 and SWMU 41. Potential cancer risks and hazard indices were calculated for construction workers, maintenance workers, on-site recreational users, and on-site residents and are summarized in Table 6-30. Sample calculations are presented in Appendix E. Results of the risk assessment in RAGS Part D format is included in Appendix E.

Construction Workers

All estimated cancer risks for construction workers were within U.S. EPA's target risk range of 10^{-4} to 10^{-6}. The estimated cancer risk for construction workers was 1.1 x 10^{-6} for exposure to surface soil, 2.4 x 10^{-9} for exposure to groundwater, 5.3 x 10^{-7} for exposure to sediment, and 3.9 x 10^{-6} for exposure to surface water. The total cancer risk across all media was 4.8 x 10^{-6}.

The estimated hazard index (HI) for a construction worker exposed to soil was 2.1, which exceeds the acceptable level of 1.0. Incidental ingestion of antimony (HI = 0.65) and iron (HI = 1.2) were the main contributors to the hazard index. The estimated hazard indices of 0.05 for exposure to groundwater, 0.05 for exposure to sediment, and 0.40 for exposure to surface water were less than the acceptable level of 1.0, indicating that no adverse health effects are anticipated for construction workers exposed to groundwater, sediment, and surface water under the defined conditions. The cumulative hazard index across all media was 2.6.

Maintenance Workers

All estimated cancer risks for maintenance workers were within U.S. EPA's target risk range of 10^{-4} to 10^{-6}. The estimated cancer risks for maintenance workers were 3.0 x 10^{-6} for exposures to surface soil and 5.0 x 10^{-6} for exposures to sediment. The total cancer risk across all media was 8.1 x 10^{-6}.

All estimated hazard indices were less than the acceptable level of 1.0. The hazard indices for a maintenance worker were 0.19 for exposure to surface soil and 0.01 for exposure to sediment, indicating that no adverse health effects are anticipated for maintenance workers exposed to soil and sediment under the defined conditions. The cumulative hazard index across all media was 0.21.

Adolescent Recreational Users

All estimated cancer risks for the adolescent recreational user were within U.S. EPA's target risk range of 10^{-4} to 10^{-6}, with the exception of exposure to surface water. The estimated cancer risks for the adolescent recreational user were 1.7 x 10^{-6} for exposures to surface soil, 5.4 x 10^{-6} for exposures to

sediment, and 1.1 x 10^{-4} for exposure to surface water. Dermal contact to bis(2-ethylhexyl) phthalate (ICR = 3.7 x 10^{-5}) and pentachlorophenol (ICR = 7.3 x 10^{-5}) was the major contributor to the cancer risk for exposures to surface water. The total cancer risk across all media was 1.2 x 10^{-4}.

All estimated hazard indices for the adolescent recreational user were less than the acceptable level of 1.0 with the exception of exposures to surface water. The hazard indices for an adolescent recreational user were 0.27 for exposure to soil and 0.04 for exposure to sediment, indicating that no adverse health effects are anticipated for adolescent recreational user exposed to soil and sediment under the defined conditions. In addition, bis(2-ethylhexyl) phthalate (HI = 0.93) was the main contributor to the hazard index for exposures to surface water and the hazard indices for the individual target organs were less than 1.0 for exposures to surface water. Therefore, no adverse effects are anticipated for exposure to surface water. The cumulative hazard index across all media was 1.43.

Adult Recreational Users

With the exception of ingestion of fish, all estimated cancer risks for the adult recreational user were within U.S. EPA's target risk range of 10^{-4} to 10^{-6}. The estimated cancer risks for the adult recreational user were 7.8 x 10^{-7} for exposures to surface soil, 2.8 x 10^{-6} for exposures to sediment, and 6.4 x 10^{-5} for exposure to surface water. Excluding ingestion of fish, the total cancer risk across all media was 6.7 x 10^{-5}.

All estimated hazard indices for the adult recreational user were less than the acceptable level of 1.0 with the exception of exposure to surface water and ingestion of fish. The hazard indices for an adult recreational user were 0.19 for exposure to soil and 0.03 for exposure to sediment, indicating that no adverse health effects are anticipated for the adult recreational user exposed to soil and sediment under the defined conditions. Bis(2-ethylhexyl) phthalate (HI = 0.89) was the main contributor to the hazard index for exposures to surface water and the hazard indices for the individual target organs were less than 1.0 for exposures to surface water. Therefore, no adverse effects are anticipated for exposure to surface water. The cumulative hazard index across all media excluding ingestion of fish was 1.28.

Concentrations of chemicals in surface water were used to estimate chemical concentrations in fish tissue. Cancer risks were estimated using U.S. EPA default exposure assumptions and site-specific exposure assumptions. Estimated cancer risks based on maximum surface water concentrations exceeded U.S. EPA target risk range of 10^{-4} to 10^{-6}. Cancer risks from recreational users ingesting fish based on the estimated chemical concentrations in fish tissue using the maximum surface water concentrations were 2.0 x 10^{-3} based on U.S. EPA Region IV default exposure assumptions and 1.4 x 10^{-4} based on site-specific exposure assumptions. Pentachlorophenol and arsenic were the major contributors to the cancer risk.

HIs based on the maximum surface water concentration exceeded the acceptable level of 1.0. The estimated HIs from exposure by adult recreational users ingesting fish tissue based on the estimated chemical concentrations in fish tissue using the maximum surface water concentrations were 24 based on U.S. EPA Region IV default exposure assumptions and 8.2 using site-specific exposure assumptions. Dibenzofuran (HQ_{max} = 1.3), arsenic (HQ_{max} = 1.5), iron (HQ_{max} = 17, HQ_{avg} = 6), and manganese were the major contributors to the HIs.

Cancer risks from exposures by adult recreational users ingesting fish based on the estimated chemical concentrations in fish tissue using the average surface water/sediment concentrations and U.S. EPA Region IV default exposure assumptions were 6.0×10^{-4}, which exceeds U.S. EPA's target risk range of 10^{-4} to 10^{-6}. Pentachlorophenol was the main contributor to the cancer risk. The cancer risk from ingestion of fish by recreational users based on site-specific assumptions was 4.1×10^{-5}, which is within U.S. EPA's target risk range.

HIs based on the average surface water concentration exceeded the acceptable level of 1.0. The estimated HIs from exposure by adult recreational users ingesting fish tissue based on the estimated chemical concentrations in fish tissue using the average surface water concentrations were 6.5 based on U.S. EPA Region IV default exposure assumptions and 2.2 using site-specific exposure assumptions. Iron (HQ_{max} = 4.0, HQ_{avg} = 1.2) was the major contributors to the HIs.

The following information should be considered when evaluating the risks for adult recreational users ingesting fish:

- Chemicals were detected infrequently in surface water samples. Organics were only detected in one of eight surface water samples with the exception of bis(2-ethylhexyl)phthalate which was detected in three of eight samples. With the exception of the essential nutrients (calcium, magnesium, potassium, and sodium) most inorganics were detected in only two surface water samples.

- The surface water bodies adjacent to the site are tidally influenced and are dry at low tide. Even at high tide the surface water in the adjacent to the site is only a few inches deep. Any fish in surface water adjacent to the site originated from outside the site. The estimate fish tissue concentrations used in the estimation of cancer risks and HIs assume that the fish spend all of their time in the surface water adjacent to the site.

On-site Residents

All estimated cancer risks for the on-site child resident were within U.S. EPA's target risk range of 10^{-4} to 10^{-6}, with the exception of exposure to surface water. The estimated cancer risks for the on-site child resident were 3.0 x 10^{-5} for exposures to surface soil, 8.8 x 10^{-6} for exposures to sediment, and 1.0 x 10^{-4} for exposure to surface water. Dermal contact to bis(2-ethylhexyl) phthalate (ICR = 3.5 x 10^{-5}) and pentachlorophenol (ICR = 6.9 x 10^{-5}) was the major contributor to the cancer risk for exposures to surface water. The total cancer risk across all media was 1.4 x 10^{-4}.

All estimated cancer risks for the on-site adult resident were within U.S. EPA's target risk range of 10^{-4} to 10^{-6}, with the exception of exposure to surface water. The estimated cancer risks for the on-site adult resident were 1.5 x 10^{-5} for exposures to surface soil, 5.5 x 10^{-6} for exposures to sediment, and 2.5 x 10^{-4} for exposure to surface water. Dermal contact to bis(2-ethylhexyl) phthalate (ICR = 8.5 x 10^{-5}) and pentachlorophenol (ICR = 1.7 x 10^{-4}) was the major contributor to the cancer risk for exposures to surface water. The total cancer risk across all media was 2.8 x 10^{-4}.

All estimated cancer risks for the on-site lifelong resident were within U.S. EPA's target risk range of 10^{-4} to 10^{-6} with the exception of exposure to surface water. The estimated cancer risks for the on-site lifelong resident were 4.6 x 10^{-5} for exposures to surface soil, 1.4 x 10^{-5} for exposures to sediment, and 3.6 x 10^{-4} for exposure to surface water. Dermal contact to bis(2-ethylhexyl)phthalate (ICR = 1.2 x 10^{-4}) and pentachlorophenol (ICR = 2.4 x 10^{-4}) was the major contributor to the cancer risk for exposures to surface water. The total cancer risk across all media was 4.2 x 10^{-4}.

The estimated hazard index for a child resident exposed to soil was 10.7, which exceeds the acceptable level of 1.0. Incidental ingestions of antimony (HI = 3.2) and iron (HI = 6.3) in soil were the main contributors to the hazard index. The estimated hazard index for a child resident exposed to surface water was 1.8. Bis(2-ethylhexyl) phthalate (HI = 1.5) was the main contributor to the hazard index for exposure to surface water. The estimated hazard indices of 0.21 for exposure to sediment was less than the acceptable level of 1.0 indicating that no adverse health effects are anticipated for child residents exposed to sediment under the defined conditions. The cumulative hazard index across all media was 12.7.

The estimated hazard index for an adult resident exposed to soil was 1.22, which exceeds the acceptable level of 1.0. Incidental ingestions of antimony (HI = 0.37) and iron (HI = 0.69) were the main contributors to the hazard index. The hazard indices for the target organs for adult residents exposed to soil were 0.01 for the liver, 0.009 for body weight, 1.1 for blood, 0.07 for skin, 0.05 for the kidney, and 0.02 for the central nervous system. The estimated hazard index for an adult resident exposed to surface water was 1.1. Bis(2-ethylhexyl) phthalate (HI = 0.89) was the main contributor to the hazard index for exposures to

surface water. The hazard indices for the individual target organs for exposure to surface water were less than 1.0. The estimated hazard indices of 0.02 for exposure to sediment was less than the acceptable level of 1.0, indicating that no adverse health effects are anticipated for adult residents exposed to sediment under the defined conditions. The cumulative hazard index across all media was 2.3.

6.4.3 Lead

Lead was identified as a COPC in surface soil at the Site 1. Lead was detected at a maximum concentration of 8,380 mg/kg, which exceeds the Office of Solid Waste and Environmental Response (OSWER) soil screening level of 400 mg/kg for residential land use (U.S. EPA, 1994a).

Exposure to lead in surface soil at the Site 1 by residential children was evaluated using the U.S. EPA IEUBK Model, as discussed in Section 6.2.7.5. As recommended by the model, the average concentration of lead in surface soil of 834 mg/kg was used for the exposure point concentration. Default parameters were used for the rest of the model input parameters. IEUBK Model outputs are included in Appendix E. The estimated geometric mean blood-lead level for children exposed to lead in site surface soil was 8.3 micrograms per deciliter (µg/dL), which is less than the established level of concern of 10 µg/dL. The IEUBK model estimates that 68 percent of children are expected to have blood-lead levels greater than 10 µg/dL, which exceeds the U.S. EPA acceptable range of less than 5 percent of children having a blood-lead level of 10 µg/dL. The IEUBK results indicate that adverse effects are anticipated for children exposed to lead in surface soil at the Site 1.

Exposure to lead in surface soil at Site 1 by construction workers was evaluated by use of a slope-factor approach developed by the U.S. EPA Technical Review Workgroup for Lead (U.S. EPA, 1996c). Exposures to lead in soil by maintenance workers could not be evaluated with this model since the exposure frequency of 30 days a year is less than the model's lower limit of 90 days a year. As recommended by the model, the average concentration of lead in surface soil of 834 mg/kg was used for the exposure point concentration. A value of 100 mg/day was used as the incidental ingestion rate since the input assumptions for the model should be based on average exposures and not reasonable maximum exposures (U.S. EPA, 1999a). Default parameters were used for the rest of the model input parameters. The model estimated that the 95th percentile blood-lead concentration among fetuses born to women having site exposures ranged from 7.3 µg/dl to 10.9 µg/dL, which slightly exceeds the acceptable level of 10 µg/dL.

6.5 UNCERTAINTY ANALYSIS

There is uncertainty associated with all aspects of the baseline human health risk assessment presented in this section. A summary of the uncertainties, including a discussion of how they may affect the final risk numbers, is provided in this section.

Uncertainty in the selection of COPCs is related to the current status of the predictive databases, the grouping of samples, and the procedures used to include or exclude constituents as COPCs. Uncertainty associated with the exposure assessment includes the values used as input variables for a given intake route/scenario, the assumptions made to determine exposure point concentrations, and the predictions regarding future land use and population characteristics. Uncertainty in the toxicity assessment includes the quality of the existing toxicity data needed to support dose-response relationships and the weight-of-evidence used for determining the carcinogenicity of COPC. Uncertainty in risk characterization includes that associated with exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier activities.

While there are various sources of uncertainty, as described above, the direction of uncertainty can be influenced by the assumptions made throughout the risk assessment, including selection of COPCs and selection of values for dose-response relationships. Throughout the entire risk assessment, assumptions that consider safety factors are made so that the final calculated risks are overestimated.

Generally, risk assessments carry two types of uncertainty -- measurement and informational uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements. For example, this type of uncertainty is associated with analytical data collected for each site. The risk assessment reflects the accumulated variances of the individual values used.

Informational uncertainty stems from inadequate availability of information needed to complete the toxicity and exposure assessments. Often, this gap is significant, such as the absence of information on the effects of human exposure to low doses of a chemical, the biological mechanism of action of a chemical, or the behavior of a chemical in soil.

Once the risk assessment is complete, the results must be reviewed and evaluated to identify the type and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates must be made to ensure that the particular assumptions made are protective of sensitive subpopulations or the maximum exposed individuals. If a number of conservative assumptions are combined in an exposure model, the resulting calculations can propagate the uncertainties associated with those assumptions, thereby producing a much larger uncertainty for the final results. This uncertainty is biased toward over predicting both carcinogenic and noncarcinogenic risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

This interpretation is especially relevant when the risks exceed the point-of-departure for defining "acceptable" risk. For example, when risks calculated using a high degree of uncertainty are below an "acceptable" risk level (i.e., 1×10^{-6}), the interpretation of no significant risk is typically straightforward. However, when risks calculated using a high degree of uncertainty are above an "acceptable" risk level (i.e., 1×10^{-4}), a conclusion can be difficult unless uncertainty is considered.

6.5.1 Uncertainty in Selection of COPCs

There is a minor amount of uncertainty associated with the selection of COPCs that may impact the numerical risk estimates presented in Section 6.4, Risk Characterization. The most significant issues related to uncertainty in COPC selection for Site 1 and Site 41 are the screening levels used and the absence of screening levels for a few chemicals detected in the site media. A brief discussion of each of these issues is provided in the remainder of this section.

6.5.1.1 COPC Screening Levels

The use of predetermined screening values based on conservative land use scenarios (i.e., residential land use for soil and sediment, and ingestion/inhalation for groundwater/surface water), in combination with the use of risk-based screening values corresponding to a 1×10^{-6} ILCR and a 0.1 HI, should ensure that the significant contributors to risk from a site are evaluated. The elimination of chemicals that are present at concentrations that correspond to a less than 1×10^{-6} ILCR and less than 0.1 HI should not affect the final conclusions of the risk assessment since these chemicals are not expected to cause a potential health concern.

6.5.1.2 Absence of COPC Screening Levels

There are two chemicals [benzo(g,h,i)perylene and phenanthrene] for which no health criteria are available and for which no risk-based COPC screening criteria could be developed. Therefore, as recommended by EPA Region 4 (1995a), the screening criterion for naphthalene was used as a surrogate for these chemicals since the chemical structures of these chemicals are similar to that of naphthalene. Therefore, there is some uncertainty associated with screening these chemicals using the screening criterion for naphthalene. The maximum detected concentrations of benzo(g,h,i)perylene and phenanthrene in soil/sediment are approximately one or more orders of magnitude lower than the screening criteria for naphthalene. Consequently, the absence of screening criteria for benzo(g,h,i)perylene and phenanthrene and the use of naphthalene as a surrogate for these chemicals does not affect the conclusions of the risk assessment.

6.5.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises because of the methods used to calculate exposure point concentrations, the determination of land use conditions, the selection of receptors and scenarios, and the selection of exposure parameters. Each of these is discussed below.

6.5.2.1 Land Use

The current land use patterns at the site are well established, thereby reducing the uncertainty associated with land use assumptions. Land use at the site is currently limited and is expected to be limited in the future.

6.5.2.2 Exposure Point Concentrations

For some chemicals in surface soil, surface water, and sediment, the distribution of the chemical was not defined and the maximum detected concentration was used as the exposure point concentration. As a result, the estimations of risk, where the maximum concentrations were used as the exposure point concentration, are most likely to be overstated because it is unlikely that potential receptors would be exposed to the maximum concentration over the entire exposure period.

6.5.2.3 Exposure Routes and Receptor Identification

Receptors quantitatively evaluated in the human health risk assessment for Site 1 and SWMU 41 included construction workers, maintenance workers, on-site recreational users, and on-site residents. Since Site 1 and SWMU 41 are a landfill, it is very unlikely that any construction activity or residential development will occur on the site. Consequently, there is uncertainty associated with the selection of construction workers and on-site residents as receptors at Site 1 and SWMU 41.

6.5.2.4 Exposure Parameters

Each exposure factor selected for use in the risk assessment has some associated uncertainty. Generally, exposure factors are based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally have a broad distribution. To avoid underestimation of exposure, the U.S. EPA guidelines on the RME receptor were used, which generally consist of the 95th percentile for most parameters. Therefore, the selected values for the RME receptor represent the upper bound of the observed or expected habits of the majority of the population.

Generally, the uncertainty can be assessed quantitatively for a number of assumptions made in determining factors for calculating exposures and intakes. Many of these parameters were determined

from statistical analyses on human population characteristics. Often the database used to summarize a particular exposure parameter (i.e., body weight) is quite large. Consequently, the values chosen for such variables in the RME scenario have low uncertainty. For many parameters for which limited information exists (i.e., dermal absorption of organic chemicals from soil), there is greater uncertainty. However, there are often sufficient data to estimate these parameters with low uncertainty.

Many of the quantities used to calculate exposures and risks in this report are selected from a distribution of possible values. For the RME scenario, the value representing the 95th percentile is generally selected for each parameter to ensure that the assessment bounds the actual risks from a postulated exposure. This risk number is used in risk management decisions but does not indicate what a more average or typical exposure might be or what risk range might be expected for individuals in the exposed population.

6.5.3 Uncertainty in the Toxicological Evaluation

Uncertainties associated with the toxicity assessment (determination of RfDs and CSFs and use of available criteria) are presented in this section.

6.5.3.1 Derivation of Toxicity Criteria

Uncertainty associated with the toxicity assessment is associated with hazard assessment and dose-response evaluations for the COPCs. The hazard assessment deals with characterizing the nature and strength of the evidence of causation or the likelihood that a chemical that induces adverse effects in animals will also induce adverse effects in humans. Hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination, using the U.S. EPA methods. Positive animal cancer test data suggest that humans contain tissue(s) that may also manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of noncancer effects, however, positive animal data suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans.

Uncertainty in hazard assessment arises from the nature and quality of the animal and human data. Uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose-related; when pharmacokinetic data indicate a similar fate in humans and animals; when postulated mechanisms of toxicity are similar for humans and animals; and when the chemical of concern is structurally similar to other chemicals for which the toxicity is more completely characterized.

Uncertainty in the dose-response evaluation includes the determination of a CSF for the carcinogenic assessment and derivation of an RfD for the noncarcinogenic assessment. Uncertainty is introduced from

interspecies (animal to human) extrapolation, which, in the absence of quantitative pharmacokinetic or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Uncertainty also results from intraspecies variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so that intragroup biological variation is minimal, but the human population of concern may reflect a great deal of heterogeneity including unusual sensitivity or tolerance to the COPC. Even toxicity data from human occupational exposure reflect a bias, because only those individuals sufficiently healthy to attend work regularly (the "healthy worker effect") and those not unusually sensitive to the chemical, are likely to be occupationally exposed. Finally, uncertainty arises from the quality of the key study from which the quantitative estimate is derived and the database. For cancer effects, the uncertainty associated with dose-response factors is mitigated by assuming the 95 percent upper bound for the slope factor. Another source of uncertainty in carcinogenic assessment is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a nonthreshold assumption of carcinogenesis. There is evidence to suggest, however, that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (Williams and Weisburger, 1991); therefore, the use of the linearized multistage model is conservative for chemicals that exhibit a threshold for carcinogenicity.

For noncancer effects, additional uncertainty factors may be applied in the derivation of the RfD to mitigate poor quality of the key study or gaps in the database. Additional uncertainty for noncancer effects arises from the use of an effect level in the estimation of an RfD, because this estimation is predicated on the assumption of a threshold below which adverse effects are not expected. Therefore, an uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises in estimation of an RfD for chronic exposure from less-than-chronic data. Unless empirical data indicate that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the less-than-chronic study. Uncertainty in the derivation of RfDs is mitigated by the use of uncertainty and modifying factors that normally range between 3 and 10. The resulting combination of uncertainty and modifying factors may reach 1,000 or more.

The derivation of dermal RfDs and CSFs from oral values may cause uncertainty. This is particularly the case when no gastrointestinal absorption rates are available in the literature or when only qualitative statements regarding absorption are available. Whenever possible, gastrointestinal absorption rates from U.S. EPA Region 4 were used for all chemicals in the human health risk assessment. U.S. EPA is currently revising the dermal guidance and has interim gastrointestinal absorption rates that differ from those recommended by U.S. EPA Region 4. For example, U.S. EPA Region 4 recommends a gastrointestinal absorption rate of 31 percent for PAHs. The draft U.S. EPA dermal guidance lists a gastrointestinal absorption rate of 89 percent for PAHs and recommends that the oral CSF be used as the

dermal CSF. Consequently, risks from dermal exposures evaluated using the draft U.S. EPA guidance will be lower than those evaluated using the U.S. EPA Region 4 guidance. Therefore, dermal exposures based on the U.S. EPA Region 4 guidance may overestimate the cancer risks.

6.5.3.2 Use of PAH Toxicity Criteria

Uncertainty also arises in the dose-response assessment for values derived for several PAHs by using studies with limitations. These criteria are used to not only calculate risks for COPCs but are also used to determine risk-based COPC screening levels for PAHs. Potentially carcinogenic PAHs for which no toxicity data are available are evaluated using benzo(a)pyrene toxicity data with estimated orders of potential potency for the average and RME receptors. This may either underestimate or overestimate the carcinogenic risks associated with PAHs.

6.5.3.3 Use of Arsenic Toxicity Criteria

The carcinogenicity of arsenic via ingestion is not confirmed by the available data. However, U.S. EPA has proposed an oral unit risk factor that was used for all oral and dermal exposures to arsenic at this site. Since arsenic is selected as a COPC for various media at Site 1 and SWMU 41, the risks associated with this chemical may be overstated. Although the more restrictive basis for evaluating risk associated with exposure to arsenic is to assume it is a carcinogen, carcinogenic effects are not the primary health effects expected to be manifested upon exposure to arsenic. The preponderance of scientific information indicates that humans are capable of metabolizing arsenic to expedite its elimination from the body (ATSDR, 1988). Its elimination from the body obviously mitigates the possibility for arsenic to manifest carcinogenic effects. Therefore, evaluating arsenic as a noncarcinogen would be more appropriate.

6.5.3.4 Use of Toxicity Criteria From NCEA

National Center for Environmental Assessment (NCEA) provisional RfDs are used to evaluate noncarcinogenic effects from exposure to dibenzofuran, aluminum, iron, and thallium. The provisional RfDs for aluminum and iron are based on the Food and Drug Administration (FDA) Recommended Daily Allowance (RDA) rather than adverse effect levels. Since the reference dose is not based on an adverse effect level, it is not really appropriate to be using this value to calculate risks. An unacceptable hazard index based on the NCEA oral reference will not necessarily indicate that adverse health effects are anticipated, only that the RDA has been exceeded. For example, iron was identified as major contributor to the hazard index for exposures to surface soil by construction workers and on-site child residents. The RDA of iron for children and adults is 18 mg/day and this is the amount of iron included in vitamin supplements. Using the RDA of 18 mg-iron/day with the exposure assumptions for an on-site residential child and the NCEA reference dose of 0.3 mg/kg/day results in an HI of 3.8, which exceeds the acceptable

level of 1.0. Women's vitamins can contain 27 mg-iron, which results in a hazard index of 1.2 for an on-site adult woman resident. Therefore, the NCEA reference dose for iron indicates that adverse health effects may be anticipated for child and adult women residents taking vitamin supplements. This suggests that it is not appropriate to use the NCEA reference dose for iron to estimate hazard indices.

6.5.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization results primarily from assumptions made regarding additivity of effects from exposure to multiple COPCs from various exposure routes. High uncertainty exists when summing cancer risks for several substances across different exposure pathways. This assumes that each substance has a similar effect and/or mode of action. Often compounds affect different organs, have different mechanisms of action, and differ in their fate in the body, so additivity may not be an appropriate assumption. However, the assumption of additivity is made to provide a conservative estimate of risk.

Finally, the risk characterization does not consider antagonistic or synergistic effects. Little or no information is available to determine the potential for antagonism or synergism for the COPCs. Therefore, this uncertainty cannot be discussed for its impact on the risk assessment, since it may either underestimate or overestimate potential human health risk.

6.6 REMEDIAL GOAL OPTIONS

In accordance with EPA Region 4 guidance remedial goal options (RGOs) were developed for those media with estimated lifetime cancer risks greater than 1×10^{-4} and total HI greater than 1.0. As discussed in Sections 6.4, HIs for construction workers exposed to iron in soil and child residents exposed to antimony and iron in surface soil and bis(2-ethylhexyl)phthalate in surface water exceeded the acceptable level of 1.0. ICRs for the adult residents exposed to pentachlorophenol in surface water and lifelong residents exposed to pentachlorophenol and bis(2-ethylhexyl)phthalate in surface water exceeded EPA's target risk range of 10^{-4} to 10^{-6}, consequently RGOs will be developed for these receptors.

RGOs for Site 1 were developed according to guidance provided in the Region 4 Human Health Risk Assessment Bulletins. The RGOs were calculated using the following equation:

$$\text{RGO[chemical i]} = \text{EPC[chemical i]} \times \text{Target Risk/Calculated Risk[chemical i]}$$

Where:

RGO[chemical i] = the chemical-specific remediation goal option.

EPC[chemical i]	=	the exposure point concentration for the chemical used in risk assessment calculations.
Target Risk	=	Target risk for carcinogens or the Target Hazard Quotients for noncarcinogens.
Calculated Risk[chemical i]	=	the total risk calculated for a specific chemical in the risk assessment.

In accordance to the Region 4 guidance, the target cancer risks to be used are 1 $x10^{-6}$, 1 x 10^{-5}, and 1 x 10^{-4} and the target HQs are 0.1, 1, and 3. RGOs for a child resident exposed to iron in surface soil were derived using an RfD based on child nutritional requirements.

The chemical-specific RGOs for construction workers, child residents, adult residents, and lifelong residents are presented in Tables 6-31 for soil and 6-32 for surface water.

TABLE 6-1

SCREENING CRITERIA USED IN SELECTION OF COPCs
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	EPA Region III RBC (1) Residential (mg/kg)		EPA SSL (2) Soil to Air (mg/kg)		EPA SSL (2) Soil to Groundwater (mg/kg)		EPA Region III RBC (1) Tap Water (ug/L)		EPA MCL (3) (ug/L)	EPA AWQC (4) (ug/L)	EPA Region III RBC (1) Fish (mg/kg)	
Volatile Organic Compounds													
67-64-1	Acetone	7800	N	100000	sat	16	N	610	N	NA	NA	140	N
78-93-3	2-Butanone	47000	N	NA		NA		1900	N	NA	NA	810	N
75-15-0	Carbon Disulfide	7800	N	720	sat	32	N	1000	N	NA	NA	140	N
67-66-3	Chloroform	100	C	0.3	C	0.6		0.15	C	100/80	5.7	0.52	C
100-41-4	Ethylbenzene	7800	N	400	sat	13		1300	N	700	3100	140	N
108-88-3	Toluene	16000	N	650	sat	12		750	N	1000	6800	270	N
1330-20-7	Xylenes, Total	1600	N	NA		NA		12000	N	10000	NA	2700	N
Semivolatile Organic Compounds													
95-50-1	1,2-Dichlorobenzene	7000	N	560	sat	17		64	N	600	NA	120	N
105-67-9	2,4-Dimethylphenol	1600	N	NA		9	N	730	N	NA	540	27	N
91-57-6	2-Methylnaphthalene	1600	N	NA		NA		120	N	NA	NA	27	N
95-48-7	2-Methylphenol	3900	N	NA		15	N	1800	N	NA	NA	68	N
120-82-1	1,2,4-Trichlorobenzene	780	N	3200	sat	5		190	n	70	260	14	N
120-12-7	Anthracene	23000	N	NA		12000	N	1800	N	NA	9600	410	N
83-32-9	Acenaphthene	4700	N	NA		570	N	370	N	NA	NA	81	N
208-96-8	Acenaphthylene	1600 (5)	N	NA		NA		6.5 (5)	N	NA	NA	NA	
56-55-3	Benzo(a)anthracene	0.87	C	NA		2	C	0.092	C	NA	0.0044	0.0043	C
50-32-8	Benzo(a)pyrene	0.087	C	NA		8		0.0092	C	0.002	0.0044	0.00043	C
205-99-2	Benzo(b)fluoranthene	0.87	C	NA		5	C	0.092	C	NA	0.0044	0.0043	C
207-08-9	Benzo(k)fluoranthene	8.7	C	NA		49	C	0.92	C	NA	0.0044	0.043	C
117-81-7	Bis(2-ethylhexyl)phthalate	46	C	31000	sat	3600		4.8	C	6	1.8	0.23	C
85-68-7	Butylbenzyl Phthalate	16000	N	930	sat	930	sat	7300	N	NA	3000	270	N
86-74-8	Carbazole	32	C	NA		0.6	C	3.3	C	NA	NA	0.16	C
218-01-9	Chrysene	87	C	NA		160	C	9.2	C	NA	0.0044	0.43	C
53-70-3	Dibenzo(a,h)anthracene	0.087	C	NA		2	C	0.0092		NA	NA	0.00043	C
84-74-2	Di-n-butyl phthalate	7800	N	2300	sat	2300	N	3700	N	NA	2700	140	N
117-84-0	Di-n-octyl phthalate	1600	N	10000	sat	10000	sat	730	N	NA	NA	27	N
132-64-9	Dibenzofuran	310	N	NA		NA		24	N	NA	NA	5.4	N
84-66-2	Diethyl Phthalate	63000	N	2000	sat	470	N	29000	N	NA	23000	1100	N
206-44-0	Fluoranthene	3100	N	NA		4300	N	1500	N	NA	300	54	N
86-73-7	Fluorene	3100	N	NA		560	N	240	N	NA	1300	54	N
91-20-3	Naphthalene	1600	N	NA		84	N	6.5	N	NA	NA	27	N

TABLE 6-1

SCREENING CRITERIA USED IN SELECTION OF COPCs
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	EPA Region III RBC (1) Residential (mg/kg)		EPA SSL (2) Soil to Air (mg/kg)		EPA SSL (2) Soil to Groundwater (mg/kg)		EPA Region III RBC (1) Tap Water (ug/L)		EPA MCL (3) (ug/L)	EPA AWQC (4) (ug/L)	EPA Region III RBC (1) Fish (mg/kg)	
193-39-5	Indeno(1,2,3-cd)pyrene	0.87	C	NA		14	C	0.092	C	NA	0.0044	0.0043	C
87-86-5	Pentachlorophenol	0.0053	C	NA		0.03		0.56	C	1	0.28	0.026	C
85-01-8	Phenanthrene	1600 (5)	N	NA		NA		6.5 (5)	N	NA	NA	NA	
108-95-2	Phenol	47000	N	NA		100	N	22000	N	NA	21000	810	N
129-00-0	Pyrene	2300	N	NA		4200	N	180	N	NA	960	41	N
Pesticides/PCBs													
72-54-8	4,4'-DDD	2.7	C	NA		16	C	0.28	C	NA	0.00059	0.013	C
72-55-9	4,4'-DDE	1.9	C	NA		54	C	0.2	C	NA	0.00059	0.0093	C
50-29-3	4,4'-DDT	1.9	C	NA		32	C	0.2	C	NA	0.00083	0.0093	C
5103-71-9	Alpha-Chlordane	1.8 (6)	C	20	C	10		0.19 (6)	C	2	0.0021	0.009	C
11096-82-5	Aroclor-1260	0.32	C	NA		NA		0.033	C	NA	0.00017	0.0016	C
57-74-9	Gamma-Chlordane	1.8 (6)	C	20	C	10		0.19 (6)	C	2	0.0021	0.009	C
	Endrin Ketone	23 (7)	N	NA		1 (7)		11 (7)	N	2	0.76	NA	
319-84-6	alpha-BHC	0.1	C	0.8	C	0.0005	C	0.011	C	NA	0.0039	0.0005	C
319-85-7	beta-BHC	0.35	C	NA		0.003	C	0.037	C	NA	0.014	0.0018	C
319-86-8	delta-BHC	0.1 (8)	C	NA		NA		0.011 (8)	C	NA	NA	NA	
58-89-9	gamma-BHC (Lindane)	0.49	C	NA		0.009	C	0.052	C	0.2	0.019	0.0024	C
Inorganics													
7429-90-5	Aluminum	78000	N	NA		NA		37000	N	50 To 200 (9)	NA	1400	N
7440-36-0	Antimony	31	N	NA		5		15	N	6	14	0.54	N
7440-38-2	Arsenic	0.43	C	750	C	29		0.045	C	50	0.018	0.0021	C
7440-39-3	Barium	5500	N	690000	N	1600		2600	N	2000	1000	95	N
7440-41-7	Beryllium	160	N	1300	C	63		73	N	4	NA	2.7	N
7440-43-9	Cadmium	39	N	1800	C	8		18	N	5		0.68	N
7440-70-2	Calcium	NA		NA		NA		NA		NA	NA	NA	
7440-47-3	Chromium	120000 (10)	N	270 (10)	C	38 (11)	C	55000 (11)	N	100 (11)	NA	2000	N
1854-02-99	Hexavalent Chromium	230	N	270	C	38	C	110	N	NA	NA	4.1	N
7440-48-4	Cobalt	4700	N	NA		NA		2200	N	NA	NA	27	N
7440-50-8	Copper	3100	N	NA		NA		1500	N	1300 (13)	1300	54	N
7439-89-6	Iron	23000	N	NA		NA		11000	N	300 (9)	300	410	N
7439-92-1	Lead	400 (12)		NA		NA		NA		15 (13)	NA	NA	
7439-95-4	Magnesium	NA		NA		NA		NA		NA	NA	NA	
7439-96-5	Manganese	1600	N	NA		NA		730	N	50 (9)	50	27	N

TABLE 6-1

SCREENING CRITERIA USED IN SELECTION OF COPCs
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	EPA Region III RBC (1) Residential (mg/kg)		EPA SSL (2) Soil to Air (mg/kg)		EPA SSL (2) Soil to Groundwater (mg/kg)		EPA Region III RBC (1) Tap Water (ug/L)		EPA MCL (3) (ug/L)	EPA AWQC (4) (ug/L)	EPA Region III RBC (1) Fish (mg/kg)	
7487-94-7	Mercury	23 (14)	N	10	N	2		11 (14)	N	2	0.05	0.41	N
7440-02-0	Nickel	1600	N	13000	C	130	N	730	N	100	610	27	N
7440-09-7	Potassium	NA		NA		NA		NA		NA	NA	NA	
7440-22-4	Silver	390	N	NA		34	N	180	N	100 (9)	NA	6.8	N
7782-49-2	Selenium	390	N	NA		5	N	180	N	50	170	6.8	N
7440-23-5	Sodium	N/A		NA		NA		NA		NA	NA	NA	
7440-28-0	Thallium	5.5	N	NA		0.7		2.6	N	2	1.7	0.095	N
7440-62-2	Vanadium	550	N	NA		6000	N	260	N	NA	NA	9.5	N
7440-66-6	Zinc	23000	N	NA		12000	N	11000	N	5000 (9)	9100	410	N

Notes:

1 U.S. EPA Region 3 Risk-Based Concentration Table, April 12, 1999. (Cancer benchmark value = 1E-06, HI = 1.0)
2 U.S. EPA Soil Screening Level Guidance: Technical Background Document. May 1996.
3 U.S. EPA Drinking Water Regulations and Health Advisories, October 1996.
4 U.S. EPA National Recommended Water Quality Criteria - Correction, April 1999.
5 Value is for naphthalene.
6 Value is for chlordane.
7 Value is for endrin.
8 Value is for alpha-BHC.
9 Secondary MCLs
10 Value is for trivalent chromium.
11 Value is for total chromium.
12 OSWER screening level
13 Action level
14 Value is for mercuric chloride.
15 Value is for methyl mercury.

Definitions: N/A = Not Applicable
C = Carcinogenic
N = Non-carcinogenic
sat = Saturation concentration
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
RBC = Risk-based concentration
SSL = Soil screening level
AWQC = Ambient Water Quality Criteria

TABLE 6-2

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SURFACE SOIL
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	(1) Minimum Concentration	Minimum Qualifier	(1) Maximum Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	(2) Background Value	(3) Screening Toxicity Value	(4) US EPA SSL Soil to Air	(5) US EPA SSL Soil to Groundwater	COPC Flag	(6) Rationale for Contaminant Deletion or Selection
	Volatile Organics															
108-88-3	Toluene	0.003	J	0.003	J	mg/kg	PAI-01-SS-05-01	1/10	0.006 - 0.009	0.003	NA	1600 N	650 sat	12	No	BSL
	Semivolatile Organics															
120-82-1	1,2,4-Trichlorobenzene	0.14	J	0.14	J	mg/kg	PAI-01-SS-07-01	1/10	0.34 - 0.53	0.14	NA	78 N	3200 sat	5	No	BSL
91-57-6	2-Methylnaphthalene	0.13	J	0.13	J	mg/kg	PAI-01-SS-07-01	1/10	0.34 - 0.53	0.13	NA	160 N	NA	NA	No	BSL
120-12-7	Anthracene	0.012	J	0.035		mg/kg	PAI-01-SS-09-01	5/10	0.0085 - 0.088	0.035	NA	2300 N	NA	12000 N	No	BSL
205-99-2	Benzo(a)anthracene	0.018	J	0.28		mg/kg	PAI-01-SS-07-01	10/10	NA	0.28	NA	0.87 C	NA	2 C	No	BSL
50-32-8	**Benzo(a)pyrene**	0.02	J	0.31		mg/kg	PAI-01-SS-07-01	10/10	NA	0.31	NA	**0.087** C	NA	8 C	**Yes**	ASL
205-99-2	Benzo(b)fluoranthene	0.02		0.51		mg/kg	PAI-01-SS-07-01	10/10	NA	0.51	NA	0.87 C	NA	5 C	No	BSL
191-24-2	Benzo(g,h,i)perylene	0.038	J	0.21	J	mg/kg	PAI-01-SS-07-01	7/10	0.034 - 0.081	0.21	NA	160 (7) N	NA	NA	No	BSL
207-08-9	Benzo(k)fluoranthene	0.011		0.16		mg/kg	PAI-01-SS-07-01	10/10	NA	0.16	NA	8.7 C	NA	49 C	No	BSL
117-81-7	Bis(2-Ethylhexyl)phthalate	0.06	J	5.6		mg/kg	PAI-01-SS-12-01	4/10	0.36 - 0.53	5.6	NA	46 C	31000 sat	3600	No	BSL
85-68-7	Butylbenzyl Phthalate	2		2		mg/kg	PAI-01-SS-12-01	1/10	0.34 - 0.53	2	NA	1600 N	930 sat	930 sat	No	BSL
86-74-8	Carbazole	0.26	J	0.49		mg/kg	PAI-01-SS-14-01-AVG	5/10	0.36 - 0.4	0.49	NA	32 C	NA	0.6 C	No	BSL
218-01-9	Chrysene	0.019	J	0.33		mg/kg	PAI-01-SS-07-01	10/10	NA	0.33	NA	87 C	NA	160 C	No	BSL
84-74-2	Di-n-butyl phthalate	0.072	J	0.072		mg/kg	PAI-01-SS-12-01	1/10	0.34 - 0.53	0.072	NA	780 N	2300 sat	2300 sat	No	BSL
117-84-0	Di-n-octyl phthalate	6.4		6.4		mg/kg	PAI-01-SS-12-01	1/10	0.34 - 0.53	6.4	NA	160 N	10000 sat	10000 sat	No	BSL
132-64-9	Dibenzofuran	0.17	J	0.2	J	mg/kg	PAI-01-SS-14-01-AVG	3/10	0.34 - 0.53	0.2	NA	31 N	NA	NA	No	BSL
206-44-0	Fluoranthene	0.033		0.63		mg/kg	PAI-01-SS-07-01	10/10	NA	0.63	NA	310 N	NA	4300 N	No	BSL
86-73-7	Fluorene	0.095		0.095		mg/kg	PAI-01-SS-05-01	1/10	0.042 - 0.44	0.095	NA	310 N	NA	560 N	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	0.019	J	0.23		mg/kg	PAI-01-SS-07-01	8/10	0.025 - 0.047	0.23	NA	0.87 C	NA	14 C	No	BSL
85-01-8	Phenanthrene	0.021		0.18		mg/kg	PAI-01-SS-06-01	9/10	0.037	0.18	NA	160 (7) N	NA	NA	No	BSL
129-00-0	Pyrene	0.03	J	0.51		mg/kg	PAI-01-SS-07-01	9/10	0.094	0.51	NA	230 N	NA	4200 N	No	BSL
	Pesticides/PCBs															
72-54-8	4,4'-DDD	0.0021		0.18	J	mg/kg	PAI-01-SS-07-01	8/10	0.0094 - 0.01	0.18	NA	2.7 C	NA	16 C	No	BSL
72-55-9	**4,4'-DDE**	0.0056		4.2	J	mg/kg	PAI-01-SS-07-01	10/10	NA	4.2	NA	**1.9** C	NA	54 C	**Yes**	ASL
50-29-3	**4,4'-DDT**	0.0021		4.4	J	mg/kg	PAI-01-SS-07-01	10/10	NA	4.4	NA	**1.9** C	NA	32 C	**Yes**	ASL
5103-71-9	Alpha-Chlordane	0.0095		0.018		mg/kg	PAI-01-SS-07-01	2/10	0.0009 - 0.005	0.018	NA	1.8 (8) C	20 C	10	No	BSL
11096-82-5	Aroclor-1260	0.021		0.08		mg/kg	PAI-01-SS-09-01	3/10	0.0094 - 0.088	0.08	NA	0.32 C	NA	NA	No	BSL
	Endrin Ketone	0.012		0.012		mg/kg	PAI-01-SS-07-01	1/10	0.0017 - 0.01	0.012	NA	2.3 (9) N	NA	1 (9)	No	BSL
	Gamma-Chlordane	0.006		0.0081		mg/kg	PAI-01-SS-09-01	2/10	0.0009 - 0.005	0.0081	NA	1.8 (8) C	20 C	10	No	BSL
319-84-6	alpha-BHC	0.0037		0.042		mg/kg	PAI-01-SS-07-01	2/10	0.0009 - 0.005	0.042	NA	0.1 C	0.8 C	**0.0005** C	No	BSL
319-85-7	beta-BHC	0.0089		0.033		mg/kg	PAI-01-SS-07-01	2/10	0.0009 - 0.005	0.033	NA	0.35 C	NA	**0.003** C	No	BSL
319-86-8	delta-BHC	0.045		0.045		mg/kg	PAI-01-SS-07-01	1/10	0.0009 - 0.005	0.045	NA	0.1 (10) C	NA	NA	No	BSL
58-89-9	gamma-BHC (Lindane)	0.075		0.075		mg/kg	PAI-01-SS-07-01	1/10	0.0009 - 0.005	0.075	NA	0.49 C	NA	**0.009**	No	BSL
	Inorganics															
7429-90-5	**Aluminum**	3880		8610		mg/kg	PAI-01-SS-08-01	10/10	NA	8610	7270	**7800** N	NA	NA	**Yes**	ASL
7440-36-0	**Antimony**	0.1875		90.6		mg/kg	PAI-01-SS-09-01	9/10	0.15	90.6	NA	**3.1** N	NA	**5**	**Yes**	ASL
7440-38-2	**Arsenic**	0.58		24.9		mg/kg	PAI-01-SS-09-01	10/10	NA	24.9	1.44	**0.43** C	750	29	**Yes**	ASL
7440-39-3	Barium	15.2		178		mg/kg	PAI-01-SS-08-01	10/10	NA	178	23.6	550 N	690000	1600	No	BSL
7440-43-9	**Cadmium**	0.1		5.4		mg/kg	PAI-01-SS-08-01	10/10	NA	5.4	NA	**3.9** N	1800	8	**Yes**	ASL
7440-70-2	Calcium	420		13100		mg/kg	PAI-01-SS-05-01	10/10	NA	13100	766	NA	NA	NA	No	NUT
7440-47-3	Chromium	7		53.2		mg/kg	PAI-01-SS-08-01	10/10	NA	53.2	6.23	12000 (11) N	270	**38**	No	BSL

TABLE 6-2

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SURFACE SOIL
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)		US EPA SSL Soil to Air (4)	US EPA SSL Soil to Groundwater (5)		COPC Flag	Rationale for Contaminant Deletion or Selection (6)
7440-48-4	Cobalt	0.33		13.7		mg/kg	PAI-01-SS-08-01	10/10	NA	13.7	0.363	470	N	NA	NA		No	BSL
7440-50-8	Copper	6.5		131		mg/kg	PAI-01-SS-08-01	10/10	NA	131	1.52	310	N	NA	NA		No	BSL
57-12-5	Cyanide	0.73		0.86		mg/kg	PAI-01-SS-08-01	2/10	0.42 - 0.61	0.86	NA	160	N	NA	NA		No	BSL
7439-89-6	**Iron**	2560		147000		mg/kg	PAI-01-SS-08-01	10/10	NA	147000	3920	**2300**	N	NA	NA		**Yes**	ASL
7439-92-1	**Lead**	58.4		8380		mg/kg	PAI-01-SS-09-01	10/10	NA	8380	12.5	**400 (12)**	C	NA	NA		**Yes**	ASL
7439-96-5	Magnesium	233		1280		mg/kg	PAI-01-SS-06-01	10/10	NA	1280	515	NA		NA	NA		No	NUT
7439-96-5	**Manganese**	17.4		752		mg/kg	PAI-01-SS-08-01	10/10	NA	752	129	**160**	N	NA	NA		**Yes**	ASL
7487-94-7	Mercury	0.04		1.1		mg/kg	PAI-01-SS-07-01	10/10	NA	1.1	0.11	2.3 (13)	N	10	2		No	BSL
7440-02-0	Nickel	1.8		47.8		mg/kg	PAI-01-SS-08-01	10/10	NA	47.8	1.8	160	N	13000	130		No	BSL
7440-09-7	Potassium	190		692		mg/kg	PAI-01-SS-05-01	10/10	NA	692	313	NA		NA	NA		No	NUT
7782-49-2	Selenium	0.18		0.73		mg/kg	PAI-01-SS-05-01	5/10	0.17 - 0.2	0.73	0.285	39	N	NA	5		No	BSL
7440-22-4	Silver	0.48		2.4		mg/kg	PAI-01-SS-09-01	5/10	0.06 - 0.44	2.4	NA	39	N	NA	34	N	No	BSL
7440-23-5	Sodium	68		3530		mg/kg	PAI-01-SS-06-01	10/10	NA	3530	241	NA		NA	NA		No	NUT
7440-62-2	Vanadium	5.7		47.4		mg/kg	PAI-01-SS-09-01	10/10	NA	47.4	9.5	55	N	NA	6000		No	BSL
7440-66-6	Zinc	45.65		497		mg/kg	PAI-01-SS-08-01	10/10	NA	497	9.7	2300	N	NA	12000	N	No	BSL

Notes:

1 Minimum/maximum detected concentration.

2 Refer to supporting information for background discussion.

3 USEPA Region III Risk-Based Concentration Table, April 12, 1999b. (Cancer benchmark value = 1E-06, HI = 0.1)

4 USEPA Soil Screening Level Guidance: Technical Background Document. May 1996.

5 USEPA Soil Screening Level Guidance: Technical Background Document. May 1996. (Based on a DAF [Dilutional Attenuation Factor] of 20)

6 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

7 No value available, therefore value for naphthalene used based on similar chemical/toxicological characteristics.

8 No value available, therefore value for chlordane used based on similar chemical/toxicological characteristics.

9 No value available, therefore value for endrin used based on similar chemical/toxicological characteristics.

10 No value available, therefore value for alpha-BHC used based on similar chemical/toxicological characteristics.

11 Hexavalent chromium was not detected in soil samples, therefore value is for trivalent chromium.

12 OSWER Screening Level.

13 Value for mercuric chloride.

Shading indicates chemical exceeded screening criteria and is retained as a COPC.

