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REMEDIAL INVESTIGATION/FEASIBILITY STUDY

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for Operable Unit One

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Operable Unit One (OU1) at the Woodbridge Research Facility (WRF) has been defined as the area encompassing AREEs 1 through 6B (former dumps) and AREE 7 (former Pistol Range). A Focused Feasibility Study has been conducted to identify and screen remedial alternatives for OU1, to address contaminated groundwater, surface soil, subsurface soil, and sediment detected at AREEs associated with OU1. This report summarizes the site history, current conditions, and environmental data. Human health and ecological risk assessments are presented. General response actions, technology types, and process options appropriate for the remediation of contaminated media are identified. Process options are screened and assembled into five alternatives. Each alternative is evaluated in detail using the nine criteria identified in the NCP (40 CFR 300.430(e)). The report concludes with a comparison of the remedial options under consideration.

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FOCUSED FEASIBILITY STUDY FOR OPERABLE UNIT ONE

FINAL DOCUMENT

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LIST OF ACRONYMS

°F ..... degree Fahrenheit
µg/g ..... microgram per gram
µg/kg ..... microgram per kilogram
µg/L ..... microgram per liter
ADD ..... Average daily doses
ADI ..... Allowable Daily Intakes
amsl ..... above mean sea level
ARAR ..... applicable or relevant and appropriate requirement
AREE ..... Area Requiring Environmental Evaluation
ATSDR ..... Agency for Toxic Substances and Disease Registry
AWQC ..... ambient water quality criteria
BCF ..... bioconcentration factors
BCT ..... BRAC Cleanup Team
bgs ..... below ground surface
BRAC ..... Base Realignment and Closure
BTAG ..... Biological Technical Assistance Group
CEQ ..... Council on Environmental Quality
CERCLA ..... Comprehensive Environmental Response, Compensation, and Liability Act
CNS ..... central nervous system
CONUS ..... Continental United States
COPC ..... Chemicals of Potential Concern
CRAVE ..... Carcinogen Risk Assessment Verification Endeavor
DA ..... dose absorbed
DDD ..... 1,1-dichloro-2,2-bis(p-chlorophenyl)ethane
DDE ..... 1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene
DDT ..... 1,1,1-trichloro-2,2-bis(chlorophenyl)ethane
EEQ ..... Environmental Effects Quotient
EIS ..... Environmental Impact Statement
EqP ..... equilibrium partitioning
ER-L ..... Effects Range-Low
ER-M ..... Effects Range-Median
ESE ..... Environmental Science and Engineering, Inc.
ET ..... exposure time
FFS ..... Focused Feasibility Study

gpm ..... gallons per minute
HEAST ..... Health Effects Assessment Summary Tables
ICF KE ..... ICF Kaiser Engineers
IEC ..... inhalation exposure concentrations
IRIS ..... Integrated Risk Information System
ISE ..... Initial Site Evaluation
LADD ..... lifetime average daily dose
L/day ..... liter per day
LOAEL ..... lowest-observable-adverse-effect-level
MCL ..... Maximum Concentration Limit
MERDC ..... U.S. Army Mobility Equipment Research and Development Center
mph ..... miles per hour
NCEA ..... National Center for Environmental Assessment
NCP ..... National Oil and Hazardous Substances Pollution Contingency Plan
ND ..... Not Detected
NEPA ..... National Environmental Policy Act
NOAA ..... National Oceanic Atmospheric Administration
NOAEL ..... no-observable-adverse-effect-level
NPDES ..... National Pollutant Dishcharge Elimination System
O&M ..... Operation and Maintenance
OU ..... Operable Units
PCB ..... Polychlorinated Biphenyl
PAH ..... Polynuclear Aromatic Hydrocarbon
PCT ..... polychlorinated terphenyls
ppm ..... parts per million
PRG ..... Preliminary Remediation Goals
RA ..... Risk Assessment
QC ..... Quality Control
RAO ..... Remedial Action Objective
RBC ..... risk based concentration
RCRA ..... Resource Conservation and Recovery Act
RfC ..... reference concentrations
RfD ..... reference doses
RI ..... Remedial Investigation
RME ..... reasonable maximum exposure
SARA ..... Superfund Amendments and Reauthorization Act

SI ..... Site Investigation
SQC ..... sediment quality criteria
SVOC..... semivolatile organic compound
TAL ..... Target Analyte List
TBC..... to-be-considered
TCL ..... Target Compound List
TEL ..... threshold effect level
TOC ..... Total Organic Carbon
TP ..... Test Pit
TPH..... Total Petroleum Hydrocarbons
TRV..... toxicity reference value
TSCA ..... Toxic Substances Control Act
UCL..... Upper Confidence Limit
USAEC..... U.S. Army Environmental Center
USEPA..... U.S. Environmental Protection Agency
USFWS..... U.S. Department of Fish and Wildlife Services
UST..... Underground Storage Tank
VADEQ..... Virginia Department of Environmental Quality
VHWMR..... Virginia Hazardous Waste Management Regulation
VSWMR..... Virginia Hazardous Waste Management Regulation
VOC ..... Volatile Organic Compound
WRF..... Woodbridge Research Facility

EXECUTIVE SUMMARY

ICF Kaiser Engineers (ICF KE) has been contracted by the U.S. Army Environmental Center (USAEC) to perform a Focused Feasibility Study (FFS) for contaminated media at Operable Unit (OU) 1 within the Woodbridge Research Facility (WRF), Woodbridge, Virginia. This task has been performed under Contract No. DACA31-94-D-0064, Task Order 001. This FFS presents a summary of the site background, evaluates the risks posed to human health and the environment by conditions within OU1 and identifies, screens, and evaluates remedial action alternatives.

In July 1991, WRF was recommended for closure by the 1991 Defense Base Realignment and Closure Commission under the Base Realignment and Closure Act (BRAC). The property will be transferred to the U.S. Fish and Wildlife Service (USFWS) in sometime in the near future. Based on preliminary results of the Remedial Investigation (RI) conducted in 1995/1996, four areas of concern were identified as OUs by the BRAC Cleanup Team (BCT). Areas Requiring Environmental Evaluation (AREEs) 1 through 7 (Former Dumps, and the former Pistol Range [AREE 7]) were defined as OU1. The Main Compound Area was defined as OU2. The Main Ditch (AREE 22), and the portions of AREEs 11 and 17 that are outside the Main Compound Area were defined as OU3, and all the remaining areas of WRF were defined as OU4.

Several field investigations have been conducted over the past 12 years to evaluate the extent of contamination at OU1. The primary chemicals of concern were polychlorinated biphenyls (PCB). PCB contamination was due to past disposal activities associated with the former dumps, particularly AREE 1 and AREE 2. Transformers containing PCB-contaminated oil were reportedly disposed of at these sites. During the field investigation associated with a 1993 Site Investigation (SI), conducted by the USAEC, PCB contamination was detected in subsurface soil at AREE 1 at a level as high as 74 parts per million (ppm), which is above the Toxic Substances Control Act (TSCA) land ban limit of 50 ppm.

The results of the RI conducted in 1995/1996 indicate that elevated levels of inorganic compounds are present in surface soil, subsurface soil, sediment, surface water, and groundwater. The inorganic compounds detected are scattered throughout the site and no discrete source areas have been identified. In addition, several polynuclear aromatic hydrocarbons (PAHs) are present in all media investigated. PCB-1016 was detected in one groundwater sample collected from AREE 2. Low levels of pesticides and PAHs were also detected in groundwater at AREE 1, AREE 2, AREE 5, and AREE 6B. PCBs have also been detected in storm water runoff samples collected from OU1, particularly near AREE 1.

SUMMARY OF HUMAN HEALTH RISK ASSESSMENT

A Human Health Risk Assessment (HHRA) was performed to evaluate the potential human health effects associated with chemical contamination at OU1.

In order to streamline this assessment and establish a baseline for future monitoring, only the most conservative receptors at OU1 were evaluated (i.e. a future resident for exposures to surface soil, sediment, surface water, and groundwater, and a future excavation worker for subsurface soil) even though such exposures would not likely occur, the site will be transferred to the USFWS. The following exposure pathways were evaluated in the HHRA:

- Ingestion of Chemicals of Potential Concern (COPCs) in groundwater by child and adult residents;
- Dermal absorption of COPCs in groundwater by child and adult residents while bathing;
- Incidental ingestion and dermal absorption of COPCs in soil by child and adult residents;
- Incidental ingestion and dermal absorption of COPCs in subsurface soil by excavation workers;
- Inhalation of COPCs in airborne particulate matter from subsurface soil by excavation workers;
- Incidental ingestion and dermal absorption of COPCs in sediment from the Marsh Area grouping by child residents;

- Incidental ingestion and dermal absorption of COPCs in surface water from the Open Water Area by adult residents while swimming; and
- Dermal absorption of COPCs in surface water from the Marsh Area by child residents while wading.

The risk estimates for each pathway are the upper-bound excess lifetime cancer risks for carcinogenic chemicals and hazard indices (HIs) for noncarcinogenic chemicals. Using the risk or hazard index values, risks and potential noncarcinogenic adverse effects from exposure to site-related chemicals were assessed. Cancer risk estimates were compared to USEPA's target risk range for human health protectiveness at Superfund sites of $1x10^{-6}$ to $1x10^{-4}$. The potential for adverse noncarcinogenic effects was assessed by comparing the noncarcinogenic hazard indices to a value of one; a hazard index less than one indicates that adverse noncarcinogenic health effects would not be expected to occur.

Cumulative Risks

People may be exposed to the chemicals at one time by a combination of pathways, and therefore, the combined pathway risks for multiple pathway exposures were calculated. Cumulative risk estimates were calculated for child and adult residents, and for excavation workers, who were assumed to be exposed under future land-use conditions.

Child and Adult Residents

Cumulative risks for both child and adult residents were in the mid- to high- range of the $1x10^{-6}$ to $1x10^{-4}$ risk range for health protectiveness at Superfund sites. The cumulative hazard index for both child and adult residents was above one, due to exposures to COPCs in groundwater. Adverse effects to both child and adult residents could be associated with the Central Nervous System (CNS) (due to ingestion of manganese) and decreased birth weight (due to dermal absorption of PCB-1016). Iron (which is not associated with a specific target organ/critical effect) concentrations also resulted in elevated hazard indices.

Excavation Workers

The cumulative risk estimate for excavation workers was $2x10^{-6}$. The cumulative hazard index was equal to 2, due to the ingestion of iron in groundwater.

Overall Risks at Operable Unit One

The most significant risks associated with exposures to evaluated media at OU1 are associated with ingestion and dermal absorption of chemicals in groundwater by hypothetical future residents. Even though elevated hazard indices were calculated for exposures to chemicals in groundwater this pathway is considered to be highly unlikely for several reasons. First, residents would not likely reside at WRF, since the facility will be transferred to the USFWS for incorporation into the National Wildlife Refuge system. Second, drinking water is provided by the local public water supply system that does not utilize local groundwater, and third, the high iron levels would preclude people from installing drinking water wells at OU1. Risks and hazard indices associated with groundwater ingestion for the next most conservative receptor (i.e., a worker) also were calculated, and the risk was lower than the $1x10^{-6}$ to $1x10^{-4}$ risk range, although the HI was equal to 2 (due to iron).

Risks associated with exposures to COPC in all other media were within or below the $1x10^{-6}$ to $1x10^{-4}$ risk range for all receptors, while all noncancer hazard indices were lower than one, indicating the noncarcinogenic adverse effects would not be likely to occur.

SUMMARY OF ECOLOGICAL RISK ASSESSMENT

Risks to ecological resources from the presence of chemicals in the OU1 area were evaluated in the Ecological Risk Assessment (ERA) as part of the OU1 FFS. Data from OU1 surface soils, sediment, and the surface water of a small ephemeral pond in OU1, a wetland area adjacent to Marumsco Creek, and an open water area (consisting of the lower reaches of Marumsco Creek and the section of the Occoquan Bay adjacent to OU1) were evaluated in the ERA. Based on an evaluation of the chemicals detected in these media and the ecological resources known to occur in the OU1 area, the following ecological receptors/endpoints were selected for evaluation:

- Adverse effects to terrestrial plants such as trees and shrubs from chemicals in surface soil;
- Adverse effects to soil invertebrates (such as earthworms) from chemicals in surface soil (invertebrates are important animals in the food chain);
- Adverse effects to aquatic life such as fish and shellfish from exposure to chemicals in surface water; and
- Adverse effects to aquatic life from exposure to chemicals in sediment.

Chemicals having the potential to accumulate in the terrestrial and aquatic food webs were also detected in the environmental media, however, evaluation of the potential for bioaccumulation in the food web was deferred to the facility-wide ERA where overall bioaccumulation and exposure potentials could be more clearly understood. The following is a summary of the results of the ERA for OU1.

Adverse Effects to Terrestrial Plants

Aluminum, chromium, and vanadium exceeded the available literature-based terrestrial plant toxicity values at all surface soil sample locations suggesting the potential for adverse effects throughout OU1. However, concentrations of these chemicals did not statistically exceed those detected at background sample locations. This suggests that the majority of the detected concentrations of these chemicals are likely to be reflective of regional levels. Background levels above toxicity values are likely to be reflective of naturally elevated regional levels (in which case plants are likely to be adapted to these higher levels) or reflective of widespread contamination which is unlikely to have originated from the site.

Selenium, zinc, and manganese were also detected at concentrations above the literature-based toxicity values. However, the detected concentrations of these chemicals exceeded plant toxicity values at only a limited number of sample locations (<15% of sample locations). Further, the overall detected concentrations of these chemicals did not statistically exceed the concentrations detected at the background sample locations.

Adverse Effects to Soil Invertebrates

Available literature-based earthworm toxicity values were exceeded by the maximum detected surface soil concentrations of chromium, and to a lesser extent, mercury and zinc. Chromium concentrations exceeded the earthworm toxicity values at all sample locations, suggesting the potential for adverse effects throughout the site. However, the detected concentrations of chromium did not exceed those detected at background sample locations, suggesting they are reflective of regional and not site-related concentrations. Meanwhile, the detected zinc and mercury concentrations exceed the toxicity values at only a very limited number of sample locations (<8% of sample locations).

Adverse Effects to Aquatic Life from Chemicals in Sediment

The results of the sediment analysis suggest that aquatic life will not be adversely affected by chemicals in the sediments of the ephemeral pond located in OU1. There is, however, some potential for chemicals detected in the sediments of the wetland area adjacent to Marumsco Creek and in the open water area adjacent to OU1 to adversely affect aquatic life. Of the organic compounds detected in the sediments of the wetland and open water areas, the greatest potential for adverse effects to aquatic life is from the presence of PAHs, PCB-1260, and 1,1,1-trichloro-2,2-bis(chlorophenyl)ethane (DDT). However adverse effects, if occurring, are likely at only limited areas given the low frequency of detection of most of these chemicals.

There is also a limited potential for adverse effects to aquatic life associated with the presence of inorganic chemicals in the sediment of OU1. Iron exceeded the available sediment toxicity values in both the wetland and open water areas while copper, manganese, nickel, and silver exceeded the toxicity values in only the open water area. However, the magnitude of the exceedences suggests a very limited potential for adverse effects to aquatic life. Furthermore, with the exception of silver, the overall concentration of the chemicals detected at on-site locations did not statistically exceed those detected at background sample locations, suggesting the overall detected concentrations are reflective of regional and not site-related concentrations. Silver, meanwhile, was detected at only a single sample location.

Adverse Effects to Aquatic Life from Chemicals in Surface Water

The concentrations of the chemicals detected in the surface water of the OU1 area were compared to available Federal Ambient Water Quality Criteria (AWQC) (because these criteria are as, or more stringent than State criteria). The results of the surface water analysis show some potential adverse effects to aquatic life from inorganic contaminants. No organic chemicals were detected in any of the surface water bodies sampled. Of the inorganic chemicals detected in surface water, aluminum was detected at the highest concentrations relative to the criterion, exceeding the AWQC in all three of the sampled water bodies. Iron was detected at concentrations exceeding the AWQC in the wetland and open water areas, while lead was detected at concentrations exceeding the AWQC in the open water area.

Several factors must be considered when evaluating risks from the presence of chemicals in surface water. Precipitation events occurred for several days prior to and during the collection of surface water samples and field notes indicate a relatively high silt content in the surface water samples. Furthermore, the concentrations of the inorganic chemicals detected in the ephemeral pond and the open water areas did not statistically exceed the concentrations detected at background sample locations. These results suggest the elevated concentrations of these inorganic chemicals may have resulted from runoff and sediment suspension during the storm event and may not be reflective of concentrations at lower flow conditions. However, since erosion is occurring at the site, the remedial actions (RA)s proposed for certain AREEs (as presented below) are designed to minimize erosion which will in turn minimize future impacts from contaminant migration via this pathway.

REMEDIAL ALTERNATIVES ANALYSIS

The WRF site investigations have been conducted in accordance with CERCLA regulations. RAs under CERCLA are developed for sites where it has been demonstrated that there are risks to human health and/or the environment. The results of the risk assessments for OU1 show that there is limited risk to residential receptors from exposures to groundwater and that there may be limited ecological risks to aquatic receptors due to the presence of PCB-1260, DDT, and PAHs.

These limited risks notwithstanding, RAs are still required at OU1 since the former dumps have been classified as Open Dumps per the Virginia Soild Waste Management Regulations (VSWMRs). These regulations require corrective actions to be taken to minimize further migration of contaminants which may pose a threat to human health and the environment. The results of the RI show that PCBs are migrating (via storm water runoff) from AREE 1 toward Marumsco Creek and that contaminants have impacted groundwater at OU1. Therefore, RAs are required for OU1 to mitigate further impact to human health and the environment. The following remedial alternatives have been developed to address the contamination that is present at OU1.

The FFS Report lists and analyzes numerous possible interim and final actions, only a few of which were considered to be feasible. The following remedial alternatives passed the initial screening and were considered in detail in the FFS Report. The feasible alternatives are labeled as follows:

Alternative 1: No Action
Alternative 2: Institutional Controls with Long-Term Monitoring
Alternative 3: Containment through Surface Cover and Hot Spot Removal
Alternative 4: Removal and Disposal
Alternative 5: AREE-Specific Remedial Actions

Alternative 1: No Action

Capital Cost:	$0
Annual O&M:	$7,200
Present Worth (15 years):	$74,734

The CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) require that the "No Action" alternative be evaluated at every site to establish a baseline for comparison to other alternatives. Under this alternative, no RA of any kind would be performed. Any access controls currently in place would not be maintained. However, the No Action Alternative would not comply with

the Applicable or Relevant and Appropriate Requirements (ARARs) for OU1. Annual Operation and Maintenance (O&M) costs have been developed to comply with the five-year monitoring requirements of CERCLA.

Alternative 2: Institutional Controls

Capital Cost:	$121,776
Annual O&M:	$143,081
Present Worth (15 years):	$1,606,911

The Institutional Controls Alternative establishes legal and physical restrictions on the use of land and groundwater at OU1, to reduce risks from releases or threatened releases of environmental contaminants. Under the Institutional Controls Alternative, the remedial technologies and process options to be implemented include the following:

Site Access Restrictions

Site access restrictions will be detailed in the "Letter of Transfer" that will be prepared by the Army and signed by the Department of Defense and the Department of the Interior. This "Letter of Transfer" will be recorded at the local Registrar of Deeds office to insure that the institutional controls are maintained for perpetuity.

Access restrictions to the soils would be implemented as follows:

- Prohibitions on unauthorized digging or drilling would be initiated and maintained. Access restrictions will be communicated to all employees and enforced through appropriate administrative channels.
- Signs would be posted which state that excavation and digging are prohibited within OU1, without proper authorization. Authorization and approval may be contingent upon testing and monitoring to ensure the safety of workers. The AREEs within OU1 are regulated through the VSWMRs and the Virginia Hazardous Waste Management Regulations (VHWMRs). Any disturbance of the dumps (with the exception of cover and erosion maintenance) would be in violation of these regulations.

Groundwater Use Restrictions

Groundwater beneath OU1 is contaminated in isolated locations, and therefore restrictions on its usage needs to be implemented.

- Prohibitions on the use of groundwater for purposes other than environmental sampling will be initiated and maintained. These site restrictions will be detailed in the "Letter of Transfer" as described above. Prohibitions would be promulgated in the site's Master Plan, as supervised by either the Army, or the next expected manager, the USFWS. Prohibitions would be communicated to all employees and enforced through appropriate administrative channels.
- Restrictions would be placed in the deed to the property if the Army transfers the property to an entity other than the U.S. Government. The deed restriction will describe the fact that OU1 had isolated groundwater contamination, and should not be used.

Monitoring

Semi-annual monitoring of groundwater would be initiated and maintained in accordance with the VSWMRs for a default period of 15 years (shorter or longer as Virginia Department of Environmental Quality (VADEQ) deems necessary). In addition, monitoring of surface water, storm water runoff, and sediments would be conducted annually for five years. These monitoring data will be reviewed at the end of the first and fifth years and every five years thereafter in order to determine the need for continued monitoring.

Alternative 3: Containment through Surface Cover and Hot Spot Removal

Capital Cost:	$2,082,399
Annual O&M:	$153,538
Present Worth (15 years):	$3,676,072

Under the Containment through Surface Cover and Hot Spot Removal Alternative, protection of human health and the environment is achieved through the construction and maintenance of surface covers on each AREE, together with all institutional control and monitoring activities described in Alternative 2, and excavation and disposal of PCB-contaminated soils in AREE 1. In accordance with the VSWMRs, surface covers will be constructed of 18 inches of low permeability soil, with an additional 6 inches of topsoil placed on top of the low permeability soil. Each cover will be designed at a grade which maximizes runoff and minimizes erosion. Prior to construction, each area will be cleared of existing trees and shrubs. Following construction, each area will be revegetated with grass.

Closure is the activity of installing the soil covers. Post-closure care includes the monitoring and facility maintenance activities conducted after these covers are in place. Post-closure care activities which are performed over a period of 15 years (or longer if the VADEQ deems it necessary) are intended to ensure the following: the covers perform as designed; the covers are repaired when necessary; and any migration of contaminants to groundwater and other media is identified in a timely manner and appropriately addressed.

Alternative 4: Removal and Disposal

Capital Cost:	$6,741,399
Annual O&M:	$143,081
Present Worth (15 years):	$8,226,534

Under the Removal and Disposal Alternative, protection of human health and the environment is achieved through the excavation and off-site disposal of soil contaminants. Removal and disposal of contaminated soils at each AREE in OU1 would be performed in accordance with the VSWMRs. The depth of soils to be removed is AREE-specific based on the depth of contamination identified during previous investigations of the AREEs.

The soils at AREE 1 where elevated levels of PCBs were detected above 50 ppm (which is above the TSCA land ban limit) will be disposed of at a regulated hazardous waste facility. The remaining soils will be disposed of as non-hazardous waste in a permitted sanitary landfill. Following the removal of the soils, each site will be regraded to minimize erosion with grass. The long-term monitoring activities (to be performed for a period of 15 years or longer if the VADEQ deems it necessary) will consist of groundwater, surface water, storm water runoff, and sediment monitoring to show that no contaminants are migrating to these media.

Alternative 5: AREE-Specific Remedial Actions

Capital Cost:	$1,115,047
Annual O&M:	$59,814
Present Worth (15 years):	$1,735,898

Under the AREE-Specific Remedial Actions Alternative, protection of human health and the environment is achieved through the excavation and off-site disposal of soil contaminants and solid waste at some AREEs and surface cover at other AREEs. With their removal or containment, contaminants will cease to enter groundwater and surface water, and remaining concentrations of contaminants will decrease through natural attenuation. The proposed RAs for each AREE within OU1 are summarized below:

AREE 1

In accordance with the VSWMRs, the proposed remedial alternative for AREE 1 includes removal of surface debris; removal of debris along the shoreline; removal of debris from wetlands; installation of rip-rap along the shoreline; a geophysical survey; clearing and grubbing; slope stabilization; construction of an engineered soil cover; and long-term monitoring of groundwater, surface water, storm

water runoff, and sediment. Removal of surface debris, removal of debris in the wetlands, and removal of debris along the shoreline will be completed first. Once this task is completed a geophysical survey will be conducted to establish the extent of buried debris. Excavation of upland soils with PCB concentrations above 10.0 ppm and wetland soils/sediments with PCB concentrations above 1.0 ppm will be performed. Excavated PCB-contaminated soils/sediments will be characterized and then be disposed of off-site at a sanitary landfill or hazardous waste landfill, as appropriate.

Excavated areas will be backfilled with clean soil. After the PCB-contaminated soils/sediments have been removed, an engineered cover will be placed over the upland portion of AREE 1. The area to be covered will be based on the results of the geophysical survey. The covered area will be vegetated with grass to prevent erosion. Any wetland areas that have been impacted from the remedial activities will be restored in accordance with State and Federal requirements. All institutional controls and monitoring activities described in Alternative 2 will also be implemented.

AREEs 2/5

The objective of the RAs for these AREEs is to obtain clean-closure per the VSWMRs. The first task that will be completed in AREE 2/5 is removal of surface debris and removal of debris in the wetlands. A geophysical survey will then be conducted to locate areas where debris may have been buried. Test pits will be excavated to find and remove buried debris which will then be characterized and disposed of off-site at a sanitary landfill or hazardous waste landfill, as appropriate. Soil sampling (analyzing for PCBs, pesticides, SVOCs, and metals) will be performed in order to determine the need for removal of contaminated soils in this AREE. Excavation of upland soils with PCB concentrations above 10.0 ppm and wetland soils/sediments with PCB concentrations above 1.0 ppm will be performed and disposed of as described for AREE 1. Excavated areas will be backfilled with clean soil. Any wetlands that have been impacted will be restored in accordance with State and Federal requirements. Following the completion of site restoration activities, four quarters of groundwater and storm water runoff sampling will be completed to demonstrate that the area qualifies for clean-closure.

If clean-closure is not achieved, the Army will close AREEs 2/5 in-place in accordance with the VSWMRs. This will include: the installation of a cover, establishment of institutional controls against unauthorized groundwater use, soil disturbance, and site access; followed by semi-annual upgradient and downgradient groundwater monitoring for a default period of 15 years. Long-term monitoring of surface water, storm water runoff, and sediment will also be conducted as described for Alternative 2.

AREEs 3/6A

The objective of the RAs for AREE 3 is to obtain clean-closure per the VSWMRs. The investigations at OU1 have indicated that AREE 3 has little potential for contaminated soils or subsurface debris to exist. Surface debris will be removed and a geophysical survey will be performed. The geophysical survey will also be utilized to establish the boundaries of AREE3. Buried debris will be removed in the same manner described for AREEs 2/5. Excavation of upland soils with PCB concentrations above 10.0 ppm and wetland soils/sediments with PCB concentrations above 1.0 ppm will be performed and disposed of as described for AREE 1. Following the completion of site restoration activities, four quarters of groundwater and storm water runoff sampling will be completed to demonstrate that the area qualifies for clean-closure.

If clean-closure is not achieved, the Army will close AREE 3 in-place in accordance with the VSWMRs. This will include: the installation of a cover, establishment of institutional controls against unauthorized groundwater use, soil disturbance, and site access, followed by semi-annual upgradient and downgradient groundwater monitoring for a default period of 15 years. Long-term monitoring of surface water, storm water runoff, and sediment will also be conducted as described for Alternative 2.

The proposed remedial alternative for AREE 6A includes removal of surface debris; removal of debris from wetlands; completion of a geophysical survey; clearing and grubbing; slope stabilization; construction of an engineered soil cover; and long-term monitoring in accordance with the VSWMRs. Removal of surface debris and removal of debris in the wetlands will be completed first. Once this task is completed a geophysical survey will be conducted to establish the extent of buried debris. After the extent of buried debris is delineated, a two-foot thick engineered cover will be placed over AREE 6A. The cover will be revegetated with grass to prevent erosion. Any wetlands that are disturbed in AREE 6A will be restored in accordance with State and Federal requirements. A long-term operation and mainte-

nance plan will be initiated and will remain in effect for the following 15 years (or longer if the VADEQ deems it necessary). The plan will consist of maintenance of the soil cover and long-term groundwater, surface water, storm water runoff, and sediment monitoring. Institutional controls, will be established to restrict unauthorized use of groundwater, unauthorized soil disturbance, and unauthorized site access.

AREE 4

The objective of the RAs for AREE 4 is to obtain clean-closure per the VSWMRs. In accordance with the VSWMRs, the proposed RA for AREE 4 is similar to AREE 3. Surface debris will be removed prior to conducting a geophysical survey. Once the geophysical survey is completed, the areas where buried debris may be present will be investigated by the construction of test pits. Any buried debris and associated soil contamination will be removed, characterized, and disposed of off-site in a sanitary or hazardous waste landfill, as appropriate. Confirmatory sampling (to show that no contaminated soil is present) will be conducted during the construction of test pits. Excavation of upland soils with PCB concentrations above 10.0 ppm and wetland soils/sediments with PCB concentrations above 1.0 ppm will be performed and disposed of as described for AREE 1. Any wetlands that are disturbed will be restored in accordance with State and Federal requirements. Following the completion of site restoration activities, four quarters of groundwater and storm water runoff sampling will be completed to demonstrate that the area qualifies for clean-closure.

If clean-closure is not achieved, the Army will close AREE 4 in-place in accordance with the VSWMRs. This will include: the installation of a cover, establishment of institutional controls against unauthorized groundwater use, soil disturbance, site access, followed by semi-annual upgradient and downgradient groundwater monitoring for a default period of 15 years. Long-term monitoring of surface water, storm water runoff, and sediment will also be conducted as described for Alternative 2.

AREE 6B

The objective of the RAs for AREE 6B is to obtain clean-closure per the VSWMRs. The VSWMRs required remedial activities in AREE 6B are expected to be limited in nature. After the surface debris is removed and a geophysical survey conducted, test pits will be constructed to excavate any buried debris and associated soil contamination. The debris will be characterized and disposed of off-site at a sanitary or hazardous waste landfill, as appropriate. Excavation of upland soils with PCB concentrations above 10.0 ppm and wetland soils/sediments with PCB concentrations above 1.0 ppm will be performed. Any wetlands that are disturbed will be restored in accordance with State and Federal requirements. Following the completion of site restoration activities, four quarters of groundwater and storm water runoff sampling will be completed to demonstrate that the area qualifies for clean-closure.

If clean-closure is not achieved, the Army will close AREE 6B in-place in accordance with the VSWMRs. This will include: the installation of a cover, establishment of institutional controls against unauthorized groundwater use, soil disturbance, and site access, followed by semi-annual upgradient and downgradient groundwater monitoring for a default period of 15 years. Long-term monitoring of surface water, storm water runoff, and sediment will also be conducted as described for Alternative 2.

AREE 7

Since no contaminants have been detected at AREE 7, and AREE 7 has not been defined as an open dump, no RAs are proposed for AREE 7.

COMPARATIVE EVALUATION OF ALTERNATIVES

Overall Protection of Human Health and the Environment

Protection of human health is afforded by minimizing or eliminating human contact with site contaminants. This can be done through implementation of physical and legal barriers, or through site remediation. Because Alternatives 3 and 5 include surface covers and/or excavation together with institutional controls, they are considered to be the most protective of the five alternatives and address VSWMR requirements. Likewise, Alternative 2 protects human health through the implementation and enforcement of site and groundwater use restrictions. Alternative 4 would attempt to excavate and remove soil contaminants, preempting the need for future site and groundwater use restrictions; however it is considered less protective than Alternative 3 because complete removal of contaminants may not actually occur, and those contaminants that are removed may be released during their management as

spillage or dust. The possible release of contaminants and the absence of future monitoring and control are both undesirable. Alternative 1 provides no protection of human health or the environment and is, therefore, the least desirable alternative.

Protection of the environment would best be achieved through the implementation of Alternative 3, which will prevent contact between animals and contaminated surface soils, and will minimize future leaching of contaminants into surface water and groundwater. Alternatives 4 and 5 may succeed in removing soil contaminants; however, because it will likely generate dust and may include spillage, it is considered less protective of the environment than Alternative 3. Alternatives 1 and 2 provide no increased protection of the environment.

Compliance with Applicable or Relevant and Appropriate Requirements

Location-specific ARARs apply to OU1 because debris is located in wetlands and will be required to be removed (per the VSWMRs). Alternatives 4 and 5 are the only ones to take this action.

Action-specific ARARs apply to OU1 because seven of the eight AREEs within OU1 are open dumps and actions must be taken to either cover or close them. Alternatives 3, 4, and 5 take the required actions.

The chemical-specific ARARs for surface water are the AWQCs and the Virginia Water Quality Standards for Surface Water. Alternatives 3, 4 and 5 are expected to achieve these criteria in the long-term, as contaminants cease to be added to the surface water. Alternatives 1 and 2 take no actions and are likely to remain in noncompliance with this ARAR.

The chemical-specific ARAR for groundwater is Maximum Contaminant Levels (MCLs). Alternatives 3, 4, and 5 are expected to achieve these criteria in the long-term, as contaminants cease to be added to the groundwater. Alternatives 1 and 2 take no actions and are likely to remain in noncompliance with this ARAR.

The chemical-specific ARARs for soil are TSCA PCB levels and the Virginia Hazardous Waste Management Regulations. Alternatives 3, 4, and 5 take the required actions. Alternatives 1 and 2 take no actions and are likely to remain in noncompliance with this ARAR.

Alternatives 1 and 2 are the least desirable because they fail to comply with several ARARs. Alternatives 3, 4, and 5 will achieve soil ARARs in the short-term, and groundwater and surface water ARARs in the long-term. Because Alternatives 4 and 5 involve excavation, their likelihood of achieving water ARARs is greater than for Alternative 3.

Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence is best achieved through the minimization of wastes left in place, the minimization of residuals generated during excavation and disposal, and the adequate and reliable control of any residuals or wastes left in place. Desirability, therefore, is related to the minimization and management of wastes left in place. Alternative 4 and 5 are the most desirable because substantial amounts of waste will be removed from the site. Alternatives 1, 2, and 3 leave all wastes in place, (with the exception of the Hot Spot removal for Alternative 3) with only Alternative 3 taking control actions (surface covers) which are considered adequate and reliable. Alternatives 1 and 2 are the least desirable because they do nothing to control wastes left in place.

Reduction of Toxicity, Mobility, or Volume through Treatment

None of the alternatives involve any treatment; therefore, there will be no reduction of toxicity, mobility, or volume *through treatment*. However the reduction in mass achieved by Alternatives 4 and 5 inherently reduces toxicity and mobility as well. A reduction in mobility is achieved by Alternative 3 through the implementation of surface covers, which when properly maintained will minimize mobility by minimizing leachate. Alternatives 1 and 2 affect no changes in toxicity, mobility, or volume.

Short-Term Effectiveness

Short-term effectiveness is best achieved by minimizing additional risks to workers, the environment, and the local community during the RA. The principal threat to human health at OU1 is contact of contaminants once they have been extracted or removed. Contaminants in place are a minimal threat to human health. Therefore, the least desirable alternative is Alternative 4, because in removing and

managing site soils, workers, the local community, and the environment are afforded additional risks in the event of spillage or dust generation. Alternative 5 involves less excavation than Alternative 4. Alternatives 2, 3, and 5 involve leaving contaminants in place and conducting environmental sampling. Due to environmental sampling of contaminated media, they present a larger risk to workers than Alternative 1.

Implementability

Implementability is best achieved through a remedial alternative which is both technically and administratively feasible. The technical and administrative feasibility of the No Action Alternative is the highest because no coordinating, permitting, or other actions are required. The Institutional Controls Alternative requires the implementation of site use restrictions, which require coordination with facility and regulatory personnel, and the implementation of an on-going monitoring program. Alternative 2 is therefore highly implementable, though slightly less than the No Action Alternative. Alternatives 3, 4, and 5 require construction activities. Alternative 3's activities are all on-site and are more easy to administer than either Alternatives 4 or 5, which require off-site disposal. Alternatives 4 and 5 require trained personnel, in licensed vehicles, driving to a licensed facility. Because Alternative 3 only requires surface covering (with the exception or 4 small amount of waste to be removed at the Hot Spot), where Alternative 4 requires excavation of buried soils and wastes, Alternative 3 is also considered more technically implementable than Alternative 4. Alternative 5 is more easily implementable than Alternative 4 because less excavation of buried soils and wastes is required.

Cost

The cost comparison from least expensive to most expensive are as follows: Alternative 1; Alternative 2; Alternative 5; Alternative 3; and Alternative 4..

MODIFYING CRITERIA

State Acceptance

State acceptance will be evaluated during the review and public comment period and therefore is not evaluated here.

Community Acceptance

Community acceptance will be evaluated after the public comment period ends and a remedy is accepted.

1.0 INTRODUCTION

ICF KE has been contracted by the USAEC to perform a FFS for contaminated media within the WRF, Woodbridge, Virginia. This task has been performed under Contract No. DACA31-94-D-0064, Delivery Order 1. This FFS report presents a summary of the site background, evaluates the risks posed to human health and the environment by conditions within OU1 of WRF and identifies and screens remedial measures that are potentially applicable to the site.

In July of 1991, WRF was recommended for closure by the 1991 Defense Base Realignment and Closure Commission under BRAC. Based on preliminary results of the RI conducted in the late fall of 1995 and early spring of 1996, four areas of concern were identified as OUs by the BCT. AREEs 1 through 6B (Former Dumps) and AREE 7 (Former Pistol Range) were defined as OU1. The Main Compound Area was defined as OU2. The Main Ditch (AREE 22), and the portions of AREEs 11 and 17 that are outside the Main Compound Area were defined as OU3, and all the remaining areas of WRF were defined as OU4.

The results of previous investigations as well as the RI indicate that groundwater, surface soil, subsurface soil, surface water, and sediment at AREEs associated with OU1 have been impacted by past disposal practices at WRF. The primary contaminants of concern are PCBs, PAHs, pesticides, and selected inorganic compounds. Therefore, an FFS was performed to identify and evaluate appropriate remedies for the contaminated media at OU1.

The specific project tasks included in this FFS report are the following:

- Data from sampling performed for the Site Investigation (SI) and the RI performed in the late fall of 1995 and the early spring of 1996 are presented;
- Human Health and Ecological Risk Assessments are developed for the specific contaminants present in OU1;
- Remedial action objectives are developed for the specific contaminants, affected media, and exposure pathways;
- Remedial technologies are identified which, alone or in combination, can treat, contain, or dispose of contaminated media;
- The remedial technologies are screened to eliminate those that are not technically implementable, based either on non-attainment of chemical-specific requirements or on the volume of media which must be treated;
- As required under the CERCLA of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, the remedial technologies are assembled into remedial alternatives which, to the maximum extent practicable, utilize permanent solutions and alternative technologies; and
- A detailed analysis of the remedial alternatives is performed using the nine evaluation criteria listed in the NCP.

This FFS has been conducted in accordance with USEPA guidance documents developed for activities performed under CERCLA/SARA; the National Environmental Policy Act (NEPA) of 1969; and the President's Council on Environmental Quality (CEQ) regulations (40 CFR 1500-1508). In addition, the procedures used in the study are consistent with the Department of the Army's policy toward integrating the NEPA and CERCLA/SARA processes.

This study has been performed under the purview of the U.S. Army, USEPA Region III, and the VADEQ.

1.1 REPORT ORGANIZATION

The FFS report consists of the following sections:

Section 1.0 - Introduction

Section 2.0 - Site Background. The site geologic and hydrogeologic regime is presented. A summary of the historical data and the data collected from the RI performed in the late fall of 1995 and early spring of 1996 specific to OU1 are presented.

Section 3.0 - Human Health Risk Assessment. The results of the HHRA for the site are summarized.

Section 4.0 - Ecological Risk Assessment. The results of the ERA for the site are summarized.

Section 5.0 - Applicable, or Relevant and Appropriate Requirements. Chemical-, action-, and location-specific ARARs and to-be-considered (TBC) guidance for potential remedial actions are identified.

Section 6.0 - Development of Remedial Action Alternatives. The general response actions potentially applicable to site conditions are identified and discussed. These general response actions are broken down into technology types and process options, which are then screened based on viability and applicability to the site. The remedial alternatives are developed based on technologies which pass this screening.

Section 7.0 - Screening of Remedial Action Alternatives. Remedial alternatives are screened based on their effectiveness, implementability, and cost. Alternatives not screened are carried through, and are subjected to a detailed analysis.

Section 8.0 - Detailed Analysis of Remedial Action Alternatives. The results of the detailed evaluation of remedial alternatives and a comparison of the alternatives are described. Relative strengths, weaknesses, and trade-offs between the alternatives are identified.

Section 9.0 - References

2.0 SITE BACKGROUND

The following sections present existing information regarding WRF and, in particular, OU1. This includes information describing the site history, physical setting of the area, a summary of past activities possibly contributing to current environmental problems associated with OU1, a summary of analytical results from previous investigations at OU1, and conclusions derived from those investigations.

2.1 PHYSICAL SETTING

The WRF occupies approximately 579 acres and is situated in the eastern-most portion of Prince William County, Virginia, a short distance from the Washington D.C. metro area, as shown in Figure 2-1. The town of Woodbridge is located just to the west of the WRF. The entrance to the installation is located on Dawson Beach Road, east of U.S. Route 1.

The property immediately to the north of the installation (and to the east of Dawson Beach Road) is presently being developed into a private golf course, residential housing, and a marina. To the north of the WRF (and to the west of Dawson Beach Road), the installation is adjoined by a former military housing area and also by commercial property. The facility is bounded on the west by the Marumsco Creek and the Marumsco National Wildlife Refuge tidal wetlands. West of Marumsco Creek is Veteran's Memorial Park, a recreation area administered by Prince William County. The southern and eastern edges of the property are shoreline, facing the Belmont and Occoquan Bays.

2.1.1 Climatology

The WRF is located in the easternmost area of Prince William County, Virginia near the mouth of the Occoquan River where it empties into Belmont Bay. The climate at the site is variable due to the proximity of both the Chesapeake Bay (and Atlantic Ocean) and the Appalachian Mountains. Average annual rainfall is more than 38 inches and the annual mean daily temperature is 57°F. The coldest month is January and the hottest month is July; the growing season lasts from mid-April to mid-October. Prevailing winds are generally from the south in the summer and from the north/northwest in the winter.

2.2 TOPOGRAPHY AND DRAINAGE

Ground surface elevations at the site range between less than 2 feet to over 30 feet mean sea level (msl). The highest elevations are in the northern and western portions of the site. There are flat-lying areas along the southern and southeastern coastal areas of the site and relatively steep slopes along the southwest coastal area (facing Marumsco Creek) and in the central area of the site (facing the Main Ditch and southeast marshy area). Figure 2-2 is the detailed site topographic map that was constructed with aerial photo data that illustrates the topographic features at WRF.

The WRF site is situated within the Occoquan River basin at its discharge point into Belmont Bay. The Occoquan River and Marumsco Creek are the east and west boundaries of the promontory of land on which WRF is located. The WRF facility is drained by one surface water channel that originates off site and enters the site property near the Dawson Beach Road (Route 687) gate. This primary drainage channel is joined by at least three other tributaries before it reaches Occoquan Bay, just east of Deep Hole Point (see Figure 2-2). Past site activities have included the deepening and straightening of this drainage channel as well as the construction of drainage pathways between existing (natural) drainage features. Because of the known modifications to the natural drainage, this primary discharge channel has been named the "Main Ditch".

2.3 GEOLOGIC/HYDROGEOLOGIC DESCRIPTION

This section presents information on the physical characteristics of the subsurface materials at WRF. General characteristics of soils, geology, and stratigraphy are presented below.

2.3.1 Soils

The soils at WRF have not been mapped specifically. However, the Prince William County soil map indicates that the soils beneath the site include the Dumfries-Lunt-Marr unit and associated soil from the Neabsco-Quantico-Dumfries unit. The following section is a summary of the information provided in the Soil Survey of Prince William County, Virginia (USDA SCS, 1989).

2.3.1.1 Dumfries-Lunt-Marr

These are very deep, well drained soils that have a loamy or clayey subsoil. This soil unit consists of gently sloping to very steep soils on terraces. The soils are underlain by fluviomarine sediments of sand, silt, clay, and gravel. Minor soil associations in lowland tidal areas include the Featherstone soils.

1. The *Dumfries* soils are on strongly sloping to moderately steep side slopes. They are well drained, very deep, and have a loamy subsoil.

2. The *Lunt* soils are on gently sloping to moderately steep side slopes. They are well drained, very deep, and have a clayey subsoil.

3. The *Marr* soils are strongly sloping to moderately steep. They are very deep, well drained, and have a high content of fine sand and very fine sand.

4. The *Featherstone* soils are present at low elevations. They are very deep, level to nearly level, and very poorly drained.

The Weston (1992) document provided more site-specific information regarding site soils. However, the information reported there has not been corroborated with either the reference provided or follow-up investigation.

2.3.2 General Geology

The WRF site is located within the Coastal Plain Physiographic province which is characterized by a thick wedge of unconsolidated to loosely consolidated sediments ranging in age from Cretaceous to Recent.

Mixon et al. (1989)[1] report that the WRF is underlain by Quatemary-age sediments that were deposited during interglacial high stands of the sea. Two members of the Tabb Formation (Upper Pleistocene) are shown at the site (see Figure 2-3). This formation is comprised of gravel, sand, silt, clay and peat lithostratigraphic units of coast-parallel plains and includes coeval terrace deposits along major rivers. Stratigraphic analysis of this section of the Coastal Plain sequence has been difficult and as a result, the Tabb Formation was defined in order to clarify stratigraphic problems encountered by regional stratigraphers (Johnson and Peebles, 1991). In summary of the work, the distribution of facies within this formation is complex as it reflects both deposition and erosion throughout at least three cycles of transgression/regression within the alluvial depositional setting.

A geologic map has not been developed specifically for the site. However, reconnaissance mapping can be completed based on the Mixon et al. (1989) map and site-specific information such as topography and boring logs. First, the site topography can be divided into two general areas: 1) a low and relatively flay-lying area along the reaches of the Main Ditch and to the south and east of the site which is marshy nearest the shore; and 2) the northern, central, and western areas of the site which are higher in elevation and exhibit an undulating land surface (see Figure 2-2). based on the regional geologic map (Mixon et al. 1989). Information available in Froelich (1985), and existing site information, the higher portions of the site are probably underlain by terrace deposits of the ancestral Potomac River and the lower areas are probably areas where terrace deposits have been eroded away (if ever present) and where more recent steam/river deposits overlie the ancestral Potomac River deposits.

2.3.3 Site Stratigraphy

Cross sections prepared for the WRF site illustrate the complex distribution of subsurface geologic materials. Figure 2-2 depicts cross section location on a site-wide topographic map. Figures 2-4 through 2-13 are the geologic cross sections prepared using boring log data for monitoring wells installed at the site. Boring log data are presented in the RI report prepared for the site (USAEC, 1997). The

[1] This is a large-scale map of Virginia and, therefore, does not provide geologic detail at the site. A literature search at the U.S. Geological Survey failed to identify any small scale geologic mapping in this area of Prince William County. However, a Fairfax County geologic map (Froelich, 1985) shows similar geology on the land parcel adjacent to the northeast of WRF.

cross sections depict the variability in site subsurface sediments. For example, the subsurface stratigraphy presented in cross section A-A' (Figure 2-4) includes units composed of either clay, silt, sand, or gravel, and units composed of mixtures of these materials. The correlations shown on A-A' illustrate the laterally and vertically discontinuous nature of the stratigraphic units[2]. Cross section B-B' (Figure 2-5) illustrates what appears to be more continuity in the stratigraphic units. It should be noted that this apparent continuity may be a function of well and/or sample spacing rather than actual conditions. The actual variability in geologic materials may be much greater than that depicted on the cross sections because, in a typical sampling program, wells are not spaced closely enough to allow the delineation of each sand or clay layer/lens in a heterogeneous system. In other words, additional wells installed along any cross section may show that the stratigraphic units are not as extensive as currently shown. Therefore, correlations shown on the cross sections should be considered estimated. The cross sections are useful, however, in illustrating the heterogeneous nature of the subsurface stratigraphy at WRF (vertically and laterally discontinuous units with highly variable grain-size distributions).

Cross section A-A' shows porous, water-bearing units/lenses of silty sand, sand and gravelly sand overlain by a more continuous unit of silty clay that thins to the southwest near Occoquan Bay. The silty sand and sand units depicted on B-B' are also overlain by a silty clay layer that thins near Occoquan Bay. Cross section C-C' (Figure 2-6) depicts permeable units of sand, gravelly sand, and sandy silt that appear to be interbedded or grade into one another so that they may be hydraulically connected. These units are overlain by silty clay that thins on both sides of the section where it nears Occoquan Bay. Cross section D-D' (Figure 2-7) depicts interbedded units of silty sand, sand gravel, and silty clay. Silty clay makes up the surficial deposits except at well MW-76, near Occoquan Bay, where sand outcrops at the surface. Subsurface geologic deposits in the area of the site covered by cross sections A through D appear to have been deposited in an alluvial setting. For example, note the grading of grain sizes A-A' where sand and gravelly sand in well MW-80 appears to grade into sand that grades into silty sand in well MW-60. Similar gradation can be seen in cross section C-C' where sandy silts grade into sand that grades into gravelly sand. The apparently extensive units of near-surface clay and silty clay could have been deposited during interglacial periods. The thinning of surficial clay deposits near the Bay indicates that this layer has apparently been eroded away by surface water bodies.

Cross section E-E' and F-F' (Figures 2-8 and 2-9) depict stratigraphy similar to that discussed above. Porous, water-bearing units of sand, gravelly sand, and silty sand could be hydraulically connected due to gradation between units. Water-bearing units are overlain by a unit of silty clay and clay that appears to be continuous near the surface. This surficial clay unit does not thin or pinch out because these cross sections are not as close to the Bay or Marumsco Creek as cross sections A through D. In fact, the surficial clay unit becomes thicker in upland areas such as beneath the Main Pond near PZ-12 on cross section F-F'.

Cross sections G-G' and H-H' (Figures 2-10 and 2-11), again, are similar to the other cross sections in their depiction of water-bearing units that may be hydraulically connected overlain by a mostly continuous layer of clay/silt. Cross section G-G' depicts a few water-bearing units of sand and gravelly sand that do not appear to be hydraulically connected to other water-bearing units. These units are overlain by a layer of silty clay that likely causes aquifer conditions in these units to be confined. Cross section H-H' depicts more porous units that could be hydraulically connected. Because of the hydraulic connection, these units may act together as one aquifer. This aquifer unit is overlain by a layer of clay and silty clay that could act as a confining unit. However, the clay unit is broken by a silt unit near the surface at MW-66. In the area of this well, the aquifer could be under unconfined conditions or semi-confined conditions if the silt layer is compacted an/or contains clay.

Cross section I-I' (Figure 2-12) was constructed to depict stratigraphic conditions in the area of the Main Ditch. This cross section shows discontinuous, water-bearing units overlain by silty clay or clay that is thicker in upland areas. Based on the presence of clay near the surface in most areas of the site, the Main Ditch is likely underlain by a clay layer that separates it from hydraulic connection to deeper water-bearing units. However, there are not enough wells installed in the Main Ditch area to confirm this theory. Cross section J-J' (Figure 2-13) depicts similar conditions beneath the Main Compound area.

[2] Stratigraphic units are discontinuous due to depositional (facies changes) and erosional factors.

Note that two well clusters were used in cross section J-J' (Figure 2-13) depicts similar conditions beneath the Main Compound area. Note that two well clusters were used in cross section J-J'. In well cluster MW-62/56 (refer to Figure 2-2), only lithologic data from well MW-56 was used in the cross section because MW-62 was drilled using the mud rotary method that does not allow the collection of detailed lithologic data. In well cluster MW-39/84 (refer to Figure 2-2), only lithologic data from well MW-84 was used because well MW-39 is shallow and the boring log does not provide as much lithologic data as the log for MW-84. The boring logs for both wells show similar lithologies; however, MW-39 notes a sand-gravel-silt material of unknown thickness at approximately 6 feet msl that was not noted in MW-84.

In summary, the stratigraphy at WRF is characterized by zones/lenses of porous, water-bearing materials that are hydraulically connected in many areas but are discontinuous in others. These water-bearing materials are hydraulically connected in many areas but are discontinuous in others. These water-bearing units are overlain in most areas of the site by a clay layer that thins near the Bay and thickens in upland areas.

2.4 AQUIFER SYSTEM FRAMEWORK

The shallow groundwater flow system beneath the WRF site is composed of laterally discontinuous clay, silt, sand, and gravel units of varying thickness and sorting that were deposited in an alluvial setting. Hydrostratigraphic units have not been defined at the site because of these lateral and vertical discontinuities, or heterogeneity. Boring logs for on-site monitoring wells suggest that the primary water-bearing units at the site are composed of sand or sand and gravel that is often present below dry clay or silt units (or poorly-sorted mixtures of silt and clay with sand). Because of the high degree of heterogeneity in geologic materials at the site, the extent to which those water-bearing units are hydraulically connected is not known. Therefore, distinct aquifer units have not been identified at the WRF.

Table 2-1 summarizes important hydrogeologic information for most of the monitoring wells at the site. Boring logs were reviewed for each of these wells to estimate the approximate thickness of dry clay or silt above the screened interval, the depth at which water was first encountered during drilling, the number and types of different lithologies screened by each well, and the local aquifer condition at each well. The local aquifer condition (unconfined , confined, or semi-confined) was estimated based on the lithology in each borehole, the elevation of the top of the water-bearing unit screened by the well and the stabilized groundwater elevation (USAEC, 1997).

From the geologic cross sections it is clear that most wells have several feet of low-permeability material (clay or silty clay) at the surface. An examination of geologic information and groundwater elevation at each boring reveals that most wells have a groundwater elevation that rises above the top of the water-bearing unit(s) screened by the well. These observations indicate the presence of confined or semi-confined aquifer conditions within the water-bearing units in the subsurface.

Figure 2-14 is a bar graph of two parameters for each well. The first parameter is the difference in feet between the elevation at which water was first encountered in each of the borings and the elevation at which the water level in the well stabilized (data presented in Table 2-1). This water level variance value is plotted beside the second parameter, the thickness of clay above the well screen. It is clear that there is a positive correlation between these two parameters. Therefore, at well location where thick clay units were observed above the screen, the equilibrated water level measured in the well strongly suggests confined to semi-confined conditions at that depth. However, it should be noted that unconfined conditions appear to exist in several wells (see Table 2-1). These wells are located in both upland and low-lying areas across the site and do not appear to be present in a particular pattern that would indicate unconfined conditions in specific areas. Rather, aquifer conditions are believed to be a function of local lithology at each well.

The complex stratigraphy at the site precludes detailed analysis of any particular hydrostratigraphic unit because the extreme heterogeneity in subsurface geologic materials cannot be fully characterized with standard monitoring well design and placement. The level of detailed attained using existing monitoring well data is insufficient to define hydrostratigraphic units or to map water levels in each unit beneath the site. For example, monitoring well MW-60 on cross section A-A' is screened across a low-permeability unit of interbedded clay and silt, a water-bearing unit of silty sand, and a unit of silty clay. The resulting groundwater elevation is an average of the hydraulic head in each of these geo-

logic units. Such an average does not allow an accurate evaluation of the hydrogeologic conditions present in the water-bearing unit screened by that well. Therefore, groundwater elevation data used to construct water level maps at this site do not accurately reflect the local-scale groundwater flow conditions in the water-bearing units screened by each well. It should be noted that groundwater elevation data used to construct groundwater contour maps for this site must be clearly identified as to what unit(s) those data represent and what condition is implied with boring data (i.e., confined versus unconfined) such as that provided in Table 2-1.

2.5 GENERALIZED GROUNDWATER FLOW SYSTEM

Two main factors have led to the belief that although complex, the lithologic units in the shallow groundwater system at WRF are probably hydraulically connected throughout the area of the facility. First, the proximity of the regional discharge point (Occoquan Bay) suggests that all groundwater flow in the shallow subsurface will converge on the base level represented by the Bay. For groundwater to reach this regional discharge area, either preferred hydraulic connection pathways exist between water-bearing units or enough leakage occurs through the low-permeability zones separating water-bearing units that water moves from water-bearing unit to water-bearing unit until it reaches the regional discharge area.

Second, when the water level distribution at the site is contoured in the context of both stratigraphy and topography (the main controlling factors), the conditions under which groundwater exists are reflected in the contours. In other words, in areas of low topography (where the thinning or absence of a surficial clay layer allows water-bearing units to be under unconfined condition) the water level contours mimic site topography. At higher elevations, the water level contours (representing water levels within more porous water-bearing units under confined conditions) do not necessarily mimic site topography because groundwater flow in upland areas is controlled by the thickness and distribution of water-bearing units and not on localized surface topography. For example, on cross section H-H' water levels are near the surface in wells installed in areas of low topography (MW-69, MW-65, MW-66, and MW-67) whereas water levels in wells installed in areas of higher elevation (MW-59 and MW-60) are much lower.

The variable topography and complex stratigraphy described in Sections 2.2 and 2.3.3 appear to be the controlling factors on groundwater occurrence in the shallow subsurface at this site. These factors control whether groundwater occurs under unconfined or confined conditions[3] at any given depth and location. The subsurface stratigraphy also controls whether water-bearing units are hydraulically connected to one another. Because of these factors, the resulting water level distribution measured from on-site wells is not what one might expect for typical shallow groundwater (water table) conditions. In other words, because the monitoring wells at the site are not screened in one discreet aquifer[4], the water level distribution measured from on site wells does not represent any particular hydrostratigraphic unit; rather, it represents averaged, or composite, water levels in the shallow subsurface at the site.

Because the water level distribution is complex and aquifer units have not been defined at the site, many interpretations of small-scale groundwater flow patterns can be developed based on the data currently available. In this section, two different interpretations of groundwater flow are presented. The first assumes that water-bearing units are hydraulically connected, leading to an equilibration of water levels regardless of local aquifer conditions (confined or unconfined). The second assumes less hydraulic connections and aquifer conditions that are more dependent on the stratigraphy at each well. The small-scale groundwater flow patterns in either interpretation could prove to be realistic. However, both interpretations show that the larger-scale groundwater flow pattern at the site is radial with water traveling from recharge areas to the north and northwest of the site toward the regional discharge point of Occoquan Bay.

[3] This assumption is based on boring log and water level data collected at the site to date.

[4] Monitoring well screens are the standard length of 10 feet and, therefore, are open over two or more different lithologies. The resulting water level represents the (weighted) average water-level condition in each of the screen lithologies. This face even further complicates the understanding of water level distribution at the site. It should be noted that: 1) the monitoring wells were installed to intercept the uppermost water-bearing units; and 2) that prior to installation of the monitoring wells, little was known about the subsurface at WRF. Therefore, the use of 10-foot screens for wells at this site was an appropriate use of standard well installation methods.

The first interpretation of groundwater flow is presented in a composite water level map for the site, Figure 2-15. This map combines both water table conditions in low-lying areas of the site (where water levels mimic site topography) and confined or semi-confined conditions in the upland areas of the site (where water levels are independent of site topography) into one map to illustrate the complexity of shallow groundwater flow patterns. It is believed in this interpretation that both confined and unconfined conditions can be represented on a single contour map because water-bearing units are hydraulically connected, resulting in an equilibration of water levels with the regional base level. Therefore, regardless of local aquifer conditions, the nearby regional discharge area is a base level to which water levels equilibrate.

Small-scale groundwater contours are complex, with flow generally moving from topographic highs to lows. The Main Ditch appears to be hydraulically connected to water-bearing units, resulting in unconfined conditions immediately north of the Main Compound area. However, further upstream from that location the lack of wells prevents the characterization of the hydraulic relationship between the surface and groundwater. In the remaining areas of the site, radial groundwater flow dominates.

Second interpretation of groundwater flow is presented in additional groundwater elevation contour maps. Four different contour maps were created based on screen midpoint elevation. Wells whose screen midpoint falls within a 10-foot range in elevation were contoured on one map to illustrate the point that small-scale radial groundwater flow toward regional discharge locations remains evident. These groundwater contour maps, Figures 2-16 through 2-19, depict the behavior of groundwater at four different depths within the shallow aquifer system, 10 to 0 feet msl, 0 to –10 feet msl, –10 to –20 feet msl, and –20 to –30 feet msl. The wells in these maps were assumed to be under a more confined aquifer condition than that depicted in the composite groundwater contour map (Figure 2-15). Therefore, surface water features such as the Main Ditch do not have as much control over groundwater contours on these potentiometric surface maps.

Figure 2-16 presents groundwater contours based on groundwater elevations for wells whose screen midpoint falls between 10 and 0 feet msl. On this map, groundwater moves from the northwestern portion of the site radially toward surface water bodies (Marumsco Creek, Occoquan Bay, and Belmont Bay). Figure 2-17 provides a similar representation for wells whose screen midpoint falls between 0 and –10 feet msl. Figure 2-18 presents contours constructed based on groundwater elevations for wells with screen midpoint between –10 to –20 feet msl. Radial groundwater flow is also apparent based on these contours. However, groundwater contours in the area just north of the Main Compound area have an unusual bend. This bend could be accounted for if a zone of high hydraulic conductivity exists in a north-south orientation in the area of MW-57. A high-conductivity zone in this area would cause groundwater contours to be refracted from surrounding low-conductivity areas toward the MW-57 area. Another explanation for such curvature of groundwater contours in this area is the presence of unconfined conditions at MW-57 and confined conditions in surrounding areas. Figure 2-19 presents groundwater contours based on groundwater elevations for wells whose screen midpoint falls between –20 to –30 feet msl. Radial groundwater flow is apparent based on these contours. On these groundwater contour maps, there is very little interaction between small surface water features (such as the Main Ditch) and groundwater due to the presence of a confining clay unit that separates water-bearing units from surface water bodies.

Because the nature of aquifer is not simple, nor is it well defined, either of the above interpretations of groundwater flow at WRF may represent the actual groundwater flow condition. However, both interpretations indicate that, on a larger scale, radial groundwater flow is present from upland areas toward regional discharge points such as Occoquan Bay, Marumsco Creek, and Belmont Bay.

2.6 SUMMARY

The hydrogeology at the WRF is characterized by complex stratigraphy and variable topography. Therefore, these factors are important in determining aquifer conditions and groundwater flow patterns beneath the site. The geologic materials beneath the site are a heterogeneous mixture of clay, silt, sand, and gravel. Porous, water-bearing units were deposited as discreet zones or lenses while clay layers appear to have been deposited as more continuous units. Due to heterogeneity, the permeability of subsurface materials changes dramatically from point to point beneath the site. Because these small-scale changes can not be delineated with the available data, the degree of hydraulic connection between wa-

ter-bearing units is not known. Therefore, both unconfined and confined conditions may exist beneath the site. As a result, two interpretations of groundwater flow have been presented here, one that assumes primarily unconfined conditions and one that assumes confined conditions. These two interpretations of groundwater flow depend on the degree of hydraulic connection between water-bearing units. To define the degree of hydraulic connection between water bearing units at the site, a higher level of data is required than is currently available. Additional lithologic data would be required to determine whether water-bearing units are continuous or discreet. In addition, to define the hydraulic character of these water-bearing units, wells must be installed and carefully screened in the water-bearing unit of interest only to obtain groundwater elevations that are reflective of the hydraulic character of the aquifer material.