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE 6-3

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SURFACE SOIL
SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)		US EPA SSL Soil to Air (4)		US EPA SSL Soil to Groundwater (5)		COPC Flag	Rationale for Contaminant Deletion or Selection (6)
	Volatile Organics (mg/kg)																		
67-64-1	Acetone	0.73	J	0.73	J	mg/kg	PAI-41-SS-02-01	1/1	NA	0.73	0.266	780	N	100000	sat	16	N	No	BSL
	Semivolatile Organics (mg/kg)																		
205-99-2	Benzo(a)anthracene	0.024		0.063		mg/kg	PAI-41-SS-03-01	2/4	0.021 - 0.022	0.063	NA	0.87	C	NA		2	C	No	BSL
50-32-8	Benzo(a)pyrene	0.032	J	0.037	J	mg/kg	PAI-41-SS-03-01	2/4	0.021 - 0.022	0.037	NA	0.087	C	NA		8		No	BSL
205-99-2	Benzo(b)fluoranthene	0.01		0.068		mg/kg	PAI-41-SS-03-01	4/4	NA	0.068	NA	0.87	C	NA		5	C	No	BSL
191-24-2	Benzo(g,h,i)perylene	0.07		0.07		mg/kg	PAI-41-SS-03-01	1/4	0.034 - 0.07	0.07	NA	160 (7)	N	NA		NA		No	BSL
207-08-9	Benzo(k)fluoranthene	0.019		0.019		mg/kg	PAI-41-SS-01-01	1/4	0.0086 - 0.018	0.019	NA	8.7	C	NA		49	C	No	BSL
218-01-9	Chrysene	0.012	J	0.012	J	mg/kg	PAI-41-SS-04-01	1/4	0.022 - 0.044	0.012	NA	87	C	NA		160	C	No	BSL
206-44-0	Fluoranthene	0.026		0.2		mg/kg	PAI-41-SS-03-01	4/4	NA	0.2	NA	310	N	NA		4300	N	No	BSL
86-73-7	Fluorene	0.028		0.028		mg/kg	PAI-41-SS-03-01	1/4	0.043 - 0.087	0.028	0.646	310	N	NA		560	N	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	0.026	J	0.026	J	mg/kg	PAI-41-SS-01-01	1/4	0.021 - 0.044	0.026	NA	0.87	C	NA		14	C	No	BSL
85-01-8	Phenanthrene	0.03	J	0.19		mg/kg	PAI-41-SS-03-01	4/4	NA	0.19	NA	160 (7)		NA		NA		No	BSL
129-00-0	Pyrene	0.12		0.12		mg/kg	PAI-41-SS-03-01	1/4	0.043 - 0.087	0.12	NA	230	N	NA		4200	N	No	BSL
	Pesticides/PCBs (mg/kg)																		
72-55-9	4,4'-DDE	0.034		0.043		mg/kg	PAI-41-SS-01-01	2/4	0.085 - 0.18	0.043	NA	1.9	C	NA		54	C	No	BSL
50-29-3	4,4'-DDT	0.012		0.065		mg/kg	PAI-41-SS-01-01	2/4	0.085 - 0.18	0.065	NA	1.9	C	NA		32	C	No	BSL
	Inorganics (mg/kg)																		
7429-90-5	Aluminum	3130		6290		mg/kg	PAI-41-SS-04-01	4/4	NA	6290	7270	7800	N	NA		NA		No	BSL, BKG
7440-38-2	**Arsenic**	0.48		6.3		mg/kg	PAI-41-SS-03-01	4/4	NA	**6.3**	1.44	**0.43**	C	750	C	29		**Yes**	ASL
7440-39-3	Barium	20.7		151		mg/kg	PAI-41-SS-03-01	4/4	NA	151	23.6	550	N	690000	N	1600		No	BSL
7440-41-7	Beryllium	0.05		0.51		mg/kg	PAI-41-SS-03-01	3/4	0.14	0.51	0.095	16	N	1300	C	63		No	BSL
7440-43-9	Cadmium	0.11		1.1		mg/kg	PAI-41-SS-03-01	3/4	0.13	1.1	NA	3.9	N	1800	C	8		No	BSL
7440-70-2	Calcium	384		1830		mg/kg	PAI-41-SS-03-01	4/4	NA	1830	766	NA		NA		NA		No	NUT
7440-47-3	Chromium	4.8		13.4		mg/kg	PAI-41-SS-03-01	4/4	NA	13.4	6.23	12000 (8)	N	270		38		No	BSL
7440-48-4	Cobalt	0.36		4.3		mg/kg	PAI-41-SS-03-01	4/4	NA	4.3	0.363	470	N	NA		NA		No	BSL
7440-50-8	Copper	4.8		114		mg/kg	PAI-41-SS-03-01	4/4	NA	114	1.52	310	N	NA		NA		No	BSL
7439-89-6	**Iron**	2150		15500		mg/kg	PAI-41-SS-03-01	4/4	NA	**15500**	3920	**2300**	N	NA		NA		**Yes**	ASL
7439-92-1	Lead	26.4		161		mg/kg	PAI-41-SS-01-01	4/4	NA	161	12.5	400 (9)		NA		NA		No	BSL
7439-96-5	Magnesium	187		604		mg/kg	PAI-41-SS-03-01	4/4	NA	604	515	NA		NA		NA		No	NUT
7439-96-5	Manganese	28.3		95.7		mg/kg	PAI-41-SS-03-01	4/4	NA	95.7	129	160	N	NA		NA		No	BSL, BKG
7487-94-7	Mercury	0.04		0.18		mg/kg	PAI-41-SS-03-01	4/4	NA	0.18	0.11	2.3 (10)	N	10		2		No	BSL
7440-02-0	Nickel	1.1		13.9		mg/kg	PAI-41-SS-03-01	4/4	NA	13.9	1.8	160	N	13000		130		No	BSL
7440-09-7	Potassium	148		1170		mg/kg	PAI-41-SS-03-01	4/4	NA	1170	313	NA		NA		NA		No	NUT
7782-49-2	Selenium	0.22		1.1		mg/kg	PAI-41-SS-03-01	4/4	NA	1.1	0.285	39	N	NA		5		No	BSL
7440-22-4	Silver	0.18		0.89		mg/kg	PAI-41-SS-03-01	2/4	0.05 - 0.25	0.89	NA	39	N	NA		34	N	No	BSL
7440-23-5	Sodium	263		425		mg/kg	PAI-41-SS-03-01	4/4	NA	425	241	NA		NA		NA		No	NUT
7440-62-2	Vanadium	4.8		11		mg/kg	PAI-41-SS-03-01	4/4	NA	11	9.5	55	N	NA		6000	N	No	BSL
7440-66-6	Zinc	27.8		158		mg/kg	PAI-41-SS-03-01	4/4	NA	158	9.7	2300	N	NA		12000	N	No	BSL

TABLE 6-3

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SURFACE SOIL
SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	US EPA SSL Soil to Air (4)	US EPA SSL Soil to Groundwater (5)	COPC Flag	Rationale for Contaminant Deletion or Selection (6)

Notes:

1 Minimum/maximum detected concentration.

2 Refer to supporting information for background discussion.

3 U.S. EPA Region 3 Risk-Based Concentration Table, April 12, 1999b. (Cancer benchmark value = 1E-06, HI = 0.1)

4 U.S. EPA Soil Screening Level Guidance: Technical Background Document. May 1996.

5 U.S. EPA Soil Screening Level Guidance: Technical Background Document. May 1996. (Based on a DAF [Dilutional Attenuation Factor] of 20)

6 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

7 No value available; therefore, value for naphthalene was used based on similar chemical/toxicological characteristics.

8 Hexavalent chromium was not detected in soil samples; therefore, value is for trivalent chromium.

9 OSWER Screening Level

10 Value is for mercuric chloride.

Shading indicates chemical exceeded screening criteria and is retained as a COPC.

Definitions: N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

TABLE 6-4

OCCURRENCE, DISTRIBUTION AND SELECTON OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH GROUNDWATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
	Volatile Organics																
78-93-3	2-Butanone	3.4	J	3.4	J	ug/L	PAI-01-GW-10-01	1/1	NA	3.4	NA	190	N	NA	NA	No	BSL
67-64-1	Acetone	1.4	J	13	J	ug/L	PAI-01-GW-14-01	4/4	NA	13	NA	61	N	NA	NA	No	BSL
75-15-0	Carbon Disulfide	0.7	J	16		ug/L	PAI-01-GW-14-01	6/11	1	16	NA	100	N	NA	NA	No	BSL
67-66-3	**Chloroform**	0.3	J	0.9	J	ug/L	PAI-01-GW-14-01	3/11	1	0.9	NA	**0.15**	C	100	MCL	**Yes**	ASL
100-41-4	Ethylbenzene	0.2	J	0.2	J	ug/L	PAI-01-GW-10-01	1/11	1	0.2	NA	130	N	700	MCL	No	BSL
108-88-3	Toluene	0.5	J	2		ug/L	PAI-01-GW-07-01	3/11	1	2	NA	75	N	1000	MCL	No	BSL
1330-20-7	Xylenes, Total	1.4		2		ug/L	PAI-01-GW-09-01	2/11	1	2	NA	1200	N	10000	MCL	No	BSL
	Semivolatile Organics																
95-50-1	1,2-Dichlorobenzene	3	J	3	J	ug/L	PAI-01-GW-05-01	1/11	5 - 6	3	NA	6.4	N	600	MCL	No	BSL
105-67-9	2,4-Dimethylphenol	2	J	5	J	ug/L	PAI-01-GW-09-01	2/11	5 - 6	5	NA	73	N	NA	NA	No	BSL
91-57-6	2-Methylnaphthalene	7		7		ug/L	PAI-01-GW-10-01	1/11	5 - 6	7	NA	12	N	NA	NA	No	BSL
95-48-7	2-Methylphenol	1	J	1	J	ug/L	PAI-01-GW-10-01	1/11	5 - 6	1	NA	180	N	NA	NA	No	BSL
83-32-9	Acenaphthene	1	J	7		ug/L	PAI-01-GW-10-01	2/11	5 - 6	7	NA	37	N	NA	NA	No	BSL
120-12-7	Anthracene	1	J	1	J	ug/L	PAI-01-GW-10-01, PAI-01-GW-13-01	2/11	5 - 6	1	NA	180	N	NA	NA	No	BSL
117-81-7	Bis(2-Ethylhexyl)phthalate	1	J	1	J	ug/L	PAI-01-GW-08-01, PAI-01-GW-10-01, GW-07-01	3/11	5 - 10	1	NA	4.8	C	6	MCL	No	BSL
86-74-8	Carbazole	2	J	2	J	ug/L	PAI-01-GW-13-01	1/10	5 - 6	2	NA	3.3	C	NA	NA	No	BSL
84-74-2	Di-n-butyl phthalate	1	J	1	J	ug/L	PAI-01-GW-12-01, PAI-01-GW-08-01, PAI-01-GW-10-01, PAI-01-GW-09-01, PAI-01-GW-06-01, PAI-01-GW-11-01-AVG, PAI-01-GW-07-01	7/11	5 - 6	1	NA	370	N	NA	NA	No	BSL
117-84-0	Di-n-octyl phthalate	7		7		ug/L	PAI1-GW4-01	1/11	5 - 6	7	NA	73	N	NA	NA	No	BSL
132-64-9	**Dibenzofuran**	1	J	3	J	ug/L	PAI-01-GW-10-01	2/11	5 - 6	3	NA	**2.4**	N	NA	NA	**Yes**	ASL
84-66-2	Diethyl Phthalate	1	J	1	J	ug/L	PAI-01-GW-10-01, PAI-01-GW-06-01, PAI-01-GW-08-01, PAI-01-GW-09-01	4/11	5 - 6	1	NA	2900	N	NA	NA	No	BSL
206-44-0	Fluoranthene	1	J	1	J	ug/L	PAI-01-GW-13-01, PAI-01-GW-10-01	2/11	5 - 6	1	NA	150	N	NA	NA	No	BSL
86-73-7	Fluorene	1	J	6		ug/L	PAI-01-GW-10-01	2/11	5 - 6	6	NA	24	N	NA	NA	No	BSL
91-20-3	**Naphthalene**	1	J	57		ug/L	PAI-01-GW-10-01	4/11	5 - 6	57	NA	**0.65**	N	NA	NA	**Yes**	ASL
85-01-8	**Phenanthrene**	1	J	8		ug/L	PAI-01-GW-10-01	4/11	5 - 6	8	NA	**0.65 (5)**	N	NA	NA	**Yes**	ASL
129-00-0	Pyrene	1	J	1	J	ug/L	PAI-01-GW-10-01, PAI-01-GW-13-01	2/11	5 - 6	1	NA	18	N	NA	NA	No	BSL

TABLE 6-4

OCCURRENCE, DISTRIBUTION AND SELECTON OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH GROUNDWATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
	Inorganics																
7429-90-5	**Aluminum**	23.3		3970		ug/L	PAI1-GW4-01	5/10	22 - 27	3970	NA	**3700**	N	50 To 200	SMCL	**Yes**	ASL
7440-38-2	**Arsenic**	1.15		4.4		ug/L	PAI-01-GW-09-01	6/11	1.1 - 2.2	4.4	NA	**0.045**	C	50	MCL	**Yes**	ASL
7440-39-3	**Barium**	16.2		1030		ug/L	PAI-01-GW-07-01	11/11	NA	1030	NA	**260**	N	2000	MCL	**Yes**	ASL
7440-41-7	Beryllium	0.2		0.7		ug/L	PAI-01-GW-09-01	5/11	0.2 - 0.7	0.7	NA	7.3	N	4	MCL	No	BSL
7440-70-2	Calcium	67200		494000		ug/L	PAI-01-GW-09-01	10/10	NA	494000	NA	NA		NA	NA	No	NUT
7440-47-3	Chromium	6.4		18.4		ug/L	PAI-01-GW-09-01	9/11	6.4	18.4	NA	5500 (6)	N	100	MCL	No	BSL
7440-50-8	Copper	2.55		7.8		ug/L	PAI-01-GW-05-01	4/11	2.1 - 3.7	7.8	NA	150	N	1300	TT	No	BSL
7439-89-6	**Iron**	259		12700		ug/L	PAI-01-GW-06-01	7/10	8.6 - 84.6	12700	NA	**1100**	N	300	SMCL	**Yes**	ASL
7439-92-1	**Lead**	0.5		34.7		ug/L	PAI-01-GW-09-01	10/11	0.9	34.7	NA	**15 (7)**		15	TT	**Yes**	ASL
7439-96-5	Magnesium	9650		1180000		ug/L	PAI-01-GW-09-01	10/10	NA	1180000	NA	NA		NA	NA	No	NUT
7439-96-5	**Manganese**	40.3	J	1320		ug/L	PAI-01-GW-05-01	7/10	13.7 - 96.6	1320	NA	**73**	N	50	SMCL	**Yes**	ASL
7440-09-7	Potassium	6980		477000		ug/L	PAI-01-GW-09-01	10/10	NA	477000	NA	NA		NA	NA	No	NUT
7440-23-5	Sodium	19400		10100000		ug/L	PAI-01-GW-09-01	10/10	NA	10100000	NA	NA		NA	NA	No	NUT
7440-62-2	**Vanadium**	3.1		32.6		ug/L	PAI-01-GW-09-01	8/11	6.3 - 8.8	32.6	NA	**26**	N	NA	NA	**Yes**	ASL
7440-66-6	Zinc	4.6		16.9		ug/L	PAI-01-GW-05-01	10/11	4.3	16.9	NA	1100	N	5000	SMCL	No	BSL
	Misc																
	TEQ Human	0.004		0.017		pg/L	PAI-01-GW-DU09(s)-02	1/1	NA	0.017	NA	0.45	C	30	MCL	No	BSL

Notes:

1 Minimum/maximum detected concentration
2 Refer to supporting information for background discussion.
3 U.S. EPA Region 3 Risk-Based Concentration Table, April 12, 1999. (Cancer benchmark value = 1E-06, HI = 0.1)
4 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)
5 No value available; therefore, value for naphthalene was used based on similar chemical/toxicological characteristics.
6 Hexavalent chromium was not detected in groundwater samples; therefore, value is for trivalent chromium.
7 OSWER Screening Level
8 Value for mercuric chloride used.

Shading indicates chemical exceeded screening criteria and is retained as a COPC.

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
TT = Treatment Technique
TEQ = Toxicity equivalent concentration.

TABLE 6-5

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SURFACE WATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
	Volatile Organics																
67-64-1	Acetone	7	J	7	J	ug/L	PAI-01-SW-09-00	1/2	2	7	NA	61 (5)	N	NA	NA	No	BSL
	Semivolatile Organics																
91-57-6	2-Methylnaphthalene	10		10		ug/L	PAI-01-SW-03-00	1/8	10 - 11.5	10	NA	12 (5)	N	NA	NA	No	BSL
117-81-7	**Bis(2-Ethylhexyl)phthalate**	14		56		ug/L	PAI-01-SW-03-00	3/8	10 - 11.5	56	44.8	**1.8**		1.8	NRWQC	**Yes**	ASL
218-01-9	**Chrysene**	0.1	J	0.1	J	ug/L	PAI-01-SW-10-00	1/8	0.12 - 0.24	0.1	NA	**0.0044**		0.0044	NRWQC	**Yes**	ASL
132-64-9	**Dibenzofuran**	10		10		ug/L	PAI-01-SW-03-00	1/8	10 - 11.5	10	NA	**2.4 (5)**	N	NA	NA	**Yes**	ASL
206-44-0	Fluoranthene	0.082		0.082		ug/L	PAI-01-SW-04-00	1/8	0.12 - 0.27	0.082	NA	300		300	NRWQC	No	BSL
87-86-5	**Pentachlorophenol**	110		110		ug/L	PAI-01-SW-03-00	1/8	48 - 57	110	NA	**0.28**		0.28	NRWQC	**Yes**	ASL
108-95-2	Phenol	3	J	3	J	ug/L	PAI-01-SW-11-00	1/8	10 - 11.5	3	NA	21000		21000	NRWQC	No	BSL
	Inorganics																
7429-90-5	**Aluminum**	434		13435		ug/L	PAI-01-SW-01-00-AVG	6/8	262 - 309	13435	3113	**3700 (5)**	N	NA	NA	**Yes**	ASL
7440-38-2	**Arsenic**	13.9		13.9		ug/L	PAI-01-SW-10-00	1/8	2 - 8.3	13.9	5.13	**0.018**		0.018	NRWQC	**Yes**	ASL
7440-39-3	Barium	12.6		37.15		ug/L	PAI-01-SW-01-00-AVG	8/8	0	37.15	38.4	1000	N	NA	NA	No	BSL, BKG
7440-43-9	Cadmium	0.305		0.42		ug/L	PAI-01-SW-01-00-AVG	2/8	0.3	0.42	NA	10		10	NRWQC	No	BSL
7440-70-2	Calcium	228000		290000		ug/L	PAI-01-SW-12-00	8/8	0	290000	637000	NA		NA	NA	No	NUT
7440-47-3	Chromium	14.1		19.2		ug/L	PAI-01-SW-10-00	2/8	0.7 - 0.8	19.2	22.5	5500 (5,6)	N	NA	NA	No	BSL, BKG
7440-48-4	Cobalt	1.755		2.9		ug/L	PAI-01-SW-10-00	2/8	0.4 - 0.6	2.9	NA	220 (5)	N	NA	NA	No	BSL
7440-50-8	Copper	13.6		62.95		ug/L	PAI-01-SW-01-00-AVG	2/8	1.4 - 9	62.95	6.97	1300		1300	NRWQC	No	BSL
7439-89-6	**Iron**	175		15600		ug/L	PAI-01-SW-10-00	8/8	0	15600	2091	**300**		300	NRWQC	**Yes**	ASL
7439-92-1	**Lead**	20.9		77.5		ug/L	PAI-01-SW-01-00-AVG	2/8	1 - 17	77.5	NA	**15 (7)**		15	TT	**Yes**	ASL
7439-96-5	Magnesium	693000		883000		ug/L	PAI-01-SW-12-00	8/8	0	883000	1918667	NA		NA	NA	No	NUT
7439-96-5	**Manganese**	21.65		124		ug/L	PAI-01-SW-10-00	8/8	0	124	53.1	**50**		50	NRWQC	**Yes**	ASL
7487-94-7	**Mercury**	0.09		0.12		ug/L	PAI-01-SW-10-00	2/8	0.1 - 0.12	0.12	NA	**0.05**		0.05	NRWQC	**Yes**	ASL
7440-02-0	Nickel	3.85		5	J	ug/L	PAI-01-SW-10-00	2/8	0.6 - 1	5	NA	610		610	NRWQC	No	BSL
7440-09-7	Potassium	342500		492000		ug/L	PAI-01-SW-12-00	8/8	0	492000	831333	NA		NA	NA	No	NUT
7440-22-4	Silver	0.89		0.89		ug/L	PAI-01-SW-11-00	1/8	0.6 - 0.7	0.89	NA	18 (5)	N	NA	NA	No	BSL
7440-23-5	Sodium	5710000		7440000		ug/L	PAI-01-SW-01-00-AVG	8/8	0	7440000	16226667	NA		NA	NA	No	NUT
7440-62-2	**Vanadium**	24.2		36.1		ug/L	PAI-01-SW-10-00	2/8	0.5 - 4.1	36.1	18.2	**26 (5)**	N	NA	NA	**Yes**	ASL
7440-66-6	Zinc	7.3	J	51.025		ug/L	PAI-01-SW-01-00-AVG	4/8	5 - 28.25	51.025	10.6	9100	N	9100	NRWQC	No	BSL

Notes:

1 Minimum/maximum detected concentration.

2 Refer to supporting information for background discussion.

3 U.S. EPA National Recommended Water Quality Criteria (NRWQC) , April 1999a.

4 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

5 Water quality criteria not available EPA Region III RBC for tap water ingestion used (Cancer benchmark value = 1E-6, HI = 0.1).

6 Hexavalent chromium was not detected in groundwater samples; therefore, value is for trivalent chromium.

7 OSWER action level for drinking water.

Shading indicates chemical exceeded screening criteria and is retained as a COPC.

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
TT = Treatment Technique

TABLE 6-6a

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SEDIMENT
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
	Volatile Organics																
67-64-1	Acetone	0.016		0.063		mg/kg	PAI-01-SD-09-01	3/3	NA	0.063	NA	780	N	NA	NA	No	BSL
75-15-0	Carbon Disulfide	0.002	J	0.024	J	mg/kg	PAI-01-SD-001	6/9	0.008 - 1.2	0.024	NA	780	N	NA	NA	No	BSL
108-88-3	Toluene	0.003	J	0.007	J	mg/kg	PAI-01-SD-09-01	6/9	0.019 - 1.2	0.007	NA	1600	N	NA	NA	No	BSL
	Semivolatile Organics																
208-96-8	Acenaphthylene	0.38	J	0.38	J	mg/kg	PAI-01-SD-02-01	1/14	0.071 - 3.6	0.38	NA	160 (5)	N	NA	NA	No	BSL
120-12-7	Anthracene	0.011	J	0.77		mg/kg	PAI-01-SD-001	6/14	0.0028 - 0.85	0.77	NA	2300	N	NA	NA	No	BSL
205-99-2	**Benzo(a)anthracene**	0.03	J	2.2		mg/kg	PAI-01-SD-017	8/14	0.0071 - 0.85	2.2	NA	**0.87**	C	NA	NA	**Yes**	ASL
50-32-8	**Benzo(a)pyrene**	0.0078	J	1.7		mg/kg	PAI-01-SD-017	9/14	0.0071 - 0.85	1.7	NA	**0.087**	C	NA	NA	**Yes**	ASL
205-99-2	**Benzo(b)fluoranthene**	0.0081	J	1.8		mg/kg	PAI-01-SD-017	10/14	0.0028 - 0.85	1.8	NA	**0.87**	C	NA	NA	**Yes**	ASL
191-24-2	Benzo(g,h,i)perylene	0.03	J	0.99		mg/kg	PAI-01-SD-017	7/14	0.011 - 0.85	0.99	NA	160 (5)	N	NA	NA	No	BSL
207-08-9	Benzo(k)fluoranthene	0.0031	J	0.85		mg/kg	PAI-01-SD-017	9/14	0.0028 - 0.85	0.85	NA	8.7	C	NA	NA	No	BSL
86-74-8	Carbazole	0.086	J	0.58		mg/kg	PAI-01-SD-02-01	3/9	0.47 - 1.2	0.58	NA	32	C	NA	NA	No	BSL
218-01-9	Chrysene	0.013	J	2.3		mg/kg	PAI-01-SD-017	9/14	0.0071 - 0.85	2.3	NA	87	C	NA	NA	No	BSL
53-70-3	**Dibenzo(a,h)anthracene**	1.6		1.6		mg/kg	PAI-01-SD-017	1/14	0.011 - 0.85	1.6	NA	**0.087**	C	NA	NA	**Yes**	ASL
206-44-0	Fluoranthene	0.025		6.6		mg/kg	PAI-01-SD-017	9/14	0.0071 - 0.85	6.6	NA	310	N	NA	NA	No	BSL
86-73-7	Fluorene	0.16	J	0.16	J	mg/kg	PAI-01-SD-03-01-AVG	1/14	0.014 - 0.85	0.16	NA	310	N	NA	NA	No	BSL
193-39-5	**Indeno(1,2,3-cd)pyrene**	0.03	J	1.1		mg/kg	PAI-01-SD-017	8/14	0.0071 - 0.85	1.1	NA	**0.87**	C	NA	NA	**Yes**	ASL
85-01-8	Phenanthrene	0.025	J	2.6		mg/kg	PAI-01-SD-001	8/14	0.0057 - 0.85	2.6	NA	160 (5)	N	NA	NA	No	BSL
129-00-0	Pyrene	0.064	J	5.4		mg/kg	PAI-01-SD-017	7/14	0.014 - 0.85	5.4	NA	230	N	NA	NA	No	BSL
	Pesticides/PCBs																
72-54-8	4,4'-DDD	0.0036	J	0.26		mg/kg	PAI-01-SD-09-01	4/14	0.0057 - 0.032	0.26	NA	2.7	C	NA	NA	No	BSL
72-55-9	4,4'-DDE	0.0055	J	0.12		mg/kg	PAI-01-SD-09-01	6/14	0.0057 - 0.032	0.12	NA	1.9	C	NA	NA	No	BSL
50-29-3	4,4'-DDT	0.0032	J	0.27		mg/kg	PAI-01-SD-09-01	4/13	0.0046 - 0.032	0.27	NA	1.9	C	NA	NA	No	BSL
5103-71-9	Alpha-Chlordane	0.052		0.052		mg/kg	PAI-01-SD-09-01	1/8	0.0023 - 0.0074	0.052	NA	1.8	C	NA	NA	No	BSL
57-74-9	Gamma-Chlordane	0.13		0.13		mg/kg	PAI-01-SD-09-01	1/14	0.0023 - 0.0155	0.13	NA	1.8	C	NA	NA	No	BSL
319-84-6	alpha-BHC	0.0027		0.0027		mg/kg	PAI-01-SD-02-01	1/14	0.0023 - 0.0155	0.0027	NA	0.1	C	NA	NA	No	BSL
319-85-7	beta-BHC	0.0054		0.0054		mg/kg	PAI-01-SD-02-01	1/14	0.0023 - 0.0155	0.0054	NA	0.35	C	NA	NA	No	BSL
319-86-8	delta-BHC	0.0027		0.0027		mg/kg	PAI-01-SD-02-01	1/14	0.0023 - 0.0155	0.0027	NA	0.1 (6)	C	NA	NA	No	BSL
58-89-9	gamma-BHC (Lindane)	0.0021	J	0.0021	J	mg/kg	PAI-01-SD-02-01	1/14	0.0023 - 0.0155	0.0021	NA	0.49	C	NA	NA	No	BSL
	Inorganics																
7429-90-5	Aluminum	2110		23400		mg/kg	PAI-01-SD-02-02	14/14	NA	23400	24284	7800	N	NA	NA	No	BKG
7440-36-0	Antimony	0.55		1.3		mg/kg	PAI-01-SD-001	4/14	0.39 - 6	1.3	NA	3.1	N	NA	NA	No	BSL
7440-38-2	**Arsenic**	1.2		15.6		mg/kg	PAI-01-SD-10-01	13/14	0.27	15.6	12.2	**0.43**	C	NA	NA	**Yes**	ASL
7440-39-3	Barium	5.7		88.5		mg/kg	PAI-01-SD-09-01	14/14	NA	88.5	28.0	550	N	NA	NA	No	BSL
7440-41-7	Beryllium	0.7075		1.2		mg/kg	PAI-01-SD-10-01	3/14	0.17 - 0.95	1.2	0.977	16	N	NA	NA	No	BSL
7440-43-9	Cadmium	0.79		0.79		mg/kg	PAI-01-SD-02-02	1/14	0.04 - 0.09	0.79	0.278	7.8	N	NA	NA	No	BSL
7440-70-2	Calcium	387		14500		mg/kg	PAI-01-SD-09-01	14/14	NA	14500	4002	NA		NA	NA	No	NUT
7440-47-3	Chromium	7.1		34.4		mg/kg	PAI-01-SD-10-01	14/14	NA	34.4	35.2	12000 (8)	N	NA	NA	No	BKG

TABLE 6-6a

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SEDIMENT
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
7440-48-4	Cobalt	0.19		3.9		mg/kg	PAI-01-SD-10-01	13/14	5.7	3.9	2.63	470	N	NA	NA	No	BSL
7440-50-8	Copper	5.5		95.3		mg/kg	PAI-01-SD-001	13/14	3.3	95.3	10.1	310	N	NA	NA	No	BSL
7439-89-6	**Iron**	1930		24000		mg/kg	PAI-01-SD-02-02	14/14	NA	24000	21450	**2300**	N	NA	NA	**Yes**	ASL
7439-92-1	Lead	6.6		194		mg/kg	PAI-01-SD-09-01	14/14	NA	194	20.6	400 (9)		NA	NA	No	BSL
7439-96-5	Magnesium	597		7355		mg/kg	PAI-01-SD-013-AVG	14/14	NA	7355	6437	NA		NA	NA	No	NUT
7439-96-5	**Manganese**	12.3		190		mg/kg	PAI-01-SD-013-AVG	14/14	NA	190	186	**160**	N	NA	NA	**Yes**	ASL
7487-94-7	Mercury	0.16		0.67		mg/kg	PAI-01-SD-09-01	2/14	0.07 - 0.28	0.67	0.09	2.3 (10)	N	NA	NA	No	BSL
7440-02-0	Nickel	1.4		7.9		mg/kg	PAI-01-SD-001, PAI-01-SD-10-01	12/14	0.75 - 11.3	7.9	5.95	160	N	NA	NA	No	BSL
7440-09-7	Potassium	331		4475		mg/kg	PAI-01-SD-013-AVG	14/14	NA	4475	3190	NA		NA	NA	No	NUT
7440-22-4	Silver	0.36		2.4		mg/kg	PAI-01-SD-09-01	2/14	0.06 - 1.1	2.4	NA	39	N	NA	NA	No	BSL
7440-23-5	Sodium	2620		25550		mg/kg	PAI-01-SD-013-AVG	14/14	NA	25550	19110	NA		NA	NA	No	NUT
7440-28-0	**Thallium**	0.925		0.925		mg/kg	PAI-01-SD-013-AVG	1/14	0.38 - 1.1	0.925	0.405	**0.55**	N	NA	NA	**Yes**	ASL
7440-62-2	Vanadium	4.3		50.65		mg/kg	PAI-01-SD-013-AVG	14/14	NA	50.65	49.6	55	N	NA	NA	No	BSL
7440-66-6	Zinc	10.5		124		mg/kg	PAI-01-SD-09-01	14/14	NA	124	45.0	2300	N	NA	NA	No	BSL
	Misc.																
	TEQ Human	0.06		3.3		ng/kg	PAI-01-SD-11	3/3	NA	3.3	1.1	4.3	C	1000	(7)	No	BSL

Notes:

1 Minimum/maximum detected concentration

2 Refer to supporting information for background discussion.

3 U.S. EPA Region 3 Risk-Based Concentration Table, April 12, 1999. (Cancer benchmark value = 1E-06, HI = 0.1)

4 Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

5 No value available; therefore, value for naphthalene was used based on similar chemical/toxicological characteristics.

6 No value available; therefore, value for alpha-BHC was used based on similar chemical/toxicological characteristics.

7 U.S. EPA Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites. OSWER Directive 9200.4-26.

8 Hexavalent chromium was not detected in sediment samples; therefore, value is for trivalent chromium.

9 OSWER Screening Level

10 No value available; therefore, value for mercuric chloride used based on similar chemical/toxicological characteristics..

Shading indicates chemical exceeded screening criteria and is retained as a COPC.

Definitions:
N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic
TEQ - Toxicity equivalent concentration.

TABLE 6-6b
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
DIRECT CONTACT WITH SURFACE WATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Maximum Detected Concentration in Surface Water ug/L	Bioconcentration Factor (1) L/kg	Estimated Fish Tissue Concentration (2) ug/kg	EPA Region III RBC for Fish Ingestion (3) ug/kg		COPC Flag	Rationale for Contaminant Deletion or Selection (4)
	Semivolatile Organics							
91-57-6	2-Methylnaphthalene (5)	10	215 (6)	2150	2700	N	No	BSL
117-81-7	**Bis(2-Ethylhexyl)phthalate**	56	130	7280	**230**	**C**	**Yes**	ASL
218-01-9	Chrysene (5)	0.1	30	3.00	430	C	No	BSL
132-64-9	**Dibenzofuran (5)**	10	690	6900	**540**	**N**	**Yes**	ASL
206-44-0	Fluoranthene (5)	0.082	1150	94.3	5400	N	No	BSL
87-86-5	**Pentachlorophenol**	110	397 (6)	43670	**26**	**C**	**Yes**	ASL
108-95-2	Phenol (5)	3	7.81 (6)	23.4	81000	N	No	BSL
	Inorganics							
7429-90-5	**Aluminum (5)**	13435	95	1276325	**140000**	**N**	**Yes**	ASL
7440-38-2	**Arsenic**	13.9	44	612	**2.1**	**C**	**Yes**	ASL
7440-39-3	Barium (5)	37.15	4	149	9500	N	No	BSL
7440-43-9	Cadmium	0.42	64	26.9	68	N	No	BSL
7440-47-3	Chromium	19.2	283 (6)	5434	200000	N	No	BSL
7440-48-4	Cobalt (5)	2.9	50	145	2700	N	No	BSL
7440-50-8	Copper	62.95	36	2266	5400	N	No	BSL
7439-89-6	**Iron (5)**	15600	450	7020000	**41000**	**N**	**Yes**	ASL
7439-92-1	**Lead**	77.5	49	3798			**Yes**	NTX
7439-96-5	**Manganese (5)**	124	373	46252	**2700**	**N**	**Yes**	ASL
7487-94-7	**Mercury**	0.12	3760	451	**14**	**N**	**Yes**	ASL
7440-02-0	Nickel	5	307 (6)	1535	2700	N	No	BSL
7440-22-4	Silver (5)	0.89	0.5	0.445	680	N	No	BSL
7440-62-2	Vanadium (5)	36.1	0.01	0.361	950	N	No	BSL
7440-66-6	Zinc	51.025	47	2398	41000	N	No	BSL

Notes:
(1) - BCFs obtained from Table F-2 in Appendix F unless otherwise noted.
(2) - Estimated fish tissue concentration = bioconcentration factor x surface water concentration.
(3) - USEPA Region III RBC Table, May 8, 2001. (ICR = 1E-06, HI = 0.1)
(4) - Rationale Codes: Selection Reason: Above Screening Levels (ASL)
No Toxicity Criteria Available (NTX)
Deletion Reason: Below Screening Level (BSL)
(5) - Chemical is not considered to be a concern via bioconcentration. USEPA, 2000: Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment. EPA-823-R-00-001
(6) - USEPA 1998: Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. EPA530-D-98-001B.

TABLE 6-7

CHEMICALS RETAINED AS COPCs
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Surface Soil	Groundwater	Surface Water	Sediment	Soil to Air	Soil to Groundwater	Fish
Volatile Organics							
Chloroform		X					
Semivolatile Organics							
Benzo(a)anthracene				X			
Benzo(a)pyrene	X			X			
Benzo(b)fluoranthene				X			
Bis(2-ethylhexyl)phthalate			X				X
Chrysene			X				
Dibenzo(a,h)anthracene				X			
Dibenzofuran		X	X				X
Indeno(1,2,3-cd)pyrene				X			
Naphthalene		X					
Pentachlorophenol			X				X
Phenanthrene		X					
Pesticides/PCBs							
4,4'-DDE	X						
4,4'-DDT	X						
alpha-BHC						X	
beta-BHC						X	
gamma-BHC (Lindane)						X	
Inorganics							
Aluminum	X	X	X				X
Antimony	X					X	
Arsenic	X	X	X	X			X
Barium		X					
Cadmium	X						
Chromium						X	
Iron	X	X	X	X			X
Lead	X	X	X				X
Manganese	X	X	X	X			X
Mercury			X				
Thallium				X			
Vanadium		X	X				

Notes
X - Indicates chemical was retained as a COPC.

TABLE 6-8

SELECTION OF EXPOSURE PATHWAYS
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Surface Soil	Surface Soil	Surface Soil	Construction Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Construction workers may have contact with soil during excavation activities.
				Full-time Employees	Adult	Ingestion Dermal	On-Site On-Site	None None	No full-time employees at site.
				Maintenance Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Maintenance workers may have contact with soil during normal work activities.
				Military Personnel	Adult	Ingestion Dermal	On-Site On-Site	None None	No military personnel at site.
				Trespassers	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Access to site is restricted.
				Recreational Users	Adolescents	Ingestion Dermal	On-Site On-Site	Quant Quant	Recreational users may be exposed to soil while at site.
					Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Recreational users may be exposed to soil while at site.
				Residents	Child	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
					Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
	Surface Soil	Air	Surface Soil	Construction Workers	Adult	Inhalation	On-site	Quant	Construction workers may be exposed to fugitive dust and volatile emissions during construction activities.
				Full-time Employees	Adult	Inhalation	On-site	None	No full-time employees at site.
				Maintenance Workers	Adult	Inhalation	On-site	Quant	Maintenance workers may be exposed to fugitive dust and volatile emissions during construction activities.
				Military Personnel	Adult	Inhalation	On-site	None	No full-time military personnel at site.
				Trespassers	Adolescents	Inhalation	On-site	None	Access to site is restricted.
				Recreational Users	Adolescents	Inhalation	On-Site	Quant	Recreational users may be exposed to fugitive dust and volatile emissions from soil.
					Adult	Inhalation	On-Site	Quant	Recreational users may be exposed to fugitive dust and volatile emissions from soil.
				Residents	Child	Inhalation	On-Site	Quant	Future child residents may be exposed to fugitive dust and volatile emissions from soil.
					Adult	Inhalation	On-Site	Quant	Future adult residents may be exposed to fugitive dust and volatile emissions from soil.

TABLE 6-8

SELECTION OF EXPOSURE PATHWAYS
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
	Groundwater	Groundwater	Shallow Aquifer	Construction Workers	Adult	Ingestion Dermal	On-Site On-Site	None Quant	Groundwater is not used as a potable water supply at the site. Construction workers may contact groundwater during excavation activities.
				Full-time Employees	Adult	Ingestion Dermal	On-Site On-Site	None None	Groundwater is not suitable for use as potable water.
				Maintenance Workers	Adult	Ingestion Dermal	On-Site On-Site	None None	Groundwater is not suitable for use as potable water.
				Military Personnel	Adult	Ingestion Dermal	On-Site On-Site	None None	Site is not used by military personnel.
				Trespassers	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Access to site is restricted.
				Recreational Users	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Groundwater is not suitable for use as potable water.
					Adult	Ingestion Dermal	On-Site On-Site	None None	Groundwater is not suitable for use as potable water.
				Residents	Child	Ingestion Dermal	On-Site On-Site	None None	Groundwater is not suitable for use as potable water.
					Adult	Ingestion Dermal	On-Site On-Site	None None	Groundwater is not suitable for use as potable water.
	Groundwater	Air	Shallow Aquifer	Construction Workers	Adult	Inhalation	On-site	None	Groundwater is not suitable for use as potable water.
				Full-time Employees	Adult	Inhalation	On-site	None	Groundwater is not suitable for use as potable water.
				Maintenance Workers	Adult	Inhalation	On-site	None	Groundwater is not suitable for use as potable water.
				Military Personnel	Adult	Inhalation	On-Site	None	Site is not used by military personnel.
				Trespassers	Adolescents	Inhalation	On-Site	None	Access to site is restricted.
				Recreational Users	Adolescents	Inhalation	On-Site	None	Groundwater is not suitable for use as potable water.
					Adult	Inhalation	On-Site	None	Groundwater is not suitable for use as potable water.
				Residents	Child	Inhalation	On-Site	None	Groundwater is not suitable for use as potable water.
					Adult	Inhalation	On-Site	None	Groundwater is not suitable for use as potable water.

TABLE 6-8

SELECTION OF EXPOSURE PATHWAYS
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
	Sediment	Sediment	Sediment	Construction Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Construction workers may contact sediment during construction activities.
				Full-time Employees	Adult	Ingestion Dermal	On-Site On-Site	None None	No full-time employees at site.
				Maintenance Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Maintenance workers may contact sediment during normal work activities.
				Military Personnel	Adult	Ingestion Dermal	On-Site On-Site	None None	Site is not used by military personnel.
				Trespassers	Adolescents	Ingestion Dermal	On-Site On-Site	Quant Quant	Access to site is restricted
				Recreational Users	Adolescents	Ingestion Dermal	On-Site On-Site	Quant Quant	Recreational users may be exposed to sediment while at site.
					Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Recreational users may be exposed to sediment while at site.
				Residents	Child	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
					Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
	Surface Water	Surface Water	Surface Water	Construction Workers	Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Construction workers may contact surface water during construction activities.
				Full-time Employees	Adult	Ingestion Dermal	On-Site On-Site	None None	No full-time employees at site.
				Maintenance Workers	Adult	Ingestion Dermal	On-Site On-Site	None None	Maintenance workers do not contact surface water.
				Military Personnel	Adult	Ingestion Dermal	On-Site On-Site	None None	Site is not used by military personnel.
				Trespassers	Adolescents	Ingestion Dermal	On-Site On-Site	None None	Access to site is restricted
				Recreational Users	Adolescents	Ingestion Dermal	On-Site On-Site	Quant Quant	Recreational users may be exposed to surface water while at site.
					Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Recreational users may be exposed to surface water while at site.
				Residents	Child	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
					Adult	Ingestion Dermal	On-Site On-Site	Quant Quant	Site may be residential in the future.
		Fish	Surface Water	Recreational Users	Adult	Ingestion	On-Site	Quant	Recreation users may eat fish caught in surface water bodies located adjacent to site.

TABLE 6-9a

EXPOSURE POINT CONCENTRATION
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Surface Soil (mg/kg)	Groundwater (ug/L)	Surface Water (ug/L)	Sediment (mg/kg)
Chloroform	NA	0.9	NA	NA
Benzo(a)pyrene equivalents	0.414	NA	0.0007	3.82
Bis(2-ethylhexyl)phthalate	NA	NA	56	NA
Dibenzofuran	NA	3	10	NA
Naphthalene	NA	57	NA	NA
Pentachlorophenol	NA	NA	110	NA
Phenanthrene	NA	8	NA	NA
4,4'-DDE	2.38	NA	NA	NA
4,4'-DDT	4.4	NA	NA	NA
Aluminum	6474	3970	13435	NA
Antimony	90.6	NA	NA	NA
Arsenic	11.5	2.72	14	8.54
Barium	NA	1030	NA	NA
Cadmium	3.39	NA	NA	NA
Iron	147000	12700	15600	24000
Lead	2805	34.7	78	NA
Manganese	264	1320	101	171
Thallium	NA	NA	NA	0.454
Vanadium	NA	13.4	36	NA

Notes:
NA - Not applicable
RAGS Part D Tables for the exposure point concentrations are included in Appendix E.

TABLE 6-9b
EXPOSURE POINT CONCENTRATIONS
FOR INGESTION OF FISH
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Surface Water Concentration		Bioconcentration Factor (1)	Estimated Fish Tissue Concentration (2)	
	Maximum Detected Concentration ug/L	Average Concentration ug/L	L/kg	Maximum Detected Concentration ug/kg	Average Concentration ug/kg
Semivolatile Organics					
Bis(2-Ethylhexyl)phthalate	56	13.8	130	7280	1794
Dibenzofuran	10	5.75	690	6900	3968
Pentachlorophenol	110	35.1	397 (6)	43670	13935
Inorganics					
Aluminum	13435	4356	95	1276325	413852
Arsenic	13.9	2.95	44	612	130
Iron	15600	3597	450	7020000	1618825
Lead	77.5	18.2	49	3798	892
Manganese	124	61.4	373	46252	22915
Mercury	0.12	0.065	3760	451	244

Notes:
(1) - BCFs obtained from Table F-2 in Appendix F unless otherwise noted.
(2) - Estimated fish tissue concentration = bioconcentration factor x surface water concentration.

TABLE 6-10

VALUES USED FOR DAILY INTAKE CALCULATIONS
CONSTRUCTION WORKERS EXPOSED TO SURFACE SOIL
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	N/A	N/A	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	480	EPA, 1993	N/A	N/A	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	N/A	N/A	
	FI	Fraction Ingested	unitless	1	EPA, 1993	N/A	N/A	
	EF	Exposure Frequency	days/year	125	EPA, 1993	N/A	N/A	
	ED	Exposure Duration	years	1	(1)	N/A	N/A	
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989	N/A	N/A	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	N/A	N/A	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	N/A	N/A	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	4100	(2)	N/A	N/A	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.5	EPA, 1998	N/A	N/A	
	DABS	Absorption Factor	unitless	See Text	See Text	N/A	N/A	
	EF	Exposure Frequency	days/year	125	EPA, 1993	N/A	N/A	
	ED	Exposure Duration	years	1	(1)	N/A	N/A	
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989	N/A	N/A	

Notes:
1 - Professional judgment
2 - Assume hands, forearms, and head are exposed (EPA, 1992a).
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.
U.S. EPA, 1992a: Dermal Exposure Assessment: Principles and Applications.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-11

VALUES USED FOR DAILY INTAKE CALCULATIONS
CONSTRUCTION WORKERS EXPOSED TO GROUNDWATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	2490	(1)	NA	NA	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	(2)	NA	NA	
	ET	Exposure Time	hours/event	8	(2)	NA	NA	
	EF	Exposure Frequency	days/year	21	EPA, 1993	NA	NA	
	ED	Exposure Duration	years	1	(2)	NA	NA	See text for calculation of DAevent.
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989	NA	NA	

Notes:
1 - Assumes forearms and hands are exposed (EPA, 1992a)
2 - Professional judgment
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1992a: Dermal Exposure Assessment: Principles and Applications.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..

TABLE 6-12

VALUES USED FOR DAILY INTAKE CALCULATIONS
CONSTRUCTION WORKERS EXPOSED TO SEDIMENTS
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text.	See Text.	NA	NA	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	480	EPA, 1993	NA	NA	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	
	FI	Fraction Ingested	unitless	1	EPA, 1993	NA	NA	
	EF	Exposure Frequency	days/year	21	(1)	NA	NA	
	ED	Exposure Duration	years	1	(1)	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989	NA	NA	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text.	See Text.	NA	NA	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	4100	(2)	NA	NA	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.5	EPA, 1997	NA	NA	
	DABS	Absorption Factor	unitless	See Text.	- -	NA	NA	
	EF	Exposure Frequency	days/year	21	(1)	NA	NA	
	ED	Exposure Duration	years	1	(1)	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment
2 - Assume hands, forearms, and head are exposed (EPA, 1992a).
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1992a: Dermal Exposure Assessment: Principles and Applications.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
U.S. EPA, 1997b: Exposure Factors Handbook, EPA/600/P-95/002Fa.

TABLE 6-13

VALUES USED FOR DAILY INTAKE CALCULATIONS
CONSTRUCTION WORKERS EXPOSED TO SURFACE WATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	CR	Contact Rate	L/hour	0.01	EPA, 1995	NA	NA	$\frac{CW \times CR \times CF \times ET \times EF \times ED}{BW \times AT}$
	CF	Conversion factor	ug/mg	0.001	- -	NA	NA	
	ET	Exposure Time	hours/event	8	(1)	NA	NA	
	EF	Exposure Frequency	events/year	21	EPA, 1995	NA	NA	
	ED	Exposure Duration	years	1	(1)	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989	NA	NA	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	2490	(1)	NA	NA	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	(1)	NA	NA	
	ET	Exposure Time	hours/event	8	EPA, 1989	NA	NA	
	EF	Exposure Frequency	days/year	21	EPA, 1995	NA	NA	
	ED	Exposure Duration	years	1	(1)	NA	NA	See text for calculation of DAevent.
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..
U.S. EPA Region 4, 1995a: Supplement Guidance to RAGS: Region 4 Bulletins. Exposure Assessment Human Health Risk Assessment Bulletin No. 3.

TABLE 6-14

VALUES USED FOR DAILY INTAKE CALCULATIONS
MAINTENANCE WORKERS EXPOSED TO SURFACE SOIL
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	N/A	N/A	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	100	EPA, 1993	N/A	N/A	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	N/A	N/A	
	FI	Fraction Ingested	unitless	1	EPA, 1993	N/A	N/A	
	EF	Exposure Frequency	days/year	50	(1)	N/A	N/A	
	ED	Exposure Duration	years	25	EPA, 1993	N/A	N/A	
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	9125	EPA, 1989	N/A	N/A	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	N/A	N/A	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	N/A	N/A	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	4100	(2)	N/A	N/A	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.2	EPA, 1998	N/A	N/A	
	DABS	Absorption Factor	unitless	See Text	See Text	N/A	N/A	
	EF	Exposure Frequency	days/year	50	(1)	N/A	N/A	
	ED	Exposure Duration	years	25	EPA, 1993	N/A	N/A	
	BW	Body Weight	kg	70	EPA, 1993	N/A	N/A	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	N/A	N/A	
	AT-N	Averaging Time (Non-Cancer)	days	9125	EPA, 1989	N/A	N/A	

Notes:
1 - Professional judgment
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-15

VALUES USED FOR DAILY INTAKE CALCULATIONS
MAINTENANCE WORKERS EXPOSED TO SEDIMENT
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	100	EPA, 1993	NA	NA	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	
	FI	Fraction Ingested	unitless	1	EPA, 1993	NA	NA	
	EF	Exposure Frequency	days/year	25	(1)	NA	NA	
	ED	Exposure Duration	years	25	EPA, 1993	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	9125	EPA, 1989	NA	NA	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	4100	(2)	NA	NA	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.2	EPA, 1998	NA	NA	
	DABS	Absorption Factor	unitless	See Text	See Text	NA	NA	
	EF	Exposure Frequency	days/year	25	(1)	NA	NA	
	ED	Exposure Duration	years	25	EPA, 1993	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	9,125	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
U.S. EPA, 1997b: Exposure Factors Handbook, EPA/600/P-95/002Fa.
U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-16

VALUES USED FOR DAILY INTAKE CALCULATIONS
ADOLESCENT RECREATIONAL USERS EXPOSED TO SURFACE SOIL
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	100	(1)	NA	NA	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	
	FI	Fraction Ingested	unitless	1	EPA, 1993	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	10	(1)	NA	NA	
	BW	Body Weight	kg	45	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	3650	EPA, 1989	NA	NA	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	3820	(2)	NA	NA	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.2	EPA, 1998	NA	NA	
	DABS	Absorption Factor	unitless	See Text	See Text	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	10	(1)	NA	NA	
	BW	Body Weight	kg	45	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	3650	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
U.S. EPA, 1997b: Exposure Factors Handbook, EPA/600/P-95/002Fa.
U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-17

VALUES USED FOR DAILY INTAKE CALCULATIONS
ADOLESCENT RECREATIONAL USERS EXPOSED TO SEDIMENT
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	100	(1)	NA	NA	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	
	FI	Fraction Ingested	unitless	1	EPA, 1993	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	10	(1)	NA	NA	
	BW	Body Weight	kg	45	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	3650	EPA, 1989	NA	NA	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	3820	(2)	NA	NA	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.2	EPA, 1998	NA	NA	
	DABS	Absorption Factor	unitless	See Text	See Text	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	10	(1)	NA	NA	
	BW	Body Weight	kg	45	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	3650	EPA, 1989	NA	NA	

Notes:

1 - Professional judgment

2 - Assume 25 percent of total body surface area available for contact.

Sources:

U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

U.S. EPA, 1997b: Exposure Factors Handbook, EPA/600/P-95/002Fa.

U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-18

VALUES USED FOR DAILY INTAKE CALCULATIONS
ADOLESCENT RECREATIONAL USERS EXPOSED TO SURFACE WATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	CR	Contact Rate	L/hour	0.01	EPA, 1988	NA	NA	$\frac{CW \times CR \times CF \times ET \times EF \times ED}{BW \times AT}$
	CF	Conversion factor	ug/mg	0.001	- -	NA	NA	
	ET	Exposure Time	hours/event	2.6	EPA, 1988	NA	NA	
	EF	Exposure Frequency	events/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	10	(1)	NA	NA	
	BW	Body Weight	kg	45	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	3650	EPA, 1989	NA	NA	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	3820	(2)	NA	NA	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	(1)	NA	NA	
	ET	Exposure Time	hours/event	2.6	EPA, 1988	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	10	(1)	NA	NA	See text for calculation of DAevent.
	BW	Body Weight	kg	45	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	3650	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1988: Superfund Exposure Assessment Manual.
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..
U.S. EPA, 1997b: Exposure Factors Handbook, EPA/600/P-95/002Fa.

TABLE 6-19

VALUES USED FOR DAILY INTAKE CALCULATIONS
ADULT RECREATIONAL USERS EXPOSED TO SURFACE SOIL
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	100	(1)	NA	NA	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	
	FI	Fraction Ingested	unitless	1	EPA, 1993	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	6	(1)	NA	NA	
	BW	Body Weight	kg	70	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	5700	(2)	NA	NA	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.2	EPA, 1998	NA	NA	
	DABS	Absorption Factor	unitless	See Text	See Text	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	6	(1)	NA	NA	
	BW	Body Weight	kg	70	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
U.S. EPA, 1997b: Exposure Factors Handbook, EPA/600/P-95/002Fa.
U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-20

VALUES USED FOR DAILY INTAKE CALCULATIONS
ADULT RECREATIONAL USERS EXPOSED TO SEDIMENT
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	100	(1)	NA	NA	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	
	FI	Fraction Ingested	unitless	1	EPA, 1993	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	6	(1)	NA	NA	
	BW	Body Weight	kg	70	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	5700	(2)	NA	NA	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.2	EPA, 1998	NA	NA	
	DABS	Absorption Factor	unitless	See Text	See Text	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	6	(1)	NA	NA	
	BW	Body Weight	kg	70	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
U.S. EPA, 1997b: Exposure Factors Handbook, EPA/600/P-95/002Fa.
U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-21a

VALUES USED FOR DAILY INTAKE CALCULATIONS
ADULT RECREATIONAL USERS EXPOSED TO SURFACE WATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	CR	Contact Rate	L/hour	0.01	EPA, 1988	NA	NA	$\frac{CW \times CR \times CF \times ET \times EF \times ED}{BW \times AT}$
	CF	Conversion factor	ug/mg	0.001	- -	NA	NA	
	ET	Exposure Time	hours/event	2.6	EPA, 1988	NA	NA	
	EF	Exposure Frequency	events/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	6	(1)	NA	NA	
	BW	Body Weight	kg	70	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	5700	(2)	NA	NA	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	(1)	NA	NA	
	ET	Exposure Time	hours/event	2.6	EPA, 1988	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	6	(1)	NA	NA	See text for calculation of DAevent.
	BW	Body Weight	kg	70	EPA, 1997	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1988: Superfund Exposure Assessment Manual.
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..
U.S. EPA, 1997b: Exposure Factors Handbook, EPA/600/P-95/002Fa.

TABLE 6-21b

VALUES USED FOR DAILY INTAKE CALCULATIONS
ADULT RECREATIONAL USERS EXPOSED VIA INGESTION OF FISH
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	Default Value	RME Rationale/ Reference	Site-Specific Value	Site-Specific Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Cfish	Chemical Concentration in fish	mg/kg	See Text	See Text	See Text	See Text	Intake (mg/kg/day) =
	IR	Fish/shellfish ingestion rate	kg/day	0.054	EPA, 1995	0.145	EPA, 1995	$\frac{Cfish \times IR \times FI \times EF \times ED}{BW \times AT}$
	FI	Fraction ingested from source	unitless	1	EPA, 1995	1	EPA, 1995	
	EF	Exposure Frequency	day/year	350	EPA, 1995	45	(1)	
	ED	Exposure Duration	years	30	EPA, 1995	6	(2)	
	BW	Body Weight	kg	70	EPA, 1993	70	EPA, 1993	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	10950	EPA, 1989	2190	EPA, 1989	

Notes:

(1) - Assumes approximately one day a week.

(2) - Assumes two 3 year tours of duty.

EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..

EPA 1995: Supplement Guidance to RAGS: Region 4 Bulletins. Exposure Assessment Human Health Risk Assessment Bulletin No. 3.

TABLE 6-22

VALUES USED FOR DAILY INTAKE CALCULATIONS
ON-SITE CHILD RESIDENTS EXPOSED TO SURFACE SOIL
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	200	EPA, 1993	NA	NA	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	
	FI	Fraction Ingested	unitless	1	EPA, 1993	NA	NA	
	EF	Exposure Frequency	days/year	350	EPA, 1993	NA	NA	
	ED	Exposure Duration	years	6	EPA, 1993	NA	NA	
	BW	Body Weight	kg	15	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	2000	(1)	NA	NA	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.2	EPA, 1998	NA	NA	
	DABS	Absorption Factor	unitless	See Text	See Text	NA	NA	
	EF	Exposure Frequency	days/year	350	EPA, 1993	NA	NA	
	ED	Exposure Duration	years	6	EPA, 1993	NA	NA	
	BW	Body Weight	kg	15	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	

Notes:
1 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-23

VALUES USED FOR DAILY INTAKE CALCULATIONS
ON-SITE CHILD RESIDENTS EXPOSED TO SEDIMENT
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	200	EPA, 1993	NA	NA	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	
	FI	Fraction Ingested	unitless	1	EPA, 1993	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	6	EPA, 1993	NA	NA	
	BW	Body Weight	kg	15	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	1743	(2)	NA	NA	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.2	EPA, 1998	NA	NA	
	DABS	Absorption Factor	unitless	See Text	See Text	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	6	EPA, 1993	NA	NA	
	BW	Body Weight	kg	15	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment.
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-24

VALUES USED FOR DAILY INTAKE CALCULATIONS
ON-SITE CHILD RESIDENTS EXPOSED TO SURFACE WATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	CR	Contact Rate	L/hour	0.01	EPA, 1988	NA	NA	$\frac{CW \times CR \times CF \times ET \times EF \times ED}{BW \times AT}$
	CF	Conversion factor	ug/mg	0.001	- -	NA	NA	
	ET	Exposure Time	hours/event	2.6	EPA, 1988	NA	NA	
	EF	Exposure Frequency	events/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	6	EPA, 1993	NA	NA	
	BW	Body Weight	kg	15	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	2000	(2)	NA	NA	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	(1)	NA	NA	
	ET	Exposure Time	hours/event	2.6	EPA, 1988	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	6	EPA, 1993	NA	NA	See text for calculation of DAevent.
	BW	Body Weight	kg	15	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment.
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1988: Superfund Exposure Assessment Manual.
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..

TABLE 6-25

VALUES USED FOR DAILY INTAKE CALCULATIONS
ON-SITE ADULT RESIDENTS EXPOSED TO SURFACE SOIL
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	100	EPA, 1993	NA	NA	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	
	FI	Fraction Ingested	unitless	1	EPA, 1993	NA	NA	
	EF	Exposure Frequency	days/year	350	EPA, 1993	NA	NA	
	ED	Exposure Duration	years	24	EPA, 1993	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	NA	NA	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	5700	(1)	NA	NA	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.07	EPA, 1998	NA	NA	
	DABS	Absorption Factor	unitless	See Text	See Text	NA	NA	
	EF	Exposure Frequency	days/year	350	EPA, 1993	NA	NA	
	ED	Exposure Duration	years	24	EPA, 1993	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	NA	NA	

Notes:

1 - Assume 25 percent of total body surface area available for contact.

Sources:

U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-26

VALUES USED FOR DAILY INTAKE CALCULATIONS
ON-SITE ADULT RESIDENTS EXPOSED TO SEDIMENT
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	IR-S	Ingestion Rate	mg/day	100	(1)	NA	NA	$\frac{Cs \times IRS \times CF3 \times FI \times EF \times ED}{BW \times AT}$
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	
	FI	Fraction Ingested	unitless	1	EPA, 1993	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	24	EPA, 1993	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	NA	NA	
Dermal	CS	Chemical concentration in soil	mg/kg	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day) =
	CF3	Conversion Factor 3	kg/mg	1.0E-06	- -	NA	NA	$\frac{Cs \times CF3 \times SA \times SSAF \times DABS \times EF \times ED}{BW \times AT}$
	SA	Skin Surface Available for Contact	cm2	5700	(2)	NA	NA	
	SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.07	EPA, 1998	NA	NA	
	DABS	Absorption Factor	unitless	See Text	See Text	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	24	EPA, 1993	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
U.S. EPA, 1998a: Risk Assessment Guidance for Superfund, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 6-27

VALUES USED FOR DAILY INTAKE CALCULATIONS
ON-SITE ADULT RESIDENTS EXPOSED TO SURFACE WATER
SITE 1 - INCINERATOR LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/L	See Text	See Text	NA	NA	Intake (mg/kg/day) =
	CR	Contact Rate	L/hour	0.01	EPA, 1988	NA	NA	$\frac{CW \times CR \times CF \times ET \times EF \times ED}{BW \times AT}$
	CF	Conversion factor	ug/mg	0.001	- -	NA	NA	
	ET	Exposure Time	hours/event	2.6	EPA, 1988	NA	NA	
	EF	Exposure Frequency	events/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	24	EPA, 1993	NA	NA	
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	NA	NA	
Dermal	DAevent	Absorbed dose per event	mg/cm2-event	See Text	See Text	NA	NA	Dermally Absorbed Dose (mg/kg/day)
	SA	Skin Surface Available for Contact	cm2	5700	(2)	NA	NA	$= \frac{DAevent \times EV \times EF \times ED \times SA}{BW \times AT}$
	EV	Event Frequency	events/day	1	(1)	NA	NA	
	ET	Exposure Time	hours/event	2.6	EPA, 1988	NA	NA	
	EF	Exposure Frequency	days/year	45	(1)	NA	NA	
	ED	Exposure Duration	years	24	EPA, 1993	NA	NA	See text for calculation of DAevent.
	BW	Body Weight	kg	70	EPA, 1993	NA	NA	
	AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989	NA	NA	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	NA	NA	

Notes:
1 - Professional judgment
2 - Assume 25 percent of total body surface area available for contact.
Sources:
U.S. EPA, 1988: Superfund Exposure Assessment Manual.
U.S. EPA, 1989a: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
U.S. EPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure..

TABLE 6-28

CANCER TOXICITY DATA - ORAL/DERMAL
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal Cancer Slope Factor (2)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (3) (MM/DD/YY)
Volatile Organics							
Chloroform	6.1E-03	20%	3.1E-02	$(mg/kg/day)^{-1}$	B2	IRIS	10/01/99
Semivolatile Organics							
Benzo(a)pyrene	7.3E+00	31%	2.4E+01	$(mg/kg/day)^{-1}$	B2	IRIS	10/01/99
Bis(2-ethylhexyl)phthalate	1.4E-02	19%	7.4E-02	$(mg/kg/day)^{-1}$	B2	IRIS	10/01/99
Dibenzofuran	NA	100%	NA	$(mg/kg/day)^{-1}$	D	NA	NA
Naphthalene	NA	31%	NA	$(mg/kg/day)^{-1}$	C	IRIS	10/01/99
Pentachlorophenol	1.2E-01	100%	1.2E-01	$(mg/kg/day)^{-1}$	B2	IRIS	10/01/99
Phenanthrene	NA	31%	NA	$(mg/kg/day)^{-1}$	NA	NA	NA
Pesticides/PCBs							
DDE	3.4E-01	70%	4.9E-01	$(mg/kg/day)^{-1}$	B2	IRIS	10/01/99
DDT	3.4E-01	70%	4.9E-01	$(mg/kg/day)^{-1}$	B2	IRIS	10/01/99
alpha-BHC	6.3E+00	70%	9.0E+00	$(mg/kg/day)^{-1}$	B2	IRIS	10/01/99
beta-BHC	1.8E+00	70%	2.6E+00	$(mg/kg/day)^{-1}$	C	IRIS	10/01/99
gamma-chlordane	3.5E-01	50%	7.0E-01	$(mg/kg/day)^{-1}$	B2	IRIS	10/01/99
Inorganics							
Aluminum	NA	10%	NA	$(mg/kg/day)^{-1}$	NA	NA	NA
Antimony	NA	2%	NA	$(mg/kg/day)^{-1}$	NA	NA	NA
Arsenic	1.5E+00	41%	3.7E+00	$(mg/kg/day)^{-1}$	A	IRIS	10/01/99
Barium	NA	7%	NA	$(mg/kg/day)^{-1}$	D	IRIS	10/01/99
Cadmium	NA	1%	NA	$(mg/kg/day)^{-1}$	B1	NA	NA
Iron	NA	15%	NA	$(mg/kg/day)^{-1}$	NA	NA	NA
Lead	NA	15%	NA	$(mg/kg/day)^{-1}$	B2	NA	NA
Manganese	NA	4%	NA	$(mg/kg/day)^{-1}$	D	IRIS	10/01/99

TABLE 6-28

CANCER TOXICITY DATA - ORAL/DERMAL
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal Cancer Slope Factor (2)	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (3) (MM/DD/YY)
Thallium	NA	15%	NA	$(mg/kg/day)^{-1}$	NA	NA	NA
Methyl Mercury	NA	90%	NA	$(mg/kg/day)^{-1}$	C	IRIS	10/01/99
Vanadium	NA	1%	NA	$(mg/kg/day)^{-1}$	NA	NA	NA

Notes:
IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables
1 - USEPA Region IV, February 26, 1996.
2 - CSFdermal = CSForal/Oral to Dermal Adjustment Factor.
3 - For IRIS values, the date IRIS was searched.
For HEAST values, the date of the latest HEAST.

Weight of Evidence:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

TABLE 6-29

NON-CANCER TOXICITY DATA - ORAL/DERMAL
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3) (MM/DD/YY)
Volatile Organics										
Chloroform	Chronic	1E-02	(mg/kg/day)	20%	2.0E-03	(mg/kg/day)	Liver	1000/1	IRIS:IRIS	10/01/99:10/01/99
Semivolatile Organics										
Benzo(a)pyrene	Chronic	NA	(mg/kg/day)	31%	NA	(mg/kg/day)	Cancer	NA	NA	NA
Bis(2-ethylhexyl)phthalate	Chronic	2E-02	(mg/kg/day)	19%	3.8E-03	(mg/kg/day)	Liver	1000/1	IRIS:IRIS	10/01/99:10/01/99
Dibenzofuran	Chronic	4E-03	(mg/kg/day)	100%	4.0E-03	(mg/kg/day)	None Specified	NA	EPAIII	04/12/99
Naphthalene	Chronic	2E-02	(mg/kg/day)	31%	6.2E-03	(mg/kg/day)	Body Weight	3000/1	IRIS:IRIS	10/01/99:10/01/99
Pentachlorophenol	Chronic	3E-02	(mg/kg/day)	100%	3.0E-02	(mg/kg/day)	Liver, Kidney	100/1	IRIS:IRIS	10/01/99:10/01/99
Phenanthrene	Chronic	NA	(mg/kg/day)	31%	NA	(mg/kg/day)	NA	NA	NA	NA
Pesticides/PCBs										
DDE	Chronic	NA	(mg/kg/day)	70%	NA	(mg/kg/day)	Cancer	NA	NA	NA
DDT	Chronic	5E-04	(mg/kg/day)	70%	3.5E-04	(mg/kg/day)	Liver	100/1	IRIS:IRIS	10/01/99:10/01/99
alpha-BHC	Chronic	NA	(mg/kg/day)	70%	NA	(mg/kg/day)	NA	NA	NA	NA
beta-BHC	Chronic	NA	(mg/kg/day)	70%	NA	(mg/kg/day)	NA	NA	NA	NA
gamma-chlordane	Chronic	5E-04	(mg/kg/day)	50%	2.5E-04	(mg/kg/day)	Liver	300/1	IRIS:IRIS	10/01/99:10/01/99
Inorganics										
Aluminum	Chronic	1E+00	(mg/kg/day)	10%	1.0E-01	(mg/kg/day)	Body Weight	NA	EPAIII	04/12/99:05/26/99
Antimony	Chronic	4E-04	(mg/kg/day)	2%	8.0E-06	(mg/kg/day)	Blood	1000/1	IRIS:IRIS	10/01/99:10/01/99
Arsenic	Chronic	3E-04	(mg/kg/day)	41%	1.2E-04	(mg/kg/day)	Skin	3/1	IRIS:IRIS	10/01/99:10/01/99
Barium	Chronic	7E-02	(mg/kg/day)	7%	4.9E-03	(mg/kg/day)	CVS	3/1	IRIS:IRIS	10/01/99:10/01/99
Cadmium	Chronic	5E-04	(mg/kg/day)	1%	5.0E-06	(mg/kg/day)	Kidney	10/1	IRIS:IRIS	10/01/99:10/01/99
Iron	Chronic	3E-01	(mg/kg/day)	15%	4.5E-02	(mg/kg/day)	Blood	NA	EPAIII	04/12/99:05/26/99
Lead	Chronic	NA	(mg/kg/day)	15%	NA	(mg/kg/day)	CNS	NA	NA	NA
Manganese	Chronic	2E-02	(mg/kg/day)	4%	8.0E-04	(mg/kg/day)	CNS	1/1	IRIS:IRIS	10/01/99:10/01/99
Methyl Mercury	Chronic	1E-04	(mg/kg/day)	90%	9.0E-05	(mg/kg/day)	CNS	1-Oct	IRIS:IRIS	10/01/99:10/01/99
Thallium	Chronic	7E-05	(mg/kg/day)	15%	1.1E-05	(mg/kg/day)	None Specified	NA	EPAIII	04/12/99

TABLE 6-29

NON-CANCER TOXICITY DATA - ORAL/DERMAL
SITE 1 - INCINERATOR LANDFILL AND SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3) (MM/DD/YY)
Vanadium	Chronic	7E-03	(mg/kg/day)	1%	7.0E-05	(mg/kg/day)	None Specified	100	HEAST	07/97

Notes:
N/A = Not Applicable
1 - U.S. EPA Region 4, February 26, 1996.
2 - RfDdermal = RfDoral x Oral to Dermal Adjustment Factor
3 For IRIS values date that IRIS was searched.
For HEAST values, provide the date of HEAST.
FOR EPAIII, date of RBC Table.

NA = Not Applicable
IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables
EPAIII = U.S. EPA Region 3 Risk-Based Concentration Table, April 12, 1999b.
CNS = Central Nervous System
CVS = Cardiovascular System

TABLE 6-30

SUMMARY OF CANCER RISKS AND HAZARD INDICES
SITE 1 - INCINERATOR LANDFILL, SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-4}	Chemicals with Cancer Risks >10^{-5}	Chemicals with Cancer Risks >10^{-6}	Hazard Index	Chemicals with HI > 1
Construction Worker	Soil	Ingestion	7.6E-07	--	--	--	1.9	Iron
		Dermal Contact	3.7E-07	--	--	--	0.2	--
		Total	1.1E-06	--	--	--	2.1	Iron
	Groundwater	Dermal Contact	2.4E-09	--	--	--	0.06	--
	Sediment	Ingestion	2.3E-07	--	--	--	0.05	--
		Dermal Contact	3.0E-07	--	--	--	0.005	--
		Total	5.3E-07	--	--	--	0.05	--
	Surface Water	Ingestion	6.5E-08	--	--	--	0.009	--
		Dermal Contact	3.8E-06	--	--	Bis(2-ethylhexyl)phthalate, Pentachlorophenol	0.009	--
		Total	3.9E-06	--	--	Bis(2-ethylhexyl)phthalate, Pentachlorophenol	0.02	--
		Total All Media	4.8E-06				2.2	
Maintenance Worker	Soil	Ingestion	1.6E-06	--	--	Arsenic	0.2	--
		Dermal Contact	1.5E-06	--	--	--	0.04	--
		Total	3.0E-06	--	--	Arsenic	0.2	--
	Sediment	Ingestion	1.4E-06	--	--	--	0.01	--
		Dermal Contact	3.6E-06	--	--	cPAHs	0.002	--
		Total	5.0E-06	--	--	cPAHs	0.01	--
		Total All Media	8.1E-06				0.2	
Adolescent Recreational Users	Soil	Ingestion	8.8E-07	--	--	--	0.2	--
		Dermal Contact	7.7E-07	--	--	--	0.05	--
		Total	1.7E-06	--	--	Arsenic	0.3	--
	Sediment	Ingestion	1.6E-06	--	--	cPAHs	0.03	--
		Dermal Contact	3.8E-06	--	--	cPAHs	0.006	--
		Total	5.4E-06	--	--	cPAHs	0.04	--
	Surface Water	Ingestion	3.5E-07	--	--	--	0.009	--
		Dermal Contact	1.1E-04	--	Bis(2-ethylhexyl)phthalate, Pentachlorophenol	--	0.009	--
		Total	1.1E-04	--	Bis(2-ethylhexyl)phthalate, Pentachlorophenol	--	0.02	--
		Total All Media	1.2E-04				0.3	

TABLE 6-30

SUMMARY OF CANCER RISKS AND HAZARD INDICES
SITE 1 - INCINERATOR LANDFILL, SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-4}	Chemicals with Cancer Risks >10^{-5}	Chemicals with Cancer Risks >10^{-6}	Hazard Index	Chemicals with HI > 1
Adult Recreational Users	Soil	Ingestion	3.4E-07	--	--	--	0.1	--
		Dermal Contact	4.4E-07	--	--	--	0.05	--
		Total	7.8E-07	--	--	--	0.2	--
	Sediment	Ingestion	6.1E-07	--	--	--	0.02	--
		Dermal Contact	2.2E-06	--	--	cPAHs	0.006	--
		Total	2.8E-06	--	--	cPAHs	0.03	--
	Surface Water	Ingestion	1.4E-07	--	--	--	0.006	--
		Dermal Contact	6.3E-05	--	Bis(2-ethylhexyl)phthalate, Pentachlorophenol	--	0.006	--
		Total	6.4E-05	--	Bis(2-ethylhexyl)phthalate, Pentachlorophenol	--	0.01	--
		Total All Media	6.7E-05				0.2	
	Fish (Maximum concentration in surface water)	Conservative	2.0E-03	Pentachlorophenol, Arsenic	Bis(2-ethylhexyl)phthalate	--	24	Dibenzofuran, Pentachlorophenol, Arsenic, Iron, Manganese
		Site-Specific	1.4E-04	Pentachlorophenol	Arsenic	Bis(2-ethylhexyl)phthalate	8.2	Iron
	Fish (Average concentration in surface water)	Conservative	6.0E-04	Pentachlorophenol	Arsenic	Bis(2-ethylhexyl)phthalate	6.5	Iron
		Site-Specific	4.1E-05	--	Pentachlorophenol	Arsenic	2.2	Iron
Child Resident	Soil	Ingestion	2.5E-05	--	Arsenic	cPAHs, 4,4'-DDT	10	Antimony, Iron
		Dermal Contact	5.6E-06	--	--	cPAHs, Arsenic	0.6	--
		Total	3.0E-05	--	Arsenic	cPAHs, 4,4'-DDT	11	Antimony, Iron
	Sediment	Ingestion	5.7E-06	--	--	cPAHs, Arsenic	0.2	--
		Dermal Contact	3.1E-06	--	--	cPAHs	0.008	--
		Total	8.8E-06	--	--	cPAHs, Arsenic	0.2	--
	Surface Water	Ingestion	6.4E-07	--	--	--	0.03	--
		Dermal Contact	1.0E-04	--	Bis(2-ethylhexyl)phthalate, Pentachlorophenol	--	0.03	--
		Total	1.0E-04	--	Bis(2-ethylhexyl)phthalate, Pentachlorophenol	--	0.06	--
		Total All Media	1.4E-04				11	

TABLE 6-30

SUMMARY OF CANCER RISKS AND HAZARD INDICES
SITE 1 - INCINERATOR LANDFILL, SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks >10^{-4}	Chemicals with Cancer Risks >10^{-5}	Chemicals with Cancer Risks >10^{-6}	Hazard Index	Chemicals with HI > 1
Adult Resident	Soil	Ingestion	1.1E-05	--	--	cPAHs, Arsenic	1.1	--
		Dermal Contact	4.8E-06	--	--	Arsenic	0.1	--
		Total	1.5E-05	--	Arsenic	cPAHs	1.2	--
	Sediment	Ingestion	2.5E-06	--	--	cPAHs	0.02	--
		Dermal Contact	3.0E-06	--	--	cPAHs	0.002	--
		Total	5.5E-06	--	--	cPAHs	0.02	--
	Surface Water	Ingestion	5.5E-07	--	--	--	0.006	--
		Dermal Contact	2.5E-04	Pentachlorophenol	Bis(2-ethylhexyl)phthalate	--	0.006	--
		Total	2.5E-04	Pentachlorophenol	Bis(2-ethylhexyl)phthalate	--	0.01	--
		Total All Media	2.8E-04				1.3	
Lifelong Resident	Soil	Ingestion	3.5E-05	--	Arsenic	cPAHs, 4,4'-DDE, 4,4'-DDT	NA	--
		Dermal Contact	1.0E-05	--	--	Arsenic	NA	--
		Total	4.6E-05	--	Arsenic	cPAHs, 4,4'-DDE, 4,4'-DDT	NA	--
	Sediment	Ingestion	8.2E-06	--	--	cPAHs, Arsenic	NA	
		Dermal Contact	6.1E-06	--	--	cPAHs	NA	
		Total	1.4E-05	--	cPAHs	Arsenic	NA	--
	Surface Water	Ingestion	1.2E-06	--	--	--	NA	--
		Dermal Contact	3.6E-04	Bis(2-ethylhexyl)phthalate, Pentachlorophenol	--	--	NA	--
		Total	3.6E-04	Bis(2-ethylhexyl)phthalate, Pentachlorophenol	--	--	NA	--
		Total All Media	4.2E-04				NA	

TABLE 6-31

REMEDIAL GOAL OPTIONS FOR SOIL
SITE 1 - INCINERATOR LANDFILL, SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONSTRUCTION WORKERS							
	EPA	Target Cancer Risk Level			Target Hazard Index		
Chemical	RBC (1) (mg/kg)	10^{-6} (mg/kg)	10^{-5} (mg/kg)	10^{-4} (mg/kg)	0.1 (mg/kg)	1 (mg/kg)	3 (mg/kg)
Iron	610,000	NTX	NTX	NTX	12,421	124,213	372,640

CHILD RESIDENTS							
	EPA	Target Cancer Risk Level			Target Hazard Index		
Chemical	RBC (2) (mg/kg)	10^{-6} (mg/kg)	10^{-5} (mg/kg)	10^{-4} (mg/kg)	0.1 (mg/kg)	1 (mg/kg)	3 (mg/kg)
Antimony	31	NTX	NTX	NTX	2.84	28.4	85.3
Iron	23,000	NTX	NTX	NTX	8,490	84,904	254,711

1 - USEPA Region III RBC for industrial exposures to soil, April 12, 1999.
1 - USEPA Region III RBC for residential exposures to soil, April 12, 1999.

TABLE 6-32

REMEDIAL GOAL OPTIONS FOR SURFACE WATER
SITE 1 - INCINERATOR LANDFILL, SWMU 41 - FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CHILD RESIDENTS							
	EPA	Target Cancer Risk Level			Target Hazard Index		
Chemical	NRWQC (1) (ug/L)	10^{-6} (ug/L)	10^{-5} (ug/L)	10^{-4} (ug/L)	0.1 (ug/L)	1 (ug/L)	3 (ug/L)
Bis(2-ethylhexyl)phthalate	0.28	1.6	16	160	3.8	38	115

ADULT RESIDENTS							
	EPA	Target Cancer Risk Level			Target Hazard Index		
Chemical	NRWQC (1) (ug/L)	10^{-6} (ug/L)	10^{-5} (ug/L)	10^{-4} (ug/L)	0.1 (ug/L)	1 (ug/L)	3 (ug/L)
Pentachlorophenol	1.8	0.65	6.5	65	81	806	2419

LIFELONG RESIDENTS							
	EPA	Target Cancer Risk Level			Target Hazard Index		
Chemical	NRWQC (1) (ug/L)	10^{-6} (ug/L)	10^{-5} (ug/L)	10^{-4} (ug/L)	0.1 (ug/L)	1 (ug/L)	3 (ug/L)
Bis(2-ethylhexyl)phthalate	1.8	0.47	4.7	47	NA	NA	NA
Pentachlorophenol	0.28	0.46	4.6	46	NA	NA	NA

Notes:
(1) - U.S. EPA National Recommended Water Quality Criteria (NRWQC), April 1999,
NA - Not applicable.

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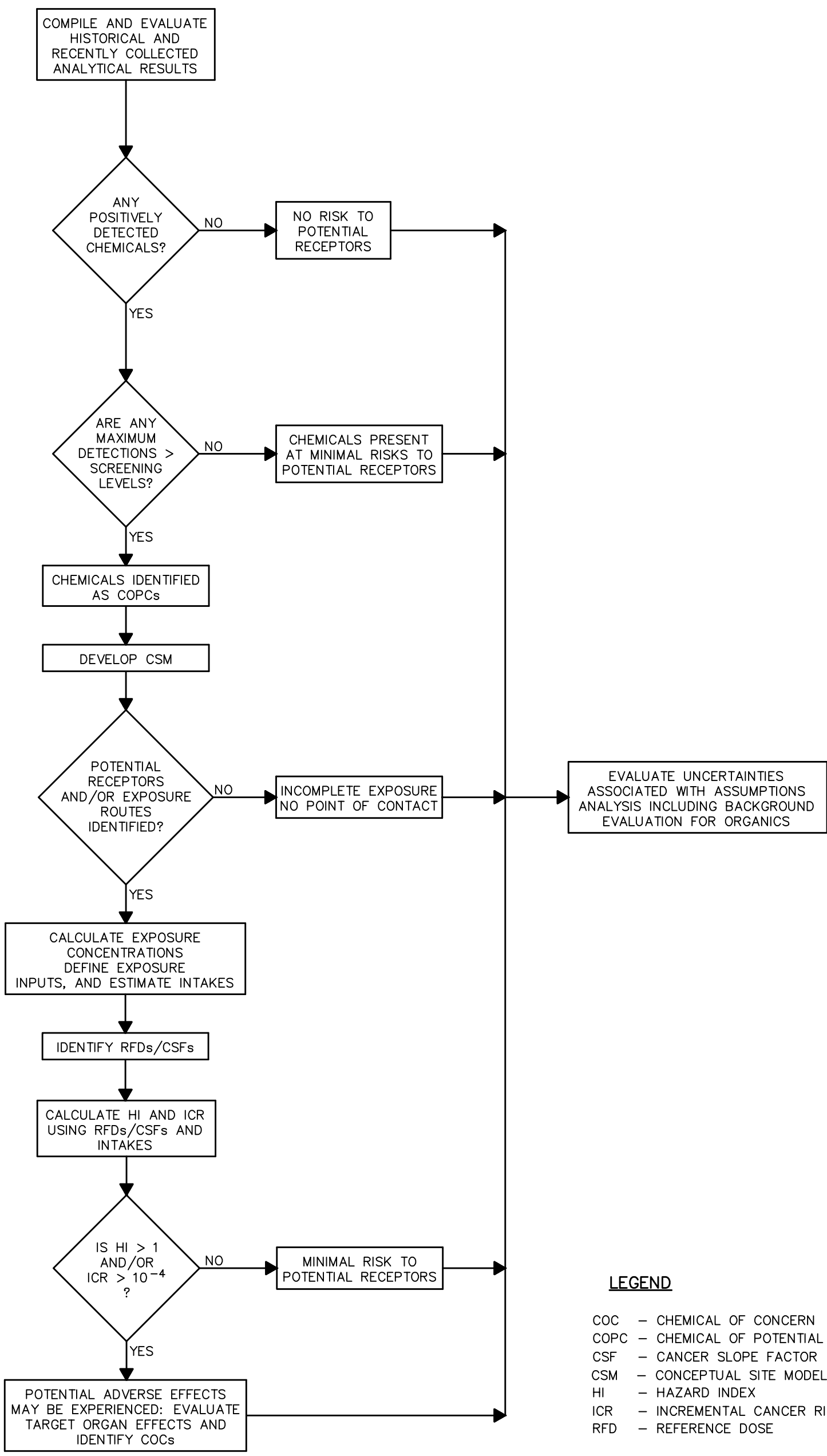

LEGEND

COC – CHEMICAL OF CONCERN
COPC – CHEMICAL OF POTENTIAL CONCERN
CSF – CANCER SLOPE FACTOR
CSM – CONCEPTUAL SITE MODEL
HI – HAZARD INDEX
ICR – INCREMENTAL CANCER RISK
RFD – REFERENCE DOSE

DRAWN BY NS DATE 9/28/99	SUMMARY OF HUMAN HEALTH RISK ASSESSMENT PROCESS SITE 1–INCINERATOR LANDFILL SITE 41–FORMER INCINERATOR MCRD PARRIS ISLAND, SOUTH CAROLINA	CONTRACT NO. 7803	
CHECKED BY DATE		APPROVED BY DATE	
COST/SCHED–AREA		APPROVED BY DATE	
SCALE NONE		DRAWING NO. FIGURE 6–1	REV. 0

FORM CADD NO. SDIV_BV.DWG – REV 0 – 1/20/98

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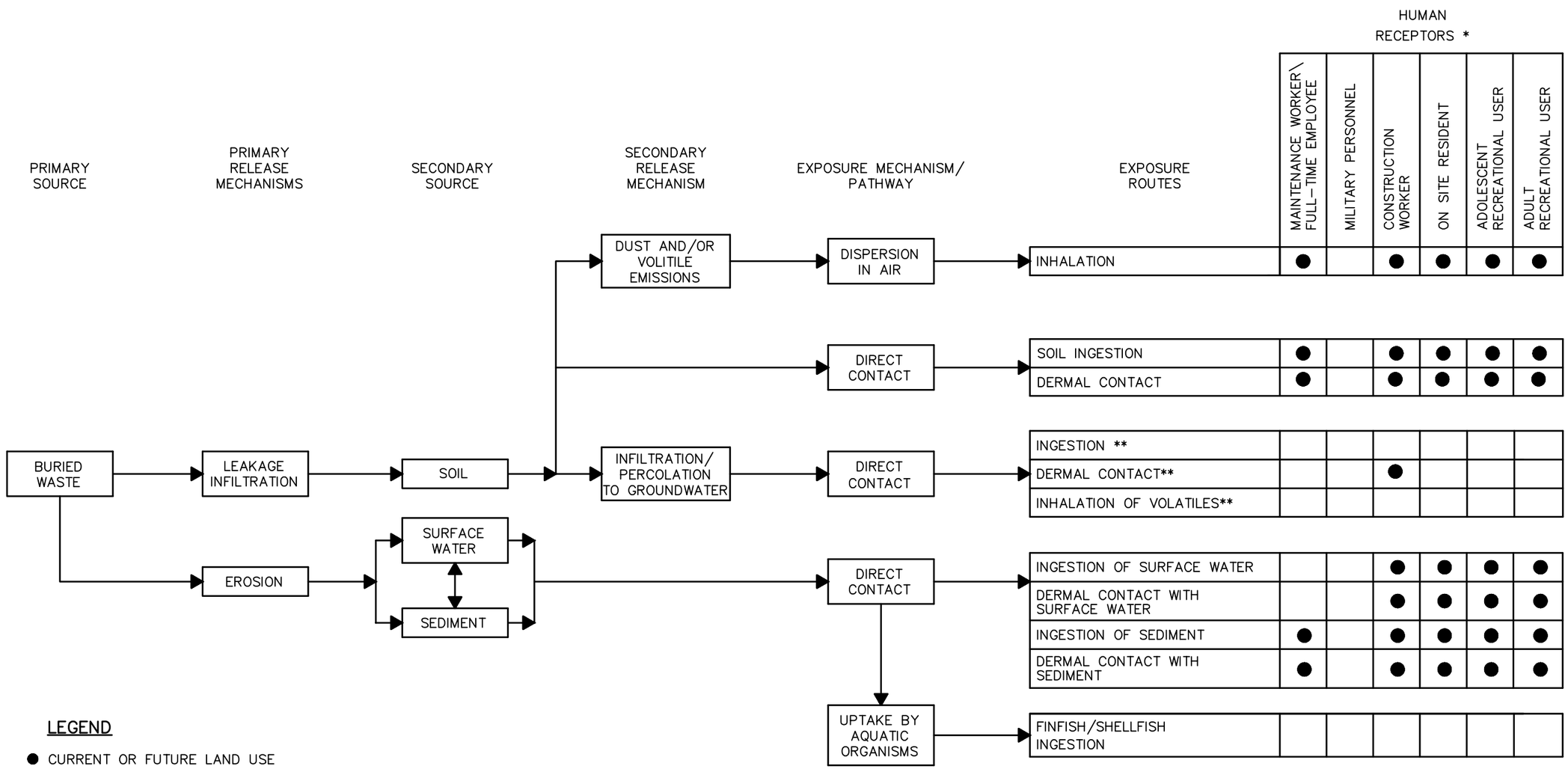

LEGEND

● CURRENT OR FUTURE LAND USE

* SOME RECEPTORS COULD BE EXPOSED VIA MORE THAN ONE PATHWAY.

** THE ONLY CURRENT ANTICIPATED EXPOSURE TO GROUNDWATER IS DURING EXCAVATION. INTENTIONAL USE OF GROUNDWATER IS ASSUMED AS A POTENTIAL PATHWAY TO RESIDENTS UNLESS SUSPECTED POOR QUALITY AND LIMITED MIGRATION IS CONFIRMED DURING SAMPLING.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY NS DATE 9/28/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE NONE

CONCEPTUAL SITE MODEL
SITE 1-INCINERATOR LANDFILL
SITE 41-FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7803
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 6-2
REV. 0

FORM CADD NO. SDV_BH12.DGN - REV 0 - 1/20/98

7.0 ECOLOGICAL RISK ASSESSMENT

The RI process requires an assessment of the potential adverse effects of site contamination on the environment. Specifically, ecological receptors that utilize Site/SWMU 1 (Site 1) and SWMU 41 and nearby areas could be at risk from environmental contamination associated with these areas. For this reason, an ecological risk assessment (ERA) was performed to characterize the potential risks from site-related contaminants to ecological receptors.

7.1 OVERVIEW OF METHODS

This section provides an outline of the general approach that was taken to assess the impacts of site contamination on ecological receptors. This assessment generally followed a two-step process, as follows:

Step 1: Preliminary Problem Formulation (Section 7.2) and Ecological Effects Evaluation (Section 7.3)

- Preliminary Problem Formulation - This first phase of an ecological risk assessment discusses the goals, breadth, and focus of the assessment. It includes general descriptions of the site, with emphasis on the habitats and ecological receptors that are present. This phase also involves characterization of contaminant sources and migration pathways, evaluation of routes of contaminant exposure, and selection of analytes to be assessed. Assessment and measurement endpoints are also selected in this phase, and a conceptual model is developed that describes how contaminants associated with Site 1 and SWMU 41 may come into contact with ecological receptors.