The level of data currently available for the site allows a reasonable estimate of the pattern of regional groundwater flow at the site. Water levels in the shallow aquifer system appear to be controlled by the nearby, local base level of Occoquan Bay, which is a regional discharge point for shallow groundwater. Groundwater moves radially from upland recharge areas north and northwest of the site toward Marumsco Creek, Occoquan Bay, and Belmont Bay.

The interaction between the Main Ditch and groundwater is difficult to assess with available well data. It is expected that over its course across the site property, the Main Ditch both loses and gains water depending on the underlying hydrogeologic unit and its degree of hydraulic connection with the Main Ditch. However, the composite water level map is drawn to show effluent conditions throughout its length to account for the possibility of shallow groundwater discharge from the subsurface to the ditch. There is a strong possibility that in areas where the ditch flows across surface clay units, there is little interaction between groundwater and the ditch.

2.7 SURFACE WATER FLOW

The facility is located in the Occoquan River drainage basin of the Occoquan watershed. Marumsco Creek bounds WRF on the southwest and drains into Occoquan Bay. The Occoquan Bay bounds the facility to the south. Belmont Bay, which is located on the facility's northeast side, is mainly fed by the Occoquan River. The facility is bisected by an unnamed creek originating from residential and partly-industrialized areas to the north. This creek flows around the main compound, and is fed by several smaller drainages before discharging to Belmont Bay. Several additional drainages are found on the property. These waters are tidal tributaries of the Potomac River and are classified by the Commonwealth of Virginia as Class II (tidal fresh) waters.

An installation-wide jurisdictional wetlands delineation of WRF was conducted in the spring and summer of 1995, in conjunction with the RI. A wetlands delineation map was constructed for OU1 and is presented as Figure A-1 in Appendix A.

The results of the wetland delineation at WRF indicate that at least six different wetland classifications can be found on the installation. These classifications include several types of scrub-shrub, emergent, and forested wetlands, all of which are categorized in the palustrine ecological system.

A large central jurisdictional wetland complex extends from the Occoquan Bay to the northern installation boundary, generally following the course of several natural and man-made drainage swales. Additionally, smaller wetlands exist along the western area that flows into the Belmont Bay, and in isolated depressional areas south and east of the main cantonment area.

2.7.1 Lithology of Sediment

The lithology of the bottom sediment within Marumsco Creek and the drainage ditches located within WRF is controlled by current-velocity distributions. Coarse-grained materials are typically found in the areas where current velocities are insufficient to transport these materials and yet sufficient to transport the fine-grained materials. Organic-rich, fine-grained material settles out of suspension in more dormant areas of creeks and drainage ditches. Tidal currents in the Belmont and Occoquan bays are such that their bottom sediments are composed of sand, which is coarser along the shoreline due to wave action.

2.8 SITE HISTORY

WRF occupies approximately 579 acres of land (USAEC, 1995b). It is bounded on the south and east by the Occoquan and Belmont Bays. The facility is bounded on the west by the Marumsco National Wildlife Refuge and physically by the Marumsco Creek. The entrance to WRF is located on Dawson Beach Road, east of U.S. Route 1. Residential, commercial, and industrial areas are located north of WRF.

In 1952, the property was assigned to the U.S. Army Command and Administrative Communications Agency and designated as the Army Transmitting Station. In 1962, the Station was reassigned to the U.S. Army Continental United States (CONUS) Regional Communications Command and redesignated as the East Coast Radio Transmitting Station. In 1965, the Station was placed under the U.S. Army Strategic Communications Command. The Station was inactive for one year, from July 1969 to July 1970, before the U.S. Army Mobility Equipment Research and Development Center (MERDC) administered the Station. During that time, seven acres reserved for housing were transferred to Fort Belvoir, which is located approximately six miles northeast of the WRF. In 1971, a consolidation of U.S. Army Materiel Command (USAMC) nuclear weapons effects research and test activities resulted in the transfer of 642 acres of the land to Harry Diamond Laboratories of Adelphi, Maryland. The site was designated as the Woodbridge Research Facility and in August 1973, 63 acres of the installation in the vicinity of Marumsco Creek were transferred to the U.S. Department of the Interior for use as a park and wildlife refuge (Marumsco National Wildlife Refuge); and the Electromagnetic Effects Laboratory was physically relocated from Fort Belvoir to WRF.

In 1991, the Defense Base Realignment and Closure Commission recommended realignment of the Army activities being conducted at WRF. In October 1992, Harry Diamond Laboratory was absorbed into the Army Research Laboratory in Adelphi, Maryland, and most activities were relocated to the Adelphi Laboratory Center, in Adelphi, Maryland. The WRF was closed as an active Army facility on September 16, 1994. The property will be transferred to the USFWS for use as a wildlife refuge sometime in the near future.

WRF has 49 sites of concern identified as AREEs. These 49 AREEs are listed in Table 2-2 and shown in Figures 2-20 and 2-21. Previous investigations have shown that contaminated media exists at many of these AREEs. OU1 (approximately 24 acres) has been defined as the area of WRF bounded by Deephole Point Road to the east, Lake Drive to the west, and Marumsco Creek and Occoquan Bay to the south. OU1 is comprised of AREE 1 (Former Dump No. 1), AREEs 2 and 5 (Former Dumps No. 2 and 5), AREE 3 (Former Dump No. 3), AREE 4 (Former Dump No. 4), AREE 6A (Former Dump No. 6A), AREE 6B (Former Dump No. 6B) and AREE 7 (Former Pistol Range). Figure 2-20 shows OU1 and the AREE locations within OU1.

2.9 USAEC REMEDIAL INVESTIGATION BACKGROUND SAMPLING, 1996

The following samples were collected from background locations near and within WRF: five surface soil samples (0-6 inches below ground surface [bgs]); three surface soil samples (0 to 2 feet bgs) and six subsurface soil samples (varying depths) collected from borings which were later converted to monitoring wells; two rounds of groundwater samples from four background monitoring wells; and five surface water and sediment samples. This section presents the results of the background analyses. The locations for on-site background samples are presented on Figure 2-22 and the locations for the surface water/sediment samples are presented in Figure 2-23.

2.9.1 Determination of Background Concentrations

A statistical analysis was performed for all sampled media, in order to determine if detected levels of inorganic compounds present at the site were representative of naturally occurring background levels.

2.9.1.1 Surface Soil

Five surface soil samples (RIBKSS1 through RIBKSS5) were collected from on-site locations that were upgradient and/or unaffected by past site activities. The locations of the surface soil samples are presented on Figure 2-22. These five background surface soil samples were analyzed for TCL

VOCs, TCL SVOCs, pesticides/PCBs, PAHs, PCTs, TPH, and TAL metals. Inorganics detected in background surface soil samples are presented in Table 2-3. Organics detected in background surface soil samples are presented in Table 2-4.

Summary of Results. The following is a summary of the inorganics detected in the background surface soil samples. Aluminum was detected in all samples in a range of concentrations from 6,550 µg/g to 14,600 µg/g. Arsenic was detected once at 3.85 µg/g in RIBKSS1, but was not detected in the duplicate. Barium was detected in RIBKSS3 and RIBKSS5 at 67 µg/g, and 73.4 µg/g, respectively. Beryllium was detected in all samples except RIBKSS4, with a maximum detected concentration of 0.785 µg/g. Calcium was detected in all samples except RIBKSS1 with a maximum concentration of 1,020 µg/g. Chromium, cobalt, copper, and iron were detected in all samples with maximum detected concentrations of 26.7 µg/g, 12.7 µg/g, 12/6 µg/g, and 23,900 µg/g, respectively. Lead was detected in all samples except RIBKSS2 with a maximum detected concentration of 22.4 µg/g. Magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were also detected in all samples with maximum detected concentrations of 1,700 µg/g, 677 µg/g, 8.98 µg/g, 597 µg/g, 487 µg/g, 47.1 µg/g, and 40.4 µg/g, respectively. Selenium was detected in one sample (RIBKSS3) at 14.2 µg/g.

Four organic compounds, benzo(b)fluoranthene, benzo(k)fluoranthene, flouranthene, and indeno(1,2,3-cd)pyrene, were detected in all background surface soil samples at maximum concentrations of 0.01 µg/g (RIBKSS3), 0.005 µg/g (RIBKSS3 and RIBKSS5), 0.018 µg/g (RIBKSS3), and 0.01 µg/g (RIBKSS4), respectively. Aldrin and methylene chloride were detected at one location at concentrations of 0.003 µg/g (RIBKSS2), and 0.02 µg/g (RIBKSS5), respectively. Anthracene and benzo (g,h,i) perylene were detected at maximum concentrations of 0.028 µg/g and 0.011 µg/g, respectively in samples collected from RIBKSS3, RIBKSS4, and RIBKSS5. Benzo(a)anthrancene, benz(a)pyrene, and pyrene were detected in all samples except RIBKSS1, with maximum concentrations of 0.005 µg/g, 0.008 µg/g, and 0.023 µg/g, respectively. Phenanthrene was detected in RIBKSS1 and RIBKSS2 with a maximum concentration of 0.347 µg/g in RIBKSS1.

2.9.1.2 Subsurface Soil

Subsurface Soil samples were collected from borings in which background monitoring wells MW-52, MW-53, and MW-54 were installed for the RI. The locations for these samples are shown on Figure 2-22. The samples were collected from 0 to 2 feet bgs and every 5 feet thereafter to the water table. All subsurface soil samples were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, and polychlorinated terphynles (PCTs). The soil samples collected from these background locations were grouped into two categories for risk assessment purposes.

The first grouping (which consists of three samples) were samples collected from 0 to 2 feet bgs. These data were combined with the five background surface soil samples to bolster the data set for background surface soil. Therefore, a total of eight surface soil samples were used to statistically determine which site surface soil concentrations were within background levels. Detected compounds for this set of subsurface soil samples is given in Table 2-5.

The second grouping from the subsurface soil samples consisted of samples collected at depths below 2 feet bgs. The six samples collected from 2 feet bgs to the water table were grouped for the purposes of determining which compounds detected in on-site samples were within background levels. Detected compounds for this set of subsurface soil samples is presented in Table 2-6.

Summary of Results The following inorganics were detected in all subsurface soil samples from 0 to 2 feet bgs (the maximum concentration detected is also listed): aluminum 22,000 µg/g; beryllium, 0.814 µg/g; calcium, 1,150 µg/g; chromium, 31.3 µg/g; cobalt, 16.6 µg/g; copper, 11.5 µg/g; iron, 28,100 µg/g; magnesium, 2610 µg/g, manganese, 875 µg/g; nickel, 11.9 µg/g; potassium, 936 µg/g; sodium, 453 µg/g; vanadium, 58.9 µg/g; and zinc, 43.9 µg/g. Barium and lead were detected in MW-53 and MW-54 soils from 0 to 2 feet bgs with maximum concentrations of 92.4 µg/g and 17.7 µg/g, respectively. Arsenic was detected in MW-53 from 0 to 2 feet bgs at 3.24 µg/g. Selenium was detected in the MW-54 subsurface 0 to 2 feet bgs soil

sample at 13 µg/g. Bis (2-ethylhexyl)phthalate was the only organic to be detected in subsurface soil samples from 0 to 2 feet bgs. It was detected in MW-53 and MW-54 at 0.18 µg/g and 0.50 µg/g, respectively.

The following inorganics were also detected in most subsurface soil samples collected from 2 feet bgs to the water table (maximum detected concentration is also listed); aluminum, 18,200 µg/g; barium, 93 µg/g; beryllium, 1.02 µg/g; calcium, 911 µg/g; chromium, 25 µg/g; cobalt, 13.9 µg/g copper, 19.1 µg/g; iron, 27,800 µg/g, magnesium, 3,700 µg/g; manganese, 617 µg/g; nickel, 20.9 µg/g; potassium, 624 µg/g; sodium, 939 µg/g; vanadium, 60.3 µg/g, and zinc, 55.6 µg/g. No organic compounds were detected in subsurface soil samples from 2 feet bgs to the water table.

2.9.1.3 Sediment

Five sediment samples (RISDBK1 through RISDBK5) were collected from Mason Neck Wildlife Refuge, which is located east of WRF. Since Mason Neck is located across the Belmont Bay from WRF, it has not been impacted from past activities related to WRF. The samples were collected from 0 to 6 inches and were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, PAHs, TAL metals, PCTs, TPH, grain size distribution, and total organic carbon (TOC). Background sediment samples locations are presented in Figure 2-23. Table 2-7 and 2-8 present the inorganic and organic compounds detected in the background sediment samples, respectively.

Summary of Results. The following inorganics were detected in all sediment background samples (maximum detected concentration is also listed): aluminum, 16,900 µg/g; beryllium, 1.38 µg/g; calcium, 6,000 µg/g; chromium, 33.7 µg/g; cobalt, 21.4 µg/g; copper, 44.4 µg/g; iron, 36,500 µg/g; magnesium, 3,740 µg/g; manganese, 1,690 µg/g; nickel, 30.3 µg/g; potassium, 2,120 µg/g; sodium, 1,710 µg/g; vanadium, 54.1 µg/g; and zinc, 168 µg/g. In addition, barium was detected in RISDSK1 at 175 µg/g and lead was detected in four of the background sediment samples with a maximum detected concentration of 42.2 µg/g.

Several PAHs, including anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene were detected in most if not all background sediment samples at low levels (<1 µg/g). In addition, 1-methyinapthalene, benzo(b)fluoranthene, and fluorene were detected in three background sediment samples with maximum detected concentrations of 1.14 µg/g, 0.083 µg/g, and 0.355 µg/g, respectively. Acenaphthene and methylene chloride were detected in two background samples with a maximum detected concentrations of 1.27 µg/g and 0.061 µg/g, respectively. Napthalene was detected in RISDBK3 at 0.636 µg/g.

2.9.1.4 Surface Water

At each sediment sample location, a surface water sample was also collected. Surface water samples were collected from 0-6 inches below the water surface and were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, PAHs, TAL metals, PCTs, TPH, total suspended solids, alkalinity, and hardness. Background surface water samples locations are presented in Figure 2-23. Inorganic compounds detected in the surface water samples are given in Table 2-9.

Summary of Results. The following inorganics were detected in all surface water background samples (maximum detected concentration is also listed): aluminum 1,930 µg/L; barium 41.8 µg/L; calcium 22,200 µg/L; iron 2,510 µg/L; lead 1.9 µg/L; magnesium 7,500 g/L; manganese 303 µg/L; potassium 3,670 µg/L; and sodium 16,500 µg/L. The concentrations detected in the surface water samples did not vary much from sample to sample. Arsenic was detected in RISWBK1 at 1.4 µg/L and chromium was detected in RISWBK2 at 10.8 µg/L. No organic compounds were detected in background surface water samples.

2.9.1.5 Groundwater

Two rounds of groundwater samples were collected from shallow monitoring wells MW-52, MW-53, MW-54, and deep monitoring well MW-63 for a total of eight samples. All groundwater samples were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, PCTs (first round only), TAL metals, PAHs,

and TPH. The samples collected from MW-52, MW-53, MW-54, and MW-63 were used to characterize inorganic background concentrations for groundwater. Organic compounds detected in the background groundwater samples were not used to establish an organic background baseline. Refer to Figure 2-22 for the location of the background monitoring wells. Table 2-10 is a summary of the inorganic compounds detected in the background groundwater samples. Table 2-11 is a summary of the organic detections reported by the laboratory for the background groundwater samples.

Summary of Results. The following inorganics (maximum concentration detected is also listed) were detected in most if not all background groundwater samples: aluminum, 12,500 µg/L; barium, 107 µg/L; calcium, 12,800 µg/L, iron, 9,620 µg/L, magnesium, 7,720 µg/L; manganese, 354 µg/L; potassium, 20,900 µg/L; and sodium, 44,300 µg/L. Arsenic was detected in wells MW-53 and MW-63 with a maximum detected concentration of 6.9 µg/L, Cadmium was detected in wells MW-53, MW-54, and MW-63 with a maximum detected concentration of 0.8 µg/L. Chromium and copper were detected at 22.3 µg/L and 8.9 µg/L, respectively in MW-53. Lead was detected in MW-53 with a maximum concentration of 6.3 µg/L. Nickel was detected at 18.4 µg/L in MW-52. Selenium was detected in all wells except MW-54 (maximum concentration of 4.2 µg/L) during the first round of sampling but was not detected in samples collected during the Round 2 sampling. Thallium was detected in MW-53 at 0.1 µg/L in the Round 1 sample but was not detected in the Round 2 sample. Vanadium was detected in MW-63 for samples collected from both sampling rounds and in well MW-53 in the sample collected during Round 1. The maximum detected concentration of vanadium in the background samples was 31.4 µg/L (MW-63). Zinc was detected in samples from wells MW-52 and MW-53 during the Round 1 sampling and in the MW-52 sampling during Round 2 with a maximum detected concentration of 46.0 µg/L.

Monitoring well MW-63 was installed as a deep background monitoring well for the RI. However, elevated levels of organic compounds were unexpectedly detected in the well. An additional AREE (AREE 41, Old Homestead) was created to further evaluate an old homestead area that may be the source for the contamination detected in this well. Inorganic results from MW-63 were used to develop site specific background concentrations in groundwater. The organic compounds that were detected in groundwater were not used to establish a background organic database. The following organic compounds were detected in groundwater samples collected from MW-63 during Round 1: 1-methylnapthalene (119 µg/L); 2-methylnapthalene (80.5 µg/L); acenaphthene (11.0 µg/L); acenapthylene (6.34 µg/L); endosulfan B (0.021 µg/L); endosulfan sulfate (0.027 µg/L); endrin (0.022 µg/L); ethybenzene (13 µg/L); fluoranthene (0.063 µg/L); fluorene (3.2 µg/L); napthalene (30 µg/L); phenanthrene (8.69 µg/L); pyrene (0.158 µg/L); toluene (5.2 µg/L); TPH, as diesel (900 µg/L): TPH, as gas (740 µg/L); and xylenes (54 µg/L). Organic compounds (and their respective maximum concentrations) detected during Round 2 sampling are as follows: 1-methylnapthalene (101 µg/L); 2-methylnapthalene (79.3 µg/L and 78.8 µg/L) in MW-63 duplicate; acenapthene (4.17 µg/L and 8.27 µg/L) in MW-63 duplicate; acenapthylene (3.01 µg/L); anthracene (2.00 µg/L); BHC.B (0.017 µg/L); BHC.G (0.098 µg/L); dieidrin (0.026 µg/L) and 0.018 µg/L in MW-63 duplicate; dimethyl phthaleate (3.90 g/L in MW-63 duplicate); endosulfan sulfate (0.019 µg/L); ethylbenzene (5.30 µg/L) and 5.20 µg/L in MW-63 duplicate; fluoranthene (0.069 µg/L) and 2.01 µg/L in MW-63 duplicate; phenanthrene (6.43 µg/L) and 6.35 µg/L in MW-63 duplicate pyrene (0.162 µg/L) and 0.137 µg/L in MW-63 duplicate; tolunene (2.30 µg/L) and 2.10 µg/L in MW-63 duplicate; TPH, as diesel (1,140 µg/L) and 1,130 µg/L in MW-63 duplicate; TPH, as gas (558 µg/L) and 538 µg/L in MW-63 duplicate; and xylenes (32.0 µg/L) and 31.0 µg/L: in MW-63 duplicate.

Inorganics compounds detected in Round 1 from MW-63 are as follows: aluminum (635 µg/L); arsenic (1.6 µg/L); barium (30.8 µg/L); calcium (24,300 µg/L); iron (433 µg/L); magnesium (3,580 µg/L); manganese (12 µg/L); potassium (14,000 µg/L); selenium (2.7 µg/L); sodium (41,300 µg/L); and vanadium (12.3 µg/L). The following inorganic compounds were detected in the groundwater sample and duplicate collected from MW-63 during Round 2; aluminum (780 µg/L) and 514 µg/L in the MW-63 duplicate; arsenic (6.9 µg/L) and 6.5 µg/L in the sample collected

from the MW-63 duplicate; barium (30.3 µg/L) and 27.2 µg/L in the MW-63 duplicate; cadmium (0.2 µg/L in the MW-63 duplicate); calcium (42,800 µg/L) and 41,600 µg/L in the MW-63 duplicate; iron (532 µg/L) and 209 µg/L in the MW-63 duplicate; lead (1.2 µg/L) in the MW-63 duplicate; magnesium (225 µg/L) and 157 µg/L in the MW-63 duplicate; manganese (10.8 µg/L) potassium (20,900 µg/L) and 20,300 µg/L in the MW-63 duplicate; sodium (44,300 µg/L) and 42,700 µg/L in the MW-63 duplicate and vanadium (31.4 µg/L) and 28.2 µg/L in the MW-63 duplicate.

Two organic compounds were detected in background monitoring well MW-52. Anthracene was detected at 0.113 µg/L in the MW-52 Round 1 sample but was not detected in the Round 2 sample. Endosulfan sulfate was detected in MW-52 Round 1 and 2 samples at concentrations of 0.146 µg/L and 0.138 µg/L, respectively. No organic compounds were detected in MW-53 and MW-54 groundwater samples.

2.10 AREE 1 - PREVIOUS AND CURRENT INVESTIGATIONS

Since 1984 several investigations have focused on AREE 1, a 0.4-acre former dump site on the southwest portion of WRF, bordered by Occoquan Bay to the south and Marumsco Creek to the west.

2.10.1 Results of Previous Investigations

The following sections present the results of previous investigations, the rationale used to choose sample locations during the RI investigation, and a summary of the analytical results of this investigation. Figure 2-24 presents the locations of samples collected during prior and current (RI) sampling events.

2.10.1.1 Environmental Science and Engineering, Inc. Remedial Investigation, 1984

Environmental Science and Engineering, Inc. (ESE) collected soil and sediment samples and installed and sampled six monitoring wells, one upgradient from the landfill (MW-7) and five downgradient (MW-8 - 12). Samples were analyzed for PCBs and PAHs.

Summary of Results. Low level PCB contamination was found in one soil sample (LF1S3) and PAHs were detected in a surface water sample (LF1W1). Periodic sampling of the monitoring wells from 1985 through 1990 detected PCBs with the highest concentration (2 µg/L) at MW-10. These results were later suspected to be unreliable and the monitoring program was terminated.

2.10.1.2 USAEC Site Inspection, 1993 - 1994

The USAEC conducted an SI that included a geophysical survey to locate subsurface anomalies, a trenching program within suspected dumping areas to verify the existence of any subsurface anomalies, a soil sampling program from within the trenches where debris was encountered, and a groundwater sampling program from existing monitoring wells (USAEC, 1995c).

Summary of Results. Five anomalies were identified and four trenches were excavated (trenches 19 - 22) to investigate the anomalies. PCB-1260 was detected in one soil sample from trench 21 and a duplicate at concentrations of 74 µg/g and 31 µg/g, respectively (USAEC, 1995c). The sample locations are presented on Figure 2-27.

No PCBs, pesticides, or VOCs were detected above method detection limits for groundwater (USAEC, 1995c).

2.10.1.3 Virginia Department of Environment, Bioaccumulation Initiative, 1994

The VADEQ collected soil, sediment, and storm water samples at locations WRF03, WRF03A through WRF03H, WRF04, WRF04A through WRF04H, and WRF10. This sampling was conducted as part of Virginia's Coastal Zone Management Program (NOAA, 1994). The samples were analyzed for PCBs, PAHs, and pesticides.

Summary of Results. PCBs were detected in sediment, stormwater, and surface soil at maximum concentrations of 0.034 mg/kg (at WRF03E), 15 µg/L (at WRF03), and 1.1 mg/kg (at WRF4F), respectively. Pesticides and PAHs were also detected in all media. The sample locations are presented on Figure 2-24.

Fish tissue sampling was also conducted during this study at WRF03. Fish collection zones are presented on Figure 2-25. Fillet and viscera were analyzed from bass, carp, catfish, herring, perch, shad (gizzard and fillet), and sunfish. Chemicals of concern detected in these samples and respective maximum concentrations of each chemical detected are as follows: PCBs (1500 µg/kg); benzo(a)pyrene (140 µg/kg); chlordane (24 µg/kg); DDD (27 µg/kg); DDE (97 µg/kg), DDT (2 µg/kg); dieldrin (3 µg/kg); and endrin (29 µg/kg).

2.10.2 Current Investigation Results

The following sections describe the sampling rationale for the RI investigation, the number of samples collected, the analyses performed on each sample for each medium, and a summary of the results. Figure 2-24 presents the location of each sample collected. Results of the sample analyses are presented in Table 2-2.

2.10.2.1 Surface Soil

Seven surface soil samples (RISS1 through RISS4 and RISS54 through RISS56) were collected and analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs to characterize the extent of surface soil contamination. The samples were collected from areas where stressed vegetation was observed, or in run-off areas, except RISS1, which was collected from an area where a suspected drum protrudes from the side of a hill. Figure 2-27 presents PCB concentrations in surface soil, subsurface soil, test pit samples, and sediment samples from previous investigations and the 1995 RI.

Summary of Results. The following inorganic compounds were detected at concentrations greater than the WRF site background maximum concentrations: aluminum, beryllium, calcium, chromium, cobalt, copper, iron, lead, mercury, potassium, sodium, and zinc. Concentrations of inorganic compounds detected in surface soil samples at AREE 1 are presented in Table 2-2. Figure 2-26 presents inorganic compounds detected above site background concentrations in surface soil samples collected in OU1.

PCB-1260 was detected in five surface soil samples collected in AREE 1: RISS1 at a concentration of 0.149 µg/g; RISS1DUP at a concentration of 0.037 µg/g; RISS4 at a concentration of 0.713 µg/g; RISS55 at a concentration of 0.279 µg/g; and RISS56 at a concentration of 0.054 µg/g. Although no RBC exists, PCB-1260 is considered a carcinogenic mixture of PCB congeners and USEPA Region III recommends that the RBC for carcinogenic PCBs (0.083 µg/g) be used as a screening value. The detected concentrations in RISS1, RISS4, and RISS55 exceed the carcinogenic RBC. PCB concentrations detected in surface soil, subsurface soil, test pit samples and sediment samples for AREE 1 are presented in Figure 2-27. Total pesticides and PAHs detected in surface soils for OU1 are presented in Figure 2-28.

2.10.2.2 Subsurface Soil

Four downgradient soil borings (MW-77 through MW-80) were drilled in which subsurface soil samples were collected from depths of 0 to 2 feet bgs and from 2 feet bgs to the water table. In addition, groundwater monitoring wells were installed at each soil boring location. Boring logs and monitoring well completion diagrams are presented in Appendix B. These soil boring locations are closer to the known area of PCB contamination than the existing monitoring wells and were collected to further characterize and evaluate subsurface contamination in AREE 1. The subsurface soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PCTs.

Summary of Results. The following inorganic compounds were detected at concentrations greater than their WRF site background maximum concentrations in the subsurface soil samples collected from 0 to 2 feet bgs: barium, beryllium, calcium, chromium, cobalt, lead, magnesium, mercury, nickel, potassium, selenium, sodium, vanadium, and zinc. Concentrations of inorganic compounds detected in subsurface soil samples (0 to 2 feet bgs) at AREE 1 are presented in Table 2-2. Figure 2-29 presents inorganic compounds detected in subsurface soils above background in OU1.

Several organic compounds (PAHs, pesticides, and PCBs) were detected in the shallow subsurface soil samples collected from 0 to 2 feet bgs in AREE 1. Concentrations of organic

compounds detected in subsurface soil samples (0 to 2 feet bgs) at AREE 1 are presented in Table 2-2. Figure 2-28 presents total PAHs and pesticides detected in surface soil samples (which includes subsurface soil samples from 0-2 feet bgs) in OU1. PAHs and pesticides were detected in concentrations less than their respective RBCs. Endosulfan sulfate, which was detected in MW-77DUP, does not have an RBC. However, for risk assessment purposes USEPA Region III recommends that the RBC for endosulfan (47 µg/g) be used as a screening value. The detected concentration of endosulfan sulfate (0.03 µg/g) is significantly less than the RBC. PCB-1260 was detected in two subsurface soil samples collected 0 to 2 feet bgs in AREE 1: MW-78 at a concentration of 0.11 µg/g, and MW-80 at a concentration of 10.8 µg/g. Although no RBC exists, PCB-1260 is considered a carcinogenic mixture of PCB congeners and USEPA Region III recommends the RBC for carcinogenic PCBs (0.083 µg/g) be used as a screening value. The detected concentrations in both MW-78 and MW-80 exceed the carcinogenic RBC.

Inorganic compounds beryllium, calcium, cobalt, and vanadium were detected at concentrations greater than their respective site background concentrations. Beryllium (site background of ND) was detected in MW-76 in the sample collected from 5-7 feet bgs (0.390 µg/g) and in the 7-9 feet bgs sample (0.499 µg/g). Beryllium was also detected in MW-77 at 7-9 feet bgs at a concentration of 0.27 µg/g and in MW-78 in the 7-9 feet bgs sample at a concentration of 0.34 µg/g; in MW-79 at 0.39 µg/g (5-7 feet bgs) and MW-80 at a concentration of 0.47 µg/g (5 feet bgs). Calcium was detected at a concentration of 702 (site background concentration of (454 µg/g) in the 5-7 foot sample collected in MW-80. Calcium was also detected at concentrations of 726 µg/g and 653 µg/g in the MW-76 boring at depths of 5-7 feet and 7-9 feet bgs. Cobalt (site background of 13.9 µg/g) was detected at a concentration of 14.4 µg/g in the 5-7 foot sample collected from the MW-80 soil boring. Vanadium (site background concentration of 25.8 µg/g) was detected in the 5-7 feet bgs sample at a concentration of 37.2 µg/g and 27.7 µg/g in the 7-9 feet bgs sample from MW-76. No other inorganic compounds were detected above their respective RBCs. Inorganic compounds detected in AREE 1 are presented in Table 2-2. Inorganics detected in subsurface soils above background in OU1 are presented in Figure 2-29.

Several organic compounds including endosulfan sulfate, methoxychlor, and PCB-1260, were detected in soil samples collected 2 feet bgs to the water table. With the exception of PCB-1260, all organic compounds were detected at concentrations less than their respective RBCs. PCB-1260 was detected in soil boring MW-80, collected 5 feet bgs, at a concentration of 1.62 µg/g, which exceeds the RBC for carcinogenic PCB congeners (0.083 µg/g). Concentrations of organic compounds detected in subsurface soil samples (2 feet bgs to the water table) in AREE 1 are presented in Table 2-2. Total pesticides and PAH concentrations detected in subsurface soils in OU1 are presented in Figure 2-30.

2.10.2.3 Test Pits

Two test pits, TP-1 and TP-2, were excavated upgradient and downgradient, respectively, of the two trenches previously excavated and sampled (refer to sample locations 01EX0101 and 01EX02, Figure 2-24) during the 1993 USAEC SI to determine the extent of PCB contamination identified during the SI. Two additional test pits (TP-24 and TP-25) were excavated to investigate the extent of additional debris that was protruding from the side of a hill on the southern portion of OU1.

- TP-1, upgradient of previously excavated area 01EX02, was excavated in two segments. Segment 1 was 24 feet long and excavated to a depth of 6.25 feet bgs. Debris was encountered at the ground surface. No debris was encountered during the excavation. One sample, TP-1A, and one duplicate, TP-1A DUP, were collected at the surface where debris was located. Segment 2 was trenched perpendicular to the road where surface debris was visible. TP-1, segment 2 was 25 feet long and excavated to a depth of 6.3 feet bgs. One sample, TP-1B, was collected beneath the surface debris. No debris was encountered during the excavation. Soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PCTs.
- TP-2 was trenched downgradient of previously excavated area 01EX02 in two segments that cut perpendicular to each other. Segment 1 was 25 feet long and excavated to a depth of 7

feet bgs. One sample, TP-2A, was collected where debris was located at 2 feet bgs. Segment 2 was 18 feet long and excavated to a depth of 7 feet bgs. One sample, TP-2B, was collected where debris was located at 2 feet bgs. The debris unearthed consisted of sheet metal, plastic, cable and pipe. Samples TP-2A and TP-2B were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PCTs.