- Preliminary Ecological Effects Evaluation - In this phase, medium-specific ecological screening guidelines for each analyte (i.e., concentrations of each contaminant above which adverse effects to ecological receptors may occur) are identified. Contaminant doses associated with toxicity to representative ecological receptors are also identified. This step is undertaken concurrently with the exposure assessment described below.

Step 2: Preliminary Exposure Assessment (Section 7.4) and Risk Calculation (Section 7.5)

- Preliminary Exposure Estimate - This portion of the ecological risk assessment includes the identification of data used to represent concentrations of contaminants to which ecological receptors may be exposed in various media and the selection of exposure point contaminant concentrations from those data. Contaminant doses for representative receptors are also calculated.

- Preliminary Risk Calculation - In this step, exposure point concentrations are compared to guidelines in order to characterize potential risk to ecological receptors. Contaminant doses associated with toxicity are compared to calculated doses for representative receptors. Analytes that are found to pose potential risk after these comparisons are selected as ecological contaminants of potential concern (COPCs).

When these two steps are completed, the results are interpreted, ecological contaminants of concern (COCs) are selected, and the uncertainties associated with the ecological risk assessment are addressed. COCs are COPCs that are shown to present unacceptable risks to ecological receptors based on their concentrations, distributions, and modes of toxicity. The above process, described in further detail below, represents the general approach recommended in the most recent U.S. EPA guidance for performing ecological risk assessments (U.S. EPA, 1997b; 2000a), which served as the basis for the ecological risk assessment methodology. Furthermore, the ecological risk assessment was conducted in accordance with Navy policy (DON, 1999) and other available guidance documents and publications (Suter, 1993; Calabrese and Baldwin, 1993; U.S EPA, 1995b; Wentsel et al., 1996; Ingersoll et al., 1997). The methods used in this ecological risk assessment and discussed below were summarized in the Master Work Plan for MCRD Parris Island (B&R Environmental, 1998b). Revisions to the Master Work Plan have been discussed with the MCRD Parris Island partnering team.

Due to the potential complexity of ecological risk assessments, they are often conducted using a tiered approach and punctuated with Scientific/Management Decision Points (SMDPs). SMDPs are meetings involving the risk managers and risk assessment team and are conducted to evaluate the work up to that point and to ensure that the ecological risk assessment is proceeding in an efficient manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met. The results are then used to identify the data required for the next tier, if necessary. The Tier 1 ecological risk assessment is also known as a screening risk assessment. The screening risk assessment uses conservative (i.e., stringent) assumptions to evaluate site data and determine whether additional ecological risk assessment or accelerated site cleanup may be warranted or that the site poses negligible ecological risks.

The second tier is a baseline ecological risk assessment, which is conducted if the results of the screening-level ecological risk assessment indicate that additional study is warranted. The baseline ecological risk assessment is a more focused study of the initial COPCs and comprises Steps 3 through 7 of the eight-step ecological risk assessment process. The baseline ecological risk assessment begins with a more balanced evaluation of the conservativeness inherent in the first two steps of the risk assessment process (U.S. EPA, 1997b; DON, 1999).

EPA Region IV has recently amended their desired approach regarding the implementation of EPA's (1997b) guidance for performing ecological risk assessments. Under the recent guidance (U.S. EPA, 2000a), food chain modeling (i.e., the calculation of estimated doses for representative receptors and the subsequent comparison of estimated doses to contaminant doses associated with toxicity) is conducted in step 3a, rather than in step 2 of the risk assessment. Furthermore in the new approach, food chain modeling is conducted only for COPCs that are known to significantly bioaccumulate or biomagnify. However, the ecological risk assessment for Site 1 and SWMU 41 was drafted prior to the dissemination of the new guidance. Therefore, the risk assessment is organized following the format described in the Master Work Plan for MCRD Parris Island (B&R Environmental, 1998a), which differs in certain aspects from the approach currently recommended by U.S. EPA (2000b). For example, all SVOCs and metals that were identified as COPCs are included in food chain modeling in this risk assessment. In addition, food chain modeling is conducted in Step 2 of this risk assessment. The differences between the procedures used herein and those recommended by Region IV's recent guidance are primarily related to format, and in no case affect the conclusions of the risk assessment.

7.2 PRELIMINARY PROBLEM FORMULATION

7.2.1 Habitat Types and Ecological Receptors

Site 1 (Incinerator Landfill) is located on the northeastern tip of Horse Island. The landfill extends approximately 670 feet into the surrounding marsh, is approximately 400 feet in width, and encompasses approximately 4 acres. An incinerator was formerly located in the landfill area and has been designated as SWMU 41.

The entire upland portion of Site 1 and SWMU 41 is forested. The overstory is dominated by slash pine (*Pinus elliottii*), loblolly pine (*Pinus taeda*), live oak (*Quercus virginiana*), and laurel oak (*Quercus laurifolia*). Other common trees include hackberry (*Celtis laevigata*) and black cherry (*Prunus serotina*). Common understory shrubs include Eastern baccharis (*Baccharis halimfolia*) and wax myrtle (*Myrica cerifera*). Saw palmetto (*Serenoa repens*), oleander (*Nerium oleander*), yaupon (*Ilex vomitoria*), and the exotic Chinese tallowtree (*Sapium sebiferum*) are also present. Common vine species include poison ivy (*Rhus radicans*), Virginia creeper (*Parthenocissus quinquefolia*), muscadine grape (*Vitis rotundifolia*), and greenbriar (*Smilax rotundifolia*). An extensive saltwater marsh is located along the northern, eastern, and western portions of the peninsula on which Site 1 and SWMU 41 are located. The marsh is dominated by cordgrass (*Spartina alterniflora*). Seashore saltgrass (*Distichlis spicata*) and glasswort (*Salicornia virginica*) are present in portions of the marsh/upland interface.

The peninsula is small in areal extent, but nevertheless a variety of wildlife species occurs there. White-tailed deer (*Odocoileus virginianus*) and raccoons *(Procyon lotor*) are known to forage in the area and

gray squirrels (*Sciurus carolinensis*) are common. Other mammalian herbivores expected to occur in the upland portion of the peninsula include the cotton rat (*Sigmodon hispidus*) and the cotton mouse (*Peromyscus gossypinus*). Eastern moles (*Scalopus aquaticus*) exist in some portions of the area. The opossum (*Didelphis virginiana*) and short-tailed shrew (*Blarina carolinensis*) probably forage throughout the area. The marsh rabbit (*Sylvilagus palustris*) and rice rat (*Oryzomys palustris*) probably forage along the edge of the marsh. Mink (*Mustela vison*) and river otters (*Lutra canadensis*) have been observed near Site 1 and SWMU 41 and are assumed to forage on the sites. Other mammalian carnivores expected to occur, at least occasionally, at the sites include the red fox (*Vulpes vulpes*) and striped skunk (*Mephitus mephitus*). A variety of birds, reptiles, and amphibians utilize the sites.

The saltwater marsh provides habitat for a variety of fauna, particularly fish and crustaceans. Several species of animals probably prey upon these fish and crustaceans. These include mammals such as the raccoon, mink, and river otter, and wading birds such as the tricolored heron (*Egretta tricolor*), great blue heron (*Ardea herodias*), green heron (*Butorides striatus)*, and snowy egret (*Egretta thula*). Various shorebirds and wintering waterfowl probably forage in the marsh.

The shallow marsh is alternately flooded and drained by changing tides, and therefore fish in the areas near the sites are largely limited to small schooling species such as mud minnows (*Umbra pygmaea*) and mummichogs (*Fundulus heteroclitus*). However, Archer's Creek is located approximately 50 feet north of the northernmost edge of the peninsula. Fish such as red drum (*Sciaenops ocellatus*), spotted seatrout (*Cynoscion nebulosus*), southern flounder (*Paralichthys lethostigma*), whiting (*Menticirrhus americanus*), and striped mullet (*Mugil cephalus)* are known to occur in Archer's Creek. These and other species probably occur, at least occasionally, in portions of the marsh during high tides.

Threatened and endangered species that could occur at or near the sites consist of the bald eagle (*Haliaeetus leucocephalus*) and wood stork (*Mycteria americana*). An active bald eagle nest is located approximately 1 mile southeast of the sites, and bald eagles (state and federally listed as threatened) could potentially forage on fish in the tidal channel north of the sites. Wood storks (state and federally listed as endangered) forage in various areas throughout the Depot, and they could forage in the marsh surrounding the sites.

Although other endangered and threatened species occur in Beaufort County (Table 2-2 of Volume I, Master Work Plan), the sites provides poor habitats for these species. For example, the manatee (*Trichechus manatus*), shortnose sturgeon (*Acipenser brevirostrum*), and various sea turtles are occasionally observed in the Broad River, Beaufort River, and Port Royal Sound, and the Atlantic bottlenosed dolphin (Tursiops truncatus) is a year-round resident of these areas. (Although not threatened or endangered, dolphins are afforded protection under the Federal Marine Mammal Act.)

However, these species usually are not associated with shallow marshes and narrow tidal channels like those near Site 1 and SWMU 41. With the exception of the bald eagle and wood stork, the likelihood of endangered and threatened species in the vicinity of the sites is probably remote.

7.2.2 Contaminant Sources and Migration Pathways

The contaminant source at Site 1 and SWMU 41 is buried material from historical landfilling activities at the sites. The contaminant migration pathways that were evaluated for the sites include volatilization, wind erosion, overland runoff, and infiltration of contaminants. Constituents in the site soil could volatilize from surficial material or become airborne via wind erosion, although the vegetation and thick layer of pine needles throughout most of the sites minimize the wind erosion pathway. Wind and wave erosion could occur, however, during a major storm event (such as a hurricane). Contaminated fugitive dust could also be generated during ground-disturbing activities, such as construction or excavation. Contaminants could then be dispersed in the surrounding environment and transported to downwind locations where they could become deposited in surface soil, surface water, or sediment.

Precipitation runoff and wave action during storm surges could carry contaminants to nearby surface water and sediment in the tidal marsh. Infiltrating precipitation could cause contamination of subsurface soil and groundwater. Groundwater from the sites could discharge to surface water in the marsh, where groundwater contaminants could be subsequently deposited in sediment or in the tissues of aquatic organisms.

7.2.3 Exposure Routes

Aquatic and semi-aquatic animals in the tidal marsh near the sites could be exposed to contaminants through direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Aquatic vegetation could be exposed to contaminants through foliar uptake and root translocation. Aquatic and semi-aquatic animals and vegetation could also be exposed to constituents from contaminated groundwater that discharges to nearby surface water.

Terrestrial animals could be exposed to soil contaminants through ingestion of contaminated food items. Animals can incidentally ingest soil while grooming fur, preening feathers, digging, grazing close to the soil, or feeding on items to which soil has adhered (such as roots and tubers). Terrestrial invertebrates and larger burrowing animals could be exposed to soil contaminants through direct contact. Terrestrial vegetation could be exposed to contaminants via direct aerial deposition and root translocation. Aerial deposition was not investigated, primarily because the contaminant sources at the sites are largely covered by vegetation and pine needles, reducing the amount of bare soil and fugitive dust. Terrestrial

animal receptors could also come into contact with contaminants in surface water through drinking, although this exposure route represents a negligible portion of total exposure for most receptors (Sample et al., 1996). In addition, the salinity of the surface water in the marsh precludes its use as drinking water. Nevertheless, organisms that prey on aquatic species could incidentally ingest surface water when consuming food items. Therefore, this exposure route was investigated for wading birds and the raccoon.

Exposure to contaminants in the soil via dermal contact may occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons probably minimize transfer of contaminants across dermal tissue. In addition, little information is available (e.g., absorption factors) to evaluate dermal exposures to wildlife.

Inhalation does not represent a significant exposure pathway because air contaminant concentrations are assumed to be quite low, even for burrowing wildlife. In addition, inhalation ecotoxicity data for chronic exposure are lacking. Therefore, the air pathway was not considered for ecological receptors.

7.2.4 Selection of Analytes to be Investigated

Analytes initially included for quantitative analysis were all analytes detected in surface water, sediment, surface soil, and groundwater samples. However, calcium, magnesium, potassium, and sodium were excluded since they are essential nutrients that are toxic only at extremely high concentrations. Due to the scarcity of data for these essential nutrients, it was not possible to develop ranges of toxicity for them even at high concentrations. The limited toxicity data available indicate that high dietary intake of these nutrients is well tolerated. The process that was used to select COPCs from the detected analytes is described in Section 7.5. Profiles describing the environmental fate, transport, and toxicity of COPCs are presented in Appendix F.

7.2.5 Assessment and Measurement Endpoints

One of the major tasks in preliminary problem formulation is the selection of assessment and measurement endpoints. An assessment endpoint is “an explicit expression of actual environmental values that are to be protected” and measurement endpoints are “measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint” (U.S. EPA, 1997b). The assessment endpoints selected for this ecological risk assessment were based on the environmental setting, contaminants known to exist at the sites, contaminant fate and transport mechanisms, exposure pathways, mechanisms of ecotoxicity, and likely categories of receptors that could be affected by site-related contaminants. The assessment endpoints at Site 1 and SWMU 41consist of the protection of the following groups of receptors from adverse effects of site-related contaminants on growth, survival, and reproduction:

- Benthic invertebrate communities
- Fish communities (forage fish and higher trophic level fish)
- Piscivorous birds
- Vermivorous birds
- Omnivorous birds
- Carnivorous birds
- Carnivorous mammals
- Omnivorous mammals
- Herbivorous mammals
- Soil invertebrates
- Mammals that feed on soil invertebrates
- Terrestrial and aquatic vegetation

Amphibians and reptiles are absent from the above list of assessment endpoints since toxicity data for amphibians and reptiles are sparse, resulting in a small, sporadic toxicity database. A discussion of the uncertainties associated with the absence of toxicity data for amphibians and reptiles is provided in Section 7.9.

Measurement endpoints are often used to make inferences about risks to the assessment endpoints, since they are more easily quantified or observed than assessment endpoints. Measurement endpoints for this risk assessment consisted of contaminant concentrations associated with adverse effects on growth, survival, and reproduction of aquatic organisms (surface water screening levels), benthic organisms (sediment screening levels), and terrestrial vegetation and soil invertebrates (surface soil screening levels). In addition, measurement endpoints for representative receptor groups were contaminant doses associated with adverse effects on growth, survival, and reproduction of these receptors. Taken together, the measurement endpoints address all of the groups of receptors chosen as assessment endpoints.

7.2.6 Conceptual Site Model

The conceptual model is designed to diagram the potentially exposed receptor populations and applicable exposure pathways, based on the physical nature of the sites and the potential contaminant source areas. Actual or potential exposures of ecological receptors associated with Site 1 and SWMU 41 were determined by identifying the most likely pathways of contaminant release and transport. A complete exposure pathway has three components: a source of contaminants that can be released to the environment; a route of contaminant transport through an environmental medium; and an exposure route

or contact point for an ecological receptor. A preliminary conceptual model for Site 1 and SWMU 41 is presented in Figure 7-1. Dermal (direct contact) and inhalation exposure routes are included in the conceptual model since they are theoretically possible, but as mentioned earlier, they represent minor exposure routes and were not investigated.

7.3 PRELIMINARY ECOLOGICAL EFFECTS EVALUATION

For this ecological risk assessment, exposure-point concentrations of detected analytes in surface water, groundwater, sediment, and surface soil were compared to ecologically based guidelines to determine if the analytes should be selected as COPCs. In addition, toxic doses of contaminants were compared to modeled doses for representative receptors. The methods used for the selection of ecological screening values are discussed below.

7.3.1 Ecological Screening Values

Maximum concentrations of chemicals detected in Site 1 and SWMU 41 media were initially compared to Region-4-approved ecological screening values (ESVs). If the maximum concentration was less than the ESV, the chemical was eliminated from further consideration. If the maximum concentration equaled or exceeded the ESV, or if an ESV was not available, the chemical was considered to be an ecological COPC and was retained for further study in the ecological risk assessment.

The ESVs used for the initial screening of groundwater, surface water, surface soil, and sediment were those established by EPA Region 4 (U.S. EPA, 2000b). Since Site 1 borders a tidal marsh, the surface water samples were saline (average salinity = 21 ppt). Therefore, salt water ESVs were used for the surface water screening value comparison. Groundwater samples were also saline (average salinity = 20 ppt), and therefore chemical concentrations were compared to surface water ESVs for salt water in accordance with U.S. EPA Region 4 policy (U.S. EPA, 1995b).

Following recent discussions with U.S. EPA Region 4 (ABB, 1997), the ESV for benzo(a)pyrene was used as a surrogate for high molecular weight PAHs when ESVs were not available for those compounds. Likewise, the ESV for naphthalene was used as a surrogate for low molecular weight PAHs and the ESV for diethylhexyl phthalate (DEHP) was used when ESVs were not available for phthalates. The ESV for the most toxic form of each metal was used.

7.3.2 Toxicity Reference Values (TRVs)

Contaminant exposure via the food chain was modeled to investigate potential risks to representative receptors. Toxicity reference values (TRVs), which are contaminant doses associated with adverse

effects on growth, survival, and reproduction, were obtained for comparison to doses that the receptors may receive in the environment. TRVs were preferentially selected that represent a threshold for sublethal effects, such as impairment of reproduction or growth, and were obtained for each type of receptor (e.g., avian carnivore), as discussed below.

Since toxicity data for the specific receptors chosen herein were usually not available, toxicity data from laboratory species were extrapolated to receptor species. Most of the toxicity data were obtained from a comprehensive review of wildlife toxicity data by Sample et al. (1996), but a few values were obtained from other services. Data were also obtained from a U.S. EPA Environmental Response Team (ERT, 1997) report, as well as the Integrated Risk Information System (IRIS) and the Agency for Toxic Substances and Disease Registry (ATSDR) toxicity profiles. No-observed-adverse-effects-levels (NOAELs) and lowest-observed-adverse-effects-levels (LOAELs) were used in the models. Following U.S. EPA Region 4 guidance, LOAELs were divided by a factor of 10 to obtain NOAELs if NOAELs were not available for a contaminant, and VOCs were not included in food chain modeling, since analytes with log K_{ow} values less than 3.5 (VOCs) generally do not accumulate in animal tissue (Suter, 1993). TRVs used in this ecological risk assessment and their sources are presented in Tables 7-1 (mammals) and 7-2 (birds and fish).

7.3.3 Representative Receptors

Species used in the food chain modeling (Table 7-3) were chosen to represent the groups of receptors most likely to be exposed to the highest contaminant concentrations because of their position in the food web, diet (ingestion rate and food type), home range (contained within the area of contamination), and body size. The socio-cultural nature of the receptor species (e.g., threatened or endangered species) was also considered. The selected species are assumed to be representative of other species within the same trophic group or guild and represent the groups of organisms specified in the assessment endpoints. For each of the representative species, information on life history was collected, including diet, body weight, food ingestion rates, and home range. Maximum food ingestion rates and minimum body weights were generally used in the food chain models. Information regarding the representative receptors chosen for this ecological risk assessment is presented below.

7.3.3.1 Short-Tailed Shrew (*Blarina carolinensis*)

The short-tailed shrew was selected as a representative insectivorous small mammal. It can be found in forested areas, brushy areas, and near marshes. It feeds primarily on insects but will prey on earthworms, snails, centipedes, slugs, and even small vertebrates (Burt and Grossenheider, 1980). The short-tailed shrew has a voracious appetite for its body size, and as a result, may receive high doses of contaminants relative to other small mammals. Its home range is approximately 0.5 to 2.4 acres (Cothran

et al 1991; U.S. EPA, 1993), allowing it to potentially spend all or much of its time at Site 1 and SWMU 41.

7.3.3.2 Cotton Mouse (*Peromyscus gossypinus*)

The cotton mouse was chosen as a representative herbivorous small mammal. It is frequently associated with forested areas and moist habitats along the wetland/upland interface (Burt and Grossenheider, 1980). It is common in the Southeast and feeds on grasses, sedges, seeds, fruits, grains, and bark. Since its home range is usually less than 1 acre (U.S. EPA, 1993), it could reside permanently within the sites.

7.3.3.3 Raccoon (*Procyon lotor*)

The raccoon was selected as a representative mammalian omnivore. The raccoon is found in a variety of habitats and particularly in swamps, floodplain forests, and marshes. The raccoon is an opportunistic feeder that will consume terrestrial and aquatic plants and animals. Crustaceans are common forage items for raccoons in marine and estuarine environments, and fish usually comprise less than three percent of the diet (U.S. EPA, 1993). The raccoon is the primary mammalian predator of the blue crab (Darnell, 1959). A common but false belief regarding the raccoon's food habits is that a raccoon always washes its food before eating it. When foraging in shallow water, however, a raccoon will sometimes dip a food item in water prior to eating it (Brown, 1997; Lowery, 1974). The size of a raccoon's home range depends on factors such as age, sex, habitat, food sources, and season. A literature review of several studies reported home ranges of up to 6,000 acres, although values of 200 to 600 acres were most common (U.S. EPA, 1993). Raccoon home ranges during a 1-year period on a Georgia coastal island were 161 acres for adult males and 96 acres for adult females (Lotze, 1979).

7.3.3.4 Red Fox (*Vulpes vulpes*)

The red fox was chosen as a representative mammalian predator. The red fox is common in South Carolina and the entire eastern United States. It is one of only a few mid-size carnivorous mammals in the region. Its principal food items are small mammals (especially mice and voles) but it also preys on insects and birds. The red fox utilizes many habitat types but prefers deciduous woodlands and edge areas. Home ranges vary from 50 to over 3,000 acres, but most values in the literature are within a range of 140 to 2,100 acres (U.S. EPA, 1993). Thus, although the red fox is known to exist at MCRD Parris Island, Site 1 and SWMU 41 would comprise only a small portion of its home range.

7.3.3.5 American Woodcock (*Scolopax minor*)

The American woodcock was selected as a representative vermivorous (earthworm-eating) avian species. It also consumes insects and other soil invertebrates. The species is common in South Carolina and the entire eastern United States. The woodcock prefers moist woodlands and thickets. Its home range varies from approximately 8 to 185 acres (U.S. EPA, 1993).

7.3.3.6 American Robin (*Turdus migratorius*)

The American robin was chosen as a representative omnivorous bird. Common winter food items include seeds and fruit. Insects and invertebrates, especially earthworms, are eaten more frequently in the spring and summer. The robin is common in South Carolina and the entire eastern United States in a variety of habitats. During the non-breeding seasons, robins in South Carolina are joined by migratory individuals from the northern United States, roaming over large areas and usually forming communal roosts within 1 to 2 miles of foraging areas. The home range during breeding season is approximately 0.5 to 2.0 acres (U.S. EPA, 1993). Therefore, a robin might forage exclusively at Site 1 and SWMU 41 only during nesting.

7.3.3.7 Great Blue Heron (*Ardea herodias*)

The great blue heron was selected as a representative avian piscivore. The species is common in South Carolina and the entire eastern United States. It forages primarily in marshes and along gently sloping shorelines, particularly where small fish are plentiful in shallow areas. Fish are the preferred prey, commonly comprising about 90 to 98 percent of the diet, and are usually less than 25 cm in length. Great blue herons will also consume reptiles, amphibians, and crustaceans (U.S. EPA, 1993). Breeding populations in South Carolina are non-migratory. The distance between foraging areas and communal nesting/roosting areas ranges from 0 to 12 miles (U.S. EPA, 1993). Parnell and Soots (1978) found that the average distance between foraging areas and nesting/roosting areas along the North Carolina coast was 4 to 5 miles. While feeding, individual herons defend areas averaging 1.5 to 20 acres (U.S. EPA, 1993).

The MCRD Parris Island Partnering Team recently decided that smaller wading birds such as the green heron (*Butorides striatus*) instead of the great blue heron should be used to represent piscivorous wading birds. However, the ecological risk assessment for Site 1 and SWMU 41 was drafted prior to the Partnering Team decision. A comparison of these two species is presented in Appendix F-5. Food chain hazard quotients for the green heron would be approximately 6 percent greater than food chain hazard quotients for the great blue heron. The reader is advised to keep this in mind when reviewing the food chain hazard quotients presented in Section 7.7.5 and discussed in Section 7.8.

7.3.3.8 Osprey (*Pandion haliaetus*)

In addition to the great blue heron, the osprey was selected as a representative avian piscivore. The osprey would generally be expected to prey on larger fish than the great blue heron. Ospreys are found near freshwater or saltwater, and their diet is almost completely restricted to fish. The distance that ospreys travel from their nests to forage depends on the availability of suitable nest sites near areas with sufficient fish. Most values in the literature for the osprey's foraging radius were within a range of 0.3 to 6 miles (U.S. EPA, 1993).

7.3.3.9 Red-Tailed Hawk (*Buteo jamaicensis*)

The red-tailed hawk was selected as a representative avian carnivore. This hawk is common in South Carolina and the entire eastern United States, and it forages in a variety of habitats. The red-tailed hawk feeds primarily on small mammals but will also consume small birds, lizards, snakes, and insects (U.S. EPA, 1993). Breeding populations in South Carolina are non-migratory. The home range size is highly variable, depending on the available habitat. Mean home ranges varied from 150 to over 4,300 acres in several studies summarized by U.S. EPA (1993). The home range shown in Table 7-3 (940-2,440 acres) represents the data from habitats most similar to those at MCRD Parris Island (U.S. EPA, 1993). The habitat at Site 1 and SWMU 41 would constitute a minor portion of the hawk's foraging area.

7.3.3.10 Mummichog (*Fundulus heteroclitus*)

The mummichog represents a forage fish, i.e., a fish that is a food source of other organisms. The mummichog is one of the most abundant and productive fish species in coastal areas from the Gulf of St. Lawrence to Texas. It inhabits brackish coves, inlets, tidal creeks, and salt marshes. The mummichog feeds primarily on crustaceans, polychaetes, insects, algae, and detritus and is an important food source for many predators. It is one of the most stationary estuarine fish, with a summer home range of approximately 40 yards along tidal creeks; however, some may move as much as 400 yards (Abraham, 1985).

7.3.3.11 Red Drum (*Sciaenops ocellatus*)

The red drum represents upper trophic level fish. This fish is distributed in coastal and estuarine waters from Massachusetts to Mexico. It uses sight and touch to forage primarily on bottom-dwelling animals. Crabs, shrimps, and fish compose the bulk of the diet for adults, and juveniles feed on copepods, amphipods, and small shrimp (Manooch and Raver, 1984; Pattillo et al., 1997). Red drum become sexually mature at 3 years of age. Eggs are spawned in nearshore and inshore waters close to barrier

island passes and channels (Pattillo et al., 1997). Red drum are known to occur in the Broad River and probably occur in the Archer's Creek channel north of Site 1 and SWMU 41.

The body weight of red drum shown in Table 7-3 (1400 grams) and used as representative of red drum in the food chain modeling calculations is the approximate maximum weight of a fish that an osprey can lift and carry (Henny, 1988). Although a bald eagle could carry a fish of more than 1400 grams, most fish preyed upon by the southern sub-species of bald eagle are less than this weight (Stalmaster, 1987).

A sediment ingestion rate could not be located for red drum. However, approximately 15 percent of an adult red drum's diet is composed of detritus (Gerking, 1994). It is assumed that this material is composed entirely of sediment as conservative estimate (Table 7-3).

7.3.3.12 Other Potential Receptors

Potential risks from ingestion of contaminants for organisms such as crustaceans and other aquatic invertebrates cannot be determined using the food chain model since ingestion toxicity data for these receptors do not exist or are not available. For example, body burdens associated with adverse effects on aquatic invertebrates can be found in the literature, but NOAELs for oral doses are rare. It should be noted that ambient water quality criteria (AWQCs) for most contaminants are based, in part, on sensitive aquatic species. Also, sediment guidelines are based on potential risks to sediment invertebrates. Thus, the surface water and sediment screening assessment accounts for the exclusion of the aquatic invertebrate species from the food chain modeling.

The osprey was selected to represent piscivorous birds rather than the bald eagle, since food ingestion on a body weight basis (and thus, the potential dosage) is greater for the osprey than the eagle (U.S. EPA, 1993). Thus, the use of the osprey as a representative piscivorous bird ensures that risks to the bald eagle are also assessed. The great blue heron rather than the wood stork was selected to represent piscivorous birds since data for body weight and food ingestion rate have been better established for the heron than for the wood stork.

7.4 PRELIMINARY EXPOSURE ESTIMATE

7.4.1 Exposure-Point Concentrations

Data used to obtain exposure-point contaminant concentrations in this ecological risk assessment were obtained from samples collected in 1998 and 1999. Raw data are presented in Appendix C. The maximum detected concentrations of analytes in surface water (filtered and unfiltered samples),

sediment, and surface soil were used as exposure-point concentrations and were compared to ecological screening levels.

The maximum detected concentrations in filtered and unfiltered groundwater were used as exposure-point contaminants in that medium. Although aquatic and semi-aquatic organisms will not be directly exposed to groundwater contaminants, they could be exposed via groundwater discharge to aquatic environments. Comparing groundwater concentrations to Region 4 surface water screening levels is a conservative measure of potential impacts to aquatic media from contaminated groundwater discharge. This measure does not take into account dilution at the discharge point(s), the amount of discharge, location of the point(s) of discharge, direction of groundwater flow, or bioavailability of groundwater contaminants.

U.S. EPA Region 4 considers 0- to 1-foot soil samples to be representative of surface soils. Surface soil samples were collected from this depth.

7.4.2 Contaminant Doses for Representative Receptors

Contaminants with maximum concentrations less than Region-4-approved ESVs were dropped from further consideration, and those with concentrations that equaled or exceeded ecological screening levels were retained as preliminary COPCs. A simple food chain model was then used to predict dietary exposures of preliminary COPCs for representative receptor species. The predicted exposures were compared to TRVs in the risk calculation step. Both the maximum and mean concentrations of contaminants were used in the model. Means were calculated using one-half the detection limit for “nondetects” and were used to provide balance to the assessment. The actual dose a receptor receives as the result of indirect or direct exposure is dependent upon the habits of the species and other factors. Mean concentrations were presented in Tables 4-2 (surface soil), 4-5 (surface water), and 4-6 (sediment).

Site 1 and SWMU 41 surface soils were initially assessed separately, and separate COPC tables were generated. Since SWMU 41 is small in areal extent, terrestrial receptors would not forage exclusively at SWMU 41. For this reason, soil data from these two contiguous sites were combined into a single data set for the food chain modeling calculations.

7.4.2.1 Dose Equation

Food chain modeling utilized the following equation to estimate contaminant intake from the ingestion of food and water and incidental ingestion of soil or sediment:

$$PD = [(C_{soil}\ FI * SA * F) + (C_{water} * W * FI) + (C_{food} * F * FA * FI)]/WR$$

where: D = predicted dose from the ingestion of food, water, and the incidental ingestion of soil or sediment (mg/kg/day)

C_{soil} = concentration in soil or sediment (mg/kg)

FI = fractional intake (portion of home range that overlaps affected area; assumed to be 100 percent)

SA = portion of diet that equals soil or sediment

F = food consumed (kg/day)

C_{water} = concentration in water (mg/L)

W = water consumed (L/day)

WR = weight of receptor (kg)

FA = portion of diet consisting of animals or vegetation

C_{food} = contaminant concentration (vegetation or prey; mg/kg)

The contaminant concentration in food (C_{food} in the equation shown above) was calculated using bioaccumulation factors (BAFs), bioconcentration factors (BCFs), and biota sediment accumulation factors (BSAFs) from published sources (see Appendix F). Values of 1.0 were assumed where BAFs, BCFs, and BSAFs were not available.

Surface soil data were used in the food chain modeling to calculate doses to the shrew, mouse, robin, woodcock, fox, and hawk as follows. Chemical concentrations in terrestrial invertebrates (food items of the shrew, robin, and woodcock) were estimated by multiplying each chemical's surface soil concentration by its associated soil-to-invertebrate BAF. Chemical concentrations in vegetation (food items of the mouse and robin) were estimated by multiplying each chemical's surface soil concentration by its associated soil-to-plant BAF. The resulting estimated concentrations in invertebrates and plants were multiplied by the associated food-to-mammal BAF to derive estimated concentrations in the shrew and mouse, respectively. The estimated mammal concentrations were then used to derive an estimated dose to the hawk and fox. Prey items of the hawk and fox were assumed to consist of equal amounts of shrews and mice. Incidental ingestion of surface soil was also included in the dose equations for the shrew, mouse, robin, woodcock, and fox. Incidental ingestion of surface soil is negligible for birds of prey (Sample and Suter, 1994) and therefore was not included in the dose equations for the hawk and osprey.

Sediment data were used to calculate doses to the raccoon, heron, osprey, mummichog, and red drum. Since BSAFs do no exist for inorganic compounds, concentrations of inorganic compounds (i.e., metals) in food items of the raccoon, heron, osprey, mummichog, and red drum were assumed to be equal to sediment concentrations. This is a conservative assumption since accumulation transfer through the food chain does not occur for most metals. Mercury, however, is known to biomagnify in aquatic systems. Therefore, mercury was also assessed using the methodology discussed in Section 7.4.3.1.

The following equation (U.S. EPA, 1997c) was used to estimate tissue concentrations (i.e., the theoretical bioaccumulation potential) of organic compounds in food items of the raccoon, heron, osprey and red drum:

$$TBP = BSAF(C_s/f_{oc})f_l$$

where	TBP	=	theoretical bioaccumulation potential (mg/kg)
	C_s	=	chemical concentration in sediment (mg/kg)
	BSAF	=	biota-sediment accumulation factor (ratio of the concentration of a chemical in tissue, normalized to lipid, to the concentration of the chemical in surface sediment, normalized to organic carbon)
	f_{oc}	=	total organic carbon (TOC) content of sediment expressed as a decimal fraction
	f_l	=	organism lipid content expressed as a decimal fraction

The average TOC in sediment samples at Site 1 was 2.49 percent. Thus, the f_{oc} used in the TBP calculations was 0.0249. Lipid content values were assumed to be 3.5 percent for the mummichog (Iannuzzi, et al., 1996) and 1.1 percent for the red drum (Sullivan and Otwell, 1992). Prey items of the raccoon, heron, and red drum were assumed to consist exclusively of mummichogs, and the osprey was assumed to forage exclusively on red drum.

Incidental ingestion of sediment was also included in the dose equations for the raccoon and red drum but was assumed to be negligible for the heron and osprey (Sample and Suter, 1994). Incidental ingestion of surface water was included in the dose equations for the raccoon and heron.

Because BSAFs have not been generated for inorganic chemicals, a subsequent food chain modeling iteration was also conducted using surface water data. In this iteration, concentrations in prey items of the raccoon, heron, red drum, and osprey were calculated by multiplying fish BCFs by filtered surface water concentrations.

The TBP formula described above was not used to calculate doses to the mummichog. Food items of the mummichog consist of a variety of crustaceans, polychaetes, insects, algae, and detritus (Abraham, 1985) and BSAFs have not been generated for these organisms. Instead, chemical concentrations in food items of the mummichog were conservatively assumed to be equal to measured sediment concentrations.

Most input parameters shown in Table 7-3 for representative receptors were obtained from the Wildlife Exposure Factors Handbook: Volumes I and II (U.S. EPA, 1993). In general, the values used for the input parameters were the most conservative (e.g., upper-bound food ingestion rate) presented in the U.S. EPA publication. Body weights are generally mean weights of males and females from geographic area nearest South Carolina. Wet weight food ingestion rates were calculated as follows:

- Shrew: 0.541 grams food/gram body weight/day (g/g bw/day) (U.S. EPA, 1993).
- Cotton mouse: calculated using rodent equation for food ingestion (g/day): $0.621 \times bw^{0.564}$ (U.S. EPA, 1993); converted to wet weight assuming 50 percent water content in food items (vegetation).
- Raccoon: calculated using mammal equation for food ingestion (g/day): $0.235 \times bw^{0.822}$ (U.S. EPA, 1993); converted to wet weight assuming 75 percent water content in food items (aquatic organisms).
- Red fox: 0.11 g/g bw/day (U.S. EPA, 1993).
- Woodcock: 0.77 g/g bw/day (U.S. EPA, 1993).
- Robin: 0.89 g/g bw/day (U.S. EPA, 1993).
- Heron: 0.18 g/g bw/day (U.S. EPA, 1993).
- Osprey: 0.21 g/g bw/day (U.S. EPA, 1993).
- Hawk: 0.112 g/g bw/day (U.S. EPA, 1993).
- Mummichog: 0.058g/g bw/day (Iannuzzi et al., 1996).
- Red drum: 0.02 g/g bw/day (Evans and Engel, 1994).

7.4.2.2 Ingestion of Surface Water

Since water in the marsh and tidal channel near the Site 1 landfill is saline (18.7 to 23.4 ppt), surface water was not considered to be a source of drinking water. However, some organisms that prey on aquatic species could incidentally ingest surface water while consuming food items. For example, a wading bird or raccoon would probably ingest a small amount of surface water when ingesting aquatic prey. Therefore, the incidental ingestion of unfiltered surface water was investigated for the great blue

heron and raccoon at Site 1. The incidental ingestion of surface water was assumed to be negligible for the other representative receptors listed in Table 7-3, due to their feeding habits. The osprey, for example, usually consumes prey items after carrying them to a perch (e.g., tree or nest) and would not incidentally ingest surface water with the prey item.

A literature review was conducted for data on the amount of surface water incidentally ingested while consuming aquatic prey items. No helpful information was found. Instead, a value was experimentally derived as follows. A euthanized shrimp (11.6 g wet weight) and minnow (0.3 g wet weight), each held by forceps, were submersed in water and then allowed to drip onto a tared, electronic balance. After 60 trials, the average mass of water that dripped from the shrimp was 0.46 g, which equates to 0.0397 g water per gram shrimp (0.46/11.6). After 190 trials, the average mass of water that dripped from the minnow was 0.0484 g, which equates to 0.161 g water per gram minnow (0.0484/0.3). Based on these results, an organism consuming shrimp immediately removed from the water would incidentally ingest an amount of surface water equal to 3.97 percent of the shrimp's body weight. Similarly, consumption of minnows would result in the ingestion of surface water at a ratio of 16.1 percent of the minnow's body weight. The greater of these two values was chosen and conservatively rounded to 20 percent. Thus, daily water consumption in the dose equation for the raccoon and great blue heron was assumed to be 20 percent of the respective food consumption.

7.4.3 Predicted Contaminant Concentrations in Representative Fish Tissue

Toxicity reference values based on oral doses in fish have been established for very few contaminants. Therefore, an assessment of potential toxicity to fish using the methods described in Section 7.4.2 was not possible for some contaminants (e.g., organochlorine pesticides). In order to reduce the uncertainty resulting from the paucity of dose-based toxicity data for fish, a residue-based approach was used for contaminants that are known to biomagnify in the food web. Specifically, this approach was used to assess the potential risks to fish from organochlorine pesticides and mercury and is described below. PCBs are also known to biomagnify in the food web but were not included in this approach since none were detected in surface water or sediment at the site.

7.4.3.1 Mercury in Red Drum

An approach based on a model developed by (NOAA) (Evans and Engel, 1994) was used in which sediment concentrations of mercury are used to predict the mercury tissue concentration in upper trophic-level fish, represented by the red drum. The model assumes that mercury uptake into the red drum occurs exclusively through prey ingestion. The three prey sources are small fish, crustaceans, and infaunal invertebrates. Mercury tissue concentrations in these prey items were estimated as follows.

Small Fish

There are few data available for predicting mercury concentrations in small fish based on mercury concentrations in sediment. In general, there is agreement that the larger species of marine fish with longer life spans usually have the highest concentrations of mercury. Mercury concentrations also increase in fish with increasing body weight. Methyl mercury is the predominant form of mercury that is accumulated.

In a study performed by Walter et al., (1973), wet weight mercury concentrations in carp (*Cyprinus carpio*) and yellow perch (*Perca flavescens*) were compared to dry weight sediment mercury concentrations. Although carp and yellow perch are freshwater fish, they are considered representative of prey species for the red drum in an estuarine environment. Based on the mercury concentrations in sediment, carp tissue, and perch tissue from this study, a biota sediment accumulation factor (BSAF) of 1.2 was derived to represent the transfer of mercury from sediment to small fish tissue, as described by the following equation:

$$Cf = (1.2)\ Cs$$

where: Cf = methyl mercury in small fish (mg/kg)
Cs = total mercury sediment concentration (mg/kg)

It is assumed that 100 percent of mercury present in small fish tissue is methyl mercury. Studies have shown that mercury predominantly occurs in the methyl form in fish muscle, which is also the tissue where most of the mercury body burden is maintained (Windom and Kendall, 1979). In a study performed on four freshwater fish species (Grieb et al., 1990), methyl mercury accounted for 99 percent of the total mercury in fish muscle. Other studies have shown that mercury is converted to its methylated form in fish tissue or by sediment microbes, reducing the significance of the methyl mercury/total mercury ratio during initial deposition or before ingestion.

Crustaceans and Infaunal Invertebrates

Based on reviews of multiple literature sources by Evans and Engel (1994), a BSAF of 2.0 was derived for mercury accumulation by all benthic organisms. This value was divided by 5 to account for the dry weight to wet weight conversion in tissue. It was assumed that 70 percent of mercury in crustacean tissue is methyl mercury and 25 percent of mercury in infaunal invertebrate tissue is methyl mercury (Evans and Engel, 1994). Concentrations of methyl mercury in crustaceans and infaunal invertebrates were estimated as follows:

$$(Ccr) = \frac{(Cs * 2)}{5} * 0.70$$

$$\text{and } Cinv = \frac{(Cs * 2)}{5} * 0.25$$

where	Ccr	=	concentration of methyl mercury in crustaceans
	Cinv	=	concentration of methyl mercury in infaunal invertebrates
	Cs	=	total mercury sediment concentration (mg/kg)

The methyl mercury concentrations from the three prey species were then incorporated into the equation developed by Evans and Engel (1994) to predict wet weight methyl mercury concentrations in the red drum. Red drum are assumed to accumulate mercury from two major sources, prey and surface water. However, surface water is considered to be a minimal exposure route. The diet of the red drum is assumed to consist of crustaceans (60 percent), small fish (30 percent), and other infaunal invertebrates (10 percent). Based on the assumption that input and excretion of methyl mercury are in balance at steady state, the total methyl mercury concentration in red drum tissue can be calculated using the following equation:

$$(a * R/(g+K)) * [(Cf)(\%Cf) + (Ccr)(\%Ccr) + (Cinv)(\%Cinv)]$$

where:

a	=	Assimilation efficiency of mercury from food, or 0.8
R	=	Feeding rate of the red drum, or 0.02/day
g	=	Growth rate coefficient, or 0.003/day
K	=	Methyl mercury excretion rate from the red drum, or 0.00035/day
Cf	=	Methyl mercury tissue concentration in small fish
%Cf	=	Percent of red drum diet composed of small fish/100, or 0.3
Ccr	=	Methyl mercury tissue concentration in crustaceans
%Ccr	=	Percent of red drum diet composed of crustaceans/100, or 0.6
Cinv	=	Methyl mercury tissue concentrations in infaunal benthic invertebrates
%Cinv	=	Percent of red drum diet composed of benthic invertebrates/100, or 0.1

The predicted concentrations of mercury in red drum tissue based on the maximum and average sediment concentrations of mercury were then compared to tissue concentrations considered to be protective of fish and to piscivorous receptors.

7.4.3.2 Pesticides in Fish Tissue

Concentrations of organochlorine pesticides in mummichog tissue were estimated by using the theoretical bioaccumulation potential (TBP) equation for organic compounds developed by U.S. EPA (1997c). This is the same method that was used to estimate contaminant doses (i.e., tissue concentrations in prey items) for representative piscivorous receptors and was described in Section 7.4.2.1. Factors used in the equation (BSAFs, sediment TOC content, and percent lipid) were identical to those previously described in that section. The predicted concentration of pesticides in mummichog tissues based on the maximum and average sediment concentrations of these COPCs were then compared to tissue concentrations considered to be protective of fish and to piscivorous receptors.

The TBP model estimates the bioaccumulation of neutral, non-polar compounds directly from sediment (U.S. EPA, 1997c), and was used was used to estimate pesticide concentrations in mummichog tissue, since this species is in close contact with sediments. The TBP exposure model does not account for exposure routes involving the ingestion of contaminated prey and/or chemicals that biomagnify. Thus, it was not used to estimate tissue concentrations in the red drum, an upper trophic level species that forages primarily on crabs, fish, and shrimp. For this reason, the evaluation of estimated concentrations of pesticides in fish tissue was limited to bottom-foraging fish represented by the mummichog.

7.5 PRELIMINARY RISK CALCULATION

The preliminary risk calculation step in the ecological risk assessment process compared contaminant doses for representative receptors to doses associated with toxic effects (U.S. EPA, 1997b). Prior to this step, the maximum concentrations of contaminants in each medium were compared to Region 4 ESVs. The ratio of the exposure point contaminant concentration to the ESV or the modeled dose to the TRV is called the Hazard Quotient (HQ), defined as follows:

$$HQ_i = EPC_i/ESV_i \text{ or } ID_i /TRV$$

where:

HQ_i	=	Hazard Quotient for analyte “i” (unitless)
EPC_I	=	Exposure Point Concentration for analyte “i” (µg/L or µg/kg or mg/kg)
ESV_i	=	Ecological Screening Value for analyte “i” (µg/L or µg/kg or mg/kg)
ID_i	=	Intake Dose for analyte “i” (mg/kg/day)
TRV_i	=	Toxicity Reference Value for analyte “i” (mg/kg/day)

When the ratio of the exposure point concentration or intake dose to its respective guideline equaled or exceeded 1.0, adverse impacts were considered possible, and the contaminant was retained as a COPC. The HQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an exposure-point concentration or intake dose exceeds or is less than a guideline.

When an HQ value equals or exceeds 1.0, it is an indication that ecological receptors are potentially at risk; additional evaluation or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk, especially since most guidelines are conservatively derived.

The use of HQs is probably the most common method used for risk characterization in ecological risk assessments. Advantages of this method include the following (Barnthouse et al., 1986):

- The HQ method is relatively easy to use, is generally accepted, and can be applied to any data.
- The method is useful when a large number of contaminants must be screened.

This method of risk characterization has some inherent limitations. One primary limitation is that it is a "no/maybe" method for relating toxicity to exposure. That is, it uses single values for exposure concentrations and guidelines. The HQ method does not account for the variability in both these parameters.

The results of the comparison of maximum contaminant concentrations in each medium to Region 4 screening levels are presented in screening tables. The screening tables include the frequency of detection for each analyte, the maximum exposure point concentration, and contaminant-specific Region 4 screening level. Tables were also generated that present the HQ values for each representative receptor used in the food chain modeling using maximum contaminant concentrations. Separate tables are provided for average concentrations.

In summary, the COPC selection process was as follows:

1. The maximum concentrations of detected chemicals in Site 1 surface water, groundwater, sediment, and surface soil and in SWMU 41 surface soil were compared to Region 4 screening levels (ESVs), with the exception of the essential nutrients mentioned earlier. If the maximum concentration was less than the Region 4 ESV, the chemical was dropped from further consideration; if it equaled or exceeded the Region 4 ESV, the chemical was selected as a COPC. If a Region 4 ESV was not available, the chemical was selected as a COPC.