- TP-24 was trenched in one segment perpendicular to TP-1 and in two segments approximately 80 feet north of TP1. Visible debris on the surface was removed to allow continued excavation of soils beneath it. TP-24 was 25 feet long and excavated to a depth of 5 feet bgs. No additional debris was recovered and no sample was collected.
- TP-25 was trenched in three segments approximately 90 feet south of TP-2 in order to determine the lateral extent of debris. All segments were 15 feet long and excavated to a depth of 6 feet bgs. A metal pipe and piece of metal cable were unearthed during the excavation. No samples were collected from the excavations.

Summary of Results. The following inorganic compounds were detected at concentrations greater than each of the WRF site background maximum concentrations: calcium, barium, and iron (0 to 2 feet bgs), and lead, potassium, and vanadium (below 2 feet bgs). Concentrations of inorganic compounds detected in test pit samples at AREE 1 are presented in Table 2-2. Inorganics detected in test pit samples collected from 0-2 feet bgs in OU1 are presented in Figure 2-26 and inorganics detected in test pit samples collected below 2 feet bgs are presented in Figure 2-29. Although several organic compounds were detected in test pit samples, none exceeded their respective RBCs.

Concentrations of organic compounds detected in test pit samples at AREE 1 are presented in Table 2-2. Total pesticides and total PAHs detected in test pit samples collected at ground surface are presented in Figure 2-28 and total pesticides and PAHs detected in subsurface soil samples in OU1 is presented in Figure 2-30.

2.10.2.4 Groundwater

The groundwater flow direction in the vicinity of AREE 1 is from east to west, flowing toward Marumsco Creek, based on the composite water elevation map (Figure 2-15). Four downgradient monitoring wells (MW-77 through MW-80) were installed in areas nearer to the known area of PCB contamination than the existing wells (MW-7 through MW-12) to further characterize and evaluate groundwater contamination in AREE 1. Groundwater samples collected from these wells were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PCTs.

In addition to the newly installed wells, the existing wells (MW-7 through MW-12) were also sampled. Monitoring well construction data for existing and new AREE 1 monitoring wells is presented as Table 2 in Appendix A. As discussed earlier, PCBs were detected periodically during sampling activities from 1985 through 1990 (the highest concentration detected was in MW-10 at 2 µg/L). However, these data were suspected of being unreliable and the groundwater monitoring program was terminated. During this investigation, groundwater samples collected from existing wells were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, PAHs, TAL metals, and PCTs.

Summary of Results. The following inorganic compounds were detected at concentrations greater than their WRF site background maximum concentrations: aluminum, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, selenium, thallium, vanadium, and zinc. Concentrations of inorganic compounds detected in groundwater samples at AREE 1 are presented in Table 2-2. Inorganics detected in groundwater above background concentrations in OU1 monitoring wells are presented in Figure 2-31.

The following organic compounds were detected at concentrations below their respective RBCs: 2-methylnaphthalene, acenaphthene, acenaphthylene, acetone, anthracene, alpha-BHC, alpha-BHC, G(Lindane), chrysene, endosulfan sulfate, and fluoranthene. Most of these compounds were detected at only one sample location. Concentrations of organic compounds detected in groundwater samples at AREE 1 are presented in Table 2-2. PCBs were not detected in AREE 1

groundwater samples. Total pesticides and total PAH concentrations detected in OU1 groundwater samples are presented in Figure 2-32.

2.10.2.5 Sediment

Eight sediment samples, RISD14 through RISD21 were collected south of AREE 1 along the shore of the Occoquan Bay and west of AREE 1 in Marumsco Creek. Sediment samples were collected in areas where, based on the drainage patterns at AREE 1, the potential impact of former activities at AREE 1 could be evaluated. Sediment samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs.

Summary of Results. The only inorganic compound detected at RISD17 above the WRF site background maximum concentration was silver. Silver was detected at a concentration of 3.45 µg/g in RISD17, while the WRF site background maximum concentration is nondetect. Sodium, vanadium, and zinc were detected above WRF site background maximum concentrations at RISD20. Chromium, cobalt, iron, sodium, and vanadium were detected above WRF site background maximum concentrations at RISD21. Concentrations of inorganic compounds detected in sediment at AREE 1 are presented in Table 2-2. Inorganic compounds detected above background in sediment samples are presented in Figure 2-33.

Organic compounds were not detected above their respective RBCs in sediment samples associated with AREE 1, with the exception of the sample collected from RISD20 (benzo(a)pyrene - 0.195 µg/g, RBC - 0.088µg/g and PCB-1260 - 0.084 µg/g, RBC - 0.083 µg/g). Concentrations of organic compounds detected in sediment at AREE 1 are presented in Table 2-2. Total pesticides and PAHs detected in OU1 sediment samples are presented in Figure 2-34.

2.10.2.6 Surface Water

Eight surface water samples, RISW14 through RISW21, were collected in the same locations as the sediment samples for AREE 1. Surface water samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs.

Summary of Results. The following inorganic compounds were detected in surface water samples collected in AREE 1 at concentrations exceeding the WRF site background maximum concentrations: aluminum, barium, chromium, copper, iron, lead, manganese, potassium, vanadium, and zinc. Concentrations of inorganic compounds detected in surface water at AREE 1 are presented in Table 2-2. Inorganic compounds detected above background concentrations in surface water are presented in Figure 2-35.

Organic compounds were not detected in the surface water samples associated with AREE 1.

2.10.2.7 Surface Water Runoff

Four surface water runoff samples (SWRO1 through SWRO4) were collected from topographical low areas that receive surface water runoff from AREE 1. Surface water runoff samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs. Sample locations are shown on Figure 2-27.

Screening criteria is not available for surface water runoff samples; therefore, the following section lists inorganic and organic compounds detected in surface water runoff samples collected in AREE 1. Inorganic concentrations detected in surface water runoff samples are presented in Table 2-2. Inorganics detected in surface water runoff samples from OU1 are presented in Figure 2-36.

Summary of Results. The following inorganic compounds were detected in surface water runoff sample SWR01 at the following concentrations: aluminum (6,480 µg/L); arsenic (2.2 µg/L); barium (49.8 µg/L); calcium (58,300 µg/L); chromium (10.0 µg/L); iron (9,980 µg/L); lead (5.5 µg/L); magnesium (10,600 µg/L); manganese (555 µg/L); potassium (2,660 µg/L); sodium (7,740 µg/L); vanadium (16.4 µg/L); and zinc (34.0 µg/L). Inorganic compound concentrations are presented in Table 2-2. Benzoic acid was the only organic compound detected in SWR01 at a concentration of 5.2 µg/L.

Inorganic compound concentrations detected in SWR02 include the following: arsenic (4.4 µg/L); aluminum (34,600 µg/L); barium (122 µg/L); cadmium (0.2 µg/L); calcium (27,700 µg/L); chromium (43.8 µg/L); copper (28.0 µg/L); iron (45,200 µg/L); lead (70.2 µg/L); magnesium (8,400 µg/L); manganese (344 µg/L); mercury (0.23 µg/L); nickel (25.8 µg/L); potassium (6,880 µg/L); sodium (5,680 µg/L); thallium (0.3 µg/L); vanadium (87.4 µg/L); and zinc (164 µg/L). Concentrations of organic compounds detected in SWR02 include: anthracene (1.35 µg/L); benzo(a)pyrene (0.014 µg/L); fluoranthene (0.053 µg/L); PCB-1260 µg/L (0.486 µg/L); and pyrene (0.129 µg/L).

Inorganic compounds detected in SWR03 include the following: aluminum (43,300 µg/L); arsenic (5.6 µg/L); barium (139 µg/L); cadmium (0.3 µg/L); calcium (21,800 µg/L); chromium (53.0 µg/L); copper (28.4 µg/L); iron (48,500 µg/L); lead (47.2 µg/L); magnesium (9,460 µg/L); manganese (603 µg/L); mercury (0.23 µg/L) nickel (22.6 µg/L); potassium (8,500 µg/L); sodium (5,930 µg/L); thallium (0.4 µg/L) vanadium (92.8 µg/L); and zinc (177 µg/L). Organic compounds present in SWR03 above detection limits include: anthracene (2.73 µg/L); benzo(a)pyrene (0.016 µg/L); fluoranthene (0.050 µg/L); PCB-1260 (4.40 µg/L); and pyrene (0.237 µg/L).

Concentrations of inorganic compounds present in SWR04 include the following: aluminum (35,700 µg/L); arsenic (3.4 µg/L); barium (171 µg/L); cadmium (0.3 µg/L); calcium (15,300 µg/L); chromium (60.9 µg/L); copper (33.3 µg/L); iron (57,800 µg/L); lead (42.5 µg/L); magnesium (8,860 µg/L); manganese (498 µg/L); nickel (29.0 µg/L); potassium (7,950 µg/L); sodium (3,260 µg/L); thallium (0.3 µg/L); vanadium (106 µg/L); and zinc (197 µg/L).

Three organic compounds were detected in SWR04 and include anthracene (0.923 µg/L); PCB-1260 (0.224 µg/L); and pyrene (0.151 µg/L). PCBs detected in surface water runoff samples are presented in Figure 2-27. Total pesticides and total PAH concentrations detected in surface water runoff samples from OU1 are presented in Figure 2-37.

2.10.2.8 Fish Tissue Residue Analysis

Biota samples were collected in locations near OU1 (Marumsco Creek and in the pond). Thirty-six biota samples were collected as fillet and whole body samples by species; however, only those collected near OU1 will be addressed in this FFS. Detailed descriptions of biota samples collected in the Main Ditch and in other areas of WRF can be found in the Draft Final RI report for WRF (August, 1997) and in the WRF Biota Sampling Report (USAEC, 1995). These data were not used in the OU1 risk assessment, as these data were considered to be site-wide and not specific to OU1. These data were used in the risk assessment for the OU2 and OU4 FFS. Refer to Figure 2-25 for biota sampling conducted just south of OU1 in Marumsco Creek. Samples were analyzed for lead, mercury, pesticides/PCBs, and PCTs.

The following samples were detected above the for PCB-1260 RBC (0.00041 µg/g) in fish tissue samples collected from Marumsco Creek: S.FISH-1W (126 µg/g); S.FISH-2W (105 µg/g); S.FISH-3W (97.6 µg/g); S.FISH-4W (110 µg/g); S.FISH-5W (115 µg/g); WPERCH-1W (267 µg/g); WPERCH-2W (227 µg/g); WPERCH-3W (234 µg/g); WPERCH-4W (277 µg/g); and WPERCH-5W (221 µg/g). DDE was detected above its RBC of 0.0093 µg/g in the following samples: S.FISH-1W (15.9 µg/g); S.FISH-2W (14.5 µg/g); S.FISH-3W (14 µg/g); S.FISH-4W (30.2 µg/g); W-PERCH-1W (34.9 µg/g); and W-PERCH-2W (30.9 µg/g); DDD (RBC of 13 µg/g) was detected at a concentration of 30.9 in WPERCH-2W. Alpha chlordane (RBC of 0.0024 µg/kg) was detected at a concentration of 14.7 µg/kg in WPERCH-1W; 13.2 µg/kg in WPERCH-2W; 12.3 µg/kg in WPERCH-3W; 16.3 µg/kg in WPERCH-4W; and 12.0 µg/kg in WPERCH-5W.

2.10.3 Discussion

Inorganic compounds were detected at concentrations exceeding the WRF site background maximum concentrations in surface soils, subsurface soils, groundwater, sediment, surface water, and surface water runoff. Zinc concentrations in four of the eight surface soil samples (RISS1, RISS4, RISS55 and RISS56) were considerably elevated (231 µg/g, 135 µg/g, 195 µg/g, and 301 µg/g, respec-

tively), while the site background for zinc is 43.9 µg/g. It is likely that the former landfill contributed to the elevated zinc levels in the soil. Surface water runoff sample concentrations were consistently elevated when compared to respective site background levels for inorganics. Aluminum, iron, and lead were particularly elevated and tended to increase in concentration with proximity to the Occoquan Bay; a trend which may be attributed to the accumulation of metals sorbed to soil transported by runoff. Aluminum, barium, copper, iron, lead, manganese, vanadium, and zinc were detected in one surface water sample (RISW19) in excess of site background levels. This sample was taken in Marumsco Creek near its discharge point into the Occoquan Bay. Its high metals content may be attributable to runoff from AREE 1 or sediment transported from other areas by the creek. In addition, the samples were collected during and just after storm events which may also attribute to the elevated metal concentrations.

PAHs, pesticides, and semi-volatiles were also detected in groundwater, sediment, and surface water runoff samples. Two locations had detectable levels of several compounds: groundwater from MW-77 contained detectable amounts of 2-methylnaphthalene, acenaphthene, chrysene, and fluoranthene, and sediment sample RISD18 contained detectable 2-methylnaphthalene, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, and chrysene. In addition, surface water runoff samples from SWRO2, SWRO3, and SWRO4 exhibited moderately elevated levels of anthracene and lesser amounts of benzo(a)pyrene and fluoranthene. Groundwater from MW-79 had a detectable level of anthracene. MW-7, the existing upgradient well, had an elevated acenaphthene concentration and a detectable amount of fluoranthene.

As stated earlier, groundwater flow in AREE 1 is generally east to west. This suggests that surface water runoff and groundwater discharge from contaminated areas of AREE 1 may have contributed to the PAH levels in sediment samples collected along the shore of Occoquan Bay. In addition, since WRF is located in an urbanized area and some of the PAHs detected may be a result of its location within this region. Similarly, pesticides at RISD19, collected at the same location as RISW19 (the site of elevated metals concentrations) may have been transported from sites within AREE 1 or, considering its location in Marumsco Creek, from upgradient locations. DDD and DDE were detected in surface soil sample RISS4 (below their RBCs), which is upgradient and east of the sample location for RISD19.

PCB-1260 was detected in surface and subsurface soil, sediment, and surface water runoff samples, as presented in Figure 2-27. The detected concentration of PCB-1260 in surface soil samples RISS1 (0.149 µg/g) and RISS4 (0.713 µg/g) exceeds the RBC for soil for carcinogenic PCB congeners (0.083 µg/g). Detected concentrations of PCB-1260 in soil boring MW-80 were 10.8 µg/g at 0 to 2 feet bgs and 1.62 µg/g at 5 to 10 feet bgs, both of which exceed the RBC for soil. The higher concentrations in the subsurface soil samples are most likely due to the disposal of PCBs in this area. A stiff clay layer is present in this area directly below the topsoil to a depth of approximately 4 feet bgs. PCBs would tend to bind to these clays. In addition, MW-78 had a concentration slightly above the RBC and MW-76 had detectable levels of PCB-1260 though less than the RBC. The detected concentration of PCB-1260 in RISD20, collected along Marumsco Creek, was 0.084 µg/g which exceeds the RBC (0.083 µg/g). Three of the four surface water runoff samples had PCB-1260 concentrations above detection limits with one, SWRO3, at a significantly elevated concentration (4.40 µg/L). The locations of the contaminated sites, as well as the media contaminated, indicate that, like the PAH contamination, surface water runoff from PCB-1260 contaminated sites within AREE 1 has transported the contaminant downgradient to the vicinity of Occoquan Bay, with possible off-site contributions transported by Marumsco Creek. However, sediment samples collected along the shore of the Bay (near AREE 1) during the 1995 RI did not indicate PCB contamination. The results of the Virginia Department of Environment Bioaccumulation Initiative detected PCB contamination in sediment and soils at comparable locations to those discussed here. The VADEQ study collected a storm water runoff sample, WRF03, in which PCBs were detected. This indicates that PCBs may be discharging to the Occoquan Bay from AREE 1.

2.10.4 Conclusions

Prior disposal practices at AREE 1 as a landfill have contributed to elevated zinc levels in the surface soil, PAHs in the groundwater, and PCBs in the surface and subsurface soil. Surface water runoff from AREE 1 may have transported contaminants to the Occoquan Bay, although some contamination may be due to upgradient sources (which have most likely been transported via Marumsco Creek). PCBs were not detected directly along the shoreline from samples collected for the RI; however, they

have been detected in the Occoquan Bay as well as Marumsco Creek. In addition, PCBs have been detected in surface and subsurface soils at AREE 1, and surface water runoff samples.

2.11 PREVIOUS AND CURRENT INVESTIGATIONS - AREES 2 AND 5

AREEs 2 and 5 are sites of former landfills where transformers (AREE 2), capacitors (AREE 2), and metal debris were buried. These disposal areas are located adjacent to each other, just north of where Lake Drive deadends as shown in Figure 2-38 (Prior and 1995 RI Sampling Locations for AREEs 2, 4, and 5). Due to the proximity of these AREEs, they have been evaluated as a single source area. Therefore, current sampling locations, both upgradient and downgradient, encompass both AREEs. Results from previous site investigations related to AREEs 2 and 5 are presented below. Sample locations from past (and current RI) investigations are presented in Figure 2-38. A summary table of detected concentrations is presented as Table 2-3.

2.11.1 Environmental Science and Engineering, Inc., Remedial Investigation, 1984

Surface soil and surface water samples were collected in 1984 as part of an RI (ESE, 1985). PCB-1016 was detected in surface soil samples at 2 µg/g (Landfill 2, No. 3, 330802) and 200 µg/g (Landfill 2, No. 6, 330805) and PCB-1260 was detected at 3 µg/g in Landfill 2, No. 6, 330805. Sample locations are presented in Figure 2-38 and are labeled as sample locations 3 and 6. Six monitoring wells were installed by ESE around AREE 2 in 1984, and a removal action was completed by Weston in 1985 to remove transformers, capacitors, and contaminated soil. A five-year groundwater sampling program was implemented from 1985 to 1990 to monitor PCB contamination. The PCB concentrations increased annually, with concentrations of up to 7 µg/L detected in samples collected from MW-2 and MW-3 (Weston, 1992). However, five of the six monitoring wells were sampled again by Earth Tech in 1993 as part of the USAEC SI and no PCBs or VOCs were detected in the groundwater. Di-n-octylphthalate and bis(2-ethylhexyl)phthalate were detected at concentrations of 28 µg/L and 25 µg/L, respectively, in the groundwater sample collected from MW-2 (ESE, 1985). Di-n-octylphthalate and bis(2-ethylhexyl)phthalate were detected at concentrations of 24 µg/L and 20 µg/L, respectively, in a surface water sample (Landfill 2, No. 7, 384102) collected from AREE 2 (ESE, 1985).

2.11.2 USAEC Site Inspection, 1993 - 1994

The USAEC conducted a site inspection that included a geophysical survey to locate subsurface anomalies; a trenching program within suspected dumping areas to verify the existence of any subsurface debris; a soil sampling program from within the trenches where debris was encountered; and, a groundwater sampling program from existing monitoring wells. Additionally, direct push groundwater samples, surface water, and sediment samples were collected at four locations (USAEC, 1995c).

Summary of Results. Two anomalies were identified and three trenches (trenches 13 - 15) were excavated to investigate the anomalies. Debris was found in all three trenches and one soil sample was collected from each trench and analyzed for PCBs, TPH, and pesticides. PCBs, TPH, and pesticides were detected in soil samples collected from AREE 5 at maximum concentrations of 0.33 µg/g (05EX0101), 35.1 mg/kg (05EX0101), and 0.043 µg/g (05EX0201), respectively, and were collected during the same SI associated with AREE 2 (USAEC, 1995c).

PCBs were detected in one sediment sample collected during the 1993 SI near AREE 2 at a concentration of 0.07 µg/g (02SE04, located on a narrow peninsula bordering Marumsco Creek). It should be noted that this sediment sample (02SE04) is located on the far side of a narrow peninsula, and may be impacted far more strongly by the Marumsco Creek than from surface water runoff from AREE 5 (USAEC, 1995c).

PCB-1254 was detected in a groundwater sample collected from direct push sample 05DP01 at a concentration of 0.14 µg/L (USAEC, 1995c).

2.11.3 USAEC Remedial Investigation, 1995

The following sections present sample location methodologies and analytical data resulting from the 1995 RI and conclusions derived from these data.

2.11.3.1 Surface Soil

Five surface soil samples (RISS 5-9) were collected within and around AREE 5 to characterize the extent of surficial contamination. Soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, PCTs, and TPH.

Summary of Results. The following inorganic compounds were detected at concentrations which exceed the WRF site background maximum concentrations for these compounds: aluminum, barium, beryllium, copper, lead, manganese, potassium, and sodium. Concentrations of inorganic compounds detected in surface soil samples at AREEs 2 and 5 are presented in Table 2-3. Inorganic compounds detected in surface soils above background concentrations in OU1 are presented in Figure 2-26.

Organic compounds were detected in surface soil samples collected from AREEs 2 and 5 and are summarized in Table 2-3.

2.11.3.2 Subsurface Soil

Seven shallow soil borings (one upgradient and seven downgradient), located to encompass AREEs 2 and 5, were drilled to identify potential source areas and the extent of contamination in the soil. These soil borings were later converted to monitoring wells MW-68, MW-70 through MW-74, and MW-81. A soil boring (RISB6) was installed near the SI sample location (02SW04) where PCBs were detected. In addition, two deeper monitoring wells (MW-82 and MW-83) were drilled and installed to monitor deeper groundwater in this area; however, soil samples were not collected from the borings since the wells were installed using mud rotary techniques. Boring logs and monitoring well completion diagrams are presented in Appendix A. Subsurface soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PCTs (if PCBs were detected), and TPH.

Summary of Results. Aluminum was present above site background concentrations in subsurface soil (0 to 2 feet bgs) in the sample collected from MW-70 at a concentration of 21,100 µg/g. Barium was detected in shallow subsurface soil samples (0-2 feet bgs) above the WRF site background maximum concentration of 73.4 µg/g in the sample collected from MW-81 at a concentration of 77.4 µg/g. Beryllium was detected in one sample, MW-71DUP (1.26 µg/g), collected from the 0-2 feet interval, which exceeded the WRF site background maximum concentration of 1.02 µg/g. Calcium was detected in two shallow subsurface soil samples, MW-71 and MW-71DUP, at concentrations of 522 µg/g, and 575 µg/g, respectively, and one shallow surface soil sample from MW-81 (above the site background concentration of 454 µg/g) at a concentration of 4,170 µg/g. Chromium was detected above the site background concentration of 25.0 µg/g in 0-2 feet samples collected from MW-70 (29.5 µg/g) and MW-71 (30.6 µg/g). Cobalt was detected above the site background maximum concentration of 13.9 µg/g in two shallow subsurface samples (MW-68 - 20.0 µg/g and MW-71 DUP - 37.5 µg/g). Lead was detected in four shallow subsurface soil samples at concentrations above the site background maximum concentration of 11.8 µg/g in MW-68 (14.6 µg/g), MW-74 (23.6 µg/g), MW-81 (22.4 µg/g), and RISB6 (24.3 µg/g). Manganese was detected in three shallow subsurface soil samples at concentrations of 858 µg/g (MW-68), 684 µg/g (MW-71DUP), and 1,100 µg/g (MW-81), respectively, which are all above the WRF site background maximum concentration of 617 µg/g. Potassium was detected in one sample, MW-70 (665 µg/g), above the site background concentration of 624 µg/g. Vanadium was detected in all shallow subsurface soil samples above the vanadium site background concentration of 25.8 µg/g, with the exception of MW-74. Concentrations of inorganics detected in shallow soil samples (0-2 feet bgs) and in subsurface soil samples (2 feet bgs to the water table) are presented in Table 2-3. Inorganics detected above site background in shallow subsurface soil samples (0-2 feet bgs) collected in OU1 are presented in Figure 2-26.

The subsurface soil sample collected from 5-7 feet bgs in the soil boring for MW-71 had a concentration of 0.40 µg/g for antimony, which is above the site background concentration of non-detect. Calcium was detected above the site background concentration of 454 µg/g in three samples, MW-71 (10-12 ft) at 1,260 µg/g, MW-81 (5-7 ft) at 7,520 µg/g, and MW-81 (10-12 ft) at

2,700 µg/g. Silver was detected at a concentration of 2.08 µg/g in the 5-7 foot sample collected from MW-70. The maximum site background concentration for silver is non-detect. Inorganics detected in subsurface soils (>2 feet bgs) above background are presented in Figure 2-27. Total PAH and pesticide concentrations detected in subsurface soil samples are presented in Figures 2-27 (0-2 feet bgs) and 2-30 (>2 feet bgs).

PCB-1254 were detected in the shallow subsurface (0-2 feet bgs) in the sample collected from MW-81 at concentrations of 0.22 µg/g and 1.0 µg/g, respectively. PCB-1248 was detected at a concentration of 0.36 µg/g in the 10-12 feet bgs sample collected from MW-81, which exceeds the RBC value of 0.083 µg/g.

PCB-1254 was detected in the same sample interval at a concentration of 0.16 µg/g, which is the also the RBC value for this compound. Organic compounds detected in subsurface soil samples are presented in Table 2-3.

TPH, as diesel, was detected at a concentration of 27.9 µg/g in the 0-2 feet bgs soil sample collected from MW-74 and TPH, as gas, was detected at a concentration of 9.88 µg/g, also in this sample. These values are below the Virginia Underground Storage Tank (UST) Program action level for soil of 100 µg/g. 2.0.4.3 Test Pits

2.11.3.3 Test Pits

One test pit (TP-3) was excavated in AREE 2 to evaluate the presence of PCB contamination remaining after the 1984 remedial action was performed by Weston. One test pit (TP-4) was excavated in AREE 5 to characterize the site of a former disposal pit where metal debris is partially buried. Two soil samples were collected from each test pit and analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PCTs (if PCBs were detected), and TPH. Test pit locations are presented on Figure 2-38.

- TP-3 was trenched in three segments. Segment 1 was cut perpendicular across the previous removal area. The segment was 7 feet long and excavated to a depth of 6 feet bgs. One sample TP-3B was collected at 7 feet bgs. Segment 2 also was cut perpendicular to the removal action area. This segment was 15 feet long and excavated to a depth of 9.4 feet bgs. One sample, TP-3A, was collected at 9.4 feet bgs. Segment 3 was cut in the northwest/southeast direction between segments 1 and 2. Segment 3 was 18 feet long and excavated to a depth of 9 feet bgs. No sample was collected from Segment 3. Debris consisting of rip-rap and concrete blocks was encountered between 0 - 16 inches below grade in the excavations.

- TP-4 was excavated in the woods where debris was exposed. TP-4 was 52 feet long and excavated to varying depths due to the density of the debris. The depths varied from 3 to 7 feet bgs. Two samples were collected: TP-4A at 6 feet bgs and TP-4B at 4 feet bgs. The debris consisted of pulleys, cable, pipe, and sheet metal.

Summary of Results. Several metals were detected at concentrations exceeding their respective WRF site background maximum concentrations. Inorganics detected include barium (detected in TP-4A at a concentration of 375 µg/g; WRF site background concentration of 73.8 µg/g); and beryllium (WRF site background concentration of 1.02 µg/g), detected in test pit samples TP-4A and TP-4B at concentrations of 2.44 µg/g and 1.08 µg/g, respectively. Calcium was detected in test pit sample TP-4A (8,820 µg/g) and TP-4B (535 µg/g). The WRF site background concentration for calcium is 454 µg/g. Chromium was detected in TP-3B at a concentration of 26.1 µg/g (site background of 25.0 µg/g). Cobalt was detected above the WRF site background concentration of 13.9 µg/g in test pit sample TP-4A at a concentration of 23.2 µg/g. Copper was detected at a concentration of 47.0 µg/g in test pit sample TP-4A, exceeding the WRF site background maximum concentration of 16.9 µg/g. Iron was detected at a concentration of 40,400 µg/g also in sample TP-4A, which exceeds the site background level of 27,800 µg/g. Lead exceeded the site background level of 11.8 µg/g in three samples, TP-3B, TP-4A and TP-4B, at concentrations of 12.5 µg/g, 113 µg/g and 18.9 µg/g, respectively. Manganese was detected at a concentration of 3,270 µg/g in TP-4A, which exceeds the WRF site background

maximum concentration of 617 µg/g. Potassium also exceeded the WRF site background maximum concentration of 624 µg/g in TP-3B, TP-4A, and TP-4B at concentrations of 846 µg/g, 1,230 µg/g, and 892 µg/g, respectively. Sodium was detected at a concentration of 1,190 µg/g in test pit sample TP-4A, exceeding the WRF site background maximum concentration of 933 µg/g. Vanadium concentrations exceeded the site background level of 25.8 µg/g in all test pit samples with concentrations ranging from 27.7 µg/g (TB-3A) to 49.4 µg/g (TP-4B). Zinc was detected at concentrations exceeding WRF site background maximum concentration of 46.3 µg/g in test pit samples TP-4A (416 µg/g) and TP-4B (66.2 µg/g). Inorganic compounds detected in test pit samples are presented in Table 2-3. Inorganic compounds detected in shallow (0-2 feet bgs) and deeper (>2 feet bgs) test pit samples are presented in Figures 2-26 and 2-29, respectively.

One organic compound, methylene chloride, was detected in three test pit samples, TP-3B (0.010 µg/g), TP-4A (0.03 µg/g), and TP-4B (0.01 µg/g), which are well below the RBC for this compound (85 µg/g). Organic compounds detected in test pit samples are presented in Table 2-3. Total pesticide and PAH concentrations detected in shallow (0-2 feet bgs) and deeper test pit samples (2 feet bgs) are presented in Figures 2-28 and 2-30, respectively.

2.11.3.4 Groundwater

As previously mentioned, seven shallow monitoring wells (MW-68 and MW-70 through MW-74, and MW-81) were installed to investigate potential groundwater contamination associated with these AREEs. Soil boring/monitoring well MW-68 serves as an upgradient well due to the screen placement of existing well MW-1. The top of the screen of existing well MW-1 is below the water table, thereby rendering it unable to provide monitoring data for TPH. MW-71 was installed to address the PCB contamination found at 05DP01. MW-81 is located adjacent to existing monitoring wells MW-2 and MW-3 and was completed such that the screens were placed to intercept light phase compounds, if present. In addition, two deep monitoring wells, MW-82 and MW-83 were installed. MW-82 is located adjacent to MW-2 (forming a well cluster with MW-81) to evaluate potential downward migration of PCBs in an area where PCBs have been detected in the past. Deep well MW-83 was installed to form a well cluster with shallow monitoring well MW-71.

Five of the six existing monitoring wells (MW-1 through MW-5) were resampled during the field investigation for the RI. Monitoring well MW-6 was not sampled due to a damaged well casing which may have compromised the integrity of the sample. Groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, and TAL metals, PAHs, PCTs, TPH in order to further characterize groundwater within AREEs 2 and 5. Monitoring well locations are presented in Figure 2-32.