2. All COPCs (except VOCs) identified in surface water, sediment, and surface soil were used in the food chain modeling.

3. Groundwater data were not used in the food chain modeling. Aquatic and semi-aquatic organisms will not be directly exposed to groundwater contaminants. It is assumed that potential groundwater discharge to aquatic environments is taken into account through the evaluation of surface water and sediment COPCs.

7.6 STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN

The methodology presented up to this point describes a “screening-level” assessment, or “Tier 1” assessment, since the assessment is based primarily on a comparison of maximum contaminant concentrations to conservative ecological screening levels. The use of conservative guidelines and maximum detected concentrations in the screening-level assessment is necessary to ensure that potential risks are not underestimated. However, if the hazard quotients derived from comparisons of maximum concentrations to conservative screening levels are used as the single factor for including a COPC in a baseline ecological risk assessment without consideration of other relevant information, additional ecological studies such as toxicity testing or tissue analyses could be undertaken for COPCs that do not actually pose significant risks. For this reason, and since maximum concentrations of several analytes exceed conservative ecological screening levels (see Section 7.7), Step 3a of the risk assessment process was incorporated into this ecological risk assessment (U.S. EPA, 1997b; DON, 1999).

Step 3a (Refinement of COPCs) involves the consideration of factors such as background data (mainly for inorganics), toxicological evaluation of COPCs, frequency of detection, and comparisons of COPCs to alternate guidelines (U.S. EPA, 1997b; DON, 1999). Some factors that are outside the boundaries of the simple concentration ESV comparisons have already been presented, such as average contaminant concentrations and LOAELs in the food chain modeling. The frequency of detection and spatial analysis of elevated contaminant concentrations were also evaluated in Step 3a to determine whether potential risks are widespread or limited to a small area. In addition, the magnitude of the HQs was also considered. As described earlier, the relationship between the magnitude of an HQ and toxicity is not necessarily linear. However, the magnitude of an HQ can be used as a rough approximation of the extent of potential risks, especially if there is sufficient confidence in the guideline used. Background samples have been collected and analyzed as part of current RFI/RI activities at MCRD Parris Island. As a result, soil, sediment, and surface water background data are available for use in assessing the extent to which chemical concentrations at Site 1 are due to site-related activities. Background data are provided in Table 4-1.

The use of less conservative guidelines provides balance to the conservative screening-level assessment. For example, some Region 4 sediment ESVs are based on Effects Range-Low (ER-L) values obtained from Long et al. (1995). However, an ER-L is defined as the concentration below which adverse ecological “effects would rarely be observed,” and the Effects Range-Medium (ER-M) is the point below which adverse effects “would occasionally occur” (Long et al., 1995). Therefore, ascribing risk to a sediment contaminant detected at a concentration that exceeds the ER-L but is below the ER-M can be misleading. For this reason, when contaminant concentrations exceed Region 4 ESVs, or no Region 4

ESV was available, less conservative guidelines are presented for sediment and surface soils. Few sources of ESVs other than Region 4 values are available for surface water. However, a few were located and were cited where applicable.

Alternative sediment guidelines include ER-M values, Probable Effects Levels (PELs) established by the FDEP, guidelines from various U.S. EPA publications, values established by the Ontario Ministry of Environment, and other sources. The PELs are loosely analogous to ER-Ms, which are also presented. The data set used by Long et al. (1995) to develop ER-Ls and ER-Ms was also used by FDEP to develop the PEL values (FDEP, 1994). However, unlike the ER-Ls and ER-Ms, the Threshold Effects Levels (TELs) and PELs also incorporate chemical concentrations observed or predicted to be associated with no adverse biological effects (no effects data). The PEL is the geometric mean of the 50th percentile in the effects data set and 85th percentile in the no effects data set. The PEL represents the lower limit of the range of contaminant concentrations that are usually or always associated with adverse biological effects (FDEP, 1994).

Alternative surface soil guidelines include values from Oak Ridge National Laboratory indicative of toxicity to soil invertebrates and terrestrial plants (Efroymson et al., 1997a, 1997b), U.S. EPA Region 3 (BTAG) screening values for flora and fauna (U.S. EPA, 1995c), Dutch “A” and “B” values (Beyer, 1990), and newer Dutch values (MHSP&E, 1994). Unlike some of the alternate sediment screening values discussed above, the Region III BTAG screening values are not considered to be “less conservative” values. The Region III Biological Technical Assistance Group (BTAG) values were derived to represent “a set of conservative guidelines” for use in the initial screening of data at Superfund sites (U.S. EPA, 1995c). These values are included in Step 3a to supplement the data from the other sources. The Dutch “A” values represent background values, and the “B” values indicate “moderate soil contamination that requires further study” (Beyer, 1990). Newer Dutch values (MHSP&E, 1994) were also utilized. These include target values and intervention values. Target values represent the “soil quality required for the full restoration of the soil’s functionality for human, animal and plant life,” or “soil quality ultimately aimed for.” The intervention values replace the 1990 C values and represent “the concentration levels of the contaminants in the soil . . . above which the functionality of the soil for human, plant, and animal life is seriously impaired or threatened.”

A “weight-of-evidence” approach (U.S. EPA, 1997b) was used to determine the extent of potential risks when HQ values exceeded 1.0, although analytes were automatically selected as COPCs if their maximum concentration HQ exceeded 1.0 after screening against Region 4 ESVs. Conclusions regarding the potential risks associated with Site 1 and SWMU 41, as well as recommendations for additional ecological study or remedial considerations, are presented in Section 8.0.

Note: Subsequent to their review of the first draft of this ecological risk assessment, the MCRD Parris Island Partnering Team determined that the refinement of COPCs would be assisted by the development of tables that summarize the refinement process. Accordingly, the Partnering Team developed an ecological sub-group, which was charged with creating the summary tables. The far right column in the tables (provided in Appendix F-7) indicate whether or not the COPC in question was retained for further evaluation as a COPC in the ecological risk assessment, and the reason for the decision.

7.7 SCREENING RESULTS

The results of the "screening-level" comparisons are presented below and are discussed in Section 7.8.

7.7.1 Surface Water

One VOC, five SVOCs, and 12 metals were COPCs in surface water (Table 7-4). Acetone, a VOC, was a COPC since a Region 4 screening value was not available. Four SVOCs were COPCs since Region 4 screening values were not available. Pentachlorophenol was the only SVOC whose maximum concentration exceeded its screening value; the HQ was 9.2. Region 4 screening values were not available for seven metals, and maximum concentrations of five metals (copper, lead, mercury, silver, and zinc) exceeded screening values. The maximum HQ among the metal COPCs was 21.7 (copper).

Surface water quality parameter data were not qualified. The human health and ecological risks assessments generally factor in uncertainties in the data especially for a transient media such as surface water. Since surface water was not identified as a primary risk driver, there was no need to qualify the data.

7.7.2 Sediment

Three VOCs, 15 SVOCs, nine pesticides, and 15 metals were COPCs in sediment (Table 7-5). Region 4 screening values were not available for any of the three VOCs detected in sediment (acetone, carbon disulfide, and toluene). SVOCs detected in sediment consisted of carbazole and 14 PAH compounds; all had HQs greater than 1.0. The highest SVOC HQ was 257 [(dibenzo(a,h)anthracene]. Sample SD-017 was responsible for the maximum concentration of 10 PAHs. Pesticides that were sediment COPCs consisted of alpha-chlordane, gamma-chlordane, four BHC isomers, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT. The BHC isomers were detected only in sample SD-02-01. The maximum concentrations of the remaining five pesticide COPCs were detected in sample SD-09-01. The highest pesticide HQ was for 4,4'-DDT (HQ=227). Region 4 screening values were not available for eight metals, and seven metals were COPCs because their maximum concentrations equaled or exceeded screening values. The highest metal HQ was for lead (HQ=6.4).

7.7.3 Surface Soil

7.7.3.1 Site 1

Seventeen SVOCs, 10 pesticides, one PCB, and 14 metals were COPCs in surface soil at Site 1 (Table 7-6). Region 4 screening values were not available for four SVOCs and four pesticides. Ten SVOCs (three phthalates and 10 PAHs) had maximum concentrations that exceeded Region 4 screening values. The highest SVOC HQ value was for bis(2-ethylhexyl) phthalate (HQ = 56). HQ values were especially high for 4,4'-DDE (HQ = 1680), 4,4'-DDT (HQ = 1760), and lindane (HQ = 1500). Metals with the highest HQ values were aluminum (HQ = 172), iron (HQ = 735), and lead (HQ = 167.6).

7.7.3.2 SWMU 41

One VOC (acetone), three SVOCs (fluoranthene, phenanthrene, and pyrene), two pesticides (4,4'-DDE and 4,4'-DDT), and eight metals were COPCs in surface soil at SWMU 41 (Table 7-7). Acetone was the only COPC for which a Region 4 screening value was not available. HQ values of the remaining 13 COPCs were relatively low except for 4,4'-DDE (HQ = 17.2), 4,4'-DDT (HQ = 26), aluminum (HQ = 125.8), and iron (HQ = 77.5).

7.7.4 Groundwater

Five analytes in groundwater had HQs greater than 1.0 (Table 7-8). These five COPCs consisted of naphthalene, copper, lead, mercury, and zinc. The highest HQ (9.2) was for mercury. Region 4 screening values were not available for four VOCs, 10 SVOCs, and six metals.

7.7.5 Food Chain Modeling

4,4'-DDT, 4,4'-DDD, 4,4'-DDE, aluminum, antimony, arsenic, barium, cadmium, iron, lead, mercury, vanadium, and zinc had at least one HQ greater than 1.0 for the terrestrial food chain modeling using maximum and mean concentrations of surface soil COPCs (Tables 7-9 and 7-10). Bis(2-ethylhexyl) phthalate, butylbenzyl phthalate, di-n-octyl phthalate, Aroclor 1260, alpha-BHC, delta-BHC, copper, and selenium had HQs greater than 1.0 using the maximum concentrations but not using mean concentrations (Tables 7-9 and 7-10).

4,4'-DDT, 4,4'-DDE, aluminum, arsenic, iron, lead, mercury, thallium, and vanadium had at least one HQ greater than 1.0 for the aquatic food chain modeling using maximum and mean concentrations of surface water and sediment COPCs (Tables 7-11 and 7-12). Fluoranthene, pyrene, barium, copper, zinc, and

4,4'-DDD had HQs greater than 1.0 using the maximum concentrations but not using mean concentrations (Tables 7-11 and 7-12).

Only four metals were detected in filtered surface water samples. Results of the food chain modeling using maximum and mean concentrations of filtered surface water indicated that none of these metals had HQs greater than 1.0 (Tables 7-13 and 7-14).

7.7.6 Predicted Contaminant Concentrations in Representative Fish Tissue

The predicted concentration of mercury in red drum tissue based on the maximum and average sediment concentrations of mercury and the predicted concentrations of pesticide COPCs in mummichog and red drum tissues based on the maximum and average sediment concentrations of these COPCs are shown in Table 7-15. Guidelines based on fish tissue concentrations of mercury and pesticides are shown in Tables 7-16 and 7-17, respectively.

The values shown in Tables 7-16 and 7-17 were taken primarily from two sources: the Environmental Residue Effects Database, a website maintained by the U.S. Army Corps of Engineers, Waterways Experiment Station (ERED, 1998); and the recently published Linkage Of Effects to Tissue Residues: Development of a Comprehensive Database for Aquatic Organisms Exposed to Inorganic and Organic Chemicals (Jarvinen and Ankley, 1999). Both of these sources are comprehensive collections of hundreds of previous studies, and full citations for the original studies are contained therein.

7.8 SCREENING AND STEP 3A DISCUSSION

The results of the screening level assessment and Step 3a considerations are discussed below on a COPC-specific basis.

7.8.1 Volatile Organic Compounds

Acetone

Acetone was a COPC in surface water, sediment, groundwater, and surface soil since an ESV was not available for any medium. It was detected in one SWMU 41 soil sample (730 µg/kg) but was not detected in Site 1 soil samples. Acetone was detected in one surface water sample at 7 µg/L and ranged from 16 to 63 µg/kg in sediments. Although it was detected in 4 of 4 groundwater samples, its maximum concentration was only 13 µg/L.

Toxicity data for aquatic species could not be located, but toxicity to laboratory rats from acetone appears to be in the parts-per-thousand range. For example, rats provided with drinking water containing 5,000

ppm acetone for 8 weeks followed by 10000 ppm for an additional 4 weeks did not exhibit any histopathological changes in central, peripheral, or distal axons (Spencer et al., 1978). Rats exposed to 25,000 ppm acetone in drinking water for 18 weeks exhibited no adverse effects except for weight loss (U.S. EPA, 1984). Rats provided with drinking water containing acetone at a concentration equivalent to a dose of 1071 mg/kg/day for 6 weeks exhibited no adverse effects (Larsen et al., 1991). Drinking water containing 50,000 ppm acetone (equivalent to 3.1 g acetone/kg/day) was associated with mild adverse spermatogenic effects in rats after 13 weeks exposure (Dietz et al., 1991). Acetone was detected in laboratory blank samples at concentrations up to 4.2 µg/L in water and 24 µg/kg in soils/sediments. Additionally, it was detected in only one soil sample and at relatively low concentrations in groundwater, surface water, and sediment, it should be dropped from further consideration at Site 1 and SWMU 41.

Carbon disulfide

Carbon disulfide was detected in six sediment samples and six groundwater samples and was a COPC since an ESV was not available in either medium. It was not detected in surface water or surface soil. Concentrations ranged from 2 to 24 µg/kg in sediment and from 0.7 to 16 µg/kg in groundwater. The absence of any sediment screening values for carbon disulfide precludes an assessment of its potential toxicity to ecological receptors. However, these concentrations do not appear to be excessively high. Unlike most organic compounds on the TCL list, carbon disulfide is a naturally occurring compound in marsh sediments, therefore its presence in site sediments and associated groundwater would be expected. Carbon disulfide was detected in two of six background sediment samples at concentrations of 2 and 7 µg/kg. Because carbon disulfide was not detected in surface soil or surface water and since it occurs naturally in sediments, its presence in some sediment and shallow groundwater samples at these concentrations might not be due to site-related contamination. For these reasons, carbon disulfide should be dropped from further consideration at Site 1 and SWMU 41.

Toluene

Toluene was detected in six sediment samples and was a COPC since an ESV was not available. It was not a COPC in groundwater or surface soil and was not detected in surface water. Sediment concentrations ranged from 3 to 7 µg/kg, which were much less than the lowest available guideline (1688 µg/kg), a U.S. EPA sediment quality benchmark (Table 7-18). Because of its relatively low concentrations in sediments and its absence as a COPC in other media, toluene should be dropped from further consideration at Site 1 and SWMU 41.

7.8.2 Semivolatile Organic Compounds

Pentachlorophenol

Pentachlorophenol was detected in 1 of 8 unfiltered surface water samples but was not detected in groundwater, sediment, or surface soil. Its detection limits in surface water samples exceeded the 11.9 µg/L ESV, however, with values ranging from 48 to 57 µg/L. Pentachlorophenol detection limits in all groundwater samples were less than this ESV, with values ranging from 6 to 11 µg/L. Because of pentachlorophenol's low water solubility, its presence in one surface water sample might be due to turbidity, which was noted in surface water samples. Since pentachlorophenol was detected in only one surface water sample, and was not detected in other media, this compound should be dropped from further consideration at Site 1 and SWMU 41.

1,2,4-Trichlorobenzene

1,2,4-trichlorobenzene was detected in 1 of 10 surface soil samples at Site 1 and was a COPC since an ESV was not available. It was not detected in SWMU 41 soils or in any groundwater, surface water, or sediment samples. Its single detected value (140 µg/kg) was considerably less than the 20,000 µg/kg ORNL screening value for surface soils (Table 7-19). Because of its infrequent detection and relatively low concentration in soil and since it was not detected in any other media, 1,2,4-trichlorobenzene should be dropped from further consideration at Site 1 and SWMU 41.

Carbazole

Carbazole was detected in three of nine sediment samples, 1 of 10 groundwater samples, and in 5 of 10 Site 1 surface soil samples. Screening valves for carbazole were not available, but the maximum sediment HQ was 6.5 based on the screening value for benzo(a)pyrene, a similar compound. It was not detected in SWMU 41 soils or in surface water samples. Carbazole did not have any HQs greater than 1.0 in the terrestrial or aquatic food chain modeling scenarios. Concentrations ranged from 86 to 580 µg/kg in sediment and 260 to 490 µg/kg in soil and was 2 µg/kg in one groundwater sample. The absence of screening values for carbazole prevents a complete assessment of its potential toxicity to ecological receptors. However, since the food chain modeling shows negligible risks to upper level ecological receptors, carbazole should be dropped from further consideration at Site 1 and SWMU 41.

Dibenzofuran

Dibenzofuran was detected in one of eight surface water samples (10 µg/L) and in 3 of 10 surface soil samples at Site 1 (170 to 200 µg/kg). Region 4 or alternate ESVs were not available for either medium. Dibenzofuran was not detected in groundwater, sediment, or in SWMU 41 soils. Toxicity data for oral

ingestion in birds and fish were not available, precluding an assessment of dibenzofuran via food chain modeling for those classes of organisms, but food chain HQs for all representative mammals were well below 1.0. The paucity of toxicity data for dibenzofuran prevents a complete assessment of its toxicity to ecological receptors. However, results of the food chain modeling indicate that it does not appear to be toxic to upper level representative mammals at the concentrations measured in site soils. For this reason and since dibenzofuran was not detected in groundwater and sediment and was detected in only one surface water sample at a low concentration, this compound should be dropped from further consideration at Site 1 and SWMU 41.

Phthalates

Bis(2-ethylhexyl) phthalate was detected in 3 of 11 groundwater samples, three of eight surface water samples, and 4 of 10 surface soil samples at Site 1 but was not detected in SWMU 41 soils or in sediment. Its maximum concentration was 1 µg/L in groundwater and 56 µg/L in surface water. The maximum concentration in surface soil was 5600 µg/kg in sample SS-12-01; the other three detects in soil ranged from 60 to 91 µg/kg. Food chain HQs for the robin and woodcock slightly exceeded 1.0 using the maximum concentration of bis(2-ethylhexyl) phthalate but were less than 1.0 using the mean concentration (Tables 7-9 and 7-10).

Butylbenzyl phthalate was detected in 1 of 10 surface soil samples at Site 1 (SS-12-01 at 2000 µg/kg) but was not detected in SWMU 41 soils or in sediment, surface water, and groundwater samples. The food chain HQ for the woodcock slightly exceeded 1.0 using the maximum concentration of this compound but was less than 1.0 using the mean concentration (Tables 7-9 and 7-10).

Di-n-octyl phthalate was detected in 1 of 11 groundwater samples (7 µg/L) and 1 of 10 surface soil samples (SS-12-01 at 6400 µg/kg) at Site 1 but was not detected in SWMU 41 soils or in sediment and surface water samples. Food chain HQs for the robin and woodcock exceeded 1.0 using the maximum concentration of this phthalate but were less than 1.0 using the mean concentration (Tables 7-9 and 7-10).

Phthalates were not detected in sediment, and concentrations were low (1 to 7 µg/L) in groundwater. Bis(2-ethylhexyl) phthalate was the only phthalate detected in surface water. Although a Region 4 ESV was not available for bis(2-ethylhexyl) phthalate, its maximum concentration in surface water (56 µg/L) was much less than the U.S. EPA Region 3 BTAG screening value of 360 µg/L (U.S. EPA, 1995c). Toxicity data are sparse for phthalates in soil, making it difficult to assess the toxicity of these compounds at the concentrations detected here. The food chain HQs for some terrestrial receptors slightly exceeded 1.0 using maximum phthalate concentrations, but these HQs are partially due to the lack of toxicity data. Specifically, soil-to-invertebrate BAFs were not available for the three phthalates that were COPCs in soil,

and soil-to-plant BAFs were not available for two of these three compounds. Thus, BAFs of 1.0 were used. This is probably overly conservative for phthalates.

In summary, phthalates were not detected in sediment and were not elevated in surface water or groundwater. In view of the conservative assumptions in the food chain modeling, the HQs for representative terrestrial receptors are low. In addition, phthalates are common environmental contaminants due to their use in plastics. Phthalates can also be an artifact of the sampling and/or analytical methods. For these reasons, phthalates should be dropped from further consideration at Site 1 and SWMU 41.

PAH Compounds

Fourteen PAHs were detected in sediments; all were COPCs since their maximum concentrations exceeded Region 4 ESVs. Sediment HQ values ranged from 7.6 to 257. Eleven PAHs were COPCs in soil, with HQs ranging from 1.2 to 6.3. Five PAHs were COPCs in groundwater; the HQ for naphthalene in groundwater was 2.4, and Region 4 ESVs were not available for the other four PAHs in groundwater. These four compounds were infrequently detected and at low concentrations in groundwater (1 to 8 µg/L). Two PAHs were COPCs in surface water due to the absence of Region 4 ESVs; each was detected in a single sample and at low concentrations (chrysene at 0.1 µg/L and 2-methylnaphthalene at 10 µg/L). Food chain HQs for the mummichog slightly exceeded 1.0 for fluoranthene (HQ = 1.28) and pyrene (HQ = 1.04). As discussed in Section 7.4.2.1, BSAFs were not available for the variety of organisms consumed by the mummichog, and therefore, chemical concentrations in food items of the mummichog were assumed to be equal to measured sediment concentrations. The HQs greater than 1.0 for pyrene and fluoranthene reflect this conservative assumption. Food chain HQs for all other representative terrestrial and aquatic receptors were less than 1.0 using the maximum concentrations of each PAH compound.

The infrequent detection and low concentrations of PAHs in groundwater and surface water indicate negligible risks to ecological receptors. PAHs usually occur in soils and sediment as mixtures of compounds. Few alternate guidelines were available for PAHs in surface soil, but the HQ values for PAHs in surface soil were relatively low. In addition, soil concentrations of all PAHs were less than the Dutch “B” value for benzo(a)pyrene, a compound often used as a surrogate for high molecular weight PAHs. For these reasons and since all terrestrial food chain HQs for PAHs were less than 1.0, PAHs in surface soil appear to pose negligible risks to ecological receptors at Site 1 and SWMU 41.

The maximum concentrations of most PAHs in sediment were in sample SD-017-01 (Table 7-5). As shown in Figure 4-4, this sample was also the maximum location of total PAHs. Several individual PAHs, as well as total PAHs, were also elevated in sample SD-001-01. Most PAH concentrations in other

sediment samples were not substantially elevated, and total PAH concentrations exceeded the ER-L value only in the two aforementioned samples and in samples SD-002-01 and SD-003-01. Total PAHs in samples SD-002-01 and SD-003-01 were less than most alternate guidelines shown in Table 7-18.

The concentration of total PAHs in sediment sample SD-017-01 (30,103 µg/kg) exceeded all available sediment guidelines, except the ER-M and the Ontario Severe Effects Level (Table 7-18). Total PAHs in SD-001-01 (15,985 µg/kg) exceeded the same guidelines but were less than the PEL. In addition, the maximum sediment concentrations of benzo(a)pyrene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and pyrene exceeded all available guidelines except the Ontario Severe Effects Level. Therefore, these PAH compounds, as well as total PAHs, are retained as sediment COCs. Potential risks from PAH compounds appear to be limited to benthic organisms, primarily in the vicinity of SD-017-01and SD-001-01. The results of the food chain modeling indicate that PAH compounds pose negligible risks to upper level receptors. It should be noted that the source of these compounds in sediment might not be due to site-related activities. Personnel who collected the sediment samples noted the presence of flotsam and jetsam (e.g, pilings, treated lumber scraps) throughout the marsh in the vicinity of several sampling locations. In addition, sediment sample SD-017-01 (the location of the maximum concentrations of total and several individual PAHs) was located near a shallow channel that drains an off-site area adjacent to Malecon Drive.

7.8.3 Pesticides and PCBs

Aroclor 1260

Aroclor 1260 was detected in 3 of 10 surface soil samples at Site 1 (HQ = 4.0), and was not detected in groundwater, surface water, sediment, or SWMU 41 soils. Food chain HQs for the shrew, woodcock, and fox slightly exceeded 1.0 using the maximum concentration of Aroclor 1260 but were less than 1.0 using the mean concentration (Tables 7-9 and 7-10). The three detected concentrations in surface soil (21, 37, and 80 µg/kg) were not greatly elevated relative to the Region 4 ESV of 20 µg/kg and were less than most alternate screening values shown in Table 7-19. No other PCBs were detected in any media at the site. Since the food chain modeling shows negligible risks to upper level ecological receptors using the maximum concentration of this compound and since it was absent in most media and present at relatively low concentrations in only a few soil samples, Aroclor 1260 should be dropped from further consideration at Site 1 and SWMU 41.

DDT and Metabolites

4,4'-DDT and its metabolites, 4,4'-DDD and 4,4'-DDE (hereafter referred to as DDT, DDD, and DDE, or collectively as DDTR), were COPCs in sediment and surface soil, and none of these three compounds

were detected in groundwater or surface water. Maximum HQ values in soil were 72 for DDD, 1680 for DDE, and 1,760 for DDT. Maximum HQ values in sediment were 213 for DDD, 58 for DDE, and 227 for DDT. Food chain HQs for some representative aquatic and terrestrial receptors were greater than 1.0 using maximum and mean concentrations (Tables 7-9 through 7-12) and were especially high for the robin, hawk, and woodcock based on maximum soil concentrations.

DDT and/or DDD and DDE were detected in six sediment samples. Maximum sediment concentrations of these three compounds were recorded in sample SD-09-01. Concentrations in the other five samples were considerably lower (Figure 4-4) and are within the range of concentrations considered to be typical of basewide locations (Appendix F). DDT was probably used previously throughout the base for pest control, and DDTR concentrations in all sediment samples (except SD-009-01) appear to be unrelated to Site 1 and SWMU 41. Food chain HQs based on the mean concentrations of DDT and metabolites were greater than 1.0 for the heron and osprey. These two receptors have large home ranges, but the HQs were calculated by assuming that all representative receptors foraged exclusively at Site 1 and SWMU 41. The aquatic food chain HQs would be less than 1.0 if more realistic area-use factors were used.

Numerous toxicity thresholds based on fish tissue concentrations of DDTR are available, encompassing a wide range of values (Table 7-17). The predicted tissue concentrations derived using the maximum sediment concentrations exceeded several of the values shown in Table 7-17. The predicted tissue concentrations derived using the average sediment concentrations are less than most of the values in the table. Overall, potential risks to aquatic organisms from DDTR in sediments appear to be limited to the vicinity of sample SD-09-01. DDTR concentrations in this sample exceeded most available sediment guidelines, and DDD concentrations exceeded all guidelines, including the Severe Effects Level (Table 7-19).

DDT and/or its metabolites were detected in most soil samples. Maximum soil concentrations of DDT, DDE, and DDD were observed in sample SS-07-01, where DDE and DDT concentrations exceeded all alternate guidelines, including the Dutch “intervention” value. DDTR concentrations in other soil samples were considerably lower (Figure 4-1). With two exceptions, soil concentrations in other soil samples were less than the EPA Region 3 BTAG screening value of 100 µg/kg and were within the range of concentrations considered to be typical of basewide locations (Appendix F). The two exceptions are samples SS-05-01 and, to a lesser extent, SS-06-01 (Figure 4-1). Sample SS-05-01 is near sediment sample SD-09-01, where sediment concentrations of DDTR were also elevated.

In summary, sediment concentrations of DDTR could pose potential risks to some aquatic receptors in the vicinity of sediment sample SD-09-01. Soil concentrations of DDTR could pose potential risks to some

terrestrial receptors, especially in the vicinity of soil sample SS-07-01. DDT and its metabolites DDD and DDE are retained as COCs in sediment and surface soil.

Benzenehexachloride (BHC)

The alpha, beta, delta, and gamma isomers of BHC were COPCs in sediment and surface soil, and no BHC isomers were detected in groundwater or surface water. Region 4 ESVs were not available for the alpha, beta, and delta isomers in sediment or for the delta isomer in surface soil. Maximum HQ values for the isomers with Region 4 ESVs were 16.8 (alpha-BHC), 33.0 (beta-BHC), and 1,500 (gamma-BHC) in surface soil and 6.6 (gamma-BHC) in sediment. Based on maximum soil concentrations, food chain HQs exceeded 1.0 for the shrew and fox but were less than 1.0 using mean soil concentrations (Tables 7-9 and 7-10). Based on maximum surface water and sediment concentrations, HQs for all representative aquatic receptors were less than 1.0 (Table 7-11).

The delta and gamma isomers were detected in one soil sample (SS-07-01), and the alpha and beta isomers were detected in two soil samples (SS-07-01 and SS-06-01). Alternate soil screening guidelines are sparse; the source of the Dutch “target” values shown in Table 7-17 is also the source of the Region 4 ESVs and therefore the values are identical. The sum of the isomers in soil sample SS-07-01 would be slightly greater than the only other soil ESV (100 µg/kg), the EPA Region 3 BTAG screening value. Since the terrestrial food chain HQs were not substantially elevated when the conservative assumptions in the model are considered and since BHC was infrequently detected and concentrations were not substantially elevated relative to alternate ESVs, potential risks to terrestrial receptors appear to be negligible.

BHC isomers were detected in only one sediment sample (SD-02-01), at concentrations that ranged from 2.1 to 5.4 µg/kg. These values are not elevated relative to alternate guidelines shown in Table 7-18. In particular, the maximum sediment concentrations for the delta and gamma isomers are well below U.S. EPA’s sediment quality advisory levels. In addition, the predicted tissue concentrations of BHC isomers in the mummichog (Table 7-15) are less than most of the available tissue guideline concentrations (Table 7-17). Thus, the potential risks to aquatic receptors from BHC in sediment appear to be negligible. Because of this and since potential risks to terrestrial receptors appear to be only minor (at worst), BHC should be dropped from further consideration at Site 1 and SWMU 41.

Chlordane

Alpha-chlordane is the endo-*cis* isomer of chlordane, and beta-chlordane is the endo-*trans* isomer. Both of these isomers of chlordane were COPCs in sediment and surface soil, and neither was detected in groundwater or surface water. Alpha- and gamma-chlordane were detected in two surface soil samples

(SS-07-01 and SS-09-01). Region 4 ESVs were not available for either of these isomers (or the parent compound) in surface soil. However, the soil concentrations (9.5 and 18 µg/kg for alpha-chlordane; 6 and 8.1 µg/kg for gamma-chlordane) were considerably less than the Region 4 ESV for individual organochlorinated pesticides (100 µg/kg). All food chain HQs for representative terrestrial and aquatic receptors were less than 1.0 using maximum concentrations of these compounds. Thus, based on the infrequent detections and relatively low concentrations in surface soil and the results of the food chain modeling, alpha- and gamma-chlordane appear to pose negligible risks to terrestrial receptors.

Alpha- and gamma-chlordane were detected in only one sediment sample (SD-009-01), with values of 52 µg/kg and 130 µg/kg for the alpha and gamma isomers, respectively. The sediment HQs were 104 for the alpha isomer and 260 for the gamma isomer. The concentrations in this sample were also elevated relative to other sediment guidelines for chlordane (Table 7-18). Specifically, the concentrations were considerably greater than the PEL, the apparent effects threshold (AET), and Ontario's Severe Effects Level. The concentrations are also greater than the concentrations considered to be typical of various basewide locations (13.9 µg/kg: alpha-chlordane; 13.2 µg/kg: gamma-chlordane; Appendix F).

Based on the maximum sediment concentrations of alpha- and gamma-chlordane, the predicted tissue concentrations of chlordane in the mummichog (Table 7-15) exceeded some of the tissue guidelines (Table 7-17). Since these compounds were detected in only one sediment sample, however, it is probably overly conservative to assume that fish would be exposed to these sediment concentrations for a significant portion of their lives. The predicted tissue concentrations derived using the average sediment concentrations do not appear to be elevated relative to most of the guidelines shown in Table 7-17. Overall, the potential risks from chlordane in sediment appear to be limited to benthic invertebrates in the vicinity of sediment sample SD-009-01. Chlordane is therefore selected as a sediment COC.

Endrin Ketone

Endrin ketone was detected in 1 of 14 surface soil samples and was a COPC since a Region 4 ESV was not available. It was not detected in groundwater, surface water, or sediment. Toxicity data used in the terrestrial food chain modeling for endrin ketone were not available, so endrin (its parent compound) was used as a surrogate. The food chain HQs for all terrestrial receptors were less than 1.0. Although toxicity data for endrin ketone are sparse, the concentration of this compound (12 µg/kg) was not elevated relative to available guidelines for endrin, its parent compound (Table 7-19). Because of this low concentration and its infrequent detections, endrin ketone should be dropped from further consideration at Site 1 and SWMU 41.

7.8.4 Metals

Aluminum

Aluminum was detected in all soil and sediment samples and in most surface water and groundwater samples. Region 4 ESVs were not available for surface water and sediment, and its maximum soil HQ was 172. Aluminum HQs for most representative aquatic and terrestrial receptors were greater than 1.0 using maximum and mean concentrations (Tables 7-9 through 7-12) and were especially high for the raccoon. However, as discussed in Section 7.4.2, the elevated HQs for the raccoon and other aquatic receptors may be due more to the method of HQ calculation, wherein concentrations of metals in prey items were assumed to be equal to sediment concentrations. This assumption was used since BSAFs do not exist for inorganic compounds, but it is probably overly conservative.

Aluminum was not detected in filtered surface water. As discussed by U.S. EPA (1996a), concentrations of dissolved metals, rather than total metals, more closely approximate the bioavailable fraction of metals in the water column. Aluminum concentrations in sediment were well below the only available alternate guideline (Table 7-18). In addition, the maximum concentration of aluminum in sediment (23400 µg/L) was less than its respective background concentrations, and the maximum concentration of aluminum in surface soil (8610 mg/kg) was not substantially greater than the background value. Thus, aluminum concentrations in these media might not be site related. Furthermore, aluminum is one of the most common elements in the earth's crust (Mailman, 1980). It is not readily absorbed through the skin and gastrointestinal absorption of ingested aluminum is poor due to the transformation of aluminum salts into insoluble aluminum phosphate (Venugopal and Luckey, 1978). Aluminum compounds are generally not harmful to most terrestrial organisms and are considered to be toxicologically inert, except in cases of high experimental doses or prolonged inhalation (Venugopal and Luckey, 1978). With this in mind and since concentrations in surface soil and sediment were less than or only slightly greater than background concentrations, and aluminum was not detected in filtered surface water, aluminum should be dropped from further consideration at Site 1 and SWMU 41.

Antimony

Antimony was a COPC in surface water since a Region 4 ESV was not available and was a COPC in surface soil with a maximum HQ of 25.9. Antimony was not detected in groundwater and was not a COPC in sediment. Most HQs in the food chain modeling for terrestrial mammals were greater than 1.0 (Tables 7-9 and 7-10). Oral toxicity data were not available for birds and fish and therefore risks to these receptors could not be assessed via food chain modeling (Tables 7-13 and 7-14). However, as discussed below, low concentrations in sediment and surface water indicate negligible risks to fish and other aquatic receptors.

Antimony was not detected in unfiltered surface water but was detected in one of eight filtered surface water samples at 2.075 µg/L. This value is much less than FDEP's screening value for marine surface water (4,300 µg/L: FDEP, 1994) and NOAA's screening value for marine surface water (500 µg/L: Buchman, 1999). Surface soil concentrations of antimony exceeded the Region 4 ESV (3.5 mg/kg) in only one sample (SS-09-01). Since antimony was not elevated relative to the Region 4 ESV in nearby sediment samples and was not detected in groundwater, antimony in soil does not appear to have resulted in sediment or groundwater contamination. Thus, potential ecological risks appear to be limited to terrestrial receptors in the vicinity of this sample. The food chain modeling suggests that antimony may pose moderate potential risks to mammals with small home ranges (e.g., shrews, mice). Potential risks to wide-ranging mammals would be negligible since elevated soil concentrations were limited to a single sample. As mentioned above, potential toxicity to birds could not be assessed via food chain modeling. However, since birds are wide ranging, potential risks to these receptors are also expected to be negligible. In summary, potential risks from antimony appear to be limited to soil invertebrates, plants, and small mammals such as shrews, mice, and moles in the vicinity of soil sample SS-09-01. This is discussed further in Section 7.8.5.

Arsenic

Arsenic was a COPC in sediment (HQ = 2.2) and surface soil (HQ = 2.5) but was not a COPC in surface water or groundwater. Some HQs in the terrestrial and aquatic food chain modeling were greater than 1.0 using maximum arsenic concentrations. Using mean concentrations (Tables 7-10 and 7-12), food chain HQs were greater than 1.0 only for the shrew (HQ = 3.9) and raccoon (HQ = 10.6) using NOAELs.

Arsenic concentrations in surface soil exceeded the 10 mg/kg Region 4 ESV in only two samples (SS-08-01 at 13.4 mg/kg and SS-09-01 at 24.9 mg/kg). These values are not elevated relative to alternate screening values (Table 7-19). Sediment concentrations were also not elevated relative to alternate screening values (Table 7-18), and background sediment concentrations were exceeded in only two sediment samples. Because arsenic concentrations exceeded background values in few soil and sediment samples and concentrations were not elevated relative to most available screening values and since arsenic at the site does not appear to pose significant risks to upper level receptors considering the conservative assumptions used in the food chain model, arsenic should be dropped from further consideration at Site 1 and SWMU 41.

Barium

Barium was a COPC in groundwater, surface water, and sediment since Region 4 ESVs were not available and was a COPC in surface soil with a maximum HQ of 1.1. Barium HQs for some

representative receptors were greater than 1.0 using maximum concentrations, but HQs using mean concentrations were less than or only slightly greater than 1.0 (Tables 7-9 through 7-14).

Surface soil concentrations of barium exceeded the Region 4 ESV (165 mg/kg) in only one sample (SS-08-01; 178 mg/kg), but the exceedance was slight. The maximum soil concentration was less than all alternate screening values (Table 7-19). Concentrations of barium in all unfiltered surface water samples were less than the background value, and concentrations in only one filtered surface water sample exceeded the filtered background value. Barium concentrations in sediment exceeded the 28 mg/kg background value in 3 of 14 samples. However, barium is a common element in sediments and it is not generally associated with significant toxicity (ATSDR, 1997). Due to the relatively low concentrations of barium in site media, barium should be dropped from further consideration at Site 1 and SWMU 41.

Beryllium

Beryllium was detected in 3 of 14 sediment and 5 of 11 groundwater samples and was a COPC since a Region 4 ESV was not available. Alternate sediment ESVs for beryllium were also absent (Table 7-18). It was not detected in surface water or Site 1 soil samples, and concentrations in SWMU 41 soil were less than the Region 4 ESV. Beryllium did not have any HQs greater than 1.0 in the food chain modeling for representative mammals, but toxicity data for oral ingestion were not available for birds and fish. The paucity of toxicity data prevents a complete assessment of the potential toxicity of beryllium to ecological receptors. However, its maximum concentrations in sediment (1.2 mg/kg) and groundwater (0.7 µg/L) do not appear to be particularly elevated. Since the only available toxicity data show that risks to terrestrial mammals from the maximum detected sediment and soil concentrations are negligible and since the few detected concentrations are not excessively elevated, beryllium should be dropped from further consideration at Site 1 and SWMU 41.

Cadmium

Cadmium was a COPC in sediment (HQ = 1.2) and surface soil (HQ = 3.4) but was not a COPC in surface water or groundwater. Some HQs in the terrestrial food chain modeling exceeded 1.0 using maximum and mean concentrations, but no aquatic receptors had food chain modeling HQs greater than 1.0 (Tables 7-9 through 7-12).

Concentrations in surface soil exceeded the Region 4 ESV only in samples SS-08-01 (5.4 mg/kg) and SS-09-01 (3.2 mg/kg). These values are slightly greater than some alternate screening values and less than others (Table 7-19). Cadmium was detected in only 1 of 14 sediment samples. Its concentration in this sample only slightly exceeded the Region 4 ESV and the background concentration was less than

alternate screening values (Table 7-18). Because of the infrequent detections and/or low concentrations and since cadmium at the site does not appear to pose significant risks to upper level receptors considering the conservative assumptions inherent in the food chain model, cadmium should be dropped from further consideration at Site 1 and SWMU 41.

Chromium was a COPC in surface soil with maximum HQs of 133 (Site 1) and 33.5 (SWMU 41). Chromium was not a COPC in groundwater, surface water, or sediment since all detected concentrations were less than Region IV ESVs.

The Region IV ESV for chromium is based on a study of hexavalent chromium, which is the most toxic form of this metal. Thus, the elevated soil HQs are based on a comparison of maximum concentrations to the screening value for hexavalent chromium. Hexavalent chromium was not detected in any of three surface soil samples analyzed for hexavalent chromium at Site 1. The detection limits for hexavalent chromium in these three samples were 0.83, 0.85, and 0.89 mg/kg; these detection limits were only slightly greater than the ESV for hexavalent chromium (0.4 mg/kg). Region IV surface soil ESVs are based on a literature review by Friday (1998) of several sources. The lowest ESV for total chromium in Friday's (1998) review was 64 mg/kg, and is a soil guideline recommended by the Canadian government (CCME, 1997). All surface soil concentrations of chromium at Site 1 and SWMU 41 were less than 64 mg/kg. Chromium was not included in the terrestrial food chain modeling since it was not detected at concentrations greater than the ESV for total chromium.

All surface water and groundwater concentrations were less than 50 µg/L, which is the Region IV ESV for hexavalent chromium. Since chromium was not a COPC in groundwater, surface water, or sediment, and all surface soil concentrations were less than the ESV for total chromium, this metal appears to pose negligible risks to ecological receptors at the site and should be dropped from further consideration.

Cobalt

Cobalt was a COPC in sediment and surface water because a Region 4 ESV was not available. Cobalt was not detected in groundwater and all concentrations in surface soil were less than Region 4 screening values. All HQs in the aquatic food chain modeling were less than 1.0, and cobalt was not included in terrestrial food chain modeling since it was not a COPC in surface soil.

Toxicity data for cobalt are scarce. Sediment concentrations slightly exceeded the background value in four samples, but all sediment concentrations were less than the only two available guidelines (Table 7-18). No surface water guidelines were available, and cobalt was not detected in background samples. However, cobalt was detected in only two surface water samples, and the maximum concentration in surface water appears to be qualitatively low (2.9 µg/L). Since cobalt was not elevated

(and was not a COPC) in surface soil, its presence in surface water and sediment at these concentrations is probably not site related. Cobalt is present in all natural media and is a component of certain B vitamins, which are essential for birds and mammals (ATSDR, 1997). For these reasons, cobalt should be dropped from further consideration at Site 1 and SWMU 41.

Copper

Copper was a COPC in all media. Maximum concentrations did not substantially exceed Region 4 ESVs in groundwater (HQ = 2.7), sediment (HQ = 5.1), and surface soil (HQ = 3.3). Copper was detected in two of eight surface water samples, with an HQ of 21.7. However, copper was not detected in filtered surface water. As discussed by U.S. EPA (1996a), concentrations of dissolved metals, rather than total metals, more closely approximate the bioavailable fraction of metals in the water column. Some food chain HQs slightly exceeded 1.0 for representative receptors using maximum concentrations, with a maximum HQ of 2.8 for the shrew (Table 7-9). Using the mean concentrations, all HQs were less than 1.0 (Tables 7-10 and 7-12). Sediment concentrations exceeded the Region 4 ESV and the background value in four samples, but all concentrations were below the ER-M and PEL values (Table 7-18). However, the maximum sediment concentration exceeded the probable effects concentration and approached the PEL value (Table 7-18). Because of this, and since copper can be highly toxic to aquatic biota, copper could pose risks via direct toxicity. Risks via the aquatic food chain are negligible at the site.

Soil concentrations exceeded its background value in all samples, and the Region 4 ESV was exceeded in four samples. Soil concentrations in three of these four samples exceeded 100 mg/kg, which is an ORNL phytotoxicity threshold and a Dutch “B” value, but all were less than the Dutch Intervention value (Table 7-19).

In summary, copper in surface water at Site 1 appears to pose negligible risks to ecological receptors. Soil screening values were exceeded at three locations, but the magnitudes by which they were exceeded suggest only minimal risks (if any) to plants and soil invertebrates. The terrestrial food chain modeling indicates negligible potential risks to wide ranging receptors and to minimal (at worst) potential risks to mammals such as shrews and mice that have small home ranges. Therefore, copper in soil poses negligible risks, but copper is retained as a COC.

Iron

Iron was detected in all sediment, unfiltered surface water, and soil samples and in most groundwater samples. It was a COPC in all media, with a maximum HQ of 735 in surface soil. Region 4 ESVs were not available for groundwater, surface water, or sediment. Iron was not detected in filtered surface water.

Food chain HQs were greater than 1.0 for all representative terrestrial and aquatic receptors using maximum concentrations and for most receptors using mean concentrations (Tables 7-9 through 7-12).

Unfiltered surface water concentrations exceeded the average background value in two samples. With these two samples excluded, the maximum surface water concentration was 1560 µg/kg, well below the average background concentration. Iron was not detected in filtered surface water samples. Sediment concentrations of iron exceeded the background sediment concentration (21,500 mg/kg) in four samples, with a maximum concentration of 24,000 mg/kg. This value is greater than the lowest guideline shown in Table 7-18, which is a "Lowest Effects Level" established by the Ontario Ministry of the Environment, but is much lower than the "Severe Effects Level" established by the same agency. The elevated food chain HQs for aquatic receptors are partially a result of the conservative assumption that concentrations of iron in prey items were equal to sediment concentrations.

Iron in all soil samples exceeded the Region 4 ESV, and concentrations in nine samples were greater than the background value (3920 mg/kg). Soil concentrations were particularly high in sample SS-008-01 (147,000 mg/kg) and in sample SS-009-01 (50,400 mg/kg). With these two samples excluded, the average iron concentration in soil was 6368 mg/kg. Toxicity data for iron in soil are sparse, precluding a complete assessment of the potential risks of this metal. It should be noted that even the soil background concentration (3920 mg/kg) is greater than the least conservative guideline shown in Table 7-19 (3,260 mg/kg). The terrestrial food chain HQs based on the maximum soil concentration were particularly high for the robin (NOAEL HQ = 870), woodcock (NOAEL HQ = 157), fox (NOAEL HQ = 172), and mouse (NOAEL HQ = 816). Using the maximum concentration with the two highest soil concentrations removed from the data set (11,900 mg/kg), terrestrial HQs for the same four respective receptors drop to 70.5, 12.7, 13.9, and 65.0. These HQs would be reduced by approximately one-half, based on the mean concentration with the two highest values removed from the data set (6368 mg/kg).

In summary, in view of the conservative assumptions in the food chain modeling since iron is an essential nutrient and one of the most common elements in the earth's crust, the surface water and sediment concentrations do not appear to be particularly high. Potential risks to aquatic receptors are not believed to exist under the present conditions at the site. Soil concentrations were elevated relative to the background value in most samples and are assumed to be due to the site's history as a landfill. Potential risks appear to be primarily limited to terrestrial receptors (invertebrates and terrestrial receptors with small home ranges) in the vicinity of samples SS-008-01 and SS -009-01. This is discussed further in Section 7.8.5.