Summary of Results. The following inorganic compounds were detected at concentrations exceeding their respective WRF site background maximum concentrations. Chromium was detected at a concentration of 23.5 µg/L. The site background maximum concentration for chromium is 22.3 µg/L. Iron was detected in groundwater samples collected from MW-5 (14,600 µg/L) and MW-82 (12,500 µg/L), which exceed the background concentration for iron of 9,620 µg/L. Lead was detected above the WRF site background maximum concentration of 6.3 µg/L in samples collected from the following monitoring wells: MW-1, MW-4, MW-5, and MW-72 at concentrations of 15.9 µg/L, 25.7µg/L, 15.5 µg/L, and 6.6 µg/L, respectively. Manganese was detected above background in MW-2 and MW-82, and MW-82 Round 2 at concentrations of 388 µg/L and 547 µg/L and 491 µg/g, respectively (the site background maximum concentration for manganese is 354 µg/L). Nickel was detected in MW-4 at a concentration of 28.1 µg/L (site background concentration of 18.4 µg/L). Thallium was detected in only one sample, MW-4, at a concentration of 0.1 µg/L, which is equal to the site background concentration for thallium. Zinc was detected above the site background concentration of 46 µg/L in samples collected from MW-1 and MW-4, at concentrations of 51 µg/g and 85.4 µg/g, respectively. Inorganic compounds detected in groundwater are presented in Table 2-3. Inorganic compounds detected in groundwater are presented in Figure 2-31.

All organic compounds were present in low concentrations above detection limits but below respective RBCs, with the exception of aldrin detected in MW-82 at a concentration of 0.009

µg/L (RBC of 0.004 µg/L); lindane detected in MW-82 at a concentration of 0.214 µg/L (RBC of 0.052 µg/L); DDT detected in MW-82 at a concentration of 0.051 µg/L (0.2 µg/L); heptachlor epoxide, detected in MW-82 at a concentration of 0.035, greater than the RBC concentration of 0.0012 µg/L; and PCB-1016, detected in MW-81 at a concentration of 2.93, which is greater than the RBC concentration of 0.26 µg/L. Organic compounds detected in both shallow and deep wells are presented in Table 2-3. Total pesticides and PAHs detected in groundwater are shown in Figure 2-32. Pesticide and semi-volatile plumes have been mapped for this area and are presented as Figures 2-39 and 2-40, respectively.

PAHs and PCBs were detected at low concentrations during the second round of groundwater sampling, conducted in the spring of 1996. Aldrin (RBC of 0.004 µg/L) was the only compound detected above the RBC in Round 2 sampling at a concentration of 0.010 in MW-74. PCB 1016 was detected in MW-81 at a concentration of 2.93 mg/L.

2.11.3.5 Sediment

Three sediment samples (RISD11, RISD12, and RISD13) were collected from Marumsco Creek, and from areas topographically downgradient from OU1. All sediment samples were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs. Organic and inorganic compounds detected in sediment are presented in Table 2-3.

Barium was the only inorganic compound not detected in all three sediment samples. Lead was nondetect in two sediment samples, RISD11 and RISD12. The following inorganic compounds were present in concentrations above their respective detection limits but below their respective WRF site background concentrations in all three sediment samples: aluminum (site background concentration of 16,900 µg/g); calcium (site background concentration of 6,000 µg/g; chromium (site background concentration of 33.7 µg/g); cobalt (site background concentration of 21.4 µg/g); copper (site background concentration of 44.4 µg/g); iron (site background concentration of 36,500 µg/g); magnesium (site background concentration of 3,740 µg/g); manganese (site background concentration of 1,690 µg/g); nickel (site background concentration of 30.3 µg/g); potassium (site background concentration of 2,120 µg/g); and zinc (site background concentration of 168 µg/g). The beryllium concentration equaled the site background concentration of 1.38 µg/g in RISD12. Sodium concentrations in RISD11 (2,650 µg/g) and in RISD12 (2,450 µg/g) exceeded the WRF site background concentration for sodium of 1,710 µg/g. RISD12 and RISD13, with vanadium concentrations of 60.9 µg/g and 64.4 µg/g, respectively, exceeded the WRF site background concentration of 54.1 µg/g. Inorganic compounds detected above background concentrations in sediment samples are presented in Figure 2-33.

All organic compounds detected in sediment samples were below RBCs, with the exception of benzo(a)pyrene, detected in RISD12 at a concentration of 0.198 (the RBC for benzo(a)pyrene is 0.198 µg/g). Total PCT, TPH, pesticide, and PAH concentrations detected in sediment samples are presented in Figure 2-34.

2.11.3.6 Surface Water

Three surface water samples RISW11, RISW12, and RISW13, were collected in locations identical to the corresponding sediment sample locations discussed in Section 2.5.3.5. Inorganic compounds detected in surface water samples are presented in Table 2-3. The following inorganic compounds were detected at concentrations below site background concentrations in all three surface water samples: arsenic (1.4 µg/L); cadmium (not detected [ND]); calcium (22,200 µg/L); magnesium (7,500 µg/L); manganese (303 µg/L); nickel (ND); selenium (ND); sodium (16,500 µg/L); thallium (ND); and zinc (ND). Inorganics were not detected above WRF site background maximum concentrations in RISW11.

Inorganics detected above background concentrations in RISW12 are aluminum (2,100 µg/L, with a site background concentration of 1,930 µg/L); and iron (2,770 µg/L, with a site background concentration of 2,510 µg/L). Inorganics exceeding background concentrations in RISW13 include aluminum (3,460 µg/L); barium (54.3 µg/L); copper (6.1 µg/L); iron (4,110 µg/L); lead (5.2 µg/L); potassium (4,490 µg/L); and vanadium (10.8 µg/L). Inorganics detected above background in surface water samples from OU1 are shown in Figure 2-35.

Organic compounds were not detected above RBCs in surface water samples collected from AREEs 2 and 5.

2.11.3.7 Surface Water Runoff

Three surface water runoff samples (SWR010, SWR011, and SWR012) were collected from topographically low areas that received surface water runoff from AREEs 2 and 5. Surface water runoff samples were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs (if PCBs were detected). Inorganic and organic compounds detected in surface water runoff samples are presented in Table 2-3. Sample locations and inorganic compounds detected in surface water run-off samples are presented in Figure 2-36. Total pesticides and PAHs detected in surface water runoff samples are presented in Figure 2-37.

Summary of Results. The following inorganic compounds were detected in surface water runoff sample SWR010 at the following concentrations: aluminum (2,570 µg/L); arsenic (1.2 µg/L); barium (86.3 µg/L); cadmium (0.1 µg/L); calcium (7,020 µg/L); iron (15,800 µg/L); lead (5.3 µg/L); magnesium (4,610 µg/L); manganese (863 µg/L); potassium (1,250 µg/L); sodium (9,720 µg/L); vanadium (12.2 µg/L); and zinc (27.2 µg/L). Two organic compounds, fluoranthene and endosulfan sulfate, were detected in SWR010 at concentrations of 0.023 µg/L and 0.105 µg/L, respectively.

Surface water sample SWR011 contained the following inorganic compound concentrations: aluminum (30,200 µg/L); arsenic (2.9 µg/L); barium (178 µg/L); cadmium (0.6 µg/L); calcium (6,880 µg/L); chromium (40.9 µg/L); copper (33.0 µg/L); iron (31,100 µg/L); lead (45.9 µg/L); magnesium (4,640 µg/L); manganese (571 µg/L); nickel (16.1 µg/L); potassium (6,240 µg/L); sodium (1,460 µg/L); thallium (0.4 µg/L); vanadium (82.5 µg/L); and zinc (723 µg/L). The following organic compounds were detected at the following concentrations: DDE (0.012 µg/L); DDT (0.018 µg/L); anthracene (0.161 µg/L); fluoranthene (0.022 µg/L); and pyrene (0.137 µg/L).

SWR012 contained the following inorganic compounds at the following concentrations: aluminum (1,080 µg/L); barium (72.1 µg/L); calcium (6,220 µg/L); iron (20,790 µg/L); lead (1.3 µg/L); magnesium (4,450 µg/L); manganese (1,390 µg/L); potassium (1,920 µg/L); sodium (5,640 µg/L); and zinc (86.0 µg/L). One organic compound, endosulfan sulfate was present above detection limits at a concentration of 0.495 µg/L in surface water sample SWR012.

2.11.4 Discussion

Inorganic compounds were detected at concentrations exceeding the WRF site background maximum values in surface soil samples (0 - 0.5 feet bgs), shallow soil samples collected from 0-2 feet bgs; subsurface soil samples (>2 feet bgs); test pit samples; sediment samples; surface water samples; and groundwater samples. Elevated concentrations of heavy metals were present in surface water runoff samples collected from these AREEs, and in particular, in SWR011, which is located on the edge of a wetland area, adjacent to Marumsco Creek. Inorganics of concern which substantially exceeded site background concentrations include aluminum, barium, chromium, cobalt, manganese, nickel and vanadium. Inorganics slightly above site background concentrations include beryllium, copper, lead, and zinc. A substantial portion of the inorganics above site background concentrations were detected from RISS6, RISS7, and RISS8, which are topographically downgradient from AREE 5, where metal debris was supposedly buried in the past. The former landfills 2 and 5 are likely contributing to elevated metals concentrations in surface and shallow subsurface soil. Debris uncovered in test pits excavated during the 1995 RI could be a possible source for elevated metals contamination in shallow soil samples and groundwater samples.

While organic compounds were not detected in surface soil samples above RBCs, PCB-1248 was detected in subsurface soil samples above RBC concentrations in samples collected from MW-81. MW-82 (installed adjacent to MW-81), was drilled and installed using mud rotary techniques, therefore, no soil samples were collected from this boring.

PAHs and pesticides were detected in groundwater samples above RBCs in both new and existing wells. Figures 2-39 and 2-40 present total pesticides and semi-volatile groundwater plumes associ-

ated with these AREEs. The groundwater sample collected from MW-82 (located on the eastern edge of the AREE 2 perimeter) had low levels of multiple PAH and pesticide compounds; however, none of the PAH's were above their respective RBCs. Only two of the pesticides had concentrations above RBCs. Heptachlor epoxide (RBC of 0.0012 µg/L) and aldrin (0.004 µg/L) had concentrations of 0.035 µg/L and 0.009 µg/L, respectively. The PAH and pesticides appear to be concentrated mainly in and around AREE 2, with the highest and most frequently detected compounds occurring in samples collected from wells near the southern (downgradient) portion of AREE 2. AREE 2's history as a former dump may be the source for the PAH/pesticide contamination in this area. Levels of PAHs and pesticides were found in surface and subsurface soil samples collected in this area; however, none were above site background levels. These PAHs and pesticides may have been leached from the soil and introduced into the groundwater. Methylene chloride (0.010 µg/g) was detected in a test pit sample TP-3B collected from AREE 2 at a depth of 7 feet bgs, which is well below the RBC value for methylene chloride of 760 µg/g.

2.11.5 Conclusions

Concentrations of heavy metals are present in surface soils samples above site background levels, particularly in RISS7, the only surface soil sample collected within the actual boundary of AREE 5. Elevated concentrations of metals in shallow soil samples are widespread across AREEs 2 and 5, which may be derived from debris previously disposed of in this area. Although metals were detected in test pit samples within these AREEs, elevated concentrations are more prevalent in surface soils than in subsurface soils. For example, TP-4B, collected at 4 feet bgs, had higher and more frequent detects of inorganic analytes than did test pit samples collected from deeper depths. Surface water samples also showed elevated metals concentrations, which could be attributed to metals present in surface soils within AREEs 2 and 5 and other upgradient areas, being transported from these locations by runoff.

Metals detected in groundwater were varied and detected in both existing and newly-installed wells in both AREEs. Metals seemed to be more frequently detected in existing wells located in close proximity to AREE 2.

Elevated PAH/pesticide concentrations were detected in groundwater samples collected from these AREEs. The most frequently detected concentrations were collected from MW-81 and MW-82, which are located adjacent to each other, near the eastern (downgradient) edge of AREE 2.

MW-81 is located within the former landfill (AREE 2), on the eastern side. PCBs were detected at low concentrations in the subsurface soil samples collected from MW-81. PCB-1016 was detected in the groundwater sample collected from this well during the Round 2 sampling.

2.12 AREES 3 AND 6A - PREVIOUS AND CURRENT INVESTIGATIONS

AREEs 3 and 6A are former dumps located in the northern portion of OU1, west of Deephole Point Road and east of Lake Drive. In past documents these AREEs were treated separately; however, in view of their close proximity (40 feet) to each other (an ephemeral pond separates the two), these two AREEs have been grouped together and the ephemeral pond has been included in the following discussion.

AREE 3 is thought to be located to the south and west of the ephemeral pond on the east side of Lake Drive, and is thought to be approximately 100 feet by 25 feet. The burial of debris such as wood, lead-coated wire, paper, and plastic, reportedly began in 1966, and continued until this area was covered with soil in 1973 (Weston, 1992). AREE 6A is a former dump area located west of Deephole Point Road and south of Lake Drive. This dump was identified by ground scars and soil disturbances observed in aerial photographs, and metal debris has been observed protruding from the toe of the slope along the southwestern extent of AREE 6A. The following sections present data derived from previous and current investigations focusing on AREEs 3 and 6A. Figure 2-41 presents previous and current sampling locations for these AREEs.

2.12.1 USAEC Site Inspection, 1993 - 1994

The USAEC conducted a site inspection that included a geophysical survey to locate subsurface anomalies, a trenching program within suspected dumping areas to verify the existence of any subsur-

face debris, and a soil sampling program from within the trenches where debris was encountered. Additionally, direct push groundwater samples were collected from the area (USAEC, 1995c).

Summary of Results. Three anomalies were identified in AREE 3 and three trenches were excavated (trenches 10 - 12) to investigate the anomalies. Debris was found in trench 12 and one soil sample (03EX0101) was collected from within the trench. The sample was analyzed for PCBs and pesticides. No PCBs or pesticides were detected above method detection limits (USAEC, 1995c).

Three anomalies were identified in AREE 6A by the geophysical survey and four trenches (trenches 1 - 4) were excavated to investigate the anomalies. Debris was found in trenches 1, 2, and 4. Soil samples were collected from trenches 1 and 2 (6AEX0101 and 6AEX0201) analyzed for PCBs and pesticides. Pesticides and PCBs were not detected in these soil samples (USAEC, 1995c).

During the 1993 SI, the location of the disposal area was thought to be confirmed; however, recent information suggests that it may be located farther south of the current AREE 3 perimeter, as shown on Figure 2-41.

Direct push groundwater samples were collected from AREE 3 and acetone was detected in groundwater at a level of 18 µg/L (03DP02). A total of five direct push samples (6ADP01A, 6ADP01B, 6ADP01C, 6ADP02, and 6ADP03) were collected from within AREE 6A during this investigation; however, only one (6ADP03) was submitted for pesticide/PCB analysis. Pesticides/PCBs were not detected above method detection limits in 6ADP03 (USAEC, 1995c).

PCBs were detected in sediment samples collected during the 1993 SI near AREE 3 at concentrations of 0.014 µg/g in 02SE01 (located upgradient from AREE 3, in the pond adjacent to PZ-12) and 02SE02 (located downgradient of AREEs 3 and 6A). A PCB concentration of 0.13 µg/g was detected in 02SE02 (USAEC, 1995c).

2.12.2 Current Investigation Results - USAEC Remedial Investigation, 1995

This section presents surface soil and test pit sample data for AREEs 3 and 6A derived from the RI field investigation conducted in 1995.

2.12.2.1 Surface Soil

Twelve surface soil samples (including 2 duplicate samples) were collected for site characterization (RISS10-12 near AREE 3) and (RISS17-RISS23 near AREE 6A). These soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, PAHs, and TAL metals. Inorganic and organic concentrations detected in surface soil samples are presented in Table 2-4.

Summary of Results - AREE 3: Several inorganics were detected above WRF site background maximum concentrations in surface soil samples collected from AREE 3. Aluminum was detected at a concentration of 15,500 µg/g in RISS-10, which is slightly above the WRF site background level of 14,350 µg/g. RISS-10 (12.7 µg/g) was the only surface soil sample that had a concentration above the site background maximum concentration for copper of 12.6 µg/g. Neither iron nor lead exceeded site background maximum concentrations (28,100 µg/g - iron and 22.4 µg/g - lead) for surface soil samples collected in AREE 3. Manganese was present above detection limits; however, all manganese concentrations were below the site background (875 µg/g) maximum concentration for manganese. RISS-10 (496 µg/g) was above the sodium site background concentration of 487 µg/g and RISS-12's (487 µg/g) concentration equaled the site background concentration. Inorganic compounds detected in surface soils are presented in Table 2-4. Figure 2-26 presents metals concentrations detected above WRF site background maximum concentrations for surface soils, shallow subsurface samples (0-2 feet bgs), and shallow test pit samples (0-2 feet bgs) for OU1.

All organics were non-detect with the exception of anthracene and methylene chloride which were both well below their RBC's of 2,300 µg/g and 85 µg/g, respectively. . Organic compound

concentrations detected in surface soils are presented in Table 2-4. Figure 2-28 presents total PAH and pesticide concentrations detected in surface soils at OU1.

Seven surface soil samples (RISS-17 through RISS-23) were collected to further characterize AREE 6A. Surface soil samples were collected from areas where stressed vegetation was identified. Soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PAHs. If PCBs were detected, the laboratory was instructed to analyze for PCTs.

Summary of Results - AREE 6A: The following inorganic compounds were detected at concentrations below site background levels: barium, calcium, chromium, cobalt, iron, lead, magnesium, manganese, and vanadium. Aluminum was detected at concentrations above site background levels (14,350 µg/g) in RISS22 (16,300 µg/g). Beryllium was detected at concentrations slightly exceeding background for samples RISS21DUP (0.881 µg/g) and RISS22 (0.825 µg/g). The site background level for beryllium is 0.814 µg/g. Copper was detected at values exceeding the site background value of 12.6 µg/g in RISS21 (16.4 µg/g), RISS21DUP (17.9 µg/g), and RISS22 (16.8 µg/g). The WRF maximum site background concentration for nickel is 11.9 µg/g and the sample RISS21DUP had a nickel concentration of 12.0 µg/g. All surface soil samples analyzed for potassium significantly exceeded the maximum site background level of 936 µg/g. Selenium was detected above the maximum background concentration of 14.2 µg/g in the following samples: RISS21 (17.7 µg/g); RISS21DUP (20 µg/g); and RISS22 (24.5 µg/g). Sodium exceeded the site background level of 487 µg/g in samples RISS21 (534 µg/g), RISS21DUP (535 µg/g), RISS22 (544 µg/g), and RISS23 (500 µg/g). One sample, RISS21DUP, exceeded the site background concentration of 43.9 µg/g for zinc, at a concentration of 46.7 µg/g. Inorganics detected in surface soil samples collected in AREE 6A are presented in Table 2-4. Figure 2-24 presents metals concentrations detected above WRF site background maximum concentrations for surface soils, shallow subsurface samples (0-2 feet bgs) and shallow test pit samples (0-2 feet bgs) for OU1.

Aluminum and copper were the only inorganics above site background in both AREEs 3 and 6A (in RISS10, RISS21, RISS21DUP, and RISS22) and both were above background only slightly. These samples locations are nearest the ephemeral pond, located between the two AREEs and surface water runoff from both AREEs appear to drain into the pond.

All organics concentrations detected in surface soil samples collected from both AREEs were below their respective RBC. Organic compounds detected in surface soil samples are presented in Table 2-4. Total PAHs for surface soils are presented on Figure 2-28.

2.12.2.2 Subsurface Soil

One shallow soil boring, MW-69 (later converted to a monitoring well), was drilled downgradient of AREE 3 (this boring is also located downgradient of AREE 6A) to further characterize the extent of downgradient subsurface contamination in this area. Boring logs and monitoring well completion diagrams are presented in Appendix A. Subsurface soil samples were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs (if PCBs were detected).

Summary of Results. Aluminum was present slightly below the site background concentration of 18,200 µg/g at a concentration of 16,000 µg/g in the 0-2 feet sample. Potassium was detected at a concentration of 764 µg/g (site background concentration of 624 µg/g), also in the 0-2 feet sample. Selenium was detected at a concentration of 15.5 µg/g, which slightly exceeds the site background concentration of 14.2 µg/g in the shallow subsurface soil sample collected from MW-69. All organic concentrations were below the WRF site background maximum concentrations. Figures 2-24, 2-25, 2-27, and 2-28 present inorganic and organic concentrations detected in shallow subsurface (0-2 feet bgs) and deeper subsurface (>2 feet bgs) soil samples at OU1.

Two deeper subsurface soil samples (25-27 feet bgs and 27-29 feet bgs) were collected from the MW-69 boring; however, all organic results were below the WRF site background maximum concentrations.

2.12.2.3 Test Pits

Two test pits (TP-13 and TP-14) were excavated in the AREE 3 former disposal area to characterize this site.

- TP-13 was trenched in a north/south direction, adjacent to the marsh. TP-13 was 47 feet long and excavated to a depth of 7 feet bgs. Two samples were collected: TP-13A at 6.5 feet bgs and TP-13B at 5 feet bgs. No debris was encountered during the excavation.
- TP-14 was cut parallel along the western slope in the northeast/southwest direction. TP-14 was 49 feet long and excavated to a depth of 7 feet bgs. Two samples were collected: TP-14A (TP-14A DUP) at 4 feet bgs and TP-14B at 7 feet bgs. No debris was encountered during the excavation.

Three test pits (TP-15 through TP-17) were excavated across the AREE 6A former disposal area to characterize this site.

- TP-15 was trenched in two segments north of TP-16 in order to delineate the aerial extent of debris associated with TP-16. Segment 1 was 10 feet long and excavated to a depth of 6 feet bgs. No sample was collected from segment 1. No debris was identified during the excavation of segment 1. Segment 2 was 134 feet long and excavated to a depth of 6 feet bgs. Two samples were collected: TP-15A at 1 feet bgs and TP-15B at 4 feet bgs. A crushed buried drum and creosote pole were unearthed at 36-inches below grade and black, stained, discolored soil was identified directly underneath the buried drum in segment 2.
- TP-16 was trenched in two V-shaped segments, north of TP-17 and perpendicular to the ditch where debris was identified. Segment 1 was 17 feet long and excavated to a depth of 6 feet bgs. One sample, TP-16A, was collected (in duplicate) at 3 feet bgs. Debris consisting of cable and automotive parts were identified between 30 to 37-inches below grade during the excavation. Segment 2 was 20 feet long and excavated to a depth of 5.3 feet bgs. One sample was collected, TP-16B, at 3.33 feet bgs. Debris consisting of cable was identified at approximately 35-inches below grade during the excavation.
- TP-17 was trenched in two segments. Segment 1 was cut into the side of the sloping hill where debris was protruding from the ground. One sample, TP-17A, was collected at 6 feet bgs. A length of rebar with cement was unearthed at approximately 72-inches below grade. Segment 2 was cut in an area of stressed vegetation. One sample, TP-17B, was collected at the surface.

Summary of Results - AREE 3. All inorganic concentrations were below site background maximum concentrations, with the exception of beryllium (1.16 µg/g) in sample TP-14A; and cobalt (20.3 µg/g) in sample TP-13A and 21.5 µg/g in sample TB-13B. The site background maximum concentration for beryllium is 1.02 µg/g and the site background concentration for cobalt is 13.9 µg/g. Calcium exceeded the WRF site background maximum concentration of 454 in TP-13A, at a concentration of 489 µg/g. Lead concentrations were above the site background level of 11.8 in two samples, TP-14A (12.1 µg/g) and TP-14 DUP (13.9 µg/g). Potassium concentrations were below 624 µg/g, which is the site background concentration, with the exception of TP-13A and TP-13B, having concentrations of 647 µg/g and 535 µg/g, respectively. Vanadium (site background of 25.8 µg/g) was detected in TP-13A at a concentration of 28.9 µg/g and in TP-14A at a concentration of 4.0 µg/g. Inorganics detected in test pit samples collected in AREE 3 are summarized in Table 2-4.

Summary of Results - AREE 6A. Inorganic compounds detected at concentrations below site background levels include arsenic, beryllium, manganese, and sodium. Inorganics which are above site background concentrations include: aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, nickel, potassium, vanadium, and zinc. Inorganics detected in test pit samples are presented in Table 2-4. No organics were detected above RBCs in test pit samples collected in AREE 6A. Analytical results

with respect to organic compounds are presented in Table 2-4. The samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, and TAL metals.

Organic compounds were not detected above RBCs in test pit samples collected from AREE 3. Inorganic compound concentrations above site background for AREES 3 and 6A test pit samples are shown in Figures 2-26 and 2-29.

2.12.2.4 Sediment

One sediment sample, RISD10, was collected near AREEs 3 and 6A. This sample was collected just north of the approximate boundary of AREE 3, at the edge of a ephemeral pond approximately 100 feet southeast of the perennial pond bordering Lake Drive.

Summary of Results. The following inorganic compounds were present above detection limits, but below their respective site background concentrations: aluminum (13,200 µg/g - site background of 15,200 µg/g); barium (85.2 µg/g - site background of 175 µg/g); beryllium (0.747 µg/g - site background of 1.26 µg/g); calcium (989 µg/g - site background of 6,000 µg/g); chromium (25 µg/g - site background of 30.1 µg/g); cobalt (8.97 µg/g - site background of 20.7 µg/g); copper (19.6 µg/g - site background of 41.8 µg/g); iron (13,800 µg/g - site background of 34,200 µg/g); lead (16.4 µg/g - site background of 42.2 µg/g); magnesium (2,600 µg/g - site background of 3,740 µg/g); manganese (92.8 µg/g - site background of 1,690 µg/g); nickel (14.7 µg/g - site background of 30.0 µg/g); potassium (1,130 µg/g - site background of 2,120 µg/g); sodium (657 µg/g - site background of 1,710 µg/g) vanadium (37.1 µg/g - site background of 52.5 µg/g); and zinc (72.5 µg/g - site background of 157 µg/g). Inorganics detected above background in OU1 sediments are shown in Figure 2-33.

The only organics detected in RISD10 were benzo(k)fluoranthene at a concentration of 0.002 µg/g - RBC of 8.8 µg/g; anthracene at a concentration of 0.031 µg/g - RBC of 2,300 µg/g; benzo(a)pyrene at a concentration of 0.002 µg/g - RBC of 0.088 µg/g; benzo(b)fluoranthene at a concentration of 0.004 µg/g - RBC of 0.88 µg/g; and fluoranthene at a concentration of 0.006 µg/g (RBC of 310 µg/g). Total pesticides and PAHs detected in OU1 sediments are shown in Figure 2-34.

2.12.2.5 Surface Water

One surface water sample, RISW10, was collected at the same location as RISD10. The following inorganics were detected at concentrations above their detection limits, but below WRF site background levels: aluminum (547 µg/L - site background of 1,930 µg/L); calcium (2,020 µg/L - site background of 22,200 µg/L); iron (705 µg/L - site background of 2,510 µg/L); magnesium (1,250 µg/L - site background of 7,500 µg/L); manganese (28.3 µg/L - site background of 303 µg/L); potassium (2,010 µg/L - site background of 3,670 µg/L); and sodium (1,380 µg/L - site background of 16,500 µg/L). Inorganics detected above background in surface water are presented as Figure 2-35.

Organic compounds were not present above detection limits in RISW10.

2.12.2.6 Groundwater

One monitoring well, MW-69 was installed downgradient of AREE 3 (also downgradient of AREE 6A). One groundwater sample was collected from AREE 3 (MW-69) during the 1995 RI sampling. MW-69 was also sampled during the second round of sampling. The groundwater sample was analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, PAHs, PCTs (Round 1 only), and TPH. Inorganic and organic compounds detected in groundwater are presented in Table 2-4.

Summary of Results. The following inorganic compounds exceeded the WRF maximum site background concentrations: iron (25,000 µg/L - the WRF site background maximum concentration is 9,620 µg/L); manganese (641 µg/L - the WRF maximum site background concentration for manganese is 354 µg/L); selenium (4.7 µg/L - the WRF site background maximum concentration for selenium is 4.2 µg/L). Inorganic compounds detected in groundwater above background in OU1 are presented as Figure 2-31.

One organic compound, anthracene was detected above detection limits in the groundwater sample collected from MW-69. Anthracene was detected at a concentration of 0.25 µg/L, while the RBC for anthracene is 1,100 µg/L.

2.12.2.7 Surface Water Runoff

Two surface water runoff samples (SWR05 and SWR09) were collected from topographically low areas that receive surface water runoff from AREE 6A. Surface water runoff samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs (if PCBs were detected). Sample locations are shown on Figure 2-36. This figure also presents inorganics detected above background.

Summary of Results. The following inorganic compounds were detected in SWR05 at the following concentrations: aluminum (19,200 µg/L); arsenic (1.5 µg/L); barium (147 µg/L); cadmium (1.0 µg/L); calcium (6,130 µg/L); chromium (32.1 µg/L); copper (65.9 µg/L); iron (21,700 µg/L); lead (21.9 µg/L); magnesium (5,260 µg/L); manganese (251 µg/L); nickel (29.8 µg/L); potassium (4,400 µg/L); sodium (5,930 µg/L); thallium (0.3 µg/L); vanadium (55.3 µg/L); and zinc (456 µg/L). Three organic compounds, anthracene, fluoranthene, and pyrene were detected at the following concentrations, respectively: 2.52 µg/L, 0.033 µg/L, and 0.224 µg/L. Total PAH and pesticide concentrations detected in surface water runoff samples are presented in Figure 2-37.

Inorganic compounds were detected in surface water sample SWR09 at the following concentrations: aluminum (12,800 µg/L); barium (55.3 µg/L); cadmium (0.1 µg/L); calcium (4,160 µg/L); chromium (20.1 µg/L); copper (12.0 µg/L); iron (15,100 µg/L); lead (8.5 µg/L); magnesium (3,740 µg/L); manganese (3,740 µg/L); potassium (2,940 µg/L); sodium (5,680 µg/L); thallium (0.2 µg/L); vanadium (36.0 µg/L); and zinc (51.3 µg/L). Organic compounds were not detected in SWR09.

2.12.3 Discussion

Several inorganics (aluminum, copper, manganese, and sodium) were detected slightly above site background concentrations in surface soil samples, most of which were detected in RISS10, which was collected near the southeastern perimeter of AREE 3, just east of the former excavation. RISS11 was collected in the central portion of AREE 3, and RISS12 was collected in the northwestern portion of the AREE. Test pit subsurface soil samples showed concentrations above site background maximum concentrations with respect to calcium, cobalt, lead, potassium, and vanadium. Beryllium was also detected slightly above site background maximum concentrations in one test pit sample, TP-14A, at a depth of 4 feet bgs; however, the concentration is only slightly above background and appears to be highly localized. Vanadium and lead were also present above background in TP-14A, which was collected near the formerly excavated area, as was RISS10, which exhibited slightly elevated inorganic concentrations.

Two organic compounds were detected in surface soil samples far below respective RBC values for these compounds. Both compounds, anthracene (PAH) and methylene chloride (VOC - a common laboratory contaminant), were present in extremely low concentrations; however, they were not detected in test pit samples collected within this AREE. The presence of these compounds may be due to surface water runoff from areas north of AREE 3. Methylene chloride is a common laboratory contaminant and may be qualified during the data validation process. In general, PAHs are ubiquitous across the site, which suggests that many of these compounds may be naturally-occurring.

Inorganic compounds, namely manganese and selenium were detected above background concentrations in the groundwater sample collected from MW-69; however, organic compounds were not detected above RBCs in this sample.

Inorganic compounds were detected in surface soil samples in AREE 6A exceeding site background levels for the following: aluminum, beryllium, copper, nickel, potassium, selenium, sodium, and zinc. Most of these analytes were detected in RISS21 and RISS22, which are located in the southern (topographically downgradient) portions of the site, near the former excavated area southeast of Lake Drive. Copper and sodium were detected in the 0-2 feet surface soil sample collected from the soil bor-

ing in which MW-65 was installed. MW-65 is located approximately 150 feet south of AREE 6A. MW-69, also located south of AREE 6A, had a beryllium concentration of 0.71 µg/g.

Inorganics were detected above site background maximum concentrations in test pit samples collected at depths ranging from 1 to 6 feet bgs from TP-15, TP-16, and TP-17. These concentrations indicate AREE-wide metals contamination in subsurface soils from 0-6 feet bgs. Selenium was detected in MW-69 at concentrations above site background concentrations. The surficial clay layer that is present throughout this portion of the facility may act as an impermeable barrier for migration of metals from soils to groundwater.

No organic compounds were detected at concentrations exceeding respective RBCs in surface soil samples. Most of the detected organics were present in the RISS19 sample. Semi-volatiles and pesticides were detected in shallow soils at low concentrations, with the most frequently detected compounds present in the RISS19 sample, located in the southeastern portion of AREE 6A. Di-n-butyl phthalate was detected at concentrations of 4.50 µg/g and 4.60 µg/g. Low levels of the organic compound benzo(a)pyrene were detected in one test pit sample, TP-16B, collected at a depth of 3.33 feet bgs. Low levels of seven other compounds were also detected in this sample. TP-16 is the most downgradient of the test pits excavated within this AREE. Anthracene was detected at a concentration of 0.25 µg/L in the groundwater sample collected from MW-69. No additional organic compounds were detected in this sample nor were organic compounds detected in the sample collected from MW-65.

2.12.4 Conclusions

Soils (surface and subsurface) in AREE 3 contain low levels of metals, one PAH (anthracene), and one volatile (methylene chloride). The primary metals of concern are aluminum, beryllium, copper, and lead; however, these inorganics were present in very low concentrations when compared to site background maximum concentrations. Anthracene and methylene chloride were detected in soils at concentrations well below the respective RBCs.

The primary metals detected in groundwater above site background concentrations are manganese and selenium.

Surface water runoff samples were not collected from AREE 3, so no determinations can be made concerning contaminant migration through erosion via surface water flow patterns.

Elevated metals concentrations were present in surface and in subsurface soil samples. Selenium was present in a shallow groundwater sample collected south of AREE 6A, collected from MW-69. Metals contamination in soils and groundwater is most likely due to these AREEs prior use as a landfill.

2.13 AREE 4 - PREVIOUS AND CURRENT INVESTIGATIONS

AREE 4 is a former dump site where debris, such as wire, wood, concrete, pipe insulation, and empty oil drums, were dumped from the late 1950s until 1973 when the dump was covered with dirt (Weston, 1992).

2.13.1 USAEC Site Investigation, 1993 - 1994

The USAEC conducted a site inspection that included a geophysical survey to locate subsurface anomalies, a trenching program within suspected dumping areas to verify the existence of any subsurface anomalies, and a soil sampling program from within the trenches where debris was encountered. Additionally, direct push groundwater samples were collected from the location.

Summary of Results. Numerous anomalies were identified by the geophysical survey and five trenches (trenches 5 -9) were excavated to investigate the anomalies. Debris was found in trenches 6 and 7 and one soil sample (04EX0101) was collected from trench 7. The sample was analyzed for PCBs, pesticides, VOCs, and TPH. PCBs and TPH were detected at concentrations of 0.85 µg/g and 220.7 µg/g in sample (USAEC, 1995c). The sample locations from past (and current RI) investigations are presented in Figure 2-39.

Five direct push groundwater sampling points (04DP01A, 04DP01B, 04DP01C, 04DP02, and 04DP03) were attempted during this investigation; however, only one sample (04DP03) was

collected. This sample was analyzed for VOCs and pesticides/PCBs. VOCs and pesticides/PCBs were not present above detection limits in the deep push groundwater sample.

2.13.2 Current Investigation Results - USAEC Remedial Investigation, 1995.

Previous and current sample locations for soil boring/monitoring wells, surface soil samples and test pit locations are presented in Figure 2-38. Analytical results from these samples are discussed in the following sections. A summary of analytes detected in samples collected in AREE 4 is presented as Table 2-5.

2.13.2.1 Surface Soil

Four soil samples (RISS13-16) were collected for site characterization to determine the extent of surficial contamination associated with AREE 4. The soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, PCTs (if PCBs were detected), and TPH.

Summary of Results. The following inorganics had concentrations above detection limits but below WRF site background maximum concentrations for each inorganic compound: aluminum; beryllium; calcium; chromium; cobalt; copper; iron; magnesium; manganese; nickel; potassium; vanadium; and zinc. Only two inorganic compounds, lead and sodium, were detected at levels that exceeded the WRF site background maximum concentrations. Lead was detected slightly above the site background concentration of 22.4 µg/g in surface soil samples RISS13 and RISS14 at concentrations of 22.5 µg/g and 22.7 µg/g, respectively. Sodium was detected above the site background concentration of 487 µg/g, in RISS14 and RISS16, at concentrations of 505 µg/g and 490 µg/g, respectively. Inorganics detected in surface soil samples are presented in Table 2-5. Inorganics detected in surface soil samples above background in OU1 are presented in Figure 2-26.

While many organics were detected in surface soil samples RISS13 through RISS16, all organic concentrations were below their RBCs. Organic compounds detected in surface soil samples are presented in Table 2-5. Total pesticides and PAHs detected in surface soils in OU1 are presented in Figure 2-28.

2.13.2.2 Subsurface Soil

Four soil borings (one upgradient - MW-64, and two downgradient - MW-66 and MW-67) were installed around the previously-trenched area and later converted to monitoring wells. MW-65 was installed to the west and approximately 200 feet upgradient of AREE 4. These soil borings were designed to evaluate the extent of subsurface soil contamination in downgradient areas associated with this AREE. Boring logs and monitoring well completion diagrams are presented in Appendix A. All subsurface soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PCTs (if PCBs were detected), and TPH.

Summary of Results. All inorganic compounds analyzed from soil samples collected from 0 to 2 feet bgs had concentrations above detection limits, but below WRF site background maximum concentrations. Inorganic compounds detected in soil samples (0 to 2 feet bgs) collected in AREE 4 are presented in Table 2-5.

Inorganic compounds barium, calcium, chromium, cobalt, copper, magnesium, nickel, potassium, vanadium, and zinc were detected slightly above site background concentrations in the 15 feet bgs sample collected from the soil boring in which MW-64 was installed. The remaining compounds analyzed from samples collected from 2 feet bgs to the water table were detected at concentrations below site background concentrations for each respective inorganic compound. Two inorganic compounds, copper and sodium, were detected above WRF site background maximum concentrations in MW-65 (0-2 feet bgs) and the duplicate sample collected from this boring (MW-65DUP). The WRF site background maximum concentration for copper is 12.6 µg/g and for sodium is 487 µg/g. Inorganics detected in subsurface soil samples collected at depths below two feet are presented in Table 2-5. Inorganics detected above background in subsurface (> 2 feet bgs) soil samples at OU1 are presented in Figure 2-29.

Organics were not detected above RBCs for shallow (0-2 feet bgs) soil samples collected from borings in AREE 4, with the exception of benzo(a)pyrene, detected at a concentration of 0.22 µg/g in MW-65 (site background concentration of 0.088 µg/g). No organic compounds were detected above RBC values for subsurface soil samples collected at depths from 0-2 feet bgs.

Organic compound concentrations in subsurface soil samples collected from 2 feet bgs to the water table were below respective RBCs. PAHs and pesticides detected in subsurface soil samples collected in OU1 are shown in Figure 2-30.

2.13.2.3 Test Pits

Test pits (TP) were excavated to evaluate eight geophysical anomalies previously-identified west of AREE 4. TP-5 through TP-12 were excavated to evaluate the presence of subsurface contamination. TP-10 through TP-12 were excavated in the area between AREEs 6A and 4 along a dirt road where debris has been identified. The locations of the test pits are presented in Figure 2-38. Two soil samples were collected from each test pit and were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PCTs (if PCBs were detected), and TPH. Test pit locations, lateral extent, and depths are discussed below:

- TP-5 was excavated parallel to the dirt road running north/south where hoses which contain wiring protruded from the ground surface, west of AREE 4. TP-5 was 31 feet long and excavated to a depth of 6 feet bgs. Two samples were collected: TP-5A at 5.75 bgs and TP-5B at ground surface. Debris was not encountered during the excavation of the test pit.
- TP-6 was excavated east of the dirt road where surficial debris was located in three segments. Segment 1 was 12 feet long and excavated to a depth of 6 feet bgs. One sample was collected at 5.6 feet bgs. Debris was not encountered during the excavation of the test pit.
- TP-7 was excavated downgradient of geophysical anomalies identified during the SI (USAEC, 1995). TP-7 was trenched with an east/west orientation; was 21 feet long, and was excavated to a depth of 6.5 feet bgs. Two samples were collected: TP-7A at the surface and TP-7B at 6.66 feet bgs. Debris was not encountered during the excavation of the test pit.
- TP-8 was excavated east of TP-7 with an east/west orientation. TP-8 was 25 feet long and was excavated to a depth of 8 feet bgs. Two samples were collected: TP-8A at 8 feet bgs and TP-8B at 6.5 feet bgs. Debris was not encountered during the excavation of the test pit.
- TP-9 was excavated in two segments. Segment 1 was trenched parallel to and southwest of TP-8. TP-9 was 15 feet long and excavated to a depth of 7 feet bgs. One sample was collected in duplicate, TP-9A at 7 feet bgs. Segment 2 was parallel to and southeast of TP-8. Segment 2 was 23 feet long and excavated to a depth of 8 feet bgs. One sample (TP-9B) was collected at 8 feet bgs. Debris was not encountered during the excavation of the test pit.
- TP-10 was trenched west of TP-12. TP-10 was 24 feet long and excavated to a depth of 8 feet bgs. Two samples were collected: TP-10A at 8 feet bgs and TP-10B at the surface. Debris was not encountered during the excavation of the test pit.
- TP-11 was trenched south of the road where rubber-coated hoses containing wire were observed. TP-11 was 20 feet long and excavated to a depth of 7 feet bgs. Two samples were collected: TP-11A at 7 feet bgs and TP-11B at the surface. Debris was not encountered during the excavation of the test pit.
- TP-12 was trenched in four segments cutting into the hillside on the north side of the road. Segment 1 was 11 feet long by 7 feet bgs. One sample, TP-12B was collected at 7 feet bgs. Segment 2 was 12 feet long and excavated to a depth of 7 feet bgs. No sample was collected from segment 2. Segment 3 was 11 feet long and excavated to a depth of 7 feet bgs. No sample was collected from segment 3. Segment 4 was 11 feet long and excavated to a depth of 7 feet bgs. One sample, TP-12A, was collected at the surface. Debris was not encountered during the excavation of the test pit.

Summary of Results. Aluminum was present in concentrations slightly exceeding site background maximum concentrations for 0-2 feet (14,350 µg/g) in test pit samples TP-10B (15,100 µg/g), TP-11B (14,700 µg/g), and TP-12A (15,900 µg/g). TP-8B (6.5 feet bgs) had an aluminum concentration of 18,600 µg/g, which is slightly above the WRF site background maximum concentration of 18,200 µg/g for samples collected from 2 feet bgs to the water table. Barium was detected in three samples: TP-8B (222 µg/g), TP-9B (116 µg/g), and TP-11B (103 µg/g), all of which exceeded site background concentrations of 92.4 µg/g (site background level for samples collected from 0-2 feet bgs) and 73.8 µg/g (site background level for samples collected at or below 2 feet bgs). Beryllium was present in most samples and exceeded site background concentrations, with a maximum detected concentration of 1.44 µg/g (TP-8B). Chromium was detected in seven test pit samples, all exceeding site background concentrations of 25.5 µg/g (0-2 feet bgs) and 31.3 µg/g (2 feet to the water table). Cobalt was present in three samples exceeding site background concentrations, TP-8B (15.3 µg/g), TP-9B (22.9 µg/g) and TP-11B (29.0 µg/g). Copper was detected at concentrations exceeding the WRF site background concentration of 12.6 µg/g (0-2 feet bgs) and 16.9 µg/g (subsurface samples collected below 2 feet bgs) in five soil samples. Iron was detected in four samples exceeding site background maximum concentrations of 28,100 µg/g (0-2 feet bgs), and 27,800 (2 feet to the water table). The concentration range of samples with concentrations above site background was from 31,200 µg/g to 36,700 µg/g. Manganese was present in three samples (TP-8B, TP-9B, and TP-11B), collected at the surface and between 6 and 8 feet bgs, which exceeded site background concentrations for surface and subsurface soils. The maximum concentration was detected in TP-8B and was 5,250 µg/g. Nickel was detected in three samples above site background concentrations of 11.9 µg/g (0-2 feet bgs) and 17.9 (2 feet to the water table). Potassium was detected in most test pit samples and frequently exceeded site background maximum concentrations of 936 µg/g (0-2 feet bgs) and 624 µg/g (2 feet to the water table). Sodium was detected in four samples above site background maximum concentrations of 487 µg/g (0-2 feet samples) and 933 µg/g in samples collected from 2 feet bgs to the water table. Vanadium was detected in eight samples slightly exceeding site background concentrations of 58.9 µg/g (0-2 feet bgs) and 25.8 µg/g (2 feet to the water table). Inorganics detected in test pit samples are presented in Table 2-5. Inorganics present in test pit samples above background concentrations are presented in Figures 2-26 and 2-29.

Organic compounds were not detected above RBC concentrations in test pit samples collected in AREE 4 (results are presented in Table 2-5).

2.13.2.4 Groundwater

Three monitoring wells, one upgradient (MW-64), and two downgradient (MW-66 and MW-67), were installed around the previously trenched area discussed earlier. An additional well, MW-65, was installed upgradient, approximately 200 feet west of AREE 4. These wells were designed to evaluate upgradient groundwater quality and the extent of groundwater contamination in downgradient areas associated with this AREE. Groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, PCTs (if PCBs were detected), and TPH.

Summary of Results. Inorganics were detected in groundwater samples collected from AREE 4. Arsenic was detected at a concentration of 3.1 µg/L in the sample collected from MW-67; however, the concentration did not exceed the site background maximum concentration of 6.70 µg/L. Cobalt was detected at concentrations of 32.3 µg/L, and 24.3 µg/L, also in the MW-67 and the MW-67 Round 2 groundwater sample. The site background maximum concentration is non-detect for cobalt. Iron exceeded the site background maximum concentration (9,620 µg/L) in the sample collected from MW-67 at a concentration of 10,500 µg/L. The manganese concentration for the sample collected from MW-67 was 4,670 µg/L, which exceeded the site background concentration of 354 µg/L. The groundwater sample collected from MW-64 (490 µg/L) also exceeded site background concentrations. Inorganic sample results are presented in Table 2-5.

Several inorganics were detected at concentrations below WRF site background maximum concentrations in the sample collected from MW-65. These inorganics are: aluminum, arsenic,

barium, calcium, chromium, cobalt, iron, lead, manganese, nickel, potassium, sodium, and zinc. Only two inorganic compounds, magnesium and selenium, were detected above site background concentrations. Inorganic compounds detected in groundwater samples collected from OU1 are presented in Figure 2-31.

Organic compounds were not detected in groundwater samples collected in AREE 4.

2.13.2.5 Surface Water Runoff

Two surface water runoff samples (SWR06 and SWR07) were collected from topographical low areas that receive surface water runoff from AREE 4. Surface water runoff samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs (if PCBs were detected).

Summary of Results. The following inorganic compounds were detected in SWR06: aluminum (9780 µg/L); barium (78.2 µg/L); cadmium (0.2 µg/L); calcium (4,480 µg/L); chromium (14.0 µg/L); copper (7.1 µg/L); iron (10,900 µg/L); lead (15.9 µg/L); magnesium (2,760 µg/L); manganese (187 µg/L); potassium (3,280 µg/L); sodium (2,540 µg/L); thallium (0.1 µg/L); vanadium (30.0 µg/L); and zinc (42.5 µg/L). Two organic compounds, anthracene and fluoranthene, were detected in SWR06 at concentrations of 0.485 µg/L and 0.029 µg/L, respectively. Inorganics detected above background concentrations and total pesticides and PAHs detected in surface water runoff samples from OU1 are shown in Figures 2-36 and 2-37, respectively.

Inorganic compounds and their detected levels for SWR07 are as follows: aluminum (7,010 µg/L); barium (138 µg/L); cadmium (0.5 µg/L); calcium (6,160 µg/L); chromium (11.5 µg/L); cobalt (21.6 µg/L); copper (9.8 µg/L); iron (12,300 µg/L); lead (25.4 µg/L); magnesium (5,520 µg/L); manganese (321 µg/L); nickel (19.3 µg/L); potassium (2,620 µg/L); selenium (2.3 µg/L); sodium (13,600 µg/L); thallium (0.1 µg/L); vanadium (27.4 µg/L); and zinc (112 µg/L). Organic compounds detected in SWR07 include DDD (0.010 µg/L); DDT (0.009 µg/L); anthracene (3.80 µg/L); fluoranthene (0.044 µg/L); and pyrene (0.214 µg/L).

2.13.3 Discussion

Metals are present in surface soil samples collected within this AREE. As mentioned earlier, lead was detected at concentrations exceeding site background concentrations. Lead detected in this area most likely resulted from surface water run-off from upgradient areas of the site and possibly from leaching from debris disposed of in this area. The surface water run-off in this area ultimately discharges to Marumsco Creek.

Subsurface soil samples indicate slight metals contamination in the soil boring in which MW-64 was installed. MW-64 is located just outside the AREE 4 perimeter, on the southeastern side of the AREE. Most of the metals detected above background concentrations were detected in the sample collected at the 15 to 17 foot interval, which is within the screened interval for this well. However, metals concentrations in the groundwater sample collected from MW-64 were below the maximum WRF site background concentrations, with the exception of manganese. There is a silty clay to clay layer present at this depth (a sandy layer is directly below the clay in which the screen is partially set) which could retard metals migration into the groundwater. Sodium and copper were detected above WRF site background maximum concentrations in upgradient shallow soil samples and magnesium and selenium were detected in an upgradient groundwater sample (MW-65) above site background maximum concentrations.

Aluminum, barium, beryllium, chromium, cobalt, copper, iron, lead, magnesium, nickel, potassium, sodium, vanadium, and zinc were detected at concentrations exceeding site background maximum concentrations in test pit samples (TP-5 through TP-12). The test pits were all excavated in southern (topographically and potentiometrically downgradient) areas of AREE 4, with the exception of TP-5, which was located in the eastern central portion of AREE 4. Metals concentrations in TP-5 samples were below site background concentrations, with the exception of calcium and vanadium, detected in the TP-5A sample collected at 5.75 feet bgs.

Inorganics detected in groundwater exceed site background concentrations most frequently in the sample collected from MW-67, which is a downgradient well for AREE 4. The screened interval for this well is set partially in silt and clayey silt, partially in silty sand, and partially in sand, as opposed to predominantly sand, in which MW-66 is set. The lower concentrations and number of metals detected in MW-66 may be attributed to the higher permeability and the lithology in which the well is screened. This may increase metals transport via this zone to Marumsco Creek.

2.13.4 Conclusions

Metals which slightly exceed background levels were detected in surface soil, subsurface soil, and groundwater in AREE 4. Heavy metals including lead, chromium, copper, nickel, and zinc, detected in groundwater samples, have the potential to impact Marumsco Creek, as groundwater within this area generally discharges to Marumsco Creek.

2.14 AREE 6B - FORMER DUMP NO. 6B - PREVIOUS AND CURRENT INVESTIGATIONS

AREE 6B is a former dump located at the intersection of Deephole Point Road and Shady Road across from AREE 1. It was identified based on ground scars and soil disturbances illustrated on aerial photographs for the facility taken in the 1960s and 1970s which were reviewed during the Preliminary Assessment (USAEC, 1995).

2.14.1 Site Investigation, 1993

The USAEC conducted a site inspection that included a geophysical survey to locate subsurface anomalies, a trenching program within suspected dumping areas to verify the existence of any subsurface debris, a soil sampling program from within the trenches where debris was encountered. Additionally, direct push groundwater samples were collected from the location.

Summary of Results. Two anomalies were identified by the geophysical survey and three trenches (trenches 16 - 18) were excavated to investigate the anomalies. Debris was not found in any of the trenches. No soil samples were collected (USAEC, 1995c). A supplemental investigation of the AREE was conducted and a soil boring was drilled and sampled. Sample locations from previous (and current RI) investigations are presented in Figure 2-24.

TPH was detected in soil samples collected from soil boring 06BH01 at depths of 0.5 to 1.5 feet bgs and 4.5 to 5.5 feet bgs at concentrations of 28 µg/g and 61.4 µg/g, respectively (USAEC, 1995c).

2.14.2 Current Investigation Results - USAEC Remedial Investigation, 1995

Sample locations for soil boring/monitoring wells, surface soil samples and test pit locations for this RI are presented in Figure 2-24 and a summary table of analytes detected in samples collected in this AREE during this investigation is presented as Table 2-6. Analytical results from these samples are discussed in the following sections.

2.14.2.1 Surface Soil

One surface soil sample was collected for site characterization (RISS24) and analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, PAHs, and TPH. RISS24 was collected from the north central portion of AREE 6B.

Summary of Results. The following inorganic compounds were detected at concentrations exceeding the maximum WRF site background concentrations in RISS24: aluminum (15,400 µg/g; - with a site background concentration of 14,350 µg/g); beryllium (0.857 µg/g; with a site background concentration of 0.814); copper (15.5 µg/g, with a site background concentration of 12.6 µg/g); iron (37,300 µg/g, with a site background concentration of 28,100 µg/g); and selenium (17.8 µg/g, with a site background concentration of 14.2 µg/g). Inorganics detected in surface soil samples are presented in Table 2-6. Inorganics detected above background concentrations in surface soils are shown on Figure 2-26.

Organics were not present above detection limits in the surface soil sample.

2.14.2.2 Subsurface Soil

A soil boring/monitoring well MW-60 was installed upgradient of this AREE (which is also upgradient of AREE 7) to evaluate groundwater quality in this area. Soil boring/monitoring well, MW-75, was installed downgradient from AREEs 6B and AREE 7 to evaluate groundwater quality and subsurface soil conditions in this area. Boring logs and monitoring well completion diagrams are presented in Appendix A. Subsurface soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and TPH.

Summary of Results. No inorganic compounds were detected above WRF site background concentrations in shallow subsurface soil samples collected from 0-2 feet bgs in AREE 6B. Two inorganics were detected at concentrations that exceeded or equaled the WRF site background maximum concentrations in subsurface soil samples collected from MW-60: calcium was detected in the 20 feet sample (1,150 µg/g); the MW-75, 5-7 feet sample (700 µg/g); and in the MW-75 duplicate, 5-7 feet sample (678 µg/g). The site background maximum concentration for calcium is 454 µg/g. Manganese was detected in the 35 feet sample from MW-60 (1,020 µg/g - the site background maximum concentration for manganese is 617 µg/g). Inorganics detected in shallow soil samples (0-2 feet bgs) and in subsurface soil samples collected at depths greater than 2 feet bgs are presented in Table 2-6. Inorganics detected above background concentrations in shallow soil samples collected in OU1 are presented in Figure 2-26. Inorganic compounds detected in subsurface soil samples collected at depths 2 feet bgs or greater are shown in Figure 2-29.

Organics were not detected in soil samples collected from 2 feet bgs to the water table above their respective RBC values, with the exception of benzo (a) pyrene, detected at a concentration of 0.24 µg/g in the 15-17 feet sample collected from MW-75. The WRF site background maximum concentration for benzo(a)pyrene is 0.088 µg/g. Organics detected in subsurface soil samples from depths greater than 2 feet bgs are presented in Table 2-6. Total pesticides and PAHs detected in shallow subsurface soil samples (0-2 feet bgs) and subsurface soil samples (> 2 feet bgs) are presented in Figures 2-28 and 2-30, respectively.

2.14.2.3 Test Pits

Two test pits were excavated within AREE 6B (TP-18 and TP-19) to investigate and characterize metal debris found in an area west of Deephole Point Road. A test pit (TP-20) was excavated in AREE 6B east of Deephole Point Road to investigate a suspected disposal area where TPH was detected during the 1993 SI (USAEC, 1995).

- TP-18 was trenched in two segments west of Deephole Point road where there was visible debris. Segment 1 was 13 feet long and excavated to a depth of 8.5 feet bgs parallel to the road. No sample was collected from Segment 1. Cable boxes and wire were identified during the excavation of segment 1. Segment 2 was located north of Segment 1 and trenched perpendicular to Deephole Point Road. Segment 2 was 21 feet long and excavated to a depth of 6.5 feet bgs. Two samples were collected: TP-18A at 6.6 feet bgs and TP-18B at the surface. Samples were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, and TPH. If PCBs were detected, the laboratory was instructed to analyze for PCTs.
- TP-19 was trenched south of TP-18 where there was visible debris on the surface. TP-19 was 34 feet long and excavated to a depth of 9.5 feet bgs. Two samples were collected: TP-19A at 8.3 feet bgs and TP-19B at the surface. Samples were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, and TPH. If PCBs were detected, the laboratory was instructed to analyze for PCTs. No debris was identified during the excavation of the test pit.
- TP-20 was trenched east of Deephole Point Road. The test pit was excavated with a southeast/northwest orientation into the hillside. TP-20 was 42 feet long and excavated to a depth of 7 feet bgs. Two samples were collected: TP-20A at 5 feet bgs and TP-20B at the surface. Samples were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals,

and TPH. If PCBs were detected, the laboratory was instructed to analyze for PCTs. No debris was identified during the excavation of the test pit.

Summary of Results. Several inorganics were detected at concentrations that exceeded the WRF site background maximum concentrations in samples collected at the surface (0-0.5 feet bgs). These compounds include: aluminum in TP-20B (16,200, with a site background concentration of 14,350 µg/g); calcium in TP-19B (1,280 µg/g, with a site background concentration of 1,150 µg/g); copper in TP-20B (14.3 µg/g, with a site background maximum concentration of 12.6 µg/g); magnesium in TP-20A at a concentration of 4,240 µg/g (site background = 3,700 µg/g), and nickel (site background concentration is 11.9 µg/g from 0-2 feet bgs and 17.9 µg/g at depths 2 feet bgs and greater) in TP-20A (19.00 µg/g). Two samples, TP-20A and TP-20B, had potassium concentrations above site background (0 feet - 597 µg/g and 2 feet - 936 µg/g). These samples are TP-20A (1,190 µg/g) and TP-20B (1,090 µg/g). The sodium concentration in TP-20B (650 µg/g) exceeded the WRF site background maximum concentration of 487 µg/g. Vanadium was detected at a concentration of 40.4 µg/g (TP-20A), which exceeded the site background maximum concentration of 25.8 µg/g.

Barium exceeded the site background concentration of 73.4 µg/g in TP-20A, at a concentration of 74.0 µg/g.

Copper and magnesium exceeded site background concentrations of 12.6 µg/g and 2,610 µg/g, respectively, in sample TP-20A (collected at 5 feet bgs). The copper concentration in this sample was 15.0 µg/g and the magnesium concentration was 4,240 µg/g. Inorganics detected in test pit samples are presented in Table 2-6. Inorganics detected in shallow test pit samples (0-2 feet bgs) and deeper are presented in Figures 2-26 and 2-29.

VOCs were not detected above Region III RBCs in test pit samples collected in AREE 6B. Organic compound results are presented in Table 2-6. PAHs and pesticides detected in test pit samples are presented in Figures 2-28 and 2-30.

2.14.2.4 Groundwater

One well, MW-60, was installed east of AREE 6B to evaluate groundwater quality upgradient of AREE 6B (this well is also, to a lesser degree, located upgradient of AREE 7). One downgradient monitoring well, MW-75, was installed in the extreme western portion of AREE 6B to evaluate groundwater conditions downgradient of AREE 6B. Groundwater samples were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, PAHs, and TPH.

Summary of Results. Inorganic compounds were not detected in groundwater samples above WRF site background maximum concentrations. Inorganic compounds detected in groundwater samples are presented in Table 2-6.

The following organic compounds were detected in the sample collected from MW-60 during the first round of groundwater sampling (Winter, 1995) at low concentrations: 2-methylnapthalene (2.48 µg/L); DDE (0.024 µg/L), DDT (0.019 µg/L), endosulfan sulfate (0.027 µg/L), Endosulfan II (0.021 µg/L), fluoranthene (0.034 µg/L), gamma-chlordane (0.008 µg/L), and heptachlor epoxide (0.088 µg/L). Of these compounds, none were detected during the Phase I second round of sampling (March, 1996) or in the Phase II round of sampling (Summer, 1996). Organics detected in groundwater samples are presented in Table 2-6. Total pesticides and PAHs detected in groundwater samples are shown in Figure 2-32.

Organic compounds were not detected in the groundwater sample collected from MW-75 in the first round of groundwater sampling; however, DDD was detected at a concentration of 0.006 µg/L in the second round of sampling (Fall, 1996). No additional organic compounds were detected in groundwater samples collected from this well.

2.14.3 Discussion

Aluminum, beryllium, copper, iron, and selenium were detected at concentrations exceeding WRF site background maximum concentrations in a surface soil sample collected approximately 100

feet east of Deephole Point Road. Some inorganics (calcium and manganese) were detected above background concentrations in soil samples collected from 0 feet to 35 feet bgs from MW-60. Based on soil lithologies described during drilling, MW-60 is located in a stiff clay zone, from ground surface to approximately 18 feet bgs, where a silty sand was encountered. These levels are most likely naturally occurring and not related to past land use or surface water/groundwater chemical transport. Inorganics are also present in levels slightly exceeding background concentrations in test pit samples in this AREE, the most significant metals being aluminum, chromium, copper, nickel, and vanadium. The fact that inorganics were not detected above background concentrations in groundwater samples confirms that most of the metals concentrations above background are most likely naturally-occurring.

Pesticides were detected in groundwater collected from MW-60. Pesticides were not detected during the second round of groundwater sampling and were not detected during Phase II sampling. MW-60 was originally planned to be a potentiometrically upgradient well for this area; however, based on hydrogeologic data (L-L'), it appears to be slightly downgradient of AREE 6B, relative to MW-79 and MW-76. However, the tidal effects on groundwater have not been evaluated for this area; therefore, the tidal influences on chemical concentrations cannot be evaluated at this time, nor can the upgradient and downgradient locations. The source for the PAHs and pesticides remains unknown at this time.

2.14.4 Conclusions

Metals concentrations exceeding WRF site background maximum concentrations are present in surface and subsurface soil in AREE 6B.

Inorganics were not detected above site background maximum concentrations in groundwater samples collected from wells in this area. Based on risk assessment data, lead presents the greatest ecological risk. Lead was present at concentrations slightly below site background levels in surface and subsurface soils.

Organic compounds presenting the greatest human health risk include benzo(a)pyrene, benzo(b)fluoranthene, DDT, fluoranthene, and methoxychlor. These compounds are present in low levels in groundwater analyzed from shallow groundwater east of the perimeter of the AREE, but are not present in the extreme western portion of the AREE, based on analytical results from MW-75.

2.15 AREE 7 (FORMER PISTOL RANGE) - PREVIOUS AND CURRENT INVESTIGATIONS

AREE 7 is a former pistol range located at the intersection of Deephole Point Road and Shady Lane. The range was used for small arms firing on a semi-annual basis during the 1970's.

2.15.1 USAEC Site Investigation, 1993 - 1994

After site reconnaissance, a 5 foot by 5 foot area was excavated to a depth of 5 feet and a subsurface soil investigation and a soil boring sampling program was implemented. The soil samples were collected and analyzed for metals (USAEC, 1995c).

Summary of Results. The soil sample (7EX0101) collected from the excavation contained concentrations of aluminum, beryllium, calcium, chromium, cobalt, copper, lead, manganese, nickel, potassium, sodium, vanadium, and zinc above background levels. One spent bullet was found in soil boring 07BH01 at a depth of 1.5 feet bgs and one shell casing was found in borehole 07BH04 at an approximate depth of 1 foot bgs. The analytes aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were detected in concentrations above background levels (USAEC, 1995c). The former SI sample locations from the SI and surface soil sample locations for this RI are presented on Figure 2-24.