Lead

Lead was a COPC in all media, with maximum HQs of 4.3 (groundwater), 9.1 (surface water), 6.4 (sediment), and 167.6 (surface soil). Food chain HQs were greater than 1.0 for most representative terrestrial and aquatic receptors using maximum lead concentrations and for some receptors using mean concentrations (Tables 7-9 through 7-12). Lead was detected in two of eight unfiltered surface water samples but was not detected in filtered surface water samples. Concentrations of dissolved metals, rather than total metals, more closely approximate the bioavailable fraction of metals in the water column (U.S. EPA, 1996a). Sediment concentrations exceeded the Region 4 ESV and background concentration in four samples: SD-002-01 (48.5 mg/kg), SD-001-01 (88.5 mg/kg), SD-009-01 (194 mg/kg), and SD-003-01 (138 mg/kg and 201 mg/kg in the duplicate). All sediment concentrations were less than the ER-M and most other alternate sediment guidelines, but the PEL was exceeded in the two samples with the highest concentrations (Table 7-18). The food chain HQs for representative aquatic receptors using the maximum sediment and surface water concentrations do not appear to be substantially elevated considering the conservative assumptions used in the model (prey concentration equal to sediment concentration, 100 percent absorption, 100 percent area use factor).

Surface soil concentrations exceeded the Region 4 ESV in 12 of 14 samples and exceeded the background value (12.5 mg/kg) in all samples. The elevated values in many samples are assumed to be due to site-related contamination. Concentrations in three samples (SS-007-01: 529 mg/kg; SS-008-01: 1170 mg/kg; SS-009-01: 8380 mg/kg) were especially elevated relative to the Dutch “Intervention” value of 530 mg/kg (Table 7-19). The terrestrial food chain HQs, based on the maximum soil concentration, were particularly high for the shrew (NOAEL HQ = 140), robin (NOAEL HQ = 1110), and woodcock (NOAEL HQ = 1960). Although the robin and woodcock have home ranges much larger than the area encompassed by Site 1 and SWMU 41 and the 100 percent bio-absorption factor assumed in the food chain model might be overly conservative, these HQs are nevertheless elevated and indicate potential risks to terrestrial receptors.

Two of the three surface soil samples in which lead concentrations were highest (SS-007-01 and SS-009-01) are located in the southeast portion of Site 1. Lead was not elevated in the two nearest sediment samples (SD-004-01 and SD-011-01). Thus, migration of lead from soil to sediment does not appear to have occurred in this vicinity. Likewise, migration of lead from groundwater to sediment does not appear to have occurred in this vicinity, even though lead was slightly elevated in a deep groundwater sample (GW-14; 19.8 µg/L) from the nearest monitoring well (lead was not elevated in the co-located shallow groundwater sample). The remaining soil sample in which lead was particularly elevated (SS-008-01; 1,170 mg/kg), is located in the southwest portion of Site 1. Lead was not elevated in groundwater samples collected from this portion of the site, but lead was slightly elevated in the nearest sediment sample (SD-001-01; 88.5 mg/kg). In addition, surface water sample SW-001-01, which is co-

located with sediment sample SD-001-01, is the sample in which lead in unfiltered surface water was highest (111 µg/L in SW-01-00 dup).

Lead concentrations in filtered groundwater samples were highest in samples GW-09 (36.4 µg/L) and GW-11 (mean of sample and duplicate = 28.2 µg/L). Lead was only slightly elevated in the sediment sample nearest to GW-09 (SD-002-01; 48.5 mg/kg), but was considerably elevated in the sediment sample nearest to GW-11 (SD-003-01; mean of sample and duplicate = 170 mg/kg).

In summary, results of the food chain modeling indicate negligible risks to upper trophic-level receptors from lead in surface water and sediment. Potential risks to benthic invertebrates from lead in sediment appear to be primarily limited to the vicinity of samples SD-009-01 and SD-003-01. Although the migration pathway is unclear at some locations, available data suggest that migration of lead from groundwater to sediment might be occurring at one or more locations. Potential risks to terrestrial receptors appear to be limited primarily to the vicinity of soil samples SS-007-01, SS-008-01 and SS-009-01. Therefore, lead is retained as a COC.

Manganese

Manganese was detected in all surface water, sediment, and surface soil samples and in 7 of 10 groundwater samples. Manganese was a COPC in sediment and water because Region 4 ESVs were not available. All concentrations in SWMU 41 soil samples were less than the Region 4 ESV. Manganese concentrations in soil exceeded the 100 mg/kg Region 4 ESV in three samples, with values of 143, 275, and 752 mg/kg. All of the manganese food chain HQs were less than 1.0. Although a Region 4 ESV for sediment was not available, all manganese sediment concentrations were less than alternate ESVs (Table 7-18). In addition, sediment concentrations exceeded the 186 µg/L background value only in sample SD-013 (190 µg/L). Filtered surface water concentrations ranged from 11 to 43.8 µg/L and exceeded the background value (18 µg/L) in six of eight samples.

The Region 4 soil ESV of 100 mg/kg is an ORNL value for protection of micro-organisms. This value, as well as the background soil value of 129 mg/kg, was exceeded in three samples, but alternate ESVs were exceeded only in sample SS-08-01. The food chain modeling indicates negligible ecological risks for terrestrial mammals and birds, and the relatively low exceedances of available soil screening values suggest only minor risks (if any) to plants and soil invertebrates. Furthermore, manganese was not elevated in the nearest sediment sample (SD-013-01), suggesting that contaminated soil in the vicinity has not resulted in sediment contamination. In summary, manganese concentrations appear to be elevated in only one soil sample, but the concentration in that sample suggests negligible potential risks to plants and terrestrial invertebrates. Potential risks to upper-level terrestrial and aquatic receptors are

also negligible. Therefore, manganese should be dropped from further consideration at Site 1 and SWMU 41.

Mercury

Mercury was a COPC in all media, with maximum HQs of 9.2 (groundwater), 4.8 (surface water), 5.2 (sediment), and 11.0 (surface soil). Food chain HQs exceeded 1.0 for most representative terrestrial receptors using the maximum and mean concentrations (Tables 7-9 and 7-10). Food chain HQs exceeded 1.0 for most representative aquatic receptors using maximum concentrations of surface water and sediment, but HQs were only slightly greater than 1.0 for the raccoon, heron, and osprey using the mean concentrations (Tables 7-11 and 7-12).

Mercury was not detected in unfiltered groundwater and was detected in 1 of 11 filtered groundwater samples. It was detected in two of eight unfiltered surface water samples and was not detected in filtered surface water samples. However, the detection limits in groundwater and surface water were slightly greater than the Region 4 ESV. All detected concentrations and detection limits in groundwater and surface water were less than the recommended chronic marine water quality criteria of 0.94 µg/L recently promulgated by U.S. EPA (U.S. EPA, 1999). Mercury was detected in 2 of 14 sediment samples and all detection limits were below or only slightly above the Region 4 ESV. The maximum sediment concentration (0.67 mg/kg) was similar to available less conservative guidelines below the ER-M and PEL values (Table 7-18). The aquatic food chain HQs calculated using maximum surface water and sediment concentrations were greater than 1.0 for most receptors. Using mean concentrations, HQs were greater than 1.0 only for the raccoon (1.8), heron (3.6), and osprey (4.1). The HQs for these wide-ranging receptors do not appear to be elevated when their home ranges are considered.

Numerous toxicity thresholds based on fish tissue concentrations of mercury are available (Table 7-16). These thresholds cover a wide range of values. The predicted tissue concentration of 5.06 mg/kg, derived using the maximum sediment concentration of 0.67 mg/kg, exceeded most of the guidelines. However, as mentioned above, mercury was detected in only 2 of 14 sediment samples. It is probably overly conservative to assume that fish would be exposed to this sediment concentration for a significant portion of their lives. The predicted tissue concentration of 0.95 mg/kg, derived using the average sediment concentration of 0.126 mg/kg (calculated using one-half the detection limit in non-detects), is greater than some guidelines and less than others. Thus, an accurate assessment of this derived value is difficult to accomplish. Overall, however, surface water concentrations do not appear to be elevated, and potential risks to aquatic receptors from mercury in surface water appear to be negligible. Mercury in the vicinity of sediment sample SD-09 could pose risks to benthic receptors.

Soil concentrations of mercury exceeded the 0.1 mg/kg ESV and 0.11 mg/kg background value in six samples. The maximum concentration of 1.1 mg/kg was in sample SS-007-01; concentrations in the remaining five samples only slightly exceeded the background value (Figure 4-1). Similarly, only the maximum concentration appears to be elevated relative to most of the soil guidelines shown in Table 7-19. Food chain HQs exceeded 1.0 for most representative terrestrial receptors using the maximum soil concentration and were especially high for the robin, woodcock, and shrew. The HQs for the robin and woodcock would drop considerably when the area-use factor of these two wide-ranging receptors is considered. The shrew, however, has a small home range and could reside within the vicinity of sample SS-007-01.

In summary, potential risks from mercury in soil appear to be limited to the vicinity of sample SS-007-01, where some potential risks to soil invertebrates and vermivorous receptors (primarily small mammals such as shrews and moles) could exist. Potential risks to aquatic receptors could exist in the vicinity of sediment sample SD-09. Therefore, mercury is retained as a soil and sediment COC.

Nickel

Nickel was a COPC in surface soil (HQ = 1.6) but was not detected in groundwater and was not a COPC in surface water or sediment. All HQs in the terrestrial food chain modeling were less than 1.0. Nickel was not included in the aquatic food chain modeling since it was not a COPC in sediment or surface water. Nickel concentrations exceeded the Region 4 ESV only in sample SS-08-01, at 47.8 mg/kg. This concentration does not appear to be elevated relative to most of the alternate guidelines shown in Table 7-19. For these reasons, nickel should be dropped from further consideration at Site 1 and SWMU 41.

Selenium

Selenium was a COPC in surface soil (HQ = 1.4) but was not detected in groundwater, surface water, or sediment. Some food chain HQs slightly exceeded 1.0 for terrestrial receptors using the maximum soil concentration, with a maximum HQ of 2.6 for the shrew (Table 7-9). Using the mean soil concentration, all HQs were less than 1.0 (Table 7-10). Selenium was not included in the aquatic food chain modeling since it was not a COPC in sediment or surface water. Selenium concentrations exceeded the Region 4 ESV (0.81 mg/kg) only in sample SS-03-01, at 1.1 mg/kg. This concentration is less than, or similar to, all of the alternate guidelines shown in Table 7-19.

In summary, soil concentrations of selenium exceeded the conservative Region 4 ESV in only one sample, but the exceedance was slight and the maximum soil concentration was not elevated relative to other guidelines. Selenium was not detected in any other media. Potential risks to terrestrial vertebrates

appear to be negligible, when considering the conservative assumptions inherent in the food chain model. For these reasons, selenium should be dropped from further consideration at Site 1 and SWMU 41.

Silver

Silver was a COPC in surface water, sediment, and surface soil and was not detected in groundwater. Silver was detected in only one surface water sample (HQ = 3.9). It was detected in 2 of 14 sediment samples, and concentrations exceeded the Region 4 ESV in only one sediment sample (HQ = 3.3). All concentrations in SWMU 41 soil samples were less than the Region 4 ESV, and concentrations in only two soil samples from Site 1 exceeded the ESV (maximum HQ = 1.2). All HQs in the food chain modeling were less than 1.0, but oral toxicity data were not available for birds and fish. Because silver was infrequently detected and since its maximum concentrations in all media only slightly exceeded Region 4 ESVs as well as most alternate screening values, silver should be dropped from further consideration at Site 1 and SWMU 41.

Thallium

Thallium was a COPC in sediment since a Region 4 ESV was not available. Thallium was not detected in surface water or surface soil and was not a COPC in groundwater. Thallium was not included in the terrestrial food chain modeling since it was not detected in surface soil. Raccoon HQs were greater than 1.0 using the maximum and mean concentrations (Tables 7-11 and 7-12). The raccoon HQ values greater than 1.0 were calculated by assuming that the concentrations of thallium in prey items were equal to sediment concentrations. As discussed earlier, this assumption was used since BSAFs do not exist for inorganic compounds and is probably overly conservative since transfer through the food chain is not known to occur for thallium. Oral toxicity data were not available for birds and fish and therefore, risks to these receptors could not be assessed via food chain modeling.

The absence of any sediment screening values and the absence of oral toxicity data for birds and fish preclude a complete assessment of thallium's potential toxicity to aquatic receptors. However, thallium was detected in only one sediment sample, at a concentration of 0.925 mg/kg, compared to a background value of 0.41 mg/kg. Furthermore, because thallium was not detected in surface soil or surface water and was detected in only one groundwater sample (at less than the ESV), its presence in a single sediment sample does not appear to be site related. For these reasons, thallium should be dropped from further consideration at Site 1 and SWMU 41.

Vanadium

Vanadium was a COPC in all media. Region 4 ESVs were not available for groundwater, surface water, and sediment, and the maximum HQ in surface soil was 23.7. Food chain HQs exceeded 1.0 for the shrew and raccoon (Tables 7-9 through 7-12). Vanadium was detected in two of eight unfiltered surface water samples and was not detected in unfiltered samples. Most sediment concentrations (mean: 27.3 mg/kg) were less considerably less than the background sediment concentration (50 mg/kg). Sediment concentrations exceeded the background value only in the duplicate of sample SD-013. No surface water ESVs were available from any source, and all sediment concentrations were less than the single available sediment ESV (Table 7-18). Surface soil concentrations were generally below or only slightly greater than the background soil concentration, with sample SS-09-01 (47.4 mg/kg) being the only exception. Alternate soil ESVs cover a wide range of values (Table 7-19), so the potential toxicity is difficult to assess, but vanadium is not generally considered to be toxic in the environment (Mailman, 1980).

In summary, vanadium was not detected in unfiltered surface water, and sediment concentrations were not elevated relative to its background value. Aquatic food chain HQs were not elevated when the conservative assumptions inherent in the model are considered. Thus, site-related risks to aquatic receptors are negligible. Potential risks to terrestrial receptors appear to be limited to soil invertebrates, plants, and small vermivorous mammals such as shrews and moles and only in the vicinity of soil sample SS-09-01. The relatively low maximum food chain HQ (5.4; shrew) and the moderately low vanadium concentration in this sample compared to alternate guidelines suggest that potential risks to these receptors are negligible or minor at worst. This is discussed further in Section 7.8.5.

Zinc

Zinc was a COPC in all media, with maximum HQs of 1.3 (groundwater), 1.1 (surface water), 1.0 (sediment), and 9.9 (surface soil). Food chain HQs exceeded 1.0 for most terrestrial receptors using the maximum and mean concentrations (Tables 7-9 and 7-10). Aquatic food chain HQs slightly exceeded 1.0 for the heron and osprey using the maximum concentrations, and all aquatic HQs were less than 1.0 using the mean concentrations (Tables 7-11 and 7-12). All HQs were less than 1.0 using the maximum filtered surface water concentration (Table 7-13).

Zinc concentrations exceeded the Region 4 ESV in only one of eight filtered surface water samples and 2 of 11 filtered groundwater samples, but the maximum concentrations only slightly exceeded the conservative Region 4 screening value. The maximum sediment concentration equaled but did not exceed the Region 4 ESV and was considerably less than most of the alternate guidelines shown in Table 7-18. Background concentrations were exceeded in only a few surface water and sediment

samples. Aquatic food chain HQs based on the maximum surface water and sediment concentrations exceeded 1.0 only for the heron (NOAEL HQ = 1.5) and osprey (NOAEL HQ = 1.8). As previously discussed, these values were derived by assuming that concentrations of zinc in prey items of the osprey and heron were equal to sediment concentrations. Even using this conservative assumption, the HQs for these two representative receptors were relatively low, and all other aquatic HQs were less than 1.0. For this reason and since surface water and sediment HQs were also low relative to Region 4 ESVs and/or alternate guidelines, potential risks to aquatic species are negligible.

Zinc was detected in all surface soil samples, and all concentrations exceeded the background soil concentration. Zinc concentrations in most soil samples exceeded the Region 4 ESV, and concentrations were highest in samples SS-007-01 (433 mg/kg), SS-008-01 (497 mg/kg), and SS-009-01 (471 mg/kg). Concentrations in these three samples exceed most of the alternate guidelines shown in Table 7-19 but are slightly less than the Dutch B value (500 mg/kg) indicative of "moderate soil contamination." The Region 4 ESV of 50 mg/kg was established by Efroymson et al. (1997b), indicative of toxicity to plants. However, pH is a controlling factor in the uptake of zinc into plants and in phytotoxicity, with an increase in pH being associated with a decrease in uptake and toxicity (Efroymson et al., 1997b). The relatively high soil pH values (6.3 to 7.7, Appendix C) at the site suggest that the phytotoxicity threshold of zinc at Site 1 and SWMU 41 may be higher than the Region 4 ESV.

An absorption fraction of 100 percent was assumed for the food chain modeling (i.e., 100 percent of the ingested contaminant was absorbed). However, available data indicate that gastrointestinal absorption of zinc varies from 20 to 80 percent and depends on the chemical compound, as well as on zinc levels in the body and on concentrations of other nutrients (U.S. EPA, 1984b). Thus, even though the food chain HQs for most representative terrestrial species were greater than 1.0, the HQ values would decrease when less than 100 percent absorption is assumed. Furthermore, the maximum terrestrial HQs for the three representative bird species would decrease if more realistic area-use factors were used.

In summary, potential ecological risks from zinc at Site 1 and SWMU 41 are limited to terrestrial receptors. Surface soil concentrations of zinc were generally greater than background soil concentrations and are thus assumed to be due to site-related contamination. Soil concentrations of zinc might pose risks to soil invertebrates and vermivorous receptors with small home ranges (e.g., shrews, moles) in the vicinity of samples SS-007-01, SS-008-01, and SS-009-01. However, the potential risks to these receptors appear to be minor (at worst). This is discussed further in Section 7.8.5.

7.8.5 Metals – Cumulative Toxicity

Concentrations of most metals detected at Site 1 and SWMU 41 appear to pose negligible potential risks to ecological receptors when considered as individual COPCs. However, as discussed by U.S. EPA

(1997b), the potential effects of cumulative toxicity should be considered when appropriate. The maximum soil concentrations of most metals were recorded in two samples: SS-08-01 and SS-09-01 (Table 7-6 and Figure 4-1). At both of these locations, the HI of metals in soil would be well above 1.0. The exact HI was not calculated since the toxic mechanisms of metals are complex and it is difficult to ascertain the degree to which the metals "produce effects by the same toxic mechanism" (U.S. EPA, 1997b). The important point here is that concentrations of several metals in soil at these two locations are elevated. The extent of potential cumulative toxicity to terrestrial receptors from these elevated concentrations is not clear. Likewise, definitive conclusions regarding which metals could pose the greatest potential risks from cumulative toxicity cannot be made. It is assumed, however, that the concentrations of metals in these two samples could pose potential risks to terrestrial receptors from cumulative toxicity.

7.9 SCREENING LEVEL AND STEP 3A UNCERTAINTY ANALYSIS

Uncertainty is associated with all aspects of the ecological risk assessment process. This section provides a summary of the general uncertainties involved in this ecological risk assessment, with a discussion of how they may affect the final risk values and conclusions.

The results of an ecological risk assessment must be reviewed and evaluated to identify the types and magnitudes of uncertainties involved. Relying on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. If numerous conservative assumptions are combined in the ecological risk assessment process, the resulting calculations will propagate the uncertainties associated with each of those assumptions. The resulting bias is toward over-predicting risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered.

Generally, risk assessments carry two types of uncertainty: measurement and informational. Measurement uncertainty refers to the variability inherent in measured data. The risk assessment reflects the accumulated variances of the individual values used for several different parameters. Informational uncertainty stems from the limited availability of necessary information. Often the gap between what is needed and what is available is significant. As examples, information is often absent regarding the effects of some contaminants on wildlife receptors, the biological mechanisms of contaminants, and the impacts of physiological differences on exposure pathways.

- Uncertainty is associated with each of the steps of the risk assessment process.

- Uncertainty in preliminary problem formulation can result from limited information regarding contaminant sources, release mechanisms, and exposure routes.

- Uncertainty in the ecological effects characterization arises from the quality of the existing screening values and toxicity data to support a determination of potential adverse impacts to ecological receptors.

- Uncertainty associated with the exposure assessment includes the methods used and the assumptions made to determine exposure point concentrations or calculate contaminant doses.

7.9.1 Uncertainty in the Preliminary Problem Formulation

Some portions of Site 1 and SWMU 41 could receive contaminant inputs from more than one source, although, initially, contaminants are conservatively assumed to stem directly from site-related activities. For example, the marsh surrounding the peninsula on which the sites are located probably receives contaminant inputs from floating debris and other materials via the tidal flow of marine surface water. The extent that other sources are responsible for the presence of COCs at the sites is uncertain. Since contaminant concentrations may reflect inputs from many sources, including non-Navy sources, uncertainties exist regarding whether risk characterized at the sites stems from site-related contaminants.

7.9.2 Uncertainty in the Ecological Effects Characterization

Uncertainty in this risk assessment also arises from the nature and quality of the available toxicity data used to derive guidelines. This uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose related; and when mechanisms of toxicity are similar for laboratory and wildlife species. Most guidelines are based on conservative assumptions. Although conservativeness is needed in a screening-level ecological risk assessment to ensure that the most sensitive receptors are protected, conservative guidelines may heavily overestimate potential risks and the resulting HQ values may be misleading. Region 4 screening levels and the NOAELs and LOAELs used in this assessment are based on laboratory studies that do not take into account mitigating or ameliorating physical and chemical conditions in the environment. That is, the most bioavailable (i.e., toxic) form of the contaminant is usually applied to the exposure medium. In reality, bioavailability is rarely, if ever, 100 percent. Conversely, laboratory studies frequently ignore potentially exacerbating conditions such as the possibility of synergistic effects of complex mixtures of chemicals and altered sediment chemistry due to periodic hypoxia and resultant pH depression. Ecological guidelines may underestimate potential risks when these factors are inadequately determined.

Conservative guidelines for surface water are set to protect the majority of aquatic organisms from adverse effects on growth, survival, and reproduction. The laboratory testing that is used for the development of guidelines generally uses the most toxic form of the element (ionic species derived from a

metal salt such as $AgNO_3$ or CuCl). These guidelines overestimate toxicity by not taking into account the speciation of the metal in a natural water system. U.S. EPA recognizes that other factors such as hardness and organic carbon concentrations have an effect on the toxicity of a metal. U.S. EPA has incorporated hardness coefficients into the freshwater guidelines for many metals, but coefficients for organic carbon have yet to be proposed.

As mentioned earlier, few data are available for investigating dietary exposures and related risks to reptiles and amphibians. The absence of toxicity data for these organisms precludes modeling of potential risks to them. As a result, direct conclusions about the potential risks to reptiles and amphibians cannot be made, and only qualitative inferences can be drawn.

Similarly, few data are available for investigating dietary exposures and related risks to the mummichog and red drum, the species selected as representative fish species to use in the aquatic food chain modeling. Specifically, dietary NOAELs and LOAELs for fish were not available for some of the COPCs identified in sediment and surface water at Site 1. As a result, direct conclusions about the potential risks to fish through ingestion cannot be made, and only qualitative inferences can be drawn. It should be noted that AWQCs for most contaminants are based, in part, on sensitive aquatic species (including fish species). Thus, the surface water screening assessment at least partially accounts for fish species.

In order to reduce the uncertainty resulting from the paucity of dose-based toxicity data for fish, a residue-based approach was also used to assess the potential toxicity to fish from contaminants that are known to biomagnify in the food web. However, available tissue NOAELs and LOAELs cover a wide range of values depending on species tested, dose levels, route of administration, form of chemical, and other factors. Furthermore, as discussed further in Section 7.9.3, the relationships between tissue concentrations and adverse effects are not clear. Thus, uncertainty exists for chemicals regarding the validity and applicability of tissue-based toxicity reference values.

Ecological risk assessments, unlike human health risk assessments, must consider risks to many different species. Calculation of risks for every potential receptor species is not possible. For this ecological risk assessment, conservative guidelines protective of a wide range of ecological receptors were sought. The underlying assumption associated with the use of these guidelines is that contaminant concentrations in excess of these values are indicative of potential impacts to actual receptors inhabiting the area. However, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase/decrease a receptor's contact with a contaminant are seldom known. Also, some contaminants were present for which no suitable guidelines were available, and as a result, they could not be quantitatively assessed. The use of guidelines, while necessary, will introduce error into the results of an assessment.

7.9.3 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises mainly in the methods used to obtain exposure-point concentrations. The maximum detected contaminant concentrations were initially used to represent the highest contaminant concentrations to which ecological receptors might be exposed. If the samples evaluated in this ecological risk assessment are representative of contaminant concentrations associated with the sites, then this approach is conservative and should overestimate potential risks to ecological receptors. Although the use of maximum values is appropriate for screening in an ecological risk assessment, maximum values could grossly over-predict potential risks in some situations. To somewhat mitigate these uncertainties, average concentrations were also considered in the food chain modeling, but they do not fully account for the uncertainties involved in selecting exposure-point contaminant concentrations.

Contaminant concentrations in a given medium may under-predict potential risks if sample locations are not properly selected. For example, sediment samples should be collected from areas where sediment deposition is expected to be maximal. Otherwise, sediment data may not be adequate for conservatively estimating ecological risks. Sediment grain size and percent total organic carbon (TOC) data are available for some of these samples (Table 4-8, and Appendix C). The high silt-clay content (17 to 41 percent) and TOC (1.4 to 4.2 percent) in these samples suggest that they were indeed collected from depositional areas. Nevertheless, some degree of uncertainty remains. Potential risks from soil contaminants could be underestimated by excluding sub-surface soil data from the ecological risk assessment. U.S. EPA Region IV considers 0- to 1-foot soil samples to be representative of surface soils for purposes of ecological risk assessments, but tree roots extend deeper than one foot below the surface, and some burrowing mammal species could be exposed to sub-surface soil contaminants. Deep-burrowing mammals such as armadillos, gopher tortoises, and woodchucks do not inhabit Site 1/SWMU 41. With the exception of moles, foxes, and skunks, most terrestrial animal species at the site would rarely (if ever) be exposed to soils deeper than one foot below the surface. While the uncertainty involving risks to animals is probably minimal, there is some uncertainty involving potential risks to trees via root uptake.

Dermal and inhalation exposures were not evaluated in this ecological risk assessment. As discussed in Section 7.2.3, these exposure routes are usually miniscule, but since they cannot be quantitatively assessed, only limited, qualitative conclusions regarding their significance can be drawn and uncertainties remain. Dermal exposure is usually limited by the outer coverings of most receptors. Nonetheless, certain portions of some receptors, such as food pads, eyes, and nose do not contain fur or feathers, for example, and may have a higher chance of exposure. However, these areas generally constitute a small portion of the total surface area of most receptors. Although some of the concentrations of contaminants

in surface soils and sediments are elevated, they do not appear to be high enough qualitatively to warrant concern over dermal exposure. Surface water can reach the dermis regardless of outer coverings such as fur and feathers, but interpretability of the surface water data is low.

Inhalation of contaminants is assumed to be miniscule. Airborne aerosols, particulates, and vapors are not assumed to be applicable for aquatic media. As mentioned earlier, bare soil is minimal at the sites. As a result, airborne particles would be expected to be minimal. Concentrations of VOCs in surface soils at Site 2 were low. Nevertheless, burrowing wildlife (e.g., moles) would be exposed to some contaminants via inhalation. However, data regarding inhalation exposure and toxicity for wildlife were not available.

Uncertainty is also associated with the use of literature-based BAFs, BCFs, and BSAFs used in the screening-level food chain modeling. These values often vary considerably between species and sites. This can lead to both over- and underestimation of potential risks.

Uncertainty regarding exposure to contaminated sediments also results from the assumption that contaminant concentrations in fish tissues are correlated with sediment concentrations and with adverse effects. Although it may be true that doses, tissue concentrations, and effects are all correlated, there is no indication in the two primary databases from which most of the tissue NOAELs and LOAELs were gathered (ERED, 1998; Jarvinen and Ankley, 1999) of the strength of any correlation between tissue concentrations and effects. As pointed out by Jarvinen and Ankley (1999), the use of effects/tissue-residue relationships in ecological risk assessments must incorporate consideration of contaminant toxicokinetics. The authors further discuss studies in which the toxicity associated with mercury (and other chemical) residues in fish depends on factors such as food quality, temperature, and pH. Other factors that affect the relationship between tissue concentrations and toxicity include species tested, dose levels, route of administration, and the form of chemical (Jarvinen and Ankley, 1999; Wiener and Spry, 1995). It may be appropriate to treat these data like Long et al. (1995) and other researchers have treated sediment toxicity data (i.e., by ranking concentrations, calculating distributional statistics, and verifying the predictive capability of the statistics with independent data). However, this has not been done with available tissue databases. In summary, cause and effect have not been established for the relationship between tissue concentrations and effects observed in the animals with contaminated tissue. Thus, uncertainty exists for chemicals regarding the validity and applicability of tissue-based toxicity reference values.

7.9.4 Uncertainty in the Risk Characterization

Uncertainty in the risk characterization is affected by all aspects of the ecological risk assessment process described in the above sections. Uncertainty in risk characterization also stems, in part, from

combining different components of the ecological risk assessment in this step. Each of those components already contains uncertainty. Thus, uncertainties may be propagated when these components are combined. To try to reduce the overall uncertainty in the risk assessment, the weight of evidence approach is used to make risk decisions. This approach takes the results of all aspects of the assessment into account, including the uncertainties, to make determinations of potential risk versus no risk.

Uncertainty in risk characterization of soil contaminants at Site 1 and SWMU 41 results from the lack of toxicity data regarding the cumulative toxicity of metals. Concentrations of several metals were elevated in samples SS-08-01 and SS-09-01. Concentrations of these metals, when assessed individually, appear to pose negligible or minor potential risks to terrestrial receptors. The extent to which these same concentrations of metals might contribute to cumulative toxicity is uncertain.

7.10 ECOLOGICAL RISK SUMMARY

Several inorganic and organic compounds were present in Site 1 groundwater, surface water, sediment, and surface soil samples, and in SWMU 41 surface soil samples at concentrations that exceeded U.S. EPA Region 4 ecological screening values and were, therefore, retained as COPCs. Several other compounds were retained as COPCs since screening levels were not available. Most COPCs were eliminated as COCs in Step 3a of the risk assessment process for one or more reasons, such as low frequency of detection, concentrations comparable to background values (primarily inorganics) or to alternative screening levels, and spatial analysis of detections.

Surface water contaminants do not appear to pose potential risks to ecological receptors.

Sediment concentrations of total PAHs and some individual PAHs [e.g., benzo(a)pyrene, dibenz(a,h)anthracene, ideno(1,2,3-cd)pyrene, and pyrene] were elevated relative to sediment guidelines in samples SD-017-01 and SD-001-01. The results of the food chain modeling indicate that PAH compounds pose negligible risks to upper level receptors. However, these compounds could pose potential ecological risks to benthic organisms in the vicinity of these two samples.

Chlordane concentrations could pose potential risks to some aquatic receptors in the vicinity of sediment sample SD-09-01. Sediment concentrations of DDT and its metabolites DDD and DDE could also pose potential risks to some aquatic receptors in the vicinity of sediment sample SD-09-01. Soil concentrations of DDT, DDD, and DDE could pose potential risks to some terrestrial receptors, especially in the vicinity of soil sample SS-07-01. Lead could pose potential risks to benthic invertebrates in the vicinity of sediment samples SD-009-01 and SD-003-01.

Copper could pose potential risks to benthic invertebrates in the vicinity of sediment sample SD-001. Mercury could pose potential risks to benthic invertebrates in the vicinity of sediment sample SD-009-01. Mercury could pose potential risks to terrestrial receptors in the vicinity of sample SS-007-01, and lead could pose potential risks to terrestrial receptors in the vicinity of samples SS-007-01, SS-008-01, and SS-009-01. Concentrations of most other metals detected in soils at Site 1 and SWMU 41 appear to pose negligible potential risks to ecological receptors when considered as individual COPCs. However, concentrations of several metals were elevated in samples SS-08-01 and SS-09-01. Cumulative toxicity of metals in the vicinity of these samples might pose potential risks to terrestrial receptors.

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TABLE 7-1

TOXICITY REFERENCE VALUES (TRVs) FOR MAMMALS
SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Test Species	Endpoint	Study Duration	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	Reference
Semivolatile Organic Compounds						
1,2,4-Trichlorobenzene	NA			NA	NA	NA
2-Methylnaphthalene[a]	Mouse	reproduction	days 7-16 of gestation	1	10	MacKenzie & Angevine, 1981[b]
Acenaphthylene	Mouse	tumors	110 days	1.3	2.6	ERT, 1997
Anthracene	Mouse	tumors	110 days	1.3	2.6	ERT, 1997
Benzo(a)anthracene[a]	Mouse	reproduction	days 7-16 of gestation	1	10	MacKenzie & Angevine, 1981[b]
Benzo(a)pyrene	Mouse	reproduction	days 7-16 of gestation	1	10	MacKenzie & Angevine, 1981[b]
Benzo(b)fluoranthene[a]	Mouse	reproduction	days 7-16 of gestation	1	10	MacKenzie & Angevine, 1981[b]
Benzo(g,h,i)perylene[a]	Mouse	reproduction	days 7-16 of gestation	1	10	MacKenzie & Angevine, 1981[b]
Benzo(k)fluoranthene[a]	Mouse	reproduction	days 7-16 of gestation	1	10	MacKenzie & Angevine, 1981[b]
Bis(2-Ethylhexyl)phthalate	Mouse	reproduction	105 days	18.3	183	Lamb et al., 1987[b]
Butylbenzylphthalate	Mouse	tumors	110 days	159	1590	ERT, 1997
Carbazole	Mouse	tumors	110 days	1.3	2.6	ERT, 1997
Chrysene	Mouse	tumors	110 days	1.3	2.6	ERT, 1997
Dibenzo(a,h)anthracene	Mouse	tumors	110 days	1.3	2.6	ERT, 1997
Dibenzofuran	Mouse	multinuclear hepatocytes		60	125	ATSDR, 1991
Di-n-octyl phthalate[c]	Mouse	reproduction	105 days	18.3	183	Lamb et al., 1987[b]
Fluoranthene	Mouse	tumors	110 days	1.3	2.6	ERT, 1997
Fluorene	Mouse	tumors	110 days	1.3	2.6	ERT, 1997
Indeno(1,2,3-cd)pyrene	Mouse	tumors	110 days	1.3	2.6	ERT, 1997
Phenanthrene	Mouse	tumors	110 days	1.3	2.6	ERT, 1997
Pyrene	Mouse	tumors	110 days	1.3	2.6	ERT, 1997
Pesticides/PCBs						
4,4'-DDD[d]	Rat	reproduction	2 years	0.8	4	Fitzhugh, 1948[b]
4,4'-DDE[d]	Rat	reproduction	2 years	0.8	4	Fitzhugh, 1948[b]
4,4'-DDT	Rat	reproduction	2 years	0.8	4	Fitzhugh, 1948[b]
Aroclor-1260[e]	Old field mouse	reproduction	12 months (>1 yr)	0.068	0.68	McCoy et al., 1995[b]
alpha-BHC[f]	Mink	reproduction	331 days	0.014	0.14	Bleavins et al., 1984[b]

TABLE 7-1

TOXICITY REFERENCE VALUES (TRVs) FOR MAMMALS
SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Test Species	Endpoint	Study Duration	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	Reference
beta-BHC	Rat	growth, blood chemistry	13 weeks (<1 yr)	0.4	2	Van Velsen et al., 1986[b]
delta-BHC[f]	Mink	reproduction	331 days	0.014	0.14	Bleavins et al., 1984[b]
gamma-BHC (Lindane)	Rat	reproduction	3 generations (>1)	8	80[i]	Palmer et al., 1978[b]
Alpha-Chlordane[g]	Mouse	reproduction	6 generations (>1)	4.6	9.2	Keplinger et al., 1968[b]
Gamma-Chlordane[g]	Mouse	reproduction	6 generations (>1)	4.6	9.2	Keplinger et al., 1968[b]
Endrin Ketone[h]	Mouse	reproduction	120 days	0.092	0.92	Good & Ware, 1969[b]
Metals and Inorganics						
Aluminum	Mouse	reproduction	3 generations (>1 yr)	1.93	19.3	Ondreicka et al., 1966[b]
Antimony	Mouse	lifespan, longevity	lifetime (>1 yr)	0.125	1.25	Schroeder et al., 1968[b]
Arsenic	Mouse	reproduction	3 generations	0.126	1.26	Schroeder & Mitchner, 1971[b]
Barium	Rat	growth	16 months	5.1	51[i]	Perry et al., 1983[b]
Beryllium	Rat	weight loss, longevity	lifetime (>1 yr)	0.66	6.6[i]	Schroeder & Mitchner, 1975[b]
Cadmium	Rat	reproduction	6 weeks through mating and gestation	1	10	Sutou et al., 1980[b]
Cobalt	Not provided			1	10	ERT, 1997
Copper	Mink	reproduction	357 days	11.7	15.14	Aulerich et al., 1982[b]
Iron	Not provided			50	500	ERT, 1997
Lead	Rat	reproduction	3 generations (>1 yr)	8	80	Azar et al., 1973[b]
Manganese	Rat	reproduction	through gestation for 224 days	88	284	Laskey et al., 1982[b]
Mercury	Mink	mortality, weight loss	93 days	0.015	0.025	Wobeser et al., 1976[b]
Nickel	Rat	reproduction	3 generations (>1 yr)	40	80	Ambrose et al., 1976[b]
Selenium	Rat	reproduction	1 year, through 2 generations	0.2	0.33	Rosenfeld & Beath, 1954[b]
Silver	Mouse	behavior	125 days	1.8	18	Rungby & Danscher, 1984
Thallium	Rat	reproduction	60 days	0.0074	0.074	Formigli et al., 1986[b]

TABLE 7-1

TOXICITY REFERENCE VALUES (TRVs) FOR MAMMALS
SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Test Species	Endpoint	Study Duration	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	Reference
Vanadium	Rat	reproduction	60 d prior to gestation, plus through gestation, delivery and lactation	0.21	2.1	Domingo et al., 1986[b]
Zinc	Rat	reproduction	days 1-16 of gestation	160	320	Schlinker & Cox, 1968[b]

NA Not available
a Benzo(a)pyrene value used as a surrogate.
b See Sample et al (1996) for full citation and details of study.
c Bis(2-Ethylhexyl)phthalate used as a surrogate.
d 4,4'-DDT used as a surrogate.
e Aroclor-1254 used as a surrogate.
f BHC mixed isomers used as a surrogate.
g Chlordane used as a surrogate.
h Endrin used as a surrogate.
i LOAEL not determined in study; estimated LOAEL = NOAEL x 10

TABLE 7-2

TOXICITY REFERENCE VALUES (TRVs) FOR BIRDS AND FISH
SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Test Species	Endpoint	Study Duration	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	Reference
Semivolatile Organic Compounds						
1,2,4-Trichlorobenzene	NA			NA	NA	NA
2-Methylnaphthalene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Acenaphthylene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Anthracene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Benzo(a)anthracene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Benzo(a)pyrene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Benzo(b)fluoranthene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Benzo(g,h,i)perylene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Benzo(k)fluoranthene	European starling	body weight, hemoglobin	11 days	10	100	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3	3	Martin, 1980
Bis(2-Ethylhexyl)phthalate	Ringed dove	reproduction	4 weeks	1.1	11*	Peakall, 1974[c]
	Channel catfish	mortality		NA	NA	NA
Butylbenzylphthalate[d]	Ringed dove	reproduction	4 weeks	1.1	11*	Peakall, 1974[c]
	Channel catfish	mortality		NA	NA	NA
Carbazole	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Chrysene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Dibenzo(a,h)anthracene	European starling	body weight, hemoglobin	11 days	10	100	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3	3	Martin, 1980
Dibenzofuran	European starling	body weight, hemoglobin	11 days	NA	NA	NA
	Channel catfish	mortality	9 days	NA	NA	NA

TABLE 7-2

TOXICITY REFERENCE VALUES (TRVs) FOR BIRDS AND FISH
SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Test Species	Endpoint	Study Duration	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	Reference
Di-n-octyl phthalate[d]	Ringed dove	reproduction	4 weeks	1.1	11*	Peakall, 1974[c]
	Channel catfish	mortality		NA	NA	NA
Fluoranthene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Fluorene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Indeno(1,2,3-cd)pyrene	European starling	body weight, hemoglobin	11 days	10	100	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3	3	Martin, 1980
Phenanthrene	European starling	body weight, hemoglobin	11 days	10[a]	100[a]	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3[b]	3.0[b]	Martin, 1980
Pyrene	European starling	body weight, hemoglobin	11 days	10	100	Trust et al., 1993
	Channel catfish	mortality	9 days	0.3	3	Martin, 1980
Pesticides/PCBs[e]						
4,4'-DDD[f]	Brown pelican	reproduction	5 years	0.0028	0.028	Anderson et al., 1975[c]
4,4'-DDE[f]	Brown pelican	reproduction	5 years	0.0028	0.028	Anderson et al., 1975[c]
4,4'-DDT	Brown pelican	reproduction	5 years	0.0028	0.028	Anderson et al., 1975[c]
Aroclor-1260[g]	Ring-necked pheasant	reproduction	17 weeks	0.18[h]	1.8	Dahlgren et al., 1972[c]
Alpha-Chlordane[i]	Red-winged blackbird	mortality	84 days	2.14	10.7	Stickel et al., 1983[c]
Gamma-Chlordane[i]	Red-winged blackbird	mortality	84 days	2.14	10.7	Stickel et al., 1983[c]
alpha-BHC[j]	Japanese quail	reproduction	90 days	0.56	2.25	Vos et al., 1971[c]
beta-BHC[j]	Japanese quail	reproduction	90 days	0.56	2.25	Vos et al., 1971[c]
delta-BHC[j]	Japanese quail	reproduction	90 days	0.56	2.25	Vos et al., 1971[c]
gamma-BHC (Lindane)	Mallard duck	reproduction	8 weeks	2	20	Chakravarty & Lahiri, 1986[c]
Endrin Ketone[k]	Screech owl	reproduction	> 83 days	0.01	0.1	Flemeing et al., 1982[c]
Metals and Inorganic Compounds[e]						
Aluminum	Ringed dove	reproduction	4 months	109.7	1097*	Carriere et al., 1986[c]
Antimony	NA			NA	NA	NA

TABLE 7-2

TOXICITY REFERENCE VALUES (TRVs) FOR BIRDS AND FISH
SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Test Species	Endpoint	Study Duration	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	Reference
Arsenic	Mallard duck	mortality	128 days	5.14	12.84	USFWS, 1964[c]
	Rainbow trout	growth	8 weeks	0.59	7.1	ERT, 1997
Barium	1-day-old chicks	mortality	4 weeks	20.8	41.7	Johnson et al., 1960[c]
Beryllium	NA			NA	NA	NA
Cadmium	Mallard duck	reproduction	90 days	1.45	20	White & Finley, 1978[c]
Cobalt	Not provided			1	10	ERT, 1997
Copper	1-day-old chicks	growth, mortality	10 weeks	47	61.7	Mehring et al., 1960[c]
Iron	Chicken	not provided		100	1000	ERT, 1997
Lead	Japanese quail	reproduction	12 weeks	1.13	11.3	Edens et al., 1976[c]
Manganese	Japanese quail	growth, behavior	75 days	977	9770*	Laskey & Edens, 1985[c]
Mercury	Mallard duck	reproduction	3 generations	0.0064	0.064	Heinz, 1979[c]
	Rainbow trout	growth	40 weeks	0.008	0.94	ERT, 1997
Nickel	Mallard duck	growth, mortality	90 days	77.4	107	Cain & Pafford, 1981[c]
Selenium	Mallard duck	reproduction	100 days	0.4	0.8	Heinz et al., 1989[c]
Silver	NA			NA	NA	NA
Thallium	NA			NA	NA	NA
Vanadium	Mallard duck	mortality	12 weeks	11.4	114*	White & Dieter, 1978[c]
Zinc	White leghorn hens	reproduction	44 weeks	14.5	131	Stahl et al., 1990[c]

NA = Not available
a Dimethylbenz(a)anthracene used as a surrogate.
b Benzo(a)pyrene used as a surrogate.
c See Sample et al., (1996) for full citation and details of study.
d Bis(2-Ethylhexyl)phthalate used as a surrogate.
e Fish TRVs not available for pesticides, PCBs, and metals except as noted.
f. DDT used as a surrogate.
g Aroclor-1254 used as a surrogate.
h NOAEL not determined in test. Sample et al., (1996) estimated the NOAEL by multipling the LOAEL by 0.1
i Chlordane used as a surrogate.
j BHC mixed isomers used as a surrogate.
k Endrin used as a surrogate.
* LOAEL not determined in study; estimated LOAEL = NOEAL x 10

TABLE 7-3

EXPOSURE PARAMETERS FOR REPRESENTATIVE ECOLOGICAL RECEPTORS
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Receptor	Representative Group	Body Weight[1] (grams)	Food Ingestion[1,2] (grams/day)	Assumed Diet for Exposure Assessment[1]	Home Range[1] (acres)
Short-tailed shrew (*Blarina carolinensis*)	Insectivorous mammal	9.73[3]	5.2	90% invertebrates 10% soil	0.96[1] to 2.4[3]
Cotton mouse (*Peromyscus gossypnius*)	Herbivorous Mammal	31[4]	8.6	98% vegetation 2% soil[5]	0.05 to 0.3[5]
Raccoon (*Procyon lotor*)	Omnivorous Mammal	3990	856	90.6% aquatic invertebrates 9.4% sediment	96 to 160
Red fox (*Vulpes vulpes*)	Predatory Mammal	4530	498	97.2% prey 2.8% soil	140 to 2100
American woodcock (*Scolopax minor*)	Vermivorous Bird	197	152	89.6% invertebrates 10.4% soil	8 to 185
American robin (*Turdus migratorius*)	Omnivorous Bird	77.3	69	35% invertebrates 60% vegetation 5% soil[6]	0.5 to 2.1 (nesting season)
Great Blue Heron (*Ardea herodias*)	Piscivorous Bird	2229	401	100% fish soil, sediment: none[6]	0.2 to 5 miles[7]
Osprey (*Pandion haliaetus*)	Piscivorous Bird	1486	312	100% fish soil, sediment: none[6]	0.3 to 6 miles[7]
Red-tailed hawk (*Buteo jamaicensis*)	Carnivorous Bird	1126	126	100% prey soil, sediment: none[6]	940 to 2440
Mummichog (*Fundulus heteroclitus*)	Forage fish	3.0[8]	0.174[8]	N/A; exposure assumed equal to sediment concentrations	40 to 400 yds in tidal creeks[9]
Red drum (*Sciaenops ocellatus*)	Upper trophic level fish	1400[10]	28[11]	85% prey, 15% sediment[12]	not available

1 Exposure parameters are from EPA (1993) unless otherwise noted.
2 Food ingestion includes intended food items and incidentally ingested soil or sediment. For example, a shrew would be expected to consume 4.7 g invertebrates plus 0.5 g soil per day. See Section 7.4.2.1 of text for ingestion formulas.
3 Cothran et al. (1991)
4 Lowery (1974)
5 Based on deer mouse (*Peromyscus maniculatus*)
6 Sample and Suter (1994)
7 Foraging radius (home range acreage not available)
8 Iannuzzi et al. (1996)
9 Abraham (1985)
10 Wenner (1992); see Section 7.3.3.11 of text.
11 Evans and Engel (1994)
12 Gerking (1994). See Section 7.3.3.11 of text.