2.15.2 Current Investigation Results - USAEC Remedial Investigation, 1995

Sample locations for the surface soil sample and the soil boring drilled (later converted to a monitoring well) to assess AREE 7 are presented in Figure 2-24. A summary table of detected analytes as a result of this investigation is presented in Table 2-7.

2.15.2.1 Surface Soil

One surface soil sample (RISS25) was collected in AREE 7 to evaluate possible surface soil contamination. This sample was collected near the western (downgradient) edge of AREE 7.

Summary of Results. Potassium exceeded the site background concentration of 597 µg/g. All remaining inorganics were below WRF site background maximum concentrations. Inorganics detected in surface soil samples are presented in Table 2-7. Inorganics detected above background concentrations for OU1 are shown in Figure 2-26.

Organics were not detected in RISS25 above USEPA Region III residential RBCs.

2.15.2.2 Subsurface Soil

One soil boring, MW-59 (which was later converted to a monitoring well), was drilled in AREE 7 to assess subsurface conditions. Boring logs and monitoring well completion diagrams are presented in Appendix B. Subsurface soil samples collected from these borings were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs, TAL metals, PAHs, and TPH.

Summary of Results. Inorganics were not detected at concentrations exceeding site background concentrations from shallow soil samples (0-2 ft) collected from the MW-59 soil boring. Inorganics detected in shallow subsurface soils are presented in Table 2-7.

Two subsurface soil samples were collected from boring MW-59, at depths of 25 feet and 29 feet bgs, respectively. Inorganics were not detected above site background maximum concentrations. Inorganic compounds detected in subsurface soil samples from depths in excess of 2 feet bgs are presented in Table 2-7.

Organics, pesticides/PCBs, PAHs, and TPH were not detected in subsurface soil samples.

2.15.2.3 Groundwater

One monitoring well, MW-59, was installed at AREE 7 to evaluate groundwater quality within this AREE. Groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, and TPH.

Summary of Results. Inorganic compounds were detected well below site background maximum concentrations for the groundwater sample collected from MW-59. Inorganic compounds detected in groundwater samples collected in AREE 7 are presented in Table 2-7.

No organic compounds were detected in the groundwater sample collected from MW-59.

2.15.3 Discussion

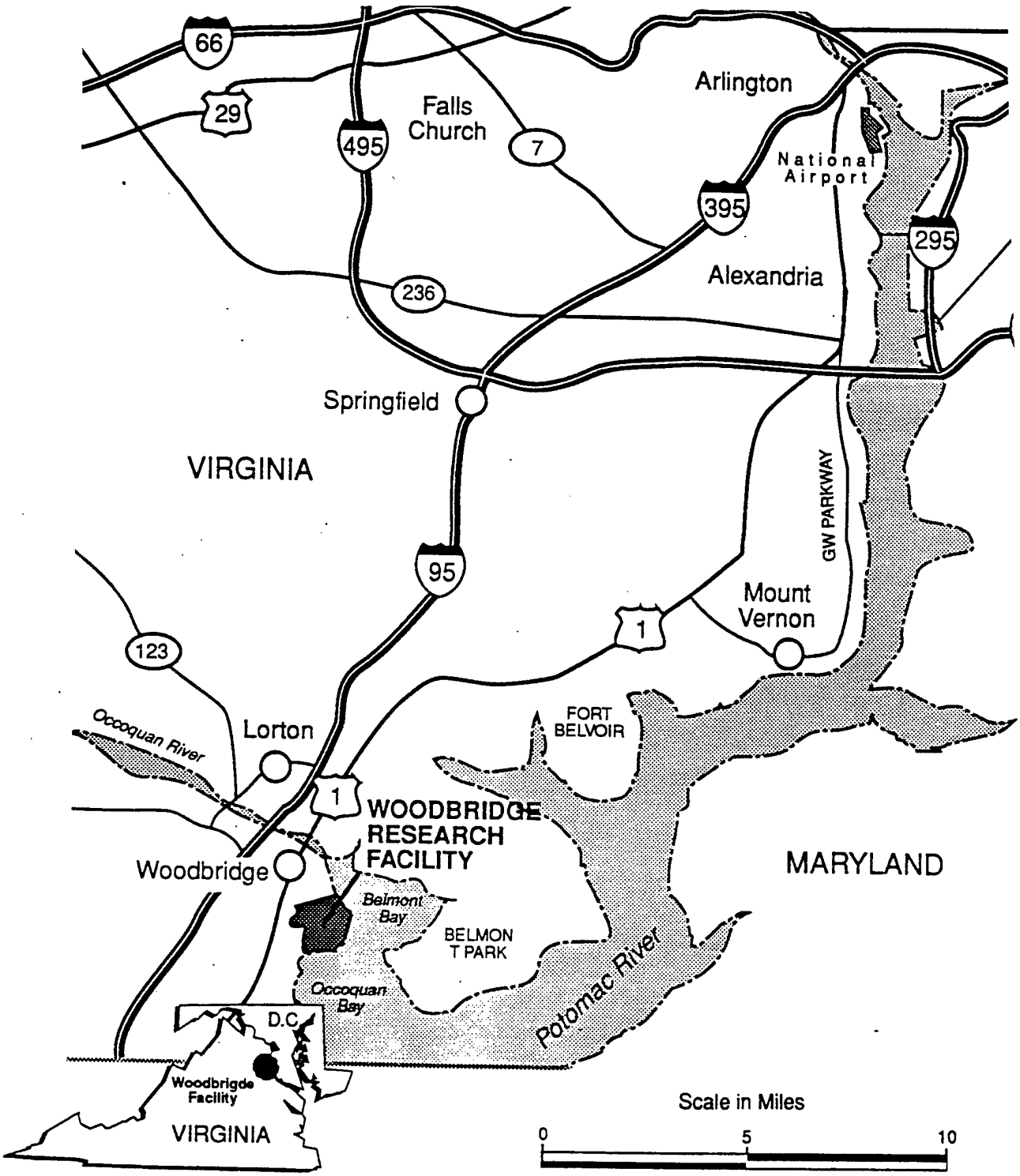
Inorganics were detected in surface, shallow soil samples (0-2 feet bgs), and subsurface soil samples at concentrations below site background levels, with the exception of RISS25, in which potassium was detected at a concentration of 1,110 µg/g (exceeding the RBC for potassium in surface soils of 936 µg/g).

Inorganics were detected at levels below background concentrations in groundwater samples collected from this AREE.

No organics were detected in surface soil, subsurface soils, or groundwater samples collected from AREE 7.

2.15.4 Conclusions

Inorganic and organic compounds were not present above maximum WRF site background concentrations or RBCs in soil samples (with the exception of potassium) or groundwater samples collected from this AREE.



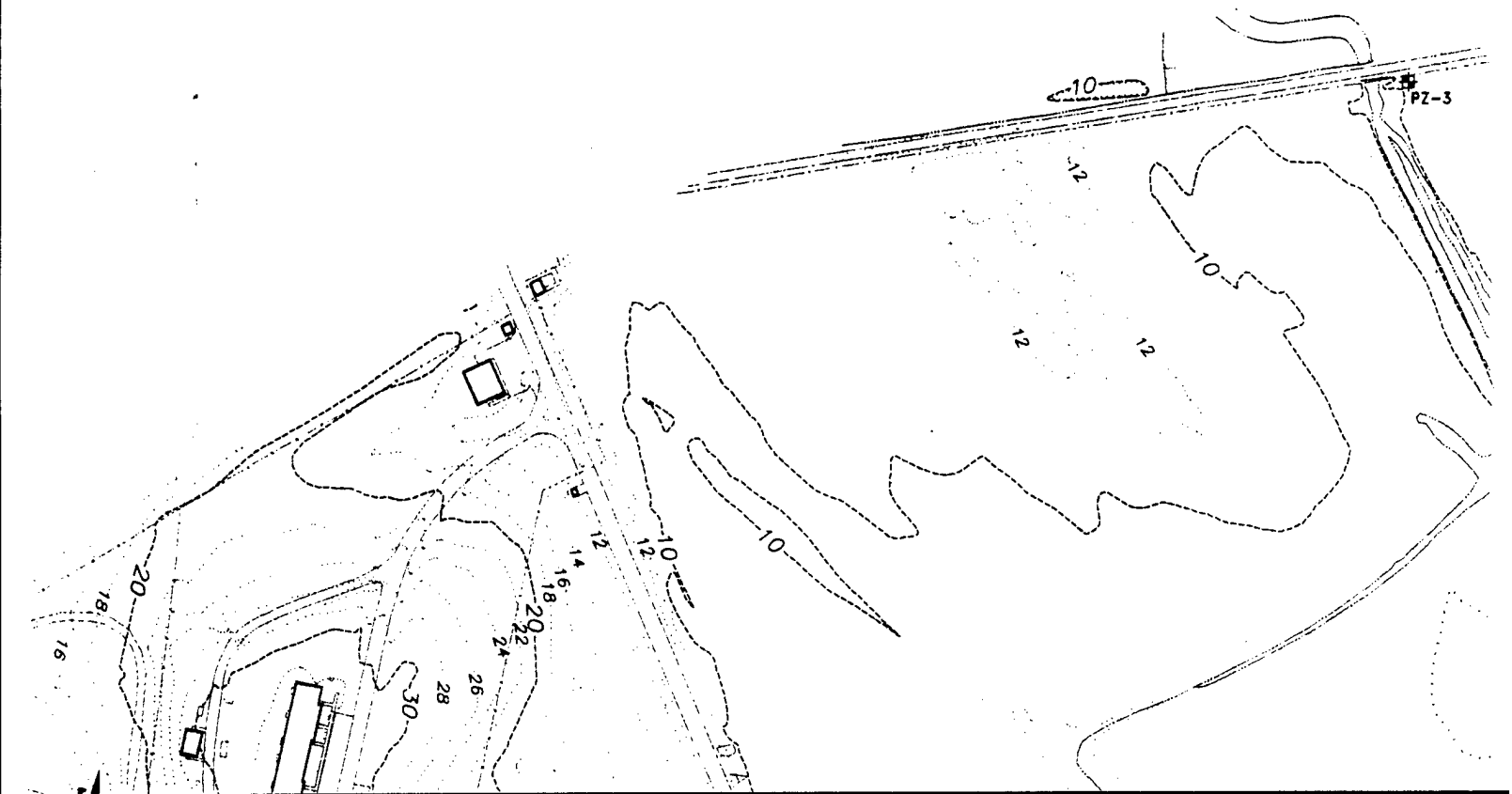
US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064	Figure 2-1 WOODBRIDGE RESEARCH FACILITY
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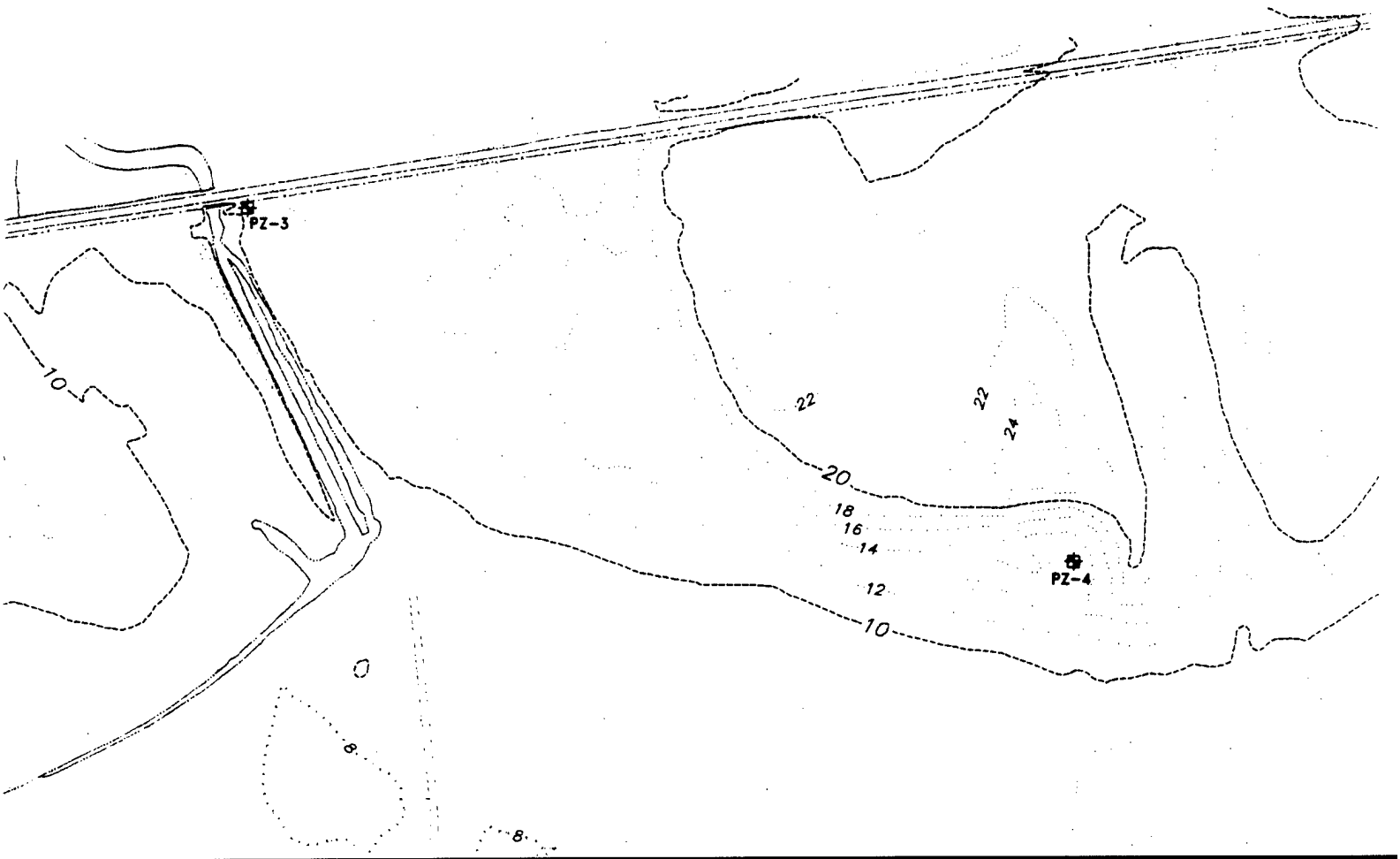
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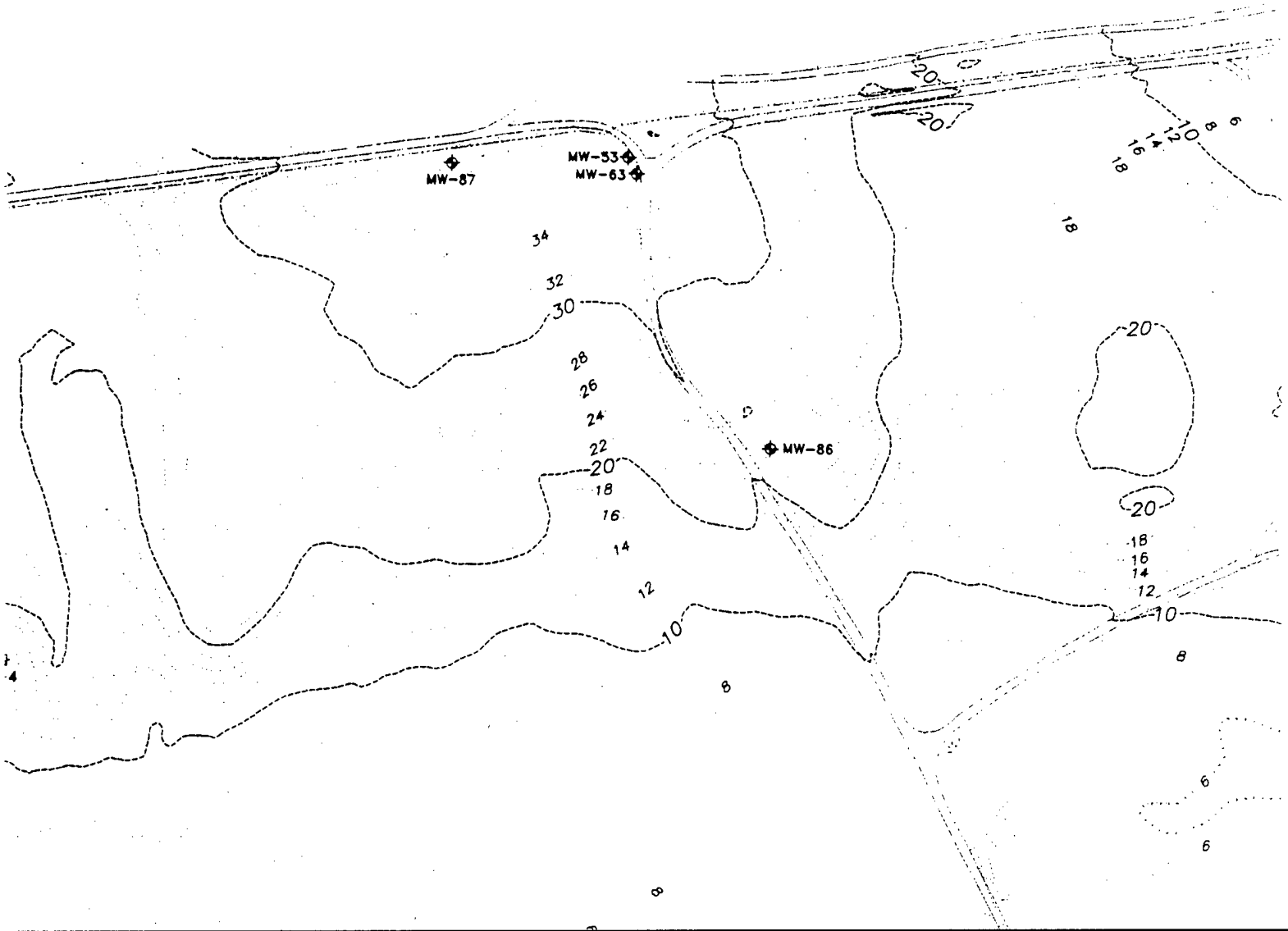
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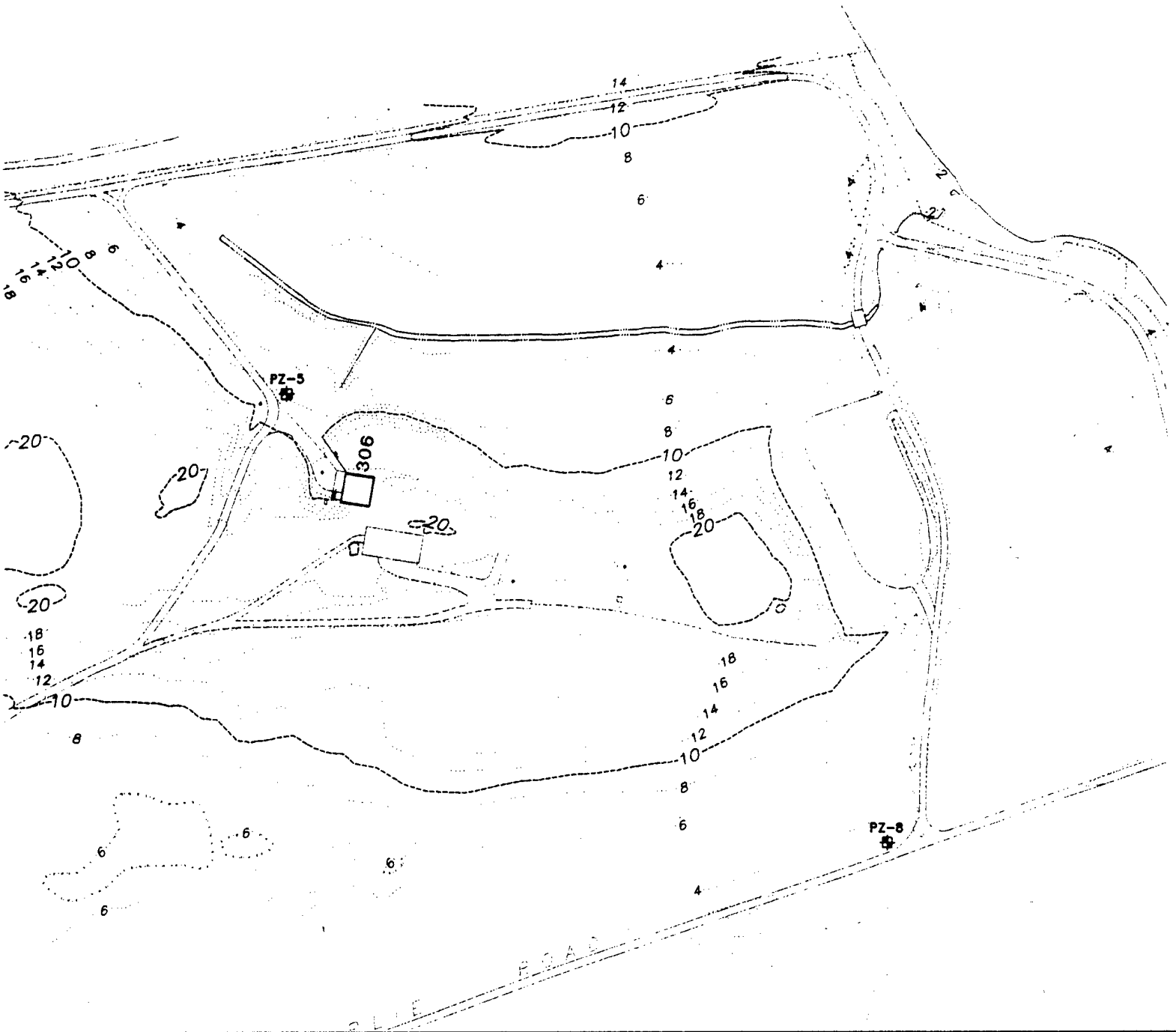
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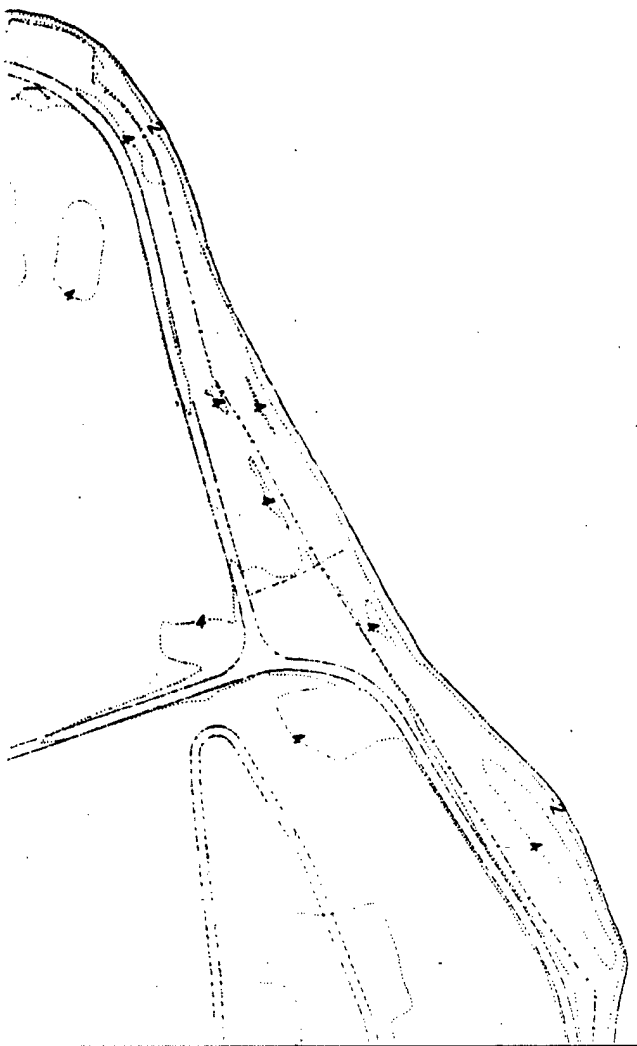
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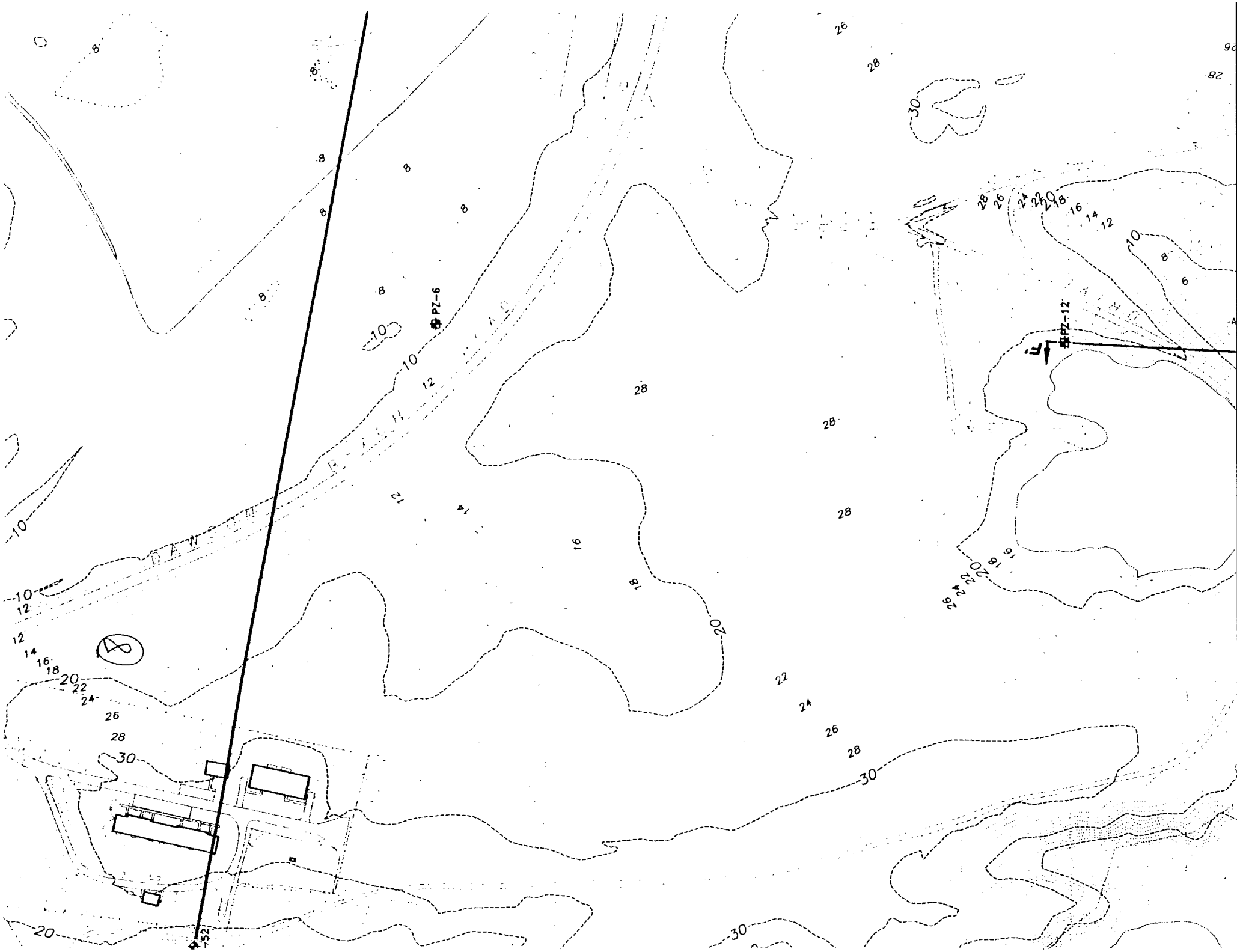
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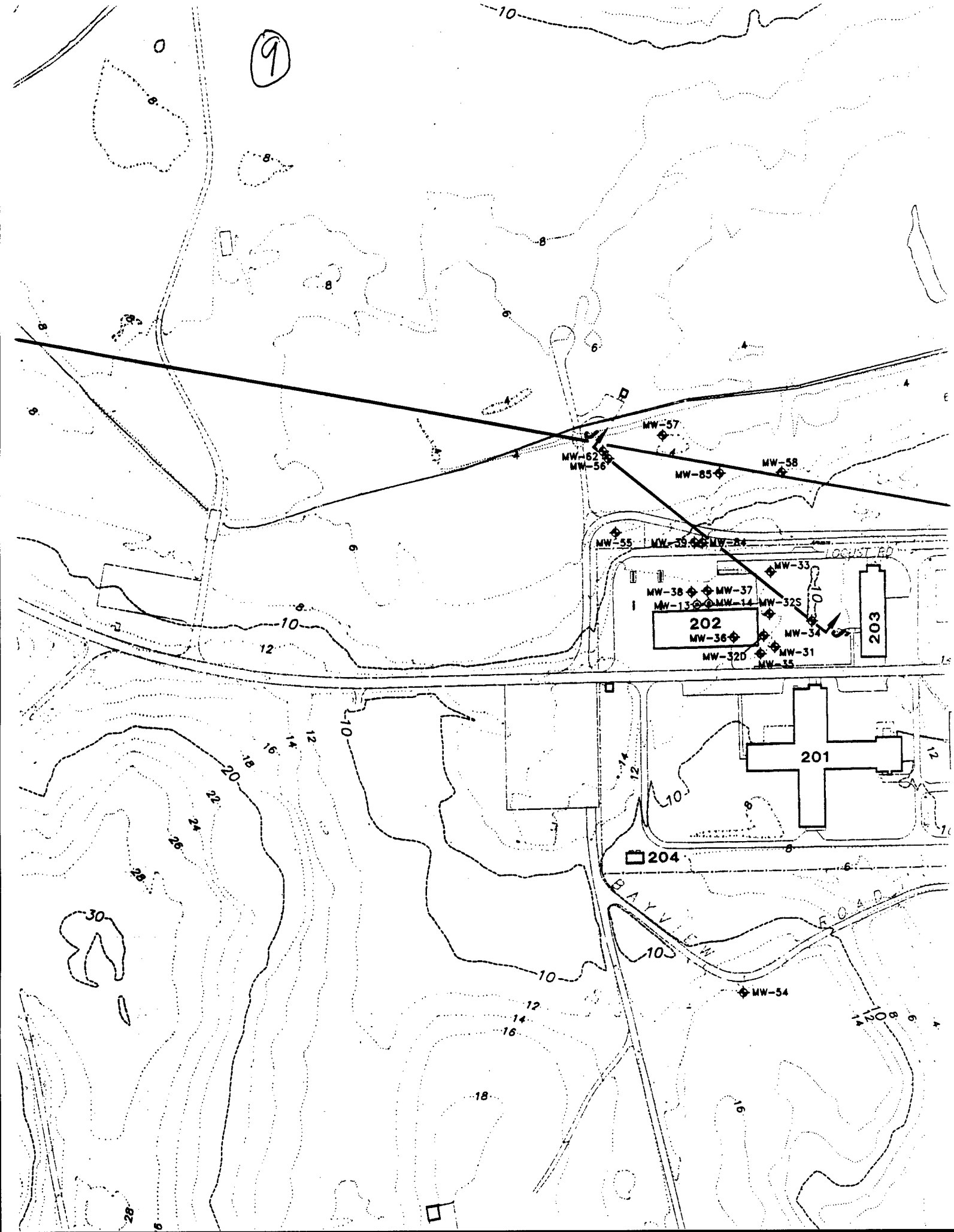