TABLE 7-4

SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SURFACE WATER - SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detection		Location of Maximum	EPA Region IV Screening Level[a]	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
Volatile Organics (ug/L)							
Acetone	1/2	7	7	PAI-01-SW-09-00	NA	NA	Yes
Semivolatile Organics (ug/L)							
2-Methylnaphthalene	1/8	10	10	PAI-01-SW-03-00	NA	NA	Yes
Bis(2-ethylhexyl) phthalate	3/8	14	56	PAI-01-SW-03-00	NA	NA	Yes
Chrysene	1/8	0.1	0.1	PAI-01-SW-10-00	NA	NA	Yes
Dibenzofuran	1/8	10	10	PAI-01-SW-03-00	NA	NA	Yes
Fluoranthene	2/8	0.082	0.22	PAI-01-SW-10-00	1.6	0.14	No
Pentachlorophenol	1/8	110	110	PAI-01-SW-03-00	11.9[b]	9.20	Yes
Phenol	1/8	3	3	PAI-01-SW-11-00	58	0.05	No
Inorganics (ug/L)							
Aluminum	6/8	434	13435	PAI-01-SW-01-00-AVG	NA	NA	Yes
Antimony	1/8	2.075	2.075	PAI-01-SW-01-00-F-AVG	NA	NA	Yes
Arsenic	1/8	13.9	13.9	PAI-01-SW-10-00	36	0.39	No
Barium	8/8	12.6	263	PAI-01-SW-12-00-F	NA	NA	Yes
Cadmium	2/8	0.305	0.42	PAI-01-SW-01-00-AVG	9.3	0.05	No
Chromium	2/8	14.1	19.2	PAI-01-SW-10-00	50	0.38	No
Cobalt	2/8	1.76	2.9	PAI-01-SW-10-00	NA	NA	Yes
Copper	2/8	13.6	62.95	PAI-01-SW-01-00-AVG	2.9	21.71	Yes
Iron	8/8	175	15600	PAI-01-SW-10-00	NA	NA	Yes
Lead	2/8	20.9	77.5	PAI-01-SW-01-00-AVG	8.5	9.12	Yes
Manganese	8/8	21.65	124	PAI-01-SW-10-00	NA	NA	Yes
Mercury	2/8	0.09	0.12	PAI-01-SW-10-00	0.025	4.80	Yes
Nickel	2/8	3.85	5	PAI-01-SW-10-00	8.3	0.60	No
Silver	1/8	0.89	0.89	PAI-01-SW-11-00	0.23	3.87	Yes
Vanadium	2/8	24.2	36.1	PAI-01-SW-10-00	NA	NA	Yes
Zinc	6/8	7.3	96.4	PAI-01-SW-12-00-F	86	1.12	Yes

NA = Not available
a Salt water screening value; average salinity of surface water = 21 ppt
b Based on a site specific pH of 7.73

TABLE 7-5

SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN
SEDIMENT - SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detection		Location of Maximum	EPA Region IV Screening Level	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
Volatile Organics (ug/kg)							
Acetone	3/3	16	63	PAI-01-SD-09-01	NA	NA	Yes
Carbon Disulfide	6/9	2	24	PAI-01-SD-001	NA	NA	Yes
Toluene	6/9	3	7	PAI-01-SD-09-01	NA	NA	Yes
Semivolatile Organics (ug/kg)							
Acenaphthylene	1/14	380	380	PAI-01-SD-02-01	5.87	64.74	Yes
Anthracene	6/14	11	770	PAI-01-SD-001	46.9	16.42	Yes
Benz(a)anthracene	8/14	30	2200	PAI-01-SD-017	74.8	29.41	Yes
Benz(a)pyrene	9/14	7.8	1700	PAI-01-SD-017	88.8	19.14	Yes
Benzo(b)fluoranthene	10/14	8.1	1800	PAI-01-SD-017	88.8[a]	20.27	Yes
Benzo(g,h,i)perylene	7/14	30	990	PAI-01-SD-017	88.8[a]	11.15	Yes
Benzo(k)fluoranthene	9/14	3.1	850	PAI-01-SD-017	88.8[a]	9.57	Yes
Carbazole	3/9	86	580	PAI-01-SD-02-01	88.8[a]	6.53	Yes
Chrysene	9/14	13	2300	PAI-01-SD-017	108	21.30	Yes
Dibenzo(a,h)anthracene	1/14	1600	1600	PAI-01-SD-017	6.22	257.23	Yes
Fluoranthene	9/14	25	6600	PAI-01-SD-017	113	58.41	Yes
Fluorene	1/14	160	160	PAI-01-SD-03-01-AVG	21.2	7.55	Yes
Indeno(1,2,3-cd)pyrene	8/14	30	1100	PAI-01-SD-017	88.8[a]	12.39	Yes
Phenanthrene	8/14	25	2600	PAI-01-SD-001	86.7	29.99	Yes
Pyrene	7/14	64	5400	PAI-01-SD-017	153	35.29	Yes
Total PAHs	10/13	981	30,103	PAI-01-SD-017	1684	15.80	Yes
Pesticides/PCBs (ug/kg)							
4,4'-DDD	4/14	3.6	260	PAI-01-SD-09-01	1.22	213.11	Yes
4,4'-DDE	6/14	5.5	120	PAI-01-SD-09-01	2.07	57.97	Yes
4,4'-DDT	4/13	3.2	270	PAI-01-SD-09-01	1.19	226.89	Yes
Alpha-Chlordane	1/8	52	52	PAI-01-SD-09-01	0.5[b]	104.00	Yes
Gamma-Chlordane	1/14	130	130	PAI-01-SD-09-01	0.5[b]	260.00	Yes
alpha-BHC	1/14	2.7	2.7	PAI-01-SD-02-01	NA	NA	Yes
beta-BHC	1/14	5.4	5.4	PAI-01-SD-02-01	NA	NA	Yes
delta-BHC	1/14	2.7	2.7	PAI-01-SD-02-01	NA	NA	Yes
gamma-BHC (Lindane)	1/14	2.1	2.1	PAI-01-SD-02-01	0.32	6.56	Yes
Inorganics (mg/kg)							
Aluminum	14/14	2110	23400	PAI-01-SD-02-02	NA	NA	Yes
Antimony	4/14	0.55	1.3	PAI-01-SD-001	2	0.65	No
Arsenic	13/14	1.2	15.6	PAI-01-SD-10-01	7.24	2.15	Yes
Barium	14/14	5.7	88.5	PAI-01-SD-09-01	NA	NA	Yes

TABLE 7-5

SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN
SEDIMENT - SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detection		Location of Maximum	EPA Region IV Screening Level	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
Beryllium	3/14	0.7075	1.2	PAI-01-SD-10-01	NA	NA	Yes
Cadmium	1/14	0.79	0.79	PAI-01-SD-02-02	0.676	1.17	Yes
Chromium	14/14	7.1	34.4	PAI-01-SD-10-01	52.3	0.66	No
Cobalt	13/14	0.19	3.9	PAI-01-SD-10-01	NA	NA	Yes
Copper	13/14	5.5	95.3	PAI-01-SD-001	18.7	5.10	Yes
Iron	14/14	1930	24000	PAI-01-SD-02-02	NA	NA	Yes
Lead	14/14	6.6	194	PAI-01-SD-09-01	30.2	6.42	Yes
Manganese	14/14	12.3	190	PAI-01-SD-013-AVG	NA	NA	Yes
Mercury	2/14	0.16	0.67	PAI-01-SD-09-01	0.13	5.15	Yes
Nickel	12/14	1.4	7.9	PAI-01-SD-001	15.9	0.50	No
Silver	2/14	0.36	2.4	PAI-01-SD-09-01	0.733	3.27	Yes
Thallium	1/14	0.925	0.925	PAI-01-SD-013-AVG	NA	NA	Yes
Vanadium	14/14	4.3	50.65	PAI-01-SD-013-AVG	NA	NA	Yes
Zinc	14/14	10.5	124	PAI-01-SD-09-01	124	1.00	Yes
Miscellaneous Compounds (pg/g)							
2,3,7,8-TCDD	0/2	<0.88	<1.6	PAI-01-SD-11-02	2.5	NA[a]	No
2,3,7,8-TCDD	2/2	1.7	2	PAI-01-SD-02A-02	2.5	0.80	No

NA = Not available
NA[a] = Not available
a = Benzo(a)pyrene used as a surrogate.
b = Screening value for chlordane.
c = Minimum and maximum concentrations are toxic equivalent (TEQ) concentrations for mammalian wildlife calculated using methods recommended by the World Health Organization (Van den Berg et al, 1998) and are based on positive detections of polychlorinated dibenzo-p-dioxins. Mammal TEQ concentrations were greater than fish and avian wildlife TEQ concentrations and thus, the mammal TEQ concentration represents the most conservative of the three values.

TABLE 7-6

SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN
SURFACE SOIL - SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detection		Location of Maximum	EPA Region IV Screening Level	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
Volatile Organics (ug/kg)							
Toluene	1/10	3	3	PAI-01-SS-05-01	50	0.06	No
Semivolatile Organics (ug/kg)							
1,2,4-Trichlorobenzene	1/10	140	140	PAI-01-SS-07-01	NA	NA	Yes
2-Methylnaphthalene	1/10	130	130	PAI-01-SS-07-01	NA	NA	Yes
Anthracene	5/10	12	35	PAI-01-SS-09-01	100	0.35	No
Benz(a)anthracene	10/10	18	280	PAI-01-SS-07-01	100[a]	2.80	Yes
Benzo(a)pyrene	10/10	20	310	PAI-01-SS-07-01	100	3.10	Yes
Benzo(b)fluoranthene	10/10	20	510	PAI-01-SS-07-01	100[a]	5.10	Yes
Benzo(g,h,i)perylene	7/10	38	210	PAI-01-SS-07-01	100[a]	2.10	Yes
Benzo(k)fluoranthene	10/10	11	160	PAI-01-SS-07-01	100[a]	1.60	Yes
Bis(2-ethylhexyl) phthalate	4/10	60	5600	PAI-01-SS-12-01	100[c]	56.00	Yes
Butylbenzyl phthalate	1/10	2000	2000	PAI-01-SS-12-01	100[c]	20.00	Yes
Carbazole	5/10	260	490	PAI-01-SS-14-01-AVG	NA	NA	Yes
Chrysene	10/10	19	330	PAI-01-SS-07-01	100[a]	3.30	Yes
Di-n-butyl phthalate	1/10	72	72	PAI-01-SS-12-01	200	0.36	No
Di-n-octyl phthalate	1/10	6400	6400	PAI-01-SS-12-01	100[c]	64.00	Yes
Dibenzofuran	3/10	170	200	PAI-01-SS-14-01-AVG	NA	NA	Yes
Fluoranthene	10/10	33	630	PAI-01-SS-07-01	100	6.30	Yes
Fluorene	1/10	95	95	PAI-01-SS-05-01	100[b]	0.95	No
Indeno(1,2,3-cd)pyrene	8/10	19	230	PAI-01-SS-07-01	100[a]	2.30	Yes
Phenanthrene	9/10	21	180	PAI-01-SS-06-01	100	1.80	Yes
Pyrene	9/10	30	510	PAI-01-SS-07-01	100	5.10	Yes
Pesticides/PCBs (ug/kg)							
4,4'-DDD	8/10	2.1	180	PAI-01-SS-07-01	2.5	72.00	Yes
4,4'-DDE	10/10	5.6	4200	PAI-01-SS-07-01	2.5	1680.00	Yes
4,4'-DDT	10/10	2.1	4400	PAI-01-SS-07-01	2.5	1760.00	Yes
Alpha-Chlordane	2/10	9.5	18	PAI-01-SS-07-01	NA	NA	Yes
Aroclor 1260	3/10	21	80	PAI-01-SS-09-01	20[d]	4.00	Yes
Endrin Ketone	1/10	12	12	PAI-01-SS-07-01	NA	NA	Yes
Gamma-Chlordane	2/10	6	8.1	PAI-01-SS-09-01	NA	NA	Yes

TABLE 7-6

SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN
SURFACE SOIL - SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detection		Location of Maximum	EPA Region IV Screening Level	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
alpha-BHC	2/10	3.7	42	PAI-01-SS-07-01	2.5	16.80	Yes
beta-BHC	2/10	8.9	33	PAI-01-SS-07-01	1	33.00	Yes
delta-BHC	1/10	45	45	PAI-01-SS-07-01	NA	NA	Yes
gamma-BHC (Lindane)	1/10	75	75	PAI-01-SS-07-01	0.05	1500.00	Yes
Inorganics (mg/kg)							
Aluminum	10/10	3880	8610	PAI-01-SS-08-01	50	172.20	Yes
Antimony	9/10	0.1875	90.6	PAI-01-SS-09-01	3.5	25.89	Yes
Arsenic	10/10	0.58	24.9	PAI-01-SS-09-01	10	2.49	Yes
Barium	10/10	15.2	178	PAI-01-SS-08-01	165	1.08	Yes
Cadmium	10/10	0.1	5.4	PAI-01-SS-08-01	1.6	3.38	Yes
Chromium	10/10	7	53.2	PAI-01-SS-08-01	0.4	133.00	Yes
Cobalt	10/10	0.33	13.7	PAI-01-SS-08-01	20	0.69	No
Copper	10/10	6.5	131	PAI-01-SS-08-01	40	3.28	Yes
Cyanide	2/10	0.73	0.86	PAI-01-SS-08-01	0.9	0.96	No
Iron	10/10	2560	147000	PAI-01-SS-08-01	200	735.00	Yes
Lead	10/10	58.4	8380	PAI-01-SS-09-01	50	167.60	Yes
Manganese	10/10	17.4	752	PAI-01-SS-08-01	100	7.52	Yes
Mercury	10/10	0.04	1.1	PAI-01-SS-07-01	0.1	11.00	Yes
Nickel	10/10	1.8	47.8	PAI-01-SS-08-01	30	1.59	Yes
Selenium	5/10	0.18	0.73	PAI-01-SS-05-01	0.81	0.90	No
Silver	5/10	0.48	2.4	PAI-01-SS-09-01	2	1.20	Yes
Vanadium	10/10	5.7	47.4	PAI-01-SS-09-01	2	23.70	Yes
Zinc	10/10	45.65	497	PAI-01-SS-08-01	50	9.94	Yes

NA = Not available
a = Benzo(a)pyrene used as a surrogate.
b = Naphthalene used as a surrogate
c = Value for total phthalates
d = Value for total PCBs

TABLE 7-7

SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN
SURFACE SOIL - SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detection		Location of Maximum	EPA Region IV Screening Level	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
Volatile Organics (ug/kg)							
Acetone	1/1	730	730	PAI-41-SS-02-01	NA	NA	Yes
Semivolatile Organics (ug/kg)							
Benz(a)anthracene	2/4	24	63	PAI-41-SS-03-01	100[a]	0.63	No
Benzo(a)pyrene	2/4	32	37	PAI-41-SS-03-01	100[b]	0.37	No
Benzo(b)fluoranthene	4/4	10	68	PAI-41-SS-03-01	100[a]	0.68	No
Benzo(g,h,i)perylene	1/4	70	70	PAI-41-SS-03-01	100[a]	0.70	No
Benzo(k)fluoranthene	1/4	19	19	PAI-41-SS-01-01	100[a]	0.19	No
Chrysene	1/4	12	12	PAI-41-SS-04-01	100[a]	0.12	No
Fluoranthene	4/4	26	200	PAI-41-SS-03-01	100	2.00	Yes
Fluorene	1/4	28	28	PAI-41-SS-03-01	100[b]	0.28	No
Indeno(1,2,3-cd)pyrene	1/4	26	26	PAI-41-SS-01-01	100[a]	0.26	No
Phenanthrene	4/4	30	190	PAI-41-SS-03-01	100	1.90	Yes
Pyrene	1/4	120	120	PAI-41-SS-03-01	100	1.20	Yes
Pesticides/PCBs (ug/kg)							
4,4'-DDE	2/4	34	43	PAI-41-SS-01-01	2.5	17.20	Yes
4,4'-DDT	2/4	12	65	PAI-41-SS-01-01	2.5	26.00	Yes
Inorganics (mg/kg)							
Aluminum	4/4	3130	6290	PAI-41-SS-04-01	50	125.80	Yes
Arsenic	4/4	0.48	6.3	PAI-41-SS-03-01	10	0.63	No
Barium	4/4	20.7	151	PAI-41-SS-03-01	165	0.92	No
Beryllium	3/4	0.05	0.51	PAI-41-SS-03-01	1.1	0.46	No
Cadmium	3/4	0.11	1.1	PAI-41-SS-03-01	1.6	0.69	No
Chromium	4/4	4.8	13.4	PAI-41-SS-03-01	0.4	33.50	Yes
Cobalt	4/4	0.36	4.3	PAI-41-SS-03-01	20	0.22	No
Copper	4/4	4.8	114	PAI-41-SS-03-01	40	2.85	Yes
Iron	4/4	2150	15500	PAI-41-SS-03-01	200	77.50	Yes
Lead	4/4	26.4	161	PAI-41-SS-01-01	50	3.22	Yes
Manganese	4/4	28.3	95.7	PAI-41-SS-03-01	100	0.96	No
Mercury	4/4	0.04	0.18	PAI-41-SS-03-01	0.1	1.80	Yes
Nickel	4/4	1.1	13.9	PAI-41-SS-03-01	30	0.46	No
Selenium	4/4	0.22	1.1	PAI-41-SS-03-01	0.81	1.36	Yes
Silver	2/4	0.18	0.89	PAI-41-SS-03-01	2	0.45	No
Vanadium	4/4	4.8	11	PAI-41-SS-03-01	2	5.50	Yes
Zinc	4/4	27.8	158	PAI-41-SS-03-01	50	3.16	Yes

NA = Not available
a = Benzo(a)pyrene used as a surrogate.
b = Naphthalene used as a surrogate

TABLE 7-8

SELECTION OF CHEMICALS OF POTENTIAL CONCERN
GROUNDWATER - SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detection		Location of Maximum	EPA Region IV Screening Level[a]	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
Volatile Organics (ug/L)							
2-Butanone	1/1	3.4	3.4	PAI-01-GW-10-01	NA	NA	Yes
Acetone	4/4	1.4	13	PAI-01-GW-14-01	NA	NA	Yes
Carbon Disulfide	6/11	0.7	16	PAI-01-GW-14-01	NA	NA	Yes
Chloroform	3/11	0.3	0.9	PAI-01-GW-14-01	815	0.00	No
Ethylbenzene	1/11	0.2	0.2	PAI-01-GW-10-01	4.3	0.05	No
Toluene	3/11	0.5	2	PAI-01-GW-07-01	37	0.05	No
Xylenes, Total	2/11	1.4	2	PAI-01-GW-09-01	NA	NA	Yes
Semivolatile Organics (ug/L)							
1,2-Dichlorobenzene	1/11	3	3	PAI-01-GW-05-01	19.7	0.15	No
2,4-Dimethylphenol	2/11	2	5	PAI-01-GW-09-01	NA	NA	Yes
2-Methylnaphthalene	1/11	7	7	PAI-01-GW-10-01	NA	NA	Yes
2-Methylphenol	1/11	1	1	PAI-01-GW-10-01	NA	NA	Yes
Acenaphthene	2/11	1	7	PAI-01-GW-10-01	9.7	0.72	No
Anthracene	2/11	1	1	PAI-01-GW-10-01; 13-01	23.5[b]	0.04	No
Bis(2-Ethylhexyl) phthalate	3/11	1	1	PAI-01-GW-08-01; -10-01; GW-07-01	NA	NA	Yes
Carbazole	1/10	2	2	PAI-01-GW-13-01	NA	NA	Yes
Di-n-butyl phthalate	7/11	1	1	various	3.4	0.29	No
Di-n-octyl phthalate	1/11	7	7	PAI1-GW4-01	NA	NA	Yes
Dibenzofuran	2/11	1	3	PAI-01-GW-10-01	NA	NA	Yes
Diethyl Phthalate	4/11	1	1	various	75.9	0.01	No
Fluoranthene	2/11	1	1	PAI-01-GW-13-01/-10-01	1.6	0.63	No
Fluorene	2/11	1	6	PAI-01-GW-10-01	23.5[b]	0.30	No
Naphthalene	4/11	1	57	PAI-01-GW-10-01	23.5	2.43	Yes
Phenanthrene	4/11	1	8	PAI-01-GW-10-01	23.5[b]	0.30	No
Pyrene	2/11	1	1	PAI-01-GW-10-01/-13-01	NA	NA	Yes
Inorganics (ug/L)							
Aluminum	5/10	23.3	3970	PAI1-GW4-01	NA	NA	Yes
Arsenic	6/11	1.15	4.4	PAI-01-GW-09-01	36	0.12	No
Barium	11/11	16.2	1230	PAI-01-GW-10-01-F	NA	NA	Yes
Beryllium	5/11	0.2	0.7	PAI-01-GW-09-01	NA	NA	Yes
Cadmium	4/11	1.7	2.7	PAI-01-GW-12-01-F	9.3	0.29	No
Chromium	9/11	6.4	26.9	PAI-01-GW-09-01-F	50	0.54	No
Copper	4/11	2.55	7.8	PAI-01-GW-05-01	2.9	2.69	Yes

TABLE 7-8

SELECTION OF CHEMICALS OF POTENTIAL CONCERN
GROUNDWATER - SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Analyte	Frequency of Detection	Range of Detection		Location of Maximum	EPA Region IV Screening Level[a]	Maximum Hazard Quotient	Selected as COPC (Yes/No?)
		Minimum	Maximum				
Iron	7/11	114	13300	PAI-01-GW-06-01-F	NA	NA	Yes
Lead	10/11	0.5	36.4	PAI-01-GW-09-01-F	8.5	4.28	Yes
Manganese	7/10	40.3	1320	PAI-01-GW-05-01	NA	NA	Yes
Mercury	1/11	0.23	0.23	PAI-01-GW-05-01-F	0.025	9.20	Yes
Thallium	1/11	3.1	3.1	PAI-01-GW-08-01-F	21.3	0.15	No
Vanadium	8/11	3.1	32.6	PAI-01-GW-09-01	NA	NA	Yes
Zinc	10/11	4.6	112	PAI-01-GW-06-01-F	86	1.30	Yes
Miscellaneous Compounds (pg/L)							
2,3,7,8-TCDD	0/1	<2	<2.1(dup)	PAI-01-GW-DU09(s)-02	10	NA[a]	No

NA = Not available
NA[a] = Not available
a Salt water screening value; average salinity of groundwater sample = 20 ppt.
b Naphthalene used as a surrogate

TABLE 7-9

RESULTS OF FOOD CHAIN MODELING
TERRESTRIAL RECEPTORS
MAXIMUM CONCENTRATIONS
SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

	Shrew		Robin		Hawk		Woodcock		Fox		Mouse	
Ecological Contaminant	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
of Concern	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ
Semivolatile Organic Compounds												
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	7.24E-03	7.24E-04	1.05E-03	1.05E-04	2.43E-05	2.43E-06	1.98E-03	1.98E-04	6.32E-04	6.32E-05	9.58E-04	9.58E-05
Benzo(a)anthracene	4.86E-03	4.86E-04	1.57E-03	1.57E-04	1.49E-05	1.49E-06	2.73E-03	2.73E-04	1.00E-03	1.00E-04	2.06E-03	2.06E-04
Benzo(a)pyrene	1.19E-02	1.19E-03	2.16E-03	2.16E-04	3.91E-05	3.91E-06	3.95E-03	3.95E-04	1.33E-03	1.33E-04	2.28E-03	2.28E-04
Benzo(b)fluoranthene	1.84E-02	1.84E-03	3.48E-03	3.48E-04	6.04E-05	6.04E-06	6.34E-03	6.34E-04	2.15E-03	2.15E-04	3.76E-03	3.76E-04
Benzo(g,h,i)perylene	6.06E-03	6.06E-04	1.33E-03	1.33E-04	1.96E-05	1.96E-06	2.39E-03	2.39E-04	8.34E-04	8.34E-05	1.55E-03	1.55E-04
Benzo(k)fluoranthene	4.75E-03	4.75E-04	1.02E-03	1.02E-04	1.54E-05	1.54E-06	1.84E-03	1.84E-04	6.40E-04	6.40E-05	1.18E-03	1.18E-04
Bis(2-Ethylhexyl)phthalate	1.49E-01	1.49E-02	**1.91E+00**	1.91E-01	4.41E-02	4.41E-03	**3.93E+00**	3.93E-01	3.48E-03	3.48E-04	4.44E-03	4.44E-04
Butylbenzylphthalate	6.12E-03	6.12E-04	6.81E-01	6.81E-02	1.58E-02	1.58E-03	**1.40E+00**	1.40E-01	1.43E-04	1.43E-05	1.83E-04	1.83E-05
Carbazole	2.10E-02	1.05E-02	5.15E-03	5.15E-04	6.44E-05	6.44E-06	7.48E-03	7.48E-04	1.63E-03	8.17E-04	7.42E-03	3.71E-03
Chrysene	5.63E-03	2.82E-03	1.95E-03	1.95E-04	2.31E-05	2.31E-06	3.45E-03	3.45E-04	9.51E-04	4.76E-04	1.87E-03	9.35E-04
Dibenzofuran	1.78E-04	8.55E-05	NA	NA	NA	NA	NA	NA	1.38E-05	6.63E-06	4.84E-05	2.32E-05
Di-n-octyl phthalate	1.70E-01	1.70E-02	**5.19E+00**	5.19E-01	6.51E-01	6.51E-02	**4.49E+00**	4.49E-01	3.84E-02	3.84E-03	9.70E-02	9.70E-03
Fluoranthene	6.28E-03	3.14E-03	3.35E-03	3.35E-04	2.38E-05	2.38E-06	5.74E-03	5.74E-04	1.67E-03	8.33E-04	3.57E-03	1.79E-03
Indeno(1,2,3-cd)pyrene	8.08E-03	4.04E-03	1.71E-03	1.71E-04	3.50E-05	3.50E-06	3.18E-03	3.18E-04	8.01E-04	4.01E-04	1.30E-03	6.52E-04
Phenanthrene	2.49E-03	1.25E-03	1.06E-03	1.06E-04	9.90E-06	9.90E-07	1.84E-03	1.84E-04	5.23E-04	2.61E-04	1.08E-03	5.39E-04
Pyrene	5.57E-03	2.78E-03	2.75E-03	2.75E-04	2.15E-05	2.15E-06	4.74E-03	4.74E-04	1.37E-03	6.83E-04	2.89E-03	1.45E-03
Pesticides/PCBs												
4,4'-DDD	3.58E-01	7.17E-02	**6.95E+01**	**6.95E+00**	**1.43E+01**	**1.43E+00**	**1.52E+02**	**1.52E+01**	4.84E-02	9.69E-03	1.86E-03	3.72E-04
4,4'-DDE	**4.32E+00**	8.64E-01	**8.72E+02**	**8.72E+01**	**1.72E+02**	**1.72E+01**	**1.88E+03**	**1.88E+02**	5.92E-01	1.18E-01	4.34E-02	8.68E-03
4,4'-DDT	**1.54E+00**	3.07E-01	**3.58E+02**	**3.58E+01**	**6.12E+01**	**6.12E+00**	**7.45E+02**	**7.45E+01**	2.21E-01	4.43E-02	4.55E-02	9.09E-03
Aroclor-1260	**3.78E+00**	3.78E-01	9.74E-01	9.74E-02	6.41E-01	6.41E-02	**2.08E+00**	2.08E-01	**1.62E+00**	1.62E-01	4.49E-02	4.49E-03
alpha-BHC	**1.46E+00**	1.46E-01	2.69E-02	8.37E-03	4.21E-03	1.05E-03	5.79E-02	1.44E-02	1.70E-01	1.70E-02	1.91E-02	1.91E-03
beta-BHC	4.01E-02	8.02E-03	2.26E-02	5.62E-03	3.46E-03	8.61E-04	4.55E-02	1.13E-02	4.88E-03	9.76E-04	1.56E-03	3.11E-04
delta-BHC	**1.56E+01**	**1.56E+00**	2.88E-01	7.17E-02	4.51E-02	1.12E-02	6.20E-01	1.54E-01	**1.82E+00**	1.82E-01	2.05E-01	2.05E-02
gamma-BHC (Lindane)	4.56E-02	4.56E-03	1.45E-01	1.45E-02	2.21E-02	2.21E-03	2.89E-01	2.89E-02	5.57E-03	5.57E-04	1.90E-03	1.90E-04
Alpha-Chlordane	3.03E-03	1.52E-03	4.59E-03	9.18E-04	4.15E-04	8.29E-05	9.98E-03	2.00E-03	1.96E-04	9.81E-05	2.35E-05	1.18E-05
Gamma-Chlordane	1.36E-03	6.82E-04	2.06E-03	4.13E-04	1.87E-04	3.73E-05	4.49E-03	8.98E-04	8.83E-05	4.41E-05	1.06E-05	5.29E-06
Endrin Ketone	5.21E-03	5.21E-04	1.40E-01	1.40E-02	1.10E-02	1.10E-03	1.56E-01	1.56E-02	1.55E-03	1.55E-04	3.99E-03	3.99E-04

TABLE 7-9

RESULTS OF FOOD CHAIN MODELING
TERRESTRIAL RECEPTORS
MAXIMUM CONCENTRATIONS
SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Concern	Shrew		Robin		Hawk		Woodcock		Fox		Mouse	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Metals and Inorganics												
Aluminum	**1.38E+02**	**1.38E+01**	**4.84E+00**	4.84E-01	1.77E-02	1.77E-03	**9.17E+00**	9.17E-01	**1.47E+01**	**1.47E+00**	**2.57E+01**	**2.57E+00**
Antimony	**3.52E+02**	**3.52E+01**	NA	NA	NA	NA	NA	NA	**4.24E+00**	4.24E-01	**1.19E+01**	**1.19E+00**
Arsenic	**2.23E+01**	**2.23E+00**	**1.36E+00**	4.54E-01	1.48E-02	4.94E-03	**2.38E+00**	7.93E-01	8.84E-01	8.84E-02	**3.11E+00**	3.11E-01
Barium	**1.70E+01**	**1.70E+00**	**3.19E+00**	**1.59E+00**	3.70E-03	1.84E-03	**6.60E+00**	**3.29E+00**	1.22E-01	1.22E-02	4.78E-01	4.78E-02
Beryllium	3.76E-01	3.76E-02	NA	NA	NA	NA	NA	NA	4.45E-03	4.45E-04	4.71E-03	4.71E-04
Cadmium	**2.00E+01**	**2.00E+00**	**1.03E+01**	7.47E-01	**3.63E+00**	2.63E-01	**2.01E+01**	**1.46E+00**	**5.04E+00**	5.04E-01	8.90E-01	8.90E-02
Copper	**2.83E+00**	**2.19E+00**	7.58E-01	5.77E-01	5.98E-02	4.55E-02	**1.22E+00**	9.26E-01	2.64E-01	2.04E-01	4.40E-01	3.40E-01
Iron	**6.94E+01**	**6.94E+00**	**8.70E+02**	**8.70E+01**	**8.54E+01**	**8.54E+00**	**1.57E+02**	**1.57E+01**	**1.72E+02**	**1.72E+01**	**8.16E+02**	**8.16E+01**
Lead	**1.40E+02**	**1.40E+01**	**1.10E+03**	**1.10E+02**	**1.90E+00**	1.90E-01	**1.96E+03**	**1.96E+02**	**3.48E+00**	3.48E-01	**1.69E+01**	**1.69E+00**
Manganese	2.68E-01	8.29E-02	6.79E-02	6.79E-03	8.96E-05	8.96E-06	9.05E-02	9.05E-03	2.73E-02	8.44E-03	1.64E-01	5.07E-02
Mercury	**6.01E+01**	**3.61E+01**	**1.59E+02**	**1.59E+01**	2.26E-01	2.26E-02	**2.15E+02**	**2.15E+01**	3.18E-01	1.91E-01	**1.34E+01**	**8.04E+00**
Nickel	6.15E-01	3.08E-01	2.38E-01	1.72E-01	1.12E-02	8.08E-03	5.02E-01	3.63E-01	2.43E-02	1.22E-02	1.25E-02	6.24E-03
Selenium	**2.64E+00**	**1.60E+00**	**1.96E+00**	9.79E-01	1.91E-01	9.56E-02	**2.09E+00**	**1.05E+00**	3.82E-01	2.32E-01	**1.04E+00**	6.27E-01
Silver	6.48E-01	6.48E-02	NA	NA	NA	NA	NA	NA	1.56E-02	1.56E-03	3.64E-02	3.64E-03
Vanadium	**5.44E+00**	5.44E-01	2.39E-01	2.39E-02	1.21E-03	1.21E-04	4.46E-01	4.46E-02	7.58E-01	7.58E-02	1.32E+00	1.32E-01
Zinc	**4.80E+00**	**2.40E+00**	**4.25E+01**	**4.71E+00**	**1.44E+01**	**1.59E+00**	**7.86E+01**	**8.70E+00**	**1.25E+00**	6.26E-01	3.26E-01	1.63E-01

NA = NOAEL/LOAEL not available

TABLE 7-10

RESULTS OF FOOD CHAIN MODELING
TERRESTRIAL RECEPTORS
MEAN CONCENTRATIONS
SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

	Shrew		Robin		Hawk		Woodcock		Fox		Mouse	
Ecological Contaminant	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
of Concern	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ
Semivolatile Organic Compounds												
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	1.05E-02	1.05E-03	1.53E-03	1.53E-04	3.53E-05	3.53E-06	2.88E-03	2.88E-04	9.19E-04	9.19E-05	1.39E-03	1.39E-04
Benzo(a)anthracene	1.47E-03	1.47E-04	4.75E-04	4.75E-05	4.51E-06	4.51E-07	8.26E-04	8.26E-05	3.04E-04	3.04E-05	6.24E-04	6.24E-05
Benzo(a)pyrene	3.74E-03	3.74E-04	6.81E-04	6.81E-05	1.23E-05	1.23E-06	1.25E-03	1.25E-04	4.19E-04	4.19E-05	7.21E-04	7.21E-05
Benzo(b)fluoranthene	4.35E-03	4.35E-04	8.22E-04	8.22E-05	1.43E-05	1.43E-06	1.50E-03	1.50E-04	5.08E-04	5.08E-05	8.89E-04	8.89E-05
Benzo(g,h,i)perylene	2.13E-03	2.13E-04	4.69E-04	4.69E-05	6.90E-06	6.90E-07	8.43E-04	8.43E-05	2.93E-04	2.93E-05	5.45E-04	5.45E-05
Benzo(k)fluoranthene	1.23E-03	1.23E-04	2.66E-04	2.66E-05	4.00E-06	4.00E-07	4.78E-04	4.78E-05	1.66E-04	1.66E-05	3.06E-04	3.06E-05
Bis(2-Ethylhexyl)phthalate	1.47E-02	1.47E-03	1.89E-01	1.89E-02	4.37E-03	4.37E-04	3.89E-01	3.89E-02	3.44E-04	3.44E-05	4.40E-04	4.40E-05
Butylbenzylphthalate	9.79E-04	9.79E-05	1.09E-01	1.09E-02	2.52E-03	2.52E-04	2.25E-01	2.25E-02	2.29E-05	2.29E-06	2.92E-05	2.92E-06
Carbazole	1.12E-02	5.61E-03	2.76E-03	2.76E-04	3.45E-05	3.45E-06	4.00E-03	4.00E-04	8.74E-04	4.37E-04	3.97E-03	1.98E-03
Chrysene	1.66E-03	8.32E-04	5.77E-04	5.77E-05	6.82E-06	6.82E-07	1.02E-03	1.02E-04	2.81E-04	1.40E-04	5.53E-04	2.76E-04
Dibenzofuran	1.70E-04	8.17E-05	NA	NA	NA	NA	NA	NA	1.32E-05	6.33E-06	4.62E-05	2.22E-05
Di-n-octyl phthalate	1.68E-02	1.68E-03	5.14E-01	5.14E-02	6.45E-02	6.45E-03	4.45E-01	4.45E-02	3.81E-03	3.81E-04	9.61E-03	9.61E-04
Fluoranthene	1.73E-03	8.67E-04	9.25E-04	9.25E-05	6.58E-06	6.58E-07	1.59E-03	1.59E-04	4.60E-04	2.30E-04	9.86E-04	4.93E-04
Indeno(1,2,3-cd)pyrene	2.52E-03	1.26E-03	5.34E-04	5.34E-05	1.09E-05	1.09E-06	9.92E-04	9.92E-05	2.50E-04	1.25E-04	4.07E-04	2.04E-04
Phenanthrene	1.17E-02	5.84E-03	4.97E-03	4.97E-04	4.64E-05	4.64E-06	8.65E-03	8.65E-04	2.45E-03	1.23E-03	5.05E-03	2.53E-03
Pyrene	1.47E-03	7.36E-04	7.28E-04	7.28E-05	5.68E-06	5.68E-07	1.25E-03	1.25E-04	3.61E-04	1.81E-04	7.65E-04	3.82E-04
Pesticides/PCBs												
4,4'-DDD	7.09E-02	1.42E-02	**1.37E+01**	1.37E+00	**2.83E+00**	2.83E-01	**3.00E+01**	3.00E+00	9.58E-03	1.92E-03	3.68E-04	7.36E-05
4,4'-DDE	4.07E-01	8.13E-02	**8.20E+01**	**8.20E+00**	**1.62E+01**	**1.62E+00**	**1.77E+02**	**1.77E+01**	5.57E-02	1.11E-02	4.08E-03	8.17E-04
4,4'-DDT	1.36E-01	2.72E-02	**3.17E+01**	**3.17E+00**	**5.41E+00**	5.41E-01	**6.59E+01**	**6.59E+00**	1.96E-02	3.92E-03	4.02E-03	8.04E-04
Aroclor-1260	8.41E-01	8.41E-02	2.17E-01	2.17E-02	1.43E-01	1.43E-02	4.64E-01	4.64E-02	3.62E-01	3.62E-02	9.99E-03	9.99E-04
alpha-BHC	3.16E-01	3.16E-02	5.83E-03	1.81E-03	9.12E-04	2.27E-04	1.25E-02	3.12E-03	3.68E-02	3.68E-03	4.15E-03	4.15E-04
beta-BHC	1.07E-02	2.14E-03	6.02E-03	1.50E-03	9.22E-04	2.30E-04	1.21E-02	3.02E-03	1.30E-03	2.60E-04	4.15E-04	8.30E-05
delta-BHC	3.16E-01	3.16E-02	5.83E-03	1.45E-03	9.12E-04	2.27E-04	1.25E-02	3.12E-03	3.68E-02	3.68E-03	4.15E-03	4.15E-04
gamma-BHC (Lindane)	6.87E-04	6.87E-05	2.18E-03	2.18E-04	3.33E-04	3.33E-05	4.36E-03	4.36E-04	8.39E-05	8.39E-06	2.86E-05	2.86E-06
Alpha-Chlordane	1.30E-03	6.49E-04	1.96E-03	3.92E-04	1.77E-04	3.55E-05	4.27E-03	8.54E-04	8.39E-05	4.20E-05	1.01E-05	5.03E-06
Gamma-Chlordane	1.13E-03	5.64E-04	1.71E-03	3.42E-04	1.54E-04	3.09E-05	3.71E-03	7.43E-04	7.30E-05	3.65E-05	8.75E-06	4.38E-06
Endrin Ketone	5.56E-03	5.56E-04	1.49E-01	1.49E-02	1.18E-02	1.18E-03	1.66E-01	1.66E-02	1.65E-03	1.65E-04	4.26E-03	4.26E-04

TABLE 7-10

RESULTS OF FOOD CHAIN MODELING
TERRESTRIAL RECEPTORS
MEAN CONCENTRATIONS
SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Concern	Shrew		Robin		Hawk		Woodcock		Fox		Mouse	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Metals and Inorganics												
Aluminum	**9.06E+01**	**9.06E+00**	**3.18E+00**	3.18E-01	1.17E-02	1.17E-03	**6.04E+00**	6.04E-01	**9.67E+00**	9.67E-01	**1.69E+01**	**1.69E+00**
Antimony	**2.74E+01**	**2.74E+00**	NA	NA	NA	NA	NA	NA	3.29E-01	3.29E-02	9.24E-01	9.24E-02
Arsenic	**3.89E+00**	3.89E-01	2.37E-01	7.90E-02	2.58E-03	8.58E-04	4.14E-01	1.38E-01	1.54E-01	1.54E-02	5.41E-01	5.41E-02
Barium	**6.74E+00**	6.74E-01	**1.27E+00**	6.33E-01	1.47E-03	7.33E-04	**2.62E+00**	**1.31E+00**	4.84E-02	4.84E-03	1.90E-01	1.90E-02
Beryllium	1.40E-01	1.40E-02	NA	NA	NA	NA	NA	NA	1.66E-03	1.66E-04	1.75E-03	1.75E-04
Cadmium	**3.43E+00**	3.43E-01	**1.76E+00**	1.28E-01	6.20E-01	4.50E-02	**3.44E+00**	2.50E-01	8.62E-01	8.62E-02	1.52E-01	1.52E-02
Copper	9.59E-01	7.41E-01	2.57E-01	1.95E-01	2.02E-02	1.54E-02	4.12E-01	3.14E-01	8.93E-02	6.90E-02	1.49E-01	1.15E-01
Iron	**9.24E+00**	9.24E-01	**1.16E+02**	**1.16E+01**	**1.14E+01**	**1.14E+00**	**2.08E+01**	**2.08E+00**	**2.29E+01**	**2.29E+00**	**1.09E+02**	**1.09E+01**
Lead	**1.39E+01**	**1.39E+00**	**1.10E+02**	**1.10E+01**	1.89E-01	1.89E-02	**1.95E+02**	**1.95E+01**	3.46E-01	3.46E-02	**1.68E+00**	1.68E-01
Manganese	4.39E-02	1.36E-02	1.11E-02	1.11E-03	1.47E-05	1.47E-06	1.48E-02	1.48E-03	4.47E-03	1.38E-03	2.68E-02	8.31E-03
Mercury	**1.15E+01**	**6.89E+00**	**3.03E+01**	**3.03E+00**	4.31E-02	4.31E-03	**4.10E+01**	**4.10E+00**	6.06E-02	3.64E-02	**2.56E+00**	**1.54E+00**
Nickel	1.06E-01	5.30E-02	4.10E-02	2.96E-02	1.92E-03	1.39E-03	8.64E-02	6.25E-02	4.19E-03	2.09E-03	2.15E-03	1.07E-03
Selenium	6.90E-01	4.18E-01	5.13E-01	2.56E-01	5.01E-02	2.50E-02	5.48E-01	2.74E-01	1.00E-01	6.06E-02	2.71E-01	1.64E-01
Silver	1.62E-01	1.62E-02	NA	NA	NA	NA	NA	NA	3.91E-03	3.91E-04	9.10E-03	9.10E-04
Vanadium	**1.39E+00**	1.39E-01	6.09E-02	6.09E-03	3.10E-04	3.10E-05	1.14E-01	1.14E-02	1.93E-01	1.93E-02	3.37E-01	3.37E-02
Zinc	**1.71E+00**	8.55E-01	**1.51E+01**	**1.68E+00**	**5.12E+00**	5.66E-01	**2.80E+01**	**3.10E+00**	4.46E-01	2.23E-01	1.16E-01	5.81E-02

NA = NOAEL/LOAEL not available

TABLE 7-11

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MAXIMUM CONCENTRATIONS
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Raccoon NOAEL HQ	Raccoon LOAEL HQ	Heron NOAEL HQ	Heron LOAEL HQ	Osprey NOAEL HQ	Osprey LOAEL HQ	Red Drum NOAEL HQ	Red Drum LOAEL HQ	Mummichog NOAEL HQ	Mummichog LOAEL HQ
Semivolatile Organic Compounds										
Acenaphthylene	1.48E-02	7.38E-03	1.07E-03	1.07E-04	3.91E-04	3.91E-05	7.16E-03	7.16E-04	7.35E-02	7.35E-03
Anthracene	5.89E-02	2.94E-02	5.65E-03	5.65E-04	2.07E-03	2.07E-04	2.55E-02	2.55E-03	1.49E-01	1.49E-02
Benzo(a)anthracene	2.19E-01	2.19E-02	1.61E-02	1.61E-03	5.92E-03	5.92E-04	7.28E-02	7.28E-03	4.25E-01	4.25E-02
Benzo(a)pyrene	1.69E-01	1.69E-02	1.25E-02	1.25E-03	4.57E-03	4.57E-04	5.63E-02	5.63E-03	3.29E-01	3.29E-02
Benzo(b)fluoranthene	1.79E-01	1.79E-02	1.32E-02	1.32E-03	4.84E-03	4.84E-04	5.96E-02	5.96E-03	3.48E-01	3.48E-02
Benzo(g,h,i)perylene	2.41E-02	2.41E-03	3.81E-04	3.81E-05	1.40E-04	1.40E-05	1.11E-02	1.11E-03	1.91E-01	1.91E-02
Benzo(k)fluoranthene	8.45E-02	8.45E-03	6.23E-03	6.23E-04	2.29E-03	2.29E-04	2.81E-02	2.81E-03	1.64E-01	1.64E-02
Carbazole	1.31E-01	6.54E-02	1.47E-02	1.47E-03	5.38E-03	5.38E-04	5.20E-02	5.20E-03	1.12E-01	1.12E-02
Chrysene	1.76E-01	8.79E-02	1.69E-02	1.69E-03	6.19E-03	6.19E-04	7.61E-02	7.61E-03	4.45E-01	4.45E-02
Dibenzo(a,h)anthracene	1.22E-01	6.12E-02	1.17E-02	1.17E-03	4.30E-03	4.30E-04	5.30E-02	5.30E-03	3.09E-01	3.09E-02
Fluoranthene	5.05E-01	2.52E-01	4.84E-02	4.84E-03	1.78E-02	1.78E-03	2.18E-01	2.18E-02	**1.28E+00**	1.28E-01
Fluorene	1.22E-02	6.12E-03	1.17E-03	1.17E-04	4.30E-04	4.30E-05	5.30E-03	5.30E-04	3.09E-02	3.09E-03
Indeno(1,2,3-cd)pyrene	8.41E-02	4.21E-02	8.07E-03	8.07E-04	2.96E-03	2.96E-04	3.64E-02	3.64E-03	2.13E-01	2.13E-02
Phenanthrene	3.95E-01	1.98E-01	4.27E-02	4.27E-03	1.57E-02	1.57E-03	1.60E-01	1.60E-02	5.03E-01	5.03E-02
Pyrene	4.13E-01	2.06E-01	3.96E-02	3.96E-03	1.45E-02	1.45E-03	1.79E-01	1.79E-02	**1.04E+00**	1.04E-01
Pesticides/PCBs										
4,4'-DDD	3.14E-02	6.28E-03	**6.57E+00**	6.57E-01	**2.41E+00**	2.41E-01	NA	NA	NA	NA
4,4'-DDE	3.19E-01	6.37E-02	**8.34E+01**	**8.34E+00**	**3.06E+01**	**3.06E+00**	NA	NA	NA	NA
4,4'-DDT	1.61E-01	3.22E-02	**4.07E+01**	**4.07E+00**	**1.49E+01**	**1.49E+00**	NA	NA	NA	NA
Alpha-Chlordane	1.50E-02	7.48E-03	2.93E-02	5.86E-03	1.08E-02	2.15E-03	NA	NA	NA	NA
Gamma-Chlordane	1.77E-02	8.86E-03	3.41E-02	6.82E-03	1.25E-02	2.50E-03	NA	NA	NA	NA
alpha-BHC	9.87E-02	9.87E-03	2.19E-03	5.46E-04	8.05E-04	2.00E-04	NA	NA	NA	NA
beta-BHC	6.91E-03	1.38E-03	4.39E-03	1.09E-03	1.61E-03	4.01E-04	NA	NA	NA	NA
delta-BHC	9.87E-02	9.87E-03	2.19E-03	5.46E-04	8.05E-04	2.00E-04	NA	NA	NA	NA
gamma-BHC (Lindane)	1.34E-04	1.34E-05	4.78E-04	4.78E-05	1.75E-04	1.75E-05	NA	NA	NA	NA
Inorganics										
Aluminum	**2.60E+03**	**2.60E+02**	**3.84E+01**	**3.84E+00**	**4.48E+01**	**4.48E+00**	NA	NA	NA	NA
Arsenic	**2.66E+01**	**2.66E+00**	**1.14E+00**	3.80E-01	**1.33E+00**	4.44E-01	5.29E-01	4.39E-02	**1.53E+00**	1.27E-01
Barium	**3.72E+00**	3.72E-01	7.66E-01	3.82E-01	8.93E-01	4.46E-01	NA	NA	NA	NA

TABLE 7-11

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MAXIMUM CONCENTRATIONS
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

	Raccoon		Heron		Osprey		Red Drum		Mummichog	
Ecological Contaminant	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
of Potential Concern	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ
Beryllium	3.90E-01	3.90E-02	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1.69E-01	1.69E-02	9.80E-02	7.11E-03	1.14E-01	8.29E-03	NA	NA	NA	NA
Cobalt	8.37E-01	8.37E-02	7.02E-01	7.02E-02	8.19E-01	8.19E-02	NA	NA	NA	NA
Copper	**1.75E+00**	**1.35E+00**	3.65E-01	2.78E-01	4.26E-01	3.24E-01	NA	NA	NA	NA
Iron	**1.03E+02**	**1.03E+01**	**4.32E+01**	**4.32E+00**	**5.04E+01**	**5.04E+00**	NA	NA	NA	NA
Lead	**5.20E+00**	5.20E-01	**3.09E+01**	**3.09E+00**	**3.60E+01**	**3.60E+00**	NA	NA	NA	NA
Manganese	4.63E-01	1.44E-01	3.50E-02	3.50E-03	4.08E-02	4.08E-03	NA	NA	NA	NA
Mercury	**9.58E+00**	**5.75E+00**	**1.88E+01**	**1.88E+00**	**2.20E+01**	**2.20E+00**	**1.68E+00**	1.43E-02	**4.86E+00**	4.13E-02
Silver	2.86E-01	2.86E-02	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	**2.68E+01**	**2.68E+00**	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	**5.17E+01**	**5.17E+00**	7.99E-01	7.99E-02	9.33E-01	9.33E-02	NA	NA	NA	NA
Zinc	1.66E-01	8.31E-02	**1.54E+00**	1.70E-01	**1.80E+00**	1.99E-01	NA	NA	NA	NA

NA = NOAEL/LOAEL not available

TABLE 7-12

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MEAN CONCENTRATIONS
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

	Raccoon		Heron		Osprey		Red Drum		Mummichog	
Ecological Contaminant of Potential Concern	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Semivolatile Organic Compounds										
Acenaphthylene	1.36E-02	6.81E-03	9.84E-04	9.84E-05	3.61E-04	3.61E-05	6.61E-03	6.61E-04	6.78E-02	6.78E-03
Anthracene	1.10E-02	5.48E-03	1.05E-03	1.05E-04	3.85E-04	3.85E-05	4.74E-03	4.74E-04	2.77E-02	2.77E-03
Benzo(a)anthracene	3.50E-02	3.50E-03	2.58E-03	2.58E-04	9.47E-04	9.47E-05	1.17E-02	1.17E-03	6.81E-02	6.81E-03
Benzo(a)pyrene	3.17E-02	3.17E-03	2.34E-03	2.34E-04	8.58E-04	8.58E-05	1.06E-02	1.06E-03	6.17E-02	6.17E-03
Benzo(b)fluoranthene	3.16E-02	3.16E-03	2.33E-03	2.33E-04	8.55E-04	8.55E-05	1.05E-02	1.05E-03	6.15E-02	6.15E-03
Benzo(g,h,i)perylene	4.83E-03	4.83E-04	7.64E-05	7.64E-06	2.80E-05	2.80E-06	2.23E-03	2.23E-04	3.84E-02	3.84E-03
Benzo(k)fluoranthene	1.49E-02	1.49E-03	1.10E-03	1.10E-04	4.03E-04	4.03E-05	4.95E-03	4.95E-04	2.89E-02	2.89E-03
Carbazole	8.50E-02	4.25E-02	9.53E-03	9.53E-04	3.49E-03	3.49E-04	3.38E-02	3.38E-03	7.28E-02	7.28E-03
Chrysene	2.98E-02	1.49E-02	2.86E-03	2.86E-04	1.05E-03	1.05E-04	1.29E-02	1.29E-03	7.54E-02	7.54E-03
Dibenzo(a,h)anthracene	1.65E-02	8.26E-03	1.58E-03	1.58E-04	5.81E-04	5.81E-05	7.15E-03	7.15E-04	4.17E-02	4.17E-03
Fluoranthene	6.91E-02	3.45E-02	6.63E-03	6.63E-04	2.43E-03	2.43E-04	2.99E-02	2.99E-03	1.75E-01	1.75E-02
Fluorene	8.52E-03	4.26E-03	8.17E-04	8.17E-05	3.00E-04	3.00E-05	3.69E-03	3.69E-04	2.15E-02	2.15E-03
Indeno(1,2,3-cd)pyrene	1.68E-02	8.39E-03	1.61E-03	1.61E-04	5.90E-04	5.90E-05	7.27E-03	7.27E-04	4.24E-02	4.24E-03
Phenanthrene	6.21E-02	3.11E-02	6.71E-03	6.71E-04	2.46E-03	2.46E-04	2.52E-02	2.52E-03	7.90E-02	7.90E-03
Pyrene	5.88E-02	2.94E-02	5.64E-03	5.64E-04	2.07E-03	2.07E-04	2.55E-02	2.55E-03	1.49E-01	1.49E-02
Pesticides/PCBs										
4,4'-DDD	3.12E-03	6.24E-04	6.53E-01	6.53E-02	2.39E-01	2.39E-02	NA	NA	NA	NA
4,4'-DDE	4.67E-02	9.33E-03	**1.22E+01**	**1.22E+00**	**4.48E+00**	4.48E-01	NA	NA	NA	NA
4,4'-DDT	1.57E-02	3.13E-03	**3.97E+00**	3.97E-01	**1.45E+00**	1.45E-01	NA	NA	NA	NA
Alpha-Chlordane	2.40E-03	1.20E-03	4.70E-03	9.40E-04	1.72E-03	3.45E-04	NA	NA	NA	NA
Gamma-Chlordane	1.63E-03	8.16E-04	3.14E-03	6.29E-04	1.15E-03	2.31E-04	NA	NA	NA	NA
alpha-BHC	1.09E-01	1.09E-02	2.41E-03	6.00E-04	8.85E-04	2.20E-04	NA	NA	NA	NA
beta-BHC	4.05E-03	8.09E-04	2.57E-03	6.39E-04	9.42E-04	2.35E-04	NA	NA	NA	NA
delta-BHC	1.09E-01	1.09E-02	2.41E-03	6.00E-04	8.85E-04	2.20E-04	NA	NA	NA	NA
gamma-BHC (Lindane)	1.87E-04	1.87E-05	6.66E-04	6.66E-05	2.44E-04	2.44E-05	NA	NA	NA	NA
Inorganics										
Aluminum	**1.13E+03**	**1.13E+02**	**1.67E+01**	**1.67E+00**	**1.95E+01**	**1.95E+00**	NA	NA	NA	NA
Arsenic	**1.06E+01**	**1.06E+00**	4.57E-01	1.52E-01	5.33E-01	1.78E-01	2.12E-01	1.76E-02	6.14E-01	5.10E-02

TABLE 7-12

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MEAN CONCENTRATIONS
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

	Raccoon		Heron		Osprey		Red Drum		Mummichog	
Ecological Contaminant	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
of Potential Concern	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ	HQ
Barium	**1.01E+00**	1.01E-01	2.07E-01	1.03E-01	2.42E-01	1.20E-01	NA	NA	NA	NA
Beryllium	1.27E-01	1.27E-02	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1.79E-02	1.79E-03	1.04E-02	7.50E-04	1.21E-02	8.75E-04	NA	NA	NA	NA
Cobalt	4.19E-01	4.19E-02	3.51E-01	3.51E-02	4.10E-01	4.10E-02	NA	NA	NA	NA
Copper	5.03E-01	3.89E-01	1.05E-01	8.00E-02	1.23E-01	9.33E-02	NA	NA	NA	NA
Iron	**5.67E+01**	**5.67E+00**	**2.38E+01**	**2.38E+00**	**2.78E+01**	**2.78E+00**	NA	NA	NA	NA
Lead	**1.30E+00**	1.30E-01	**7.72E+00**	7.72E-01	**9.00E+00**	9.00E-01	NA	NA	NA	NA
Manganese	2.26E-01	6.99E-02	1.70E-02	1.70E-03	1.99E-02	1.99E-03	NA	NA	NA	NA
Mercury	**1.81E+00**	**1.08E+00**	**3.55E+00**	3.55E-01	**4.14E+00**	4.14E-01	3.16E-01	2.69E-03	9.15E-01	7.79E-03
Silver	3.43E-02	3.43E-03	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	**1.01E+01**	**1.01E+00**	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	**2.79E+01**	**2.79E+00**	4.31E-01	4.31E-02	5.02E-01	5.02E-02	NA	NA	NA	NA
Zinc	6.03E-02	3.02E-02	5.58E-01	6.18E-02	6.51E-01	7.21E-02	NA	NA	NA	NA

NA = NOAEL/LOAEL not available

TABLE 7-13

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MAXIMUM CONCENTRATIONS - FILTERED SURFACE WATER
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Raccoon		Heron		Red Drum		Osprey	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Metals and Inorganic Compounds								
Antimony	5.57E-02	5.57E-03	NA	NA	NA	NA	NA	NA
Barium	1.28E-01	1.28E-02	9.16E-03	4.57E-03	NA	NA	1.06E-02	5.30E-03
Manganese	4.70E-02	1.46E-02	3.01E-03	3.01E-04	NA	NA	3.51E-03	3.51E-04
Zinc	9.41E-03	4.71E-03	5.63E-02	6.24E-03	NA	NA	6.56E-02	7.26E-03

NA = NOAEL/LOAEL not available

TABLE 7-14

RESULTS OF FOOD CHAIN MODELING
AQUATIC RECEPTORS
MEAN CONCENTRATIONS - FILTERED SURFACE WATER
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Raccoon		Heron		Red Drum		Osprey	
	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Metals and Inorganic Compounds								
Antimony	2.98E-02	2.98E-03	NA	NA	NA	NA	NA	NA
Barium	5.24E-02	5.24E-03	6.56E-03	3.27E-03	NA	NA	7.61E-03	3.80E-03
Manganese	2.98E-02	9.24E-03	2.04E-03	2.04E-04	NA	NA	2.38E-03	2.38E-04
Zinc	4.44E-03	2.22E-03	3.09E-02	3.42E-03	NA	NA	3.60E-02	3.99E-03

NA = NOAEL/LOAEL not available

TABLE 7-15

PREDICTED FISH TISSUE CONCENTRATIONS BASED ON SEDIMENT DATA
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Contaminant of Potential Concern (COPC)	Predicted Fish Tissue Concentrations (mg/kg wet weight)			
	Mummichog		Red Drum	
	Maximum[a]	Average[b]	Maximum[a]	Average[b]
Mercury	NA[c]	NA[c]	5.06	0.95
4,4'-DDD	0.10	0.01	NA[d]	NA[d]
4,4'-DDE	1.30	0.19	NA[d]	NA[d]
4,4'-DDT	0.63	0.062	NA[d]	NA[d]
Alpha-BHC	0.007	0.008	NA[d]	NA[d]
Beta-BHC	0.014	0.008	NA[d]	NA[d]
Delta-BHC	0.007	0.008	NA[d]	NA[d]
Gamma-BHC (Lindane)	0.005	0.007	NA[d]	NA[d]
Alpha-chlordane	0.35	0.06	NA[d]	NA[d]
Gamma-chlordane	0.41	0.037	NA[d]	NA[d]

a Fish tissue concentration based on maximum sediment concentration of COPC.
b Fish tissue concentration based on average sediment concentration of COPC.
c Mercury model was applicable only to the red drum.
d Pesticide model was applicable only to the mummichog.

TABLE 7-16

GUIDELINES FOR PROTECTION OF FISH AND PISCIVOROUS RECEPTORS
MERCURY
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Data Associated With Effects			Reference
Fish Species	**Concentration (mg/kg)**	**Endpoint/Effect**	
Fathead minnow	9.41	NOED growth	ERED, 1998
	1.31	LOED growth	ERED, 1998
	2.75 – 10.9	No effect – survival	Jarvinen and Ankley, 1999
	0.8 – 10.9	No effect – growth	Jarvinen and Ankley, 1999
	1.31, 4.76	Reduced growth	Jarvinen and Ankley, 1999
	2.84	No effect – reproduction	Jarvinen and Ankley, 1999
	1.36	Reduced growth, 2nd generation	Jarvinen and Ankley, 1999
Japanese medaka	16	NOED development, morphology	ERED, 1998: Jarvinen and Ankley, 1999
	29	LOED development, behavior	ERED, 1998
Winter flounder	2	LOED physiology	ERED, 1998
Rainbow trout	0.14	NOED growth	ERED, 1998
	2	LOED mortality	ERED, 1998
	1.9 – 12	No effect – survival	Jarvinen and Ankley, 1999
	11.2, 12.2	Reduced survival	Jarvinen and Ankley, 1999
	2.28 – 8.63	No effect – growth	Jarvinen and Ankley, 1999
	8.6 – 35	Reduced growth	Jarvinen and Ankley, 1999
	5.0 – 35	No effect – survival	Jarvinen and Ankley, 1999
Brook trout	2.7	NOED development, mortality	ERED, 1998
	3.4	LOED reproduction	ERED, 1998
Northern pike	7	LOED physiology	ERED, 1998
	12.5	Reduced survival	Jarvinen and Ankley, 1999
	10.9	No effect – survival, growth	Jarvinen and Ankley, 1999
Walleye	0.25	NOED growth	ERED, 1998
	0.25	LOED growth, development, physiology	ERED, 1998
	2.37	NOED mortality	ERED, 1998
Yellow perch	0.135	NOED growth	ERED, 1998
Goldfish	7	Reduced survival	Jarvinen and Ankley, 1999
	6.1	No effect – survival	Jarvinen and Ankley, 1999
Guppy	0.2	No effect – survival	Jarvinen and Ankley, 1999
Bluegill	6.5	Reduced survival	Jarvinen and Ankley, 1999
generic	0.1	Fish concentration protective of piscivorous birds	Eisler, 1987
generic	0.3	Fish concentration protective of piscivorous birds	Scheuhammer and Blancher, 1994
generic	1.1	Fish concentration protective of piscivorous mammals	Eisler, 1987
generic	3.0	Protection criterion for adult fish	Weiner and Spry, 1996

NOED - No Observable Effective Dose
LOED - Lowest Observable Effective Dose

TABLE 7-17

GUIDELINES FOR PROTECTION OF FISH AND PISCIVOROUS RECEPTORS
PESTICIDES
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Data Associated With Effects			Reference
Fish Species	**Concentration (mg/kg)**	**Endpoint/Effect**	
4,4'-DDD			
Fathead minnow	0.6	LOED reproduction	ERED, 1998
Mosquitofish	5.3	NOED mortality	ERED, 1998
Brook trout	4.79	LOED behavior	ERED, 1998
	0.008	No effect – survival	Jarvinen and Ankley, 1999
	1 – 5	No effect – survival, growth	Jarvinen and Ankley, 1999
Lake trout	0.9	NOED mortality	ERED, 1998
generic	0.2[a]	Protection of sensitive wildlife species	Newell et al., 1987
4,4'-DDE			
Mosquitofish	29.2	NOED mortality	ERED, 1998
Brook trout	0.042	No effect – survival	Jarvinen and Ankley, 1999
	1 – 5	No effect – survival, growth	Jarvinen and Ankley, 1999
	44.9	LOED behavior	ERED, 1998
Lake trout	1.09	LOED mortality	ERED, 1998
	2.68	No effect – growth	Jarvinen and Ankley, 1999
	0.29	reduced survival	Jarvinen and Ankley, 1999
generic	0.2[a]	Protection of sensitive wildlife species	Newell et al., 1987
generic	0.266	1 in 100 cancer risk level for piscivorous wildlife	Newell et al., 1987
4,4'-DDT			
Golden ide	95	NOED mortality	ERED, 1998
Mosquitofish	18.6	NOED mortality	ERED, 1998
Atlantic salmon	3.0	NOED growth, metabolic rate	ERED, 1998
Spiny dogfish	0.1	NOED mortality	ERED, 1998
Brook trout	3.9	LOED behavior	ERED, 1998
	1.92 – 25.6[a]	No effect – survival	Jarvinen and Ankley, 1999
	0.009	No effect – survival	Jarvinen and Ankley, 1999
	1 – 5	No effect – survival, growth	Jarvinen and Ankley, 1999
	2.8 – 7.6[a]	No effect – survival, growth	Jarvinen and Ankley, 1999
	1.92 – 25.6[a]	No effect – survival	Jarvinen and Ankley, 1999
Lake trout	2	LOED offspring survival	ERED, 1998
	2.93[a]	Reduced survival	Jarvinen and Ankley, 1999
Rainbow trout	0.15 – 4.67[a]	No effect – survival	Jarvinen and Ankley, 1999
	1.27[a]	Reduced survival	Jarvinen and Ankley, 1999
Fathead minnow	3.8	LOED reproduction	ERED, 1998
	40[a]	No effect – survival	Jarvinen and Ankley, 1999
Bluegill	4.2	LOED behavior	ERED, 1998
Atlantic menhaden	24[a]	No effect – growth	Jarvinen and Ankley, 1999
Coho salmon	16.6[a]	No effect – survival	Jarvinen and Ankley, 1999
Chinook salmon	2.2 – 11.4[a]	No effect – survival	Jarvinen and Ankley, 1999

TABLE 7-17

GUIDELINES FOR PROTECTION OF FISH AND PISCIVOROUS RECEPTORS
PESTICIDES
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Data Associated With Effects			Reference
Fish Species	**Concentration (mg/kg)**	**Endpoint/Effect**	
4,4'-DDT (continued from previous page)			
Goldfish	130[a]	No effect – survival	Jarvinen and Ankley, 1999
Golden shiner	3.6[a]	No effect – survival	Jarvinen and Ankley, 1999
Mummichog	1.5[ab]	No effect – survival	Jarvinen and Ankley, 1999
Sailfin molly	43[a]	No effect – survival, growth	Jarvinen and Ankley, 1999
Sailfin molly	77.3[a]	Reduced survival, growth	Jarvinen and Ankley, 1999
Green sunfish	24[a]	Reduced survival	Jarvinen and Ankley, 1999
generic	0.2[a]	Protection of sensitive wildlife species	Newell et al., 1987
Alpha-BHC			
rainbow trout	42[b]	No effect – survival, growth	Jarvinen and Ankley, 1999
guppy	25	No effect – survival	Jarvinen and Ankley, 1999
generic	0.1[c]	Non-carcinogenic piscivorous wildlife criterion	Newell et al., 1987
generic	0.51[c]	1 in 100 cancer risk level for piscivorous wildlife	Newell et al., 1987
Beta-BHC			
Golden ide	22.5	NOED mortality	ERED, 1998
generic	0.1[c]	Non-carcinogenic piscivorous wildlife criterion	Newell et al., 1987
generic	0.51[c]	1 in 100 cancer risk level for piscivorous wildlife	Newell et al., 1987
Delta-BHC			
generic	0.1[c]	Non-carcinogenic piscivorous wildlife criterion	Newell et al., 1987
generic	0.51[c]	1 in 100 cancer risk level for piscivorous wildlife	Newell et al., 1987
Gamma-BHC (Lindane)			
Bluegill	1.5	NOED behavior	ERED, 1998
	0.297[b]	No effect – survival, growth	Jarvinen and Ankley, 1999
Fathead minnow	6.13	NOED mortality	ERED, 1998; Jarvinen and Ankley, 1999
	9.53	LOED mortality	ERED, 1998; Jarvinen and Ankley, 1999
Brook trout	0.77[b]	NOED growth	ERED, 1998; Jarvinen and Ankley, 1999
	1.2[b]	NOED mortality	ERED, 1998; Jarvinen and Ankley, 1999
	1.2[b]	LOED mortality	ERED, 1998; Jarvinen and Ankley, 1999
	0.77[b]	No effect – growth	Jarvinen and Ankley, 1999
	1.2[b]	No effect – survival	Jarvinen and Ankley, 1999
	1.2[b]	Reduced growth	Jarvinen and Ankley, 1999

TABLE 7-17

GUIDELINES FOR PROTECTION OF FISH AND PISCIVOROUS RECEPTORS
PESTICIDES
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

Data Associated With Effects			Reference
Fish Species	**Concentration (mg/kg)**	**Endpoint/Effect**	
Gamma-BHC (Lindane) (Continued from previous page)			
Atlantic salmon	1.7	NOED mortality	ERED, 1998
Goldfish	2.3	NOED behavior	ERED, 1998
Rainbow trout	0.8 [b]	No effect – survival	Jarvinen and Ankley, 1999
Gudgeon	0.013[b]	No effect – survival	Jarvinen and Ankley, 1999
generic	0.1[c]	Non-carcinogenic piscivorous wildlife criterion	Newell et al., 1987
generic	0.51[c]	1 in 100 cancer risk level for piscivorous wildlife	Newell et al., 1987
Chlordane [d]			
Sheepshead minnow	1.38	NOED mortality, reproduction	ERED, 1998
	3.18	LOED mortality, reproduction	ERED, 1998
Spot	0.01	NOED mortality	ERED, 1998
Pinfish	16.6	LOED mortality	ERED, 1998
generic	0.5	Non-carcinogenic piscivorous wildlife criterion	Newell et al., 1987
generic	0.37	1 in 100 cancer risk level for piscivorous wildlife	Newell et al., 1987
generic	0.3	Fish concentration protective of piscivorous birds and mammals (based on human health criteria)	Eisler, 1987

NOED No Observable Effective Dose
LOED Lowest Observable Effective Dose
a total DDT
b concentration in muscle tissue; all other concentrations are whole body
c total BHC
d total chlordane

TABLE 7-18

COMPARISON OF SEDIMENT CHEMICALS OF POTENTIAL CONCERN (COPCs)
TO VARIOUS GUIDELINES
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

COPC	Maximum	Mean	EPA Region IV ESV	ER-M	PEL	PEC	AET	Ontario MOE	Other
Volatile Organic Compounds (µg/kg)									
Acetone	63	37	NA	NA	NA	NA	NA	NA	NA
Carbon Disulfide	24	77	NA	NA	NA	NA	NA	NA	NA
Toluene	7	73	NA	NA	NA	NA	NA	NA	1668[a]; 2216[b]
Semivolatile Organic Compounds (µg/kg)									
Acenapththylene	380	351	5.87	640	128	NA	71	NA	NA
Anthracene	770	143	46.9	1100	245	547.7	280	220/3700	NA
Benzo(a)anthracene	2200	352	74.8	1600	693	4200	960	320/14800	NA
Benzo(a)pyrene	1700	319	88.8	1600	763	393.7	1100	370/14400	NA
Benzo(b)fluoranthene	1800	318	NA	NA	NA	NA	1800	NA	NA
Benzo(g,h,i)perylene	990	199	NA	NA	NA	6300	670	170/3200	NA
Benzo(k)fluoranthene	850	150	NA	NA	NA	NA	1800	240/13400	NA
Carbazole	580	377	NA	NA	NA	NA	NA	NA	NA
Chrysene	2300	390	108	2800	846	5200	950	NA	NA
Dibenzo(a,h)anthracene	1600	216	6.22	260	NA	28.2	230	60/1300	NA
Fluoranthene	6600	903	113	5100	1494	834.3	1300	750/10200	3486[c]; 15438[b]
Fluorene	160	111	21.2	540	144	651.9	120	190/1600	1345[ab]
Indeno(1,2,3-cd)pyrene	1100	220	NA	NA	NA	836.7	600	200/3200	NA
Phenanthrene	2600	409	86.7	1500	544	NA	660	560/9500	2739[c];4482[b]
Pyrene	5400	769	153	2600	1398	3225	2400	490/8500	NA
Total PAHs	30,103	NA	1684	44792	16770	13660	NA	4000/100000	NA
Pesticides/PCBs (µg/kg)									
4,4'-DDD	260	25	1.22	NA	7.81	NA	16	8/60	NA
4,4'-DDE	120	18	2.07	27	374	NA	9	5/190	NA
4,4'-DDT	270	26	1.19	46.1[d]	4.77	NA	12	8/710	NA
alpha-Chlordane	52	8.3	0.5[e]	NA	4.79[e]	NA	2.8[e]	7/60[e]	NA

TABLE 7-18

COMPARISON OF SEDIMENT CHEMICALS OF POTENTIAL CONCERN (COPCs)
TO VARIOUS GUIDELINES
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

COPC	Maximum	Mean	EPA Region IV ESV	ER-M	PEL	PEC	AET	Ontario MOE	Other
gamma-Chlordane	130	12.0	0.5 [e]	NA	4.79 [e]	NA	2.8[e]	7/60 [e]	NA
alpha-BHC	2.7	3.0	NA	NA	NA	NA	NA	6/100	NA
beta-BHC	5.4	3.1	NA	NA	NA	NA	NA	5/210	NA
delta-BHC	2.7	3.0	NA	NA	NA	NA	NA	NA	323.7[b]
gamma-BHC (lindane)	2.1	2.9	0.32	NA	0.99	NA	4.8	3/10	9.21 [ab]
Metals and Inorganic Compounds (mg/kg)									
Aluminum	23400	10179	NA	NA	NA	58030	NA	NA	NA
Arsenic	15.6	6.2	7.24	70	41.6	57	35	6/33	NA
Barium	88.5	23.9	NA	NA	NA	NA	48	NA	NA
Beryllium	1.2	0.39	NA	NA	NA	NA	NA	NA	NA
Cadmium	0.79	0.08	0.676	9.6	4.21	11.7	3.0	0.6/10	NA
Cobalt	3.9	1.95	NA	NA	NA	NA	10	NA	50[f]
Copper	95.3	27.4	18.7	270	108	77.7	390	16/110	NA
Iron	24000	13221	NA	NA	NA	NA	NA	20000/40000	NA
Lead	194	48.5	30.2	218	112	396	400	31/250	NA
Manganese	190	92.5	NA	NA	NA	1081	260	460/1110	NA
Mercury	0.67	0.126	0.13	0.71	0.696	NA	0.410	0.2/2	NA
Silver	2.4	0.288	0.733	3.7	1.77	NA	3.1	NA	NA
Thallium	0.925	0.348	NA	NA	NA	NA	NA	NA	NA
Vanadium	50.65	27.3	NA	NA	NA	NA	57	NA	NA
Zinc	124	44.99	124	410	271	1532	410	120/820	NA

NA Not Available
ER-M Effects Range Medium (Long et al, 1995)
PEL Probable Effects Level (FDEP, 1994).
PEC Probable Effects Concentration, Assessment and Remediation of Contaminated Sediments Program (U.S. EPA 1996b).
AET Apparent Effects Threshold (Buchman, 1999)

TABLE 7-18

COMPARISON OF SEDIMENT CHEMICALS OF POTENTIAL CONCERN (COPCs)
TO VARIOUS GUIDELINES
SITE 1
MCRD PARRIS ISLAND, SOUTH CAROLINA

MOE	Ontario Ministry of the Environment: Lowest effect level / Severe effect level (Jones et al, 1997).
a	Sediment Quality Benchmark (U.S. EPA, 1996a) based on site-specific organic carbon content of 2.49%.
b	Sediment Quality Advisory Level (U.S. EPA, 1997c) based on site-specific organic carbon content of 2.49%.
c	Sediment Quality Criteria (U.S. EPA, 1996a) based on site-specific organic carbon content of 2.49%.
d	ER-M for total DDT
e	Value for total chlordane
f	Open water disposal guideline, Ontario Ministry of the Environment (Giesy and Hoeke, 1990)

TABLE 7-19

COMPARISON OF SURFACE SOIL CHEMICALS OF POTENTIAL CONCERN (COPCs)
TO OTHER GUIDELINES – SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

COPC	Maximum	Mean	ORNL[a] Earthworms/ microorganisms	ORNL Soil Phytotoxicity	BTAG Region III Fauna	BTAG Region III Flora	Beyer (1990) "A" Value	Beyer (1990) "B" Value	Dutch (1994) Target	Dutch (1994) Intervention
VOLATILE ORGANIC COMPOUNDS (µg/kg)										
Acetone	730	152	NA	NA	NA	NA	NA	NA	NA	NA
SEMIVOLATILE ORGANIC COMPOUNDS (µg/kg)										
1,2,4-Trichlorobenzene	140	189	20,000	NA	100	100	NA	NA	NA	NA
2-Methylnapthanlene	130	189	NA	NA	NA	NA	NA	NA	NA	NA
Benz(a)anthracene	280	84.7	NA	NA	100	100	NA	NA	NA	NA
Benzo(a)pyrene	310	97.8	NA	NA	100	NA	100	1000	NA	NA
Benzo(b)fluoranthene	510	120.6	NA	NA	100	100	NA	NA	NA	NA
Benzo(g,h,i)perylene	210	73.9	NA	NA	100	100	NA	NA	NA	NA
Benzo(k)fluoranthene	160	41.5	NA	NA	100	100	NA	NA	NA	NA
Bis(2-ethylhexyl) phthalate	5600	554.7	NA	NA	NA	NA	NA	NA	100[b]	60000[b]
Butylbenzyl phthalate	2000	320.2	NA	NA	NA	NA	NA	NA	100[b]	60000[b]
Carbazole	490	262.1	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	330	97.5	NA	NA	100	100	NA	NA	NA	NA
Di-n-octyl phthalate	6400	634	NA	NA	NA	NA	NA	NA	100[b]	60000[b]
Dibenzofuran	200	191	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	630	174	NA	NA	100	100	100	10000	NA	NA
Indeno(1,2,3-cd)pyrene	230	71.8	NA	NA	100	100	NA	NA	NA	NA
Phenanthrene	190	89.1	NA	NA	100	100	100	5000	NA	NA
Pyrene	510	134.9	NA	NA	100	100	100	10000	NA	NA
PESTICIDES/PCBs (µg/kg)										
4,4'-DDD	180	35.7	NA	NA	100	100	NA	NA	2.5	4000
4,4'-DDE	4200	395	NA	NA	100	100	NA	NA	2.5	4000
4,4'-DDT	4400	389	NA	NA	100	100	NA	NA	2.5	4000

TABLE 7-19

COMPARISON OF SURFACE SOIL CHEMICALS OF POTENTIAL CONCERN (COPCs)
TO OTHER GUIDELINES – SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

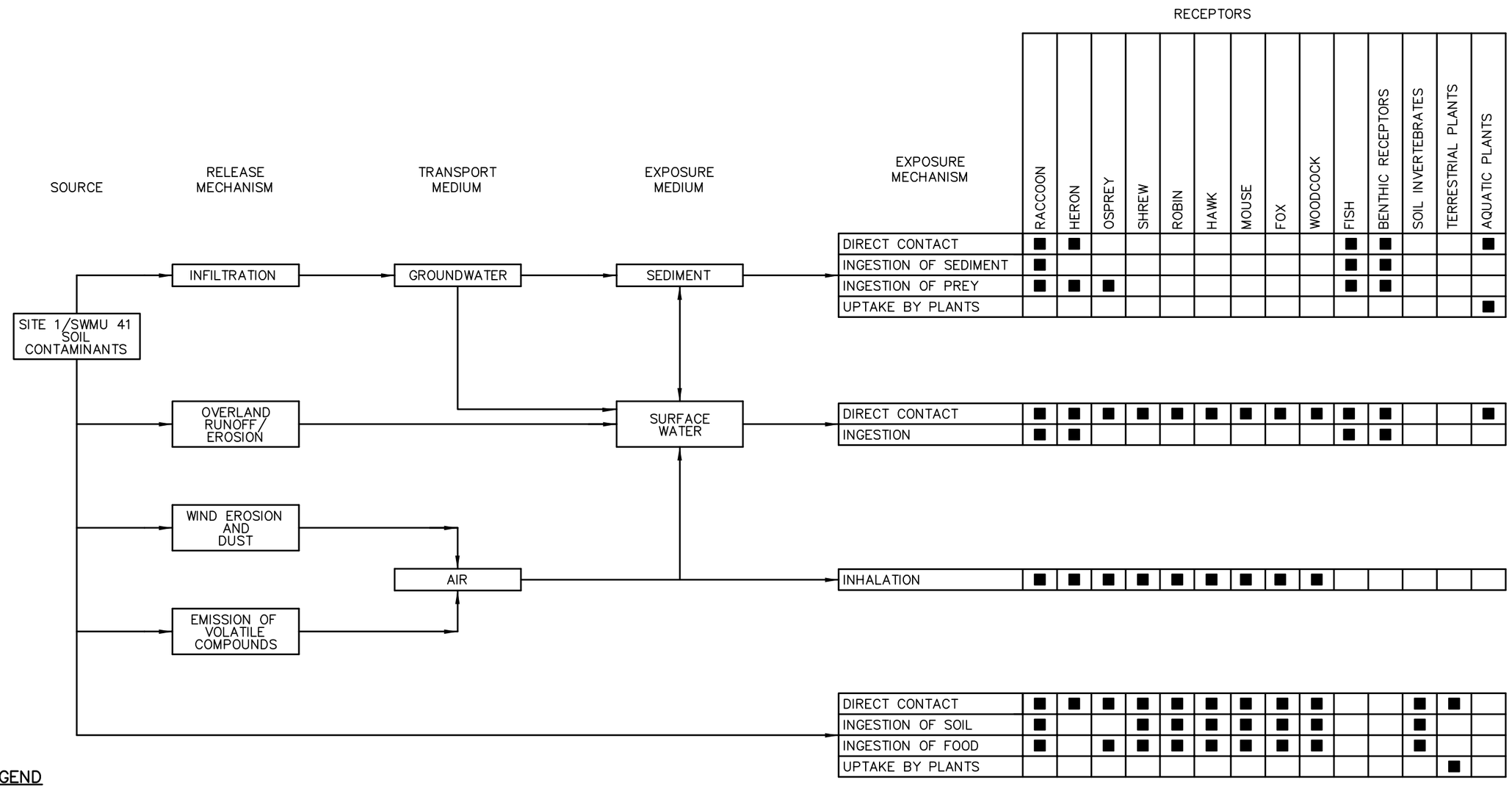
COPC	Maximum	Mean	ORNL[a] Earthworms/ microorganisms	ORNL Soil Phytotoxicity	BTAG Region III Fauna	BTAG Region III Flora	Beyer (1990) "A" Value	Beyer (1990) "B" Value	Dutch (1994) Target	Dutch (1994) Intervention
Aroclor 1260	80	17.8	NA	40000[c]	NA	100[c]	50[c]	1000[c]	20[c]	1000[c]
Alpha-Chlordane	18	7.7	NA	NA	100[d]	100[d]	NA	NA	NA	NA
Gamma-Chlordane	8.1	6.7	NA	NA	100[d]	100[d]	NA	NA	NA	NA
Alpha-BHC	42	9.1	NA	NA	100[e]	100[e]	NA	NA	2.5	NA
Beta-BHC	33	8.8	NA	NA	100[e]	100[e]	NA	NA	1.0	NA
Delta-BHC	45	9.1	NA	NA	100[e]	100[e]	NA	NA	NA	NA
Gamma-BHC (lindane)	75	11.3	NA	NA	100[e]	100[e]	NA	NA	0.05	NA
Endrin ketone	12	12.8	NA	NA	100[f]	100[f]	NA	NA	1.0[f]	NA
METALS AND INORGANIC COMPOUNDS (mg/kg)										
Aluminum	8610	5667	600	50	NA	1	NA	NA	NA	NA
Antimony	90.6	7.0	NA	5.0	NA	0.48	NA	NA	NA	NA
Arsenic	24.9	4.3	60	10	NA	328	20	30	29	55
Barium	178	70.7	3,000	500	440	440	200	400	200	625
Cadmium	5.4	0.9	20	4.0	NA	2.5	1.0	5.0	0.8	12
Copper	131	44.3	50	100	NA	15	50	100	36	190
Iron	147000	19558	200	NA	12	3,260	NA	NA	NA	NA
Lead	8380	834	500	50	0.01	2	50	150	85	530
Manganese	752	123	100	500	330	330	NA	NA	NA	NA
Mercury	1.1	0.21	0.1	0.3	0.058	0.058	0.5	2.0	0.3	10
Nickel	47.8	8.2	90	30	NA	2	50	100	35	210
Selenium	1.1	0.29	70	1.0	1.8	1.8	NA	NA	NA	NA
Silver	2.4	0.6	50	2.0	NA	0.0000098	NA	NA	NA	NA
Vanadium	47.4	12.1	20	2.0	58	0.5	NA	NA	NA	NA
Zinc	497	177	100	50	NA	10	200	500	140	720

TABLE 7-19

COMPARISON OF SURFACE SOIL CHEMICALS OF POTENTIAL CONCERN (COPCs)
TO OTHER GUIDELINES – SITE 1 AND SWMU 41
MCRD PARRIS ISLAND, SOUTH CAROLINA

NA Not Available
a lowest of earthworm and micro-organism screening values
b value for total phthalates
c value for total PCBs
d value for total chlordane
e value for total BHC
f value for total endrin

ACAD: 7394KF10.dwg 06/08/01 HJP



LEGEND

■ COMPLETE EXPOSURE PATHWAY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 12/14/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE NOT TO SCALE

CONCEPTUAL SITE MODEL
SITE 1 – INCINERATOR LANDFILL
AND SWMU 41 – FORMER INCINERATOR
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 7–1
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

8.0 CONCLUSIONS AND RECOMMENDATIONS

The conclusions developed during the Site/SWMU 1 (Site 1) and SWMU 41 RI/RFI are summarized as follows.

1.0 Surface soils were found to contain polynuclear aromatic hydrocarbons (PAHs), PCBs, pesticides, and several metals including lead, arsenic, aluminum, iron, mercury, vanadium, and zinc at concentrations greater than present in background soils and in exceedance of the most stringent human health RBCs (residential) or the most stringent ecological screening values. The highest levels of metals were generally associated with areas with little or no cover soil. As discussed in Appendix H, the observed pesticide concentrations in soil are consistent with surface application for pest control. Consequently, pesticides may not be site related.

2.0 Soil testing at SWMU 41 did not find any evidence that contamination at the two suspected locations of the former incinerator is unique from that found at Site 1. As a result, SWMU 41 will be addressed as part of Site 1. In addition, the one suspected location south of the Site 1 did not exhibit any evidence of contamination, indicating that either incineration activities never occurred in this area or that potential impacts from the historical operation have been remediated.

3.0 Arsenic, iron, lead, manganese, thallium, chloroform, and naphthalene were detected in the site groundwater at concentrations that exceed the most stringent human health criteria (drinking water standards). The presence of a salt water marsh surrounding the site and the measured salinity of the groundwater limits the use of site groundwater as a potable water supply. Naphthalene, copper, lead, mercury, and zinc were present in groundwater at concentrations that could exceed ecological screening values for surface water if groundwater to surface water attenuation factors were not present.

4.0 Bis(2-ethylhexyl)phthlate, chrysene, pentachlorophenol, arsenic, iron, manganese, and mercury were detected in surface water at concentrations in excess of background and the most stringent human health RBCs. Pentachlorophenol, copper, lead, mercury, silver, and zinc were detects in surface water at concentrations in excess of background and the most stringent ecological screening values.

5.0 Sediments were found to contain PAHs, pesticides, arsenic, cadmium, copper, iron, lead, mercury, and silver at concentrations greater than present in background sediments and in exceedance of the most stringent human health RBCs (residential) or ecological screening

values. As discussed in Appendix H, the observed pesticide concentrations in soil are consistent with surface application for pest control. Consequently, pesticides may not be site related.

6.0 TCDD and related isomers, measured as TCDD toxicity equivalent concentrations (TEQ) were found in both sediment and groundwater at the site, but at concentrations below the most stringent risk-based human health and drinking water criteria. The detected TEQ at the site were at concentrations similar to the most stringent ecological criteria for mammals and significantly less than the most stringent criteria for fish and avian receptors. As a result, significant impact to site ecological receptors would not be anticipated. The concentration of TEQ in site sediments is also similar to that found in a background sample location. As a result, the presence of TEQ is likely to be present from a regional source and is not related to Site 1 waste disposal activities.

7.0 The human health risk assessment considered site media exposure to construction workers, maintenance workers, adolescent and adult recreational users, and potential future residents. The estimated risks are summarized as follows.

- The estimated ILCR to construction workers exceeded $1x10^{-6}$, but was less than $1x10^{-4}$. This risk is within the acceptable U.S. EPA target risk range. The noncarcinogenic risk estimate for the construction worker was slightly greater than 1.0 (2.2), indicating that toxic effects are possible. However, the only chemical with a hazard quotient greater than 1.0 was iron.

- The estimated ILCR to maintenance workers exceeded $1x10^{-6}$, but was less than $1x10^{-4}$. This risk is within the acceptable U.S. EPA target risk range. The noncarcinogenic risk estimate for the maintenance worker was less than 1.0, indicating that toxic effects are not anticipated.

- For surface water with the exception of bioaccumulation through fish, the estimated ILCR the adolescent recreational user exceeded $1x10^{-4}$ for surface water (at $1.2x10^{-4}$). This risk is greater than the U.S. EPA target risk range. Bis(2-ethylhexyl) phthalate and pentachlorophenol were the major contributors to this cancer risk estimate. For soils and sediments, the estimated incremental cancer risk to adolescent recreational user exceeded $1x10^{-6}$, but was less than $1x10^{-4}$. This risk is within the acceptable U.S. EPA target risk range. The noncarcinogenic risk estimate for the adolescent recreational user indicates that toxic effects are not anticipated.

- The estimated incremental cancer risk to the adult recreational user exceeded $1x10^{-6}$, but was less than $1x10^{-4}$. This risk is within the acceptable U.S. EPA target risk range. The

noncarcinogenic risk estimate for the adult recreational user indicates that toxic effects are not anticipated.

- The human health risk assessment also considered environmental exposure from the adult recreational user via recreational fishing at the site. Chemical concentrations in fish tissue were estimated through theoretical partitioning of surface water contaminants to fish. The estimated chemical concentrations in fish tissue were then used to calculate risks to human health under a frequent consumer (daily fish consumption– default) and occasional consumer consumption (once per week) of fish from the site. Under the least stringent scenario (average concentrations and occasional fish consumption), the ILCR estimate ($4.1x10^{-5}$) was within the acceptable U.S. EPA risk range of $1x10^{-4}$ to $1x10^{-6}$. The estimated noncarcinogenic risk (2.2) slightly exceeded 1.0 indicating that toxic effects are possible. Under more stringent scenarios (frequent fish consumer and/or maximum concentrations), incremental cancers risks exceeded $1x10^{-4}$ and non carcinogenic risks were greater than 1.0. These risk estimates are higher than acceptable U.S. EPA risk criteria. Pentachlorophenol and arsenic were the main contributors to carcinogenic risk. Pentachlorophenol, dibenzofuran, arsenic, iron, and manganese were the main contributors to noncarcinogenic risk.

- The estimated ILCR to a hypothetical future child, adult, and lifelong resident exceeded $1x10^{-4}$ based on exposure to surface water. The ILCR for exposure to surface water was estimated to be $1x10^{-4}$ for the child resident, 2.5 $x10^{-4}$ for the adult resident, and $3.6x10^{-4}$ for the lifelong resident. Bis(2-ethylhexyl) phthalate and pentachlorophenol in surface water were the major contributors to this cancer risk estimate. The total ILCR across all media (surface water, soil, and sediment) was estimated to be $1.4x10^{-4}$ for the child resident, 2.8 $x10^{-4}$ for the adult resident, and $4.2x10^{-4}$ for the lifelong resident. These risk estimates are greater than the U.S. EPA target risk range. The noncarcinogenic risk estimates for a hypothetical future child (11) and adult (1.3) were greater than 1.0, indicating that toxic effects are possible.

8.0 The initial ecological risk screening determined that the maximum concentrations of pentachlorophenol and several metals, pesticides, phthalates, and PAHs at the site exceed U.S. EPA Region 4 screening values, indicating a potential risk to ecological receptors. In addition, several other chemicals were identified as COPCs because of the lack of screening criteria.

9.0 The food chain modeling evaluated 11 representative receptors and found that the majority of the initial COPCs do not represent a threat to site receptors even under a worst case scenario (organisms constantly exposed to maximum concentrations). Chemicals that pose potential risks under this scenario consist of PCBs, pesticides, phthalates, and several metals.

10.0 The food chain modeling found that under more realistic conditions which consider mean chemical concentrations, the list of chemicals in which hazard quotients (HQ) for NOAELs exceed 1.0 were reduced to the following:

- DDT(maximum HQ is 66)
- DDE (maximum HQ is 177)
- DDD (maximum HQ is 30)
- aluminum (maximum HQ is 1,130)
- antimony (maximum HQ is 27)
- arsenic (maximum HQ is 10.6)
- barium (maximum HQ is 6.7)
- cadmium (maximum HQ is 3.4)
- iron (maximum HQ is 116)
- lead (maximum HQ is 195)
- mercury (maximum HQ is 41)
- thallium (maximum HQ is 10.1)
- vanadium (maximum HQ is 27.5)
- zinc (maximum HQ is 28)

In evaluating this data the following factors should be considered.

- Except for aluminum, arsenic, thallium, and vanadium, the maximum hazard quotients were all associated with terrestrial receptors and surface soils.

- The majority of the pesticides detected at Site 1 were similar to typical concentrations found at the base.

11.0 The surface soil data are adequate to proceed to a feasibility study/corrective measures study to support a presumptive remedy at Site 1. Options for evaluation under the presumptive remedy include covering/capping of landfill contents. Protection of ecological receptors (direct contact and erosion into the sediment) is the primary concern.

12.0 The groundwater data are adequate to proceed to a feasibility study/corrective measures study to evaluation options for managing contaminated groundwater. Based on the low level of contamination, the location of the site relative to a salt water marsh, and the permeability of underlying soils, remedial options will focus on reducing infiltration and tidal effects.

13.0 Because of the transient nature of surface water, water quality concerns would be better addressed through management of sediment, soil, and groundwater.

14.0 The sediment data are adequate to proceed to a feasibility study/corrective measures study.

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