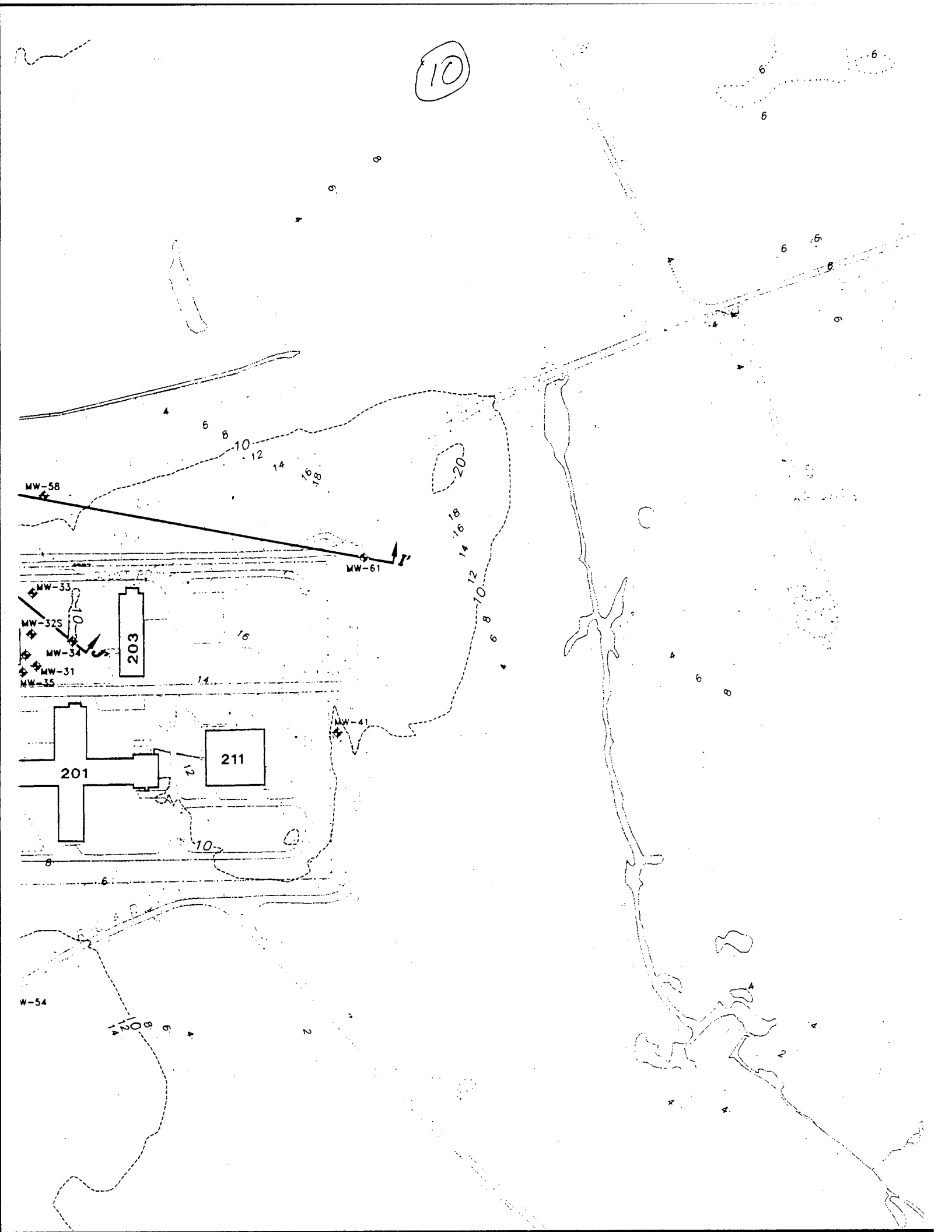
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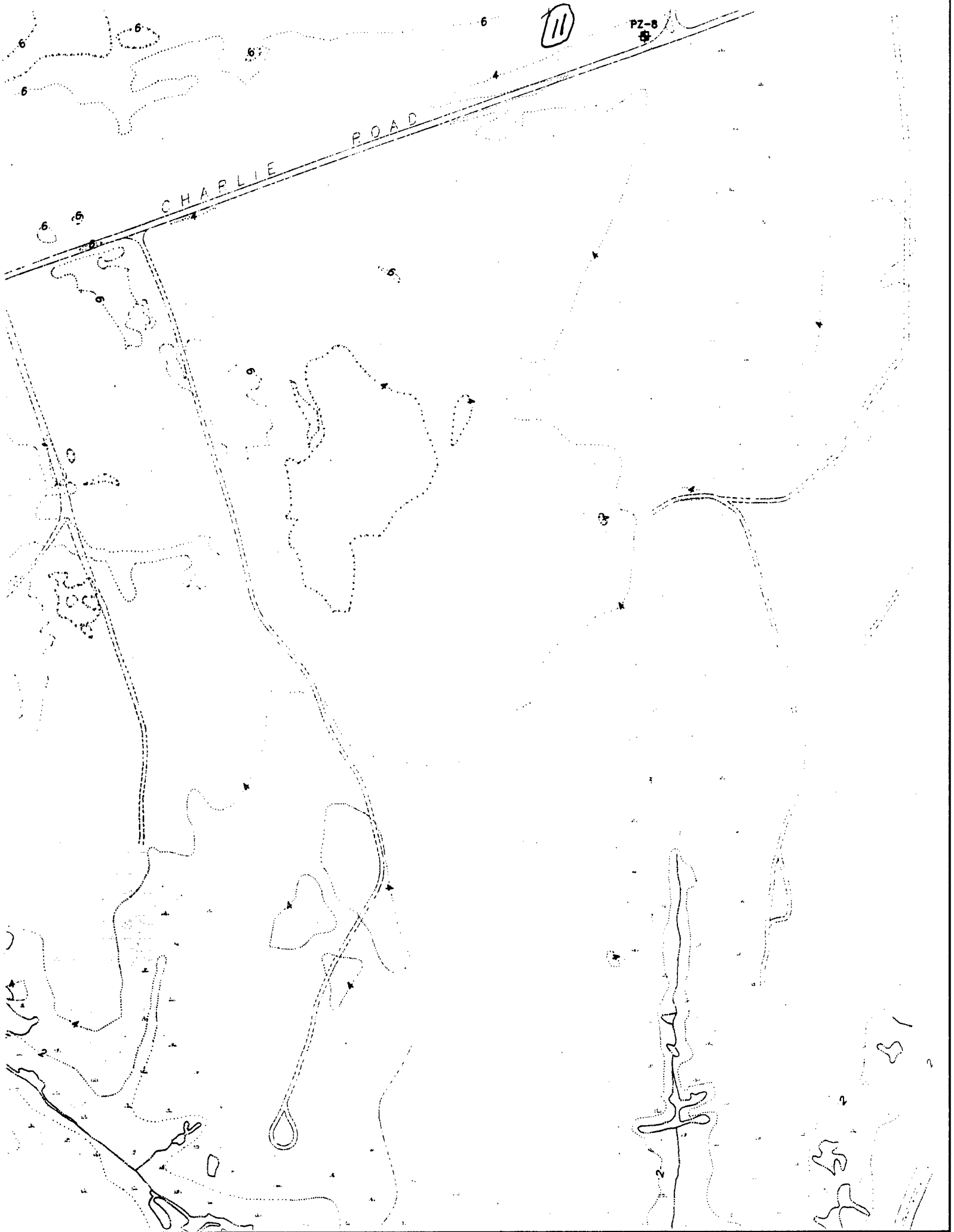


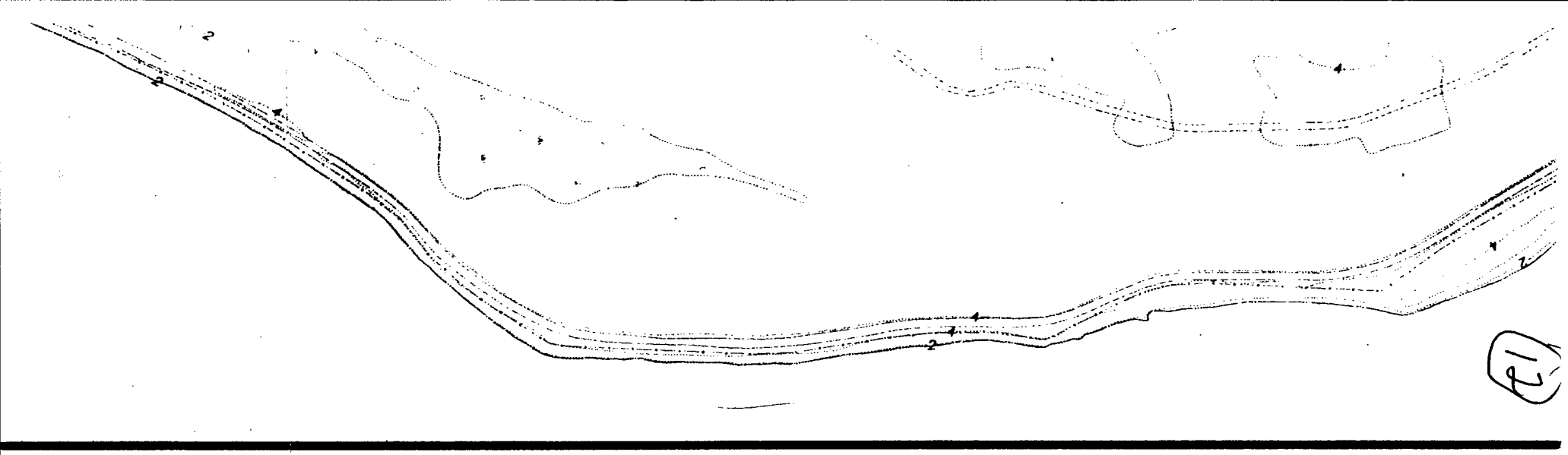
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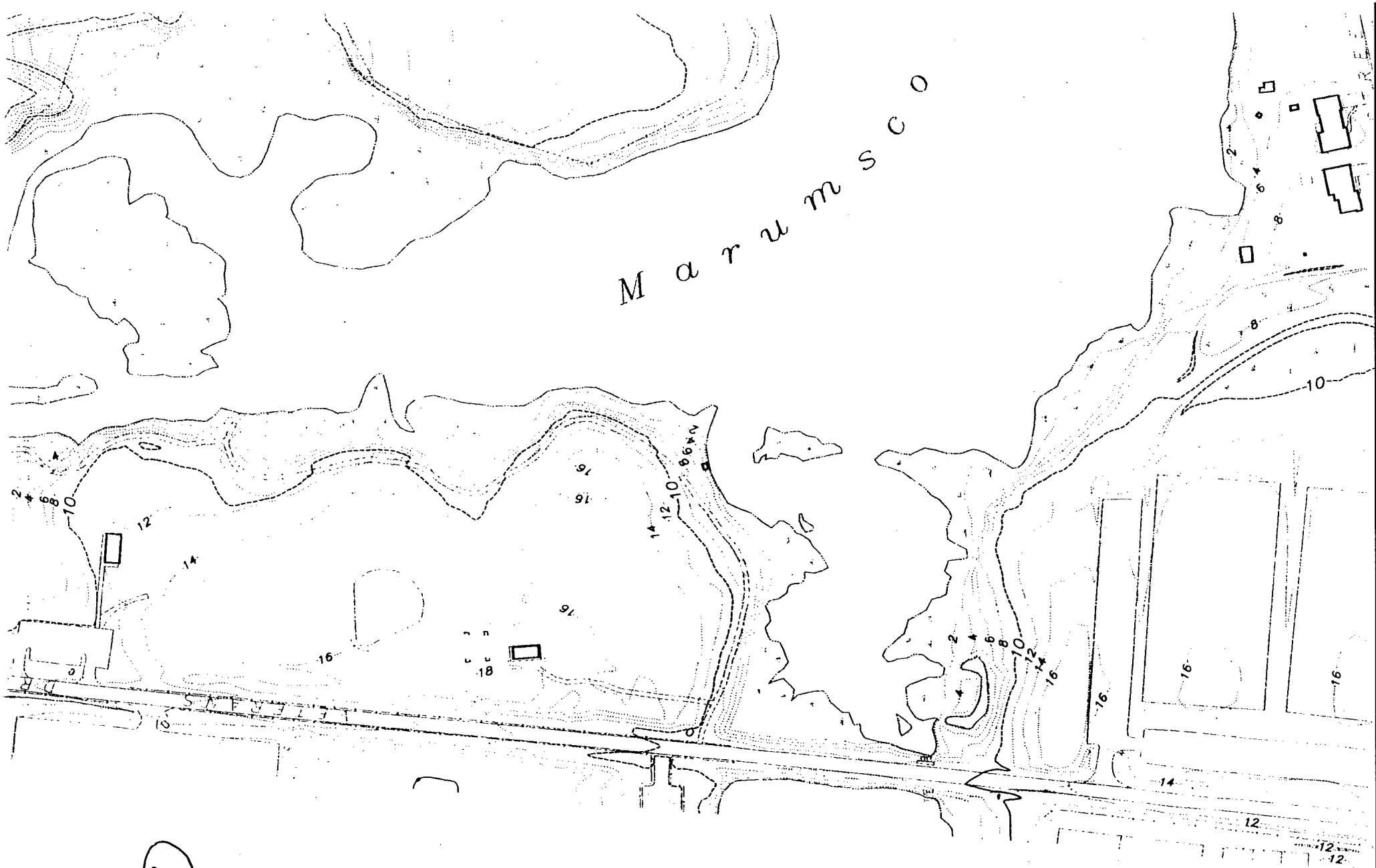

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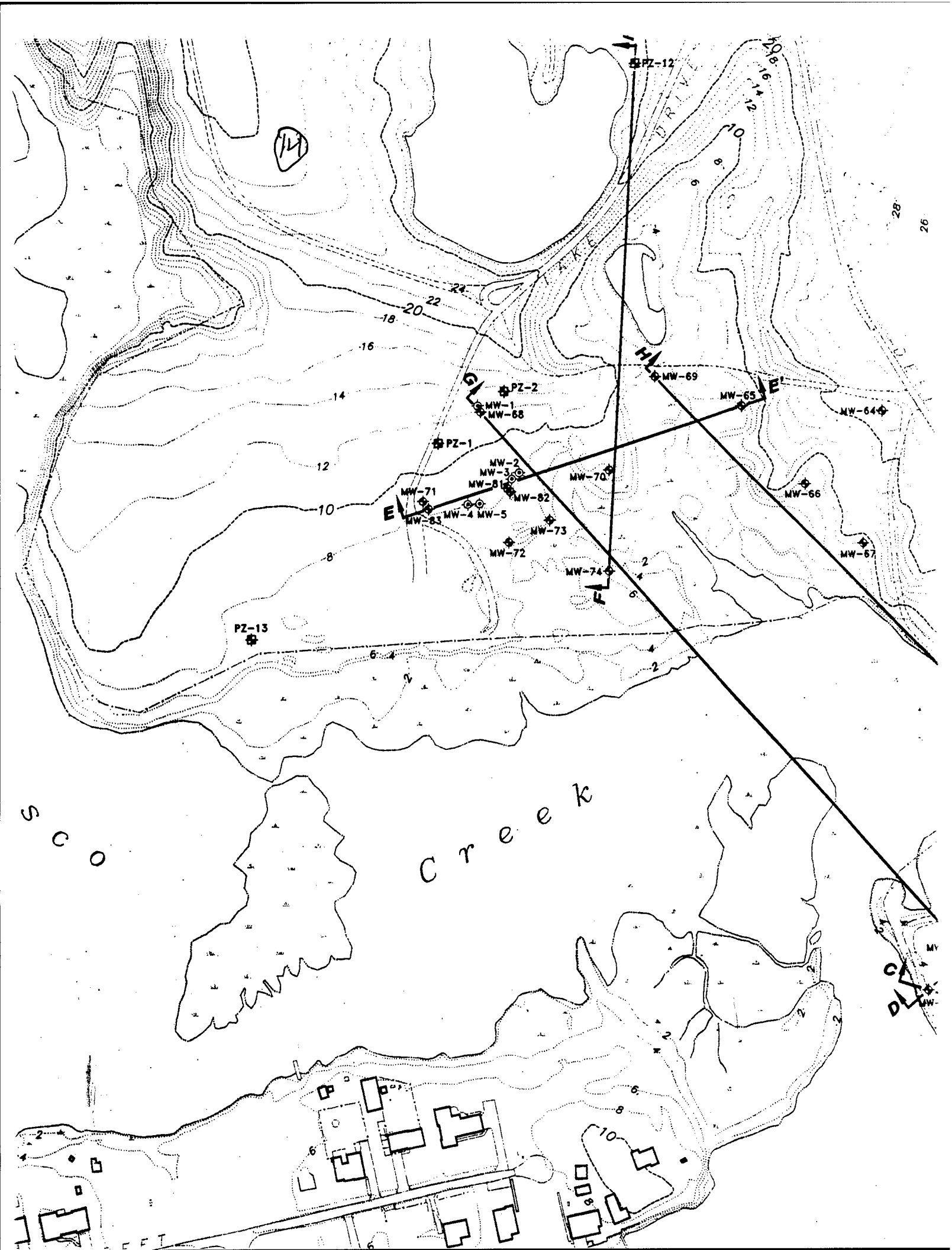

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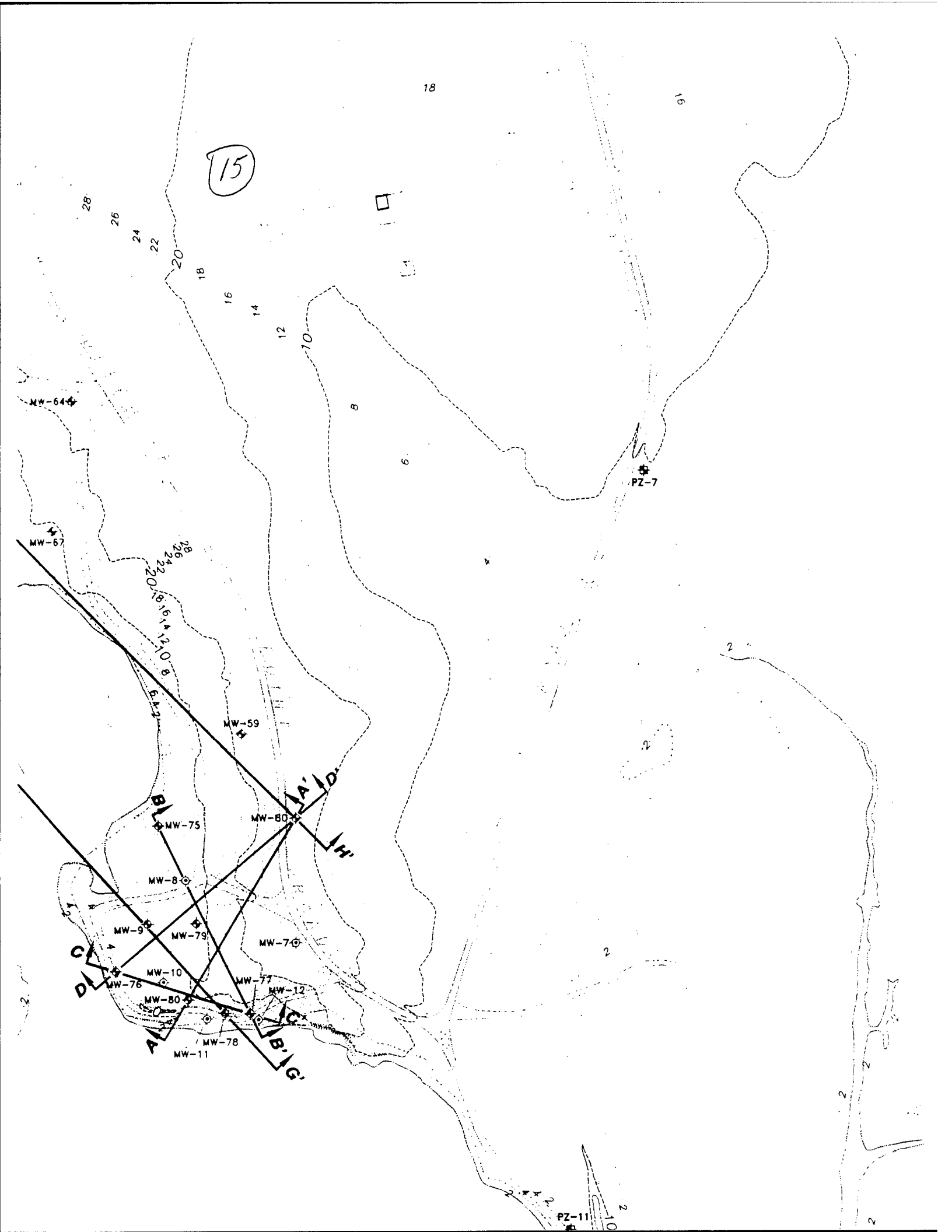

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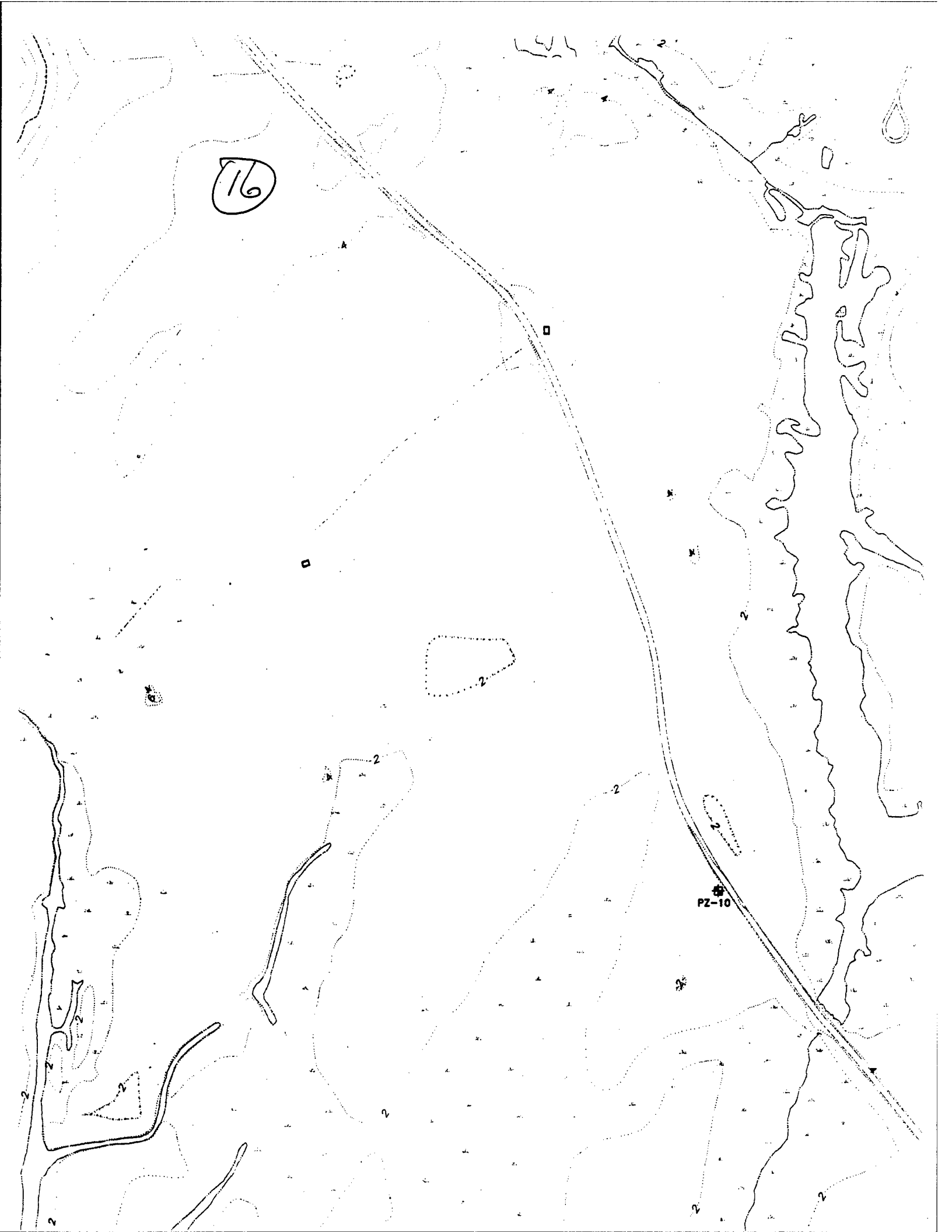




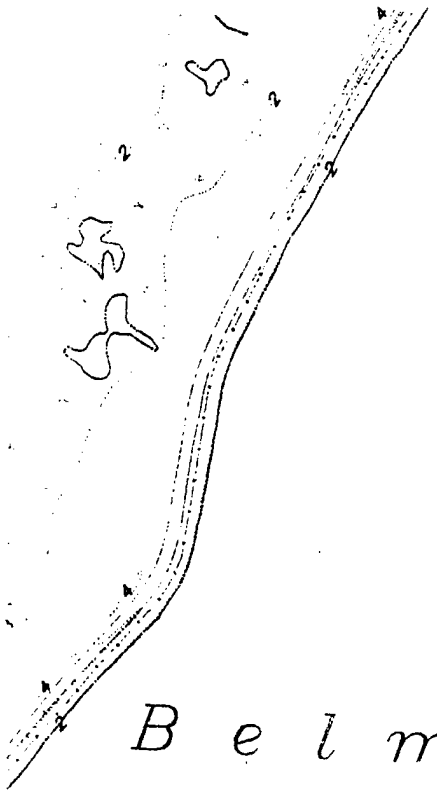
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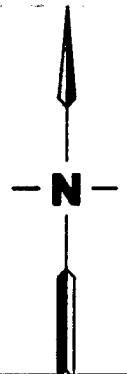
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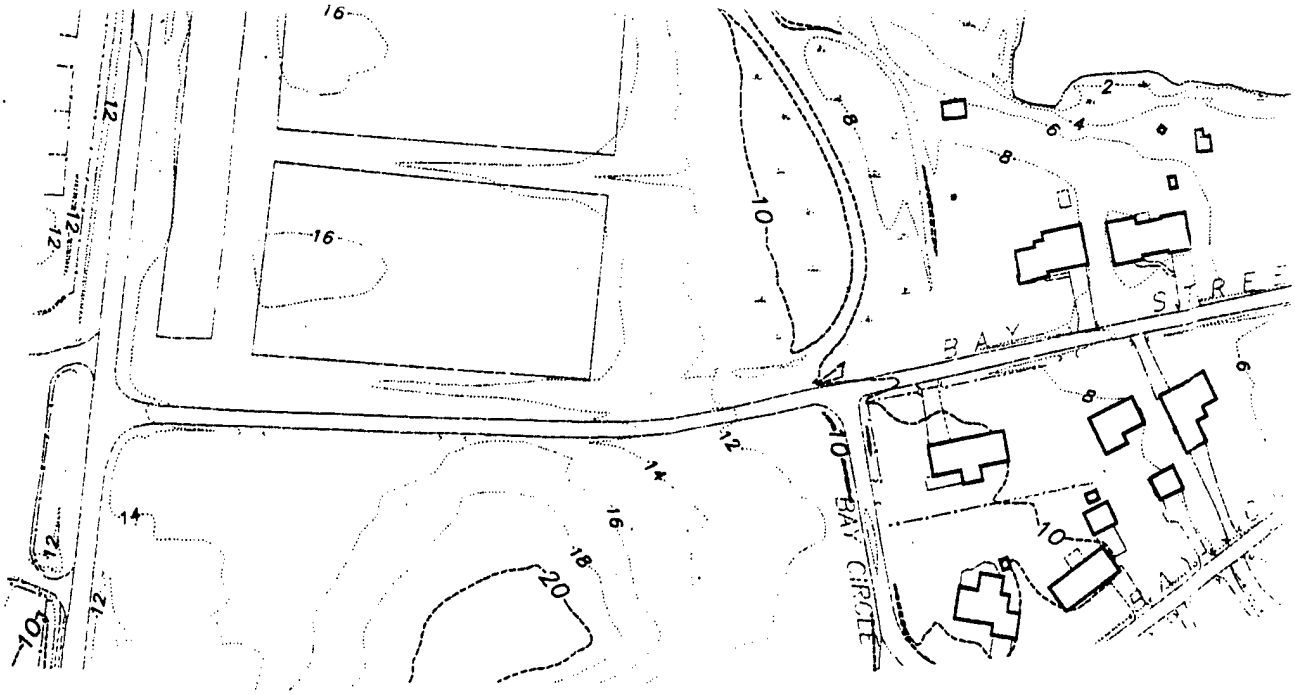
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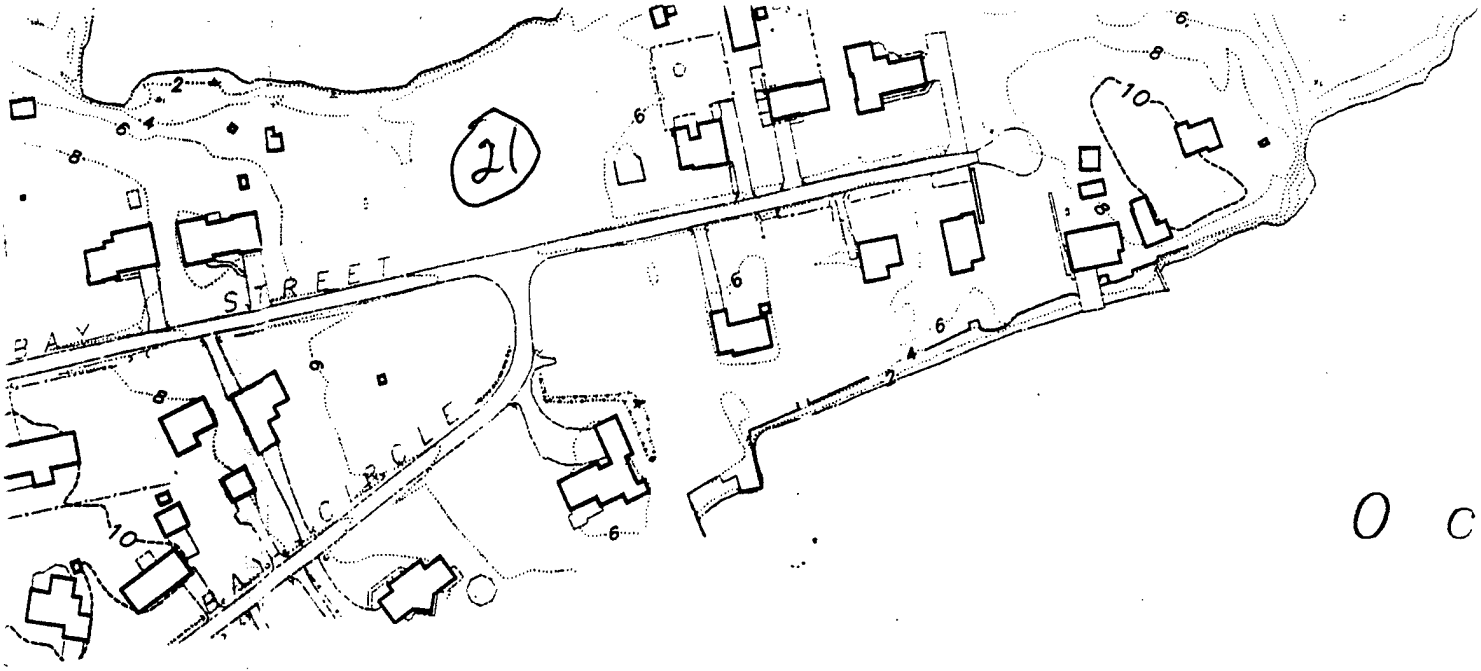
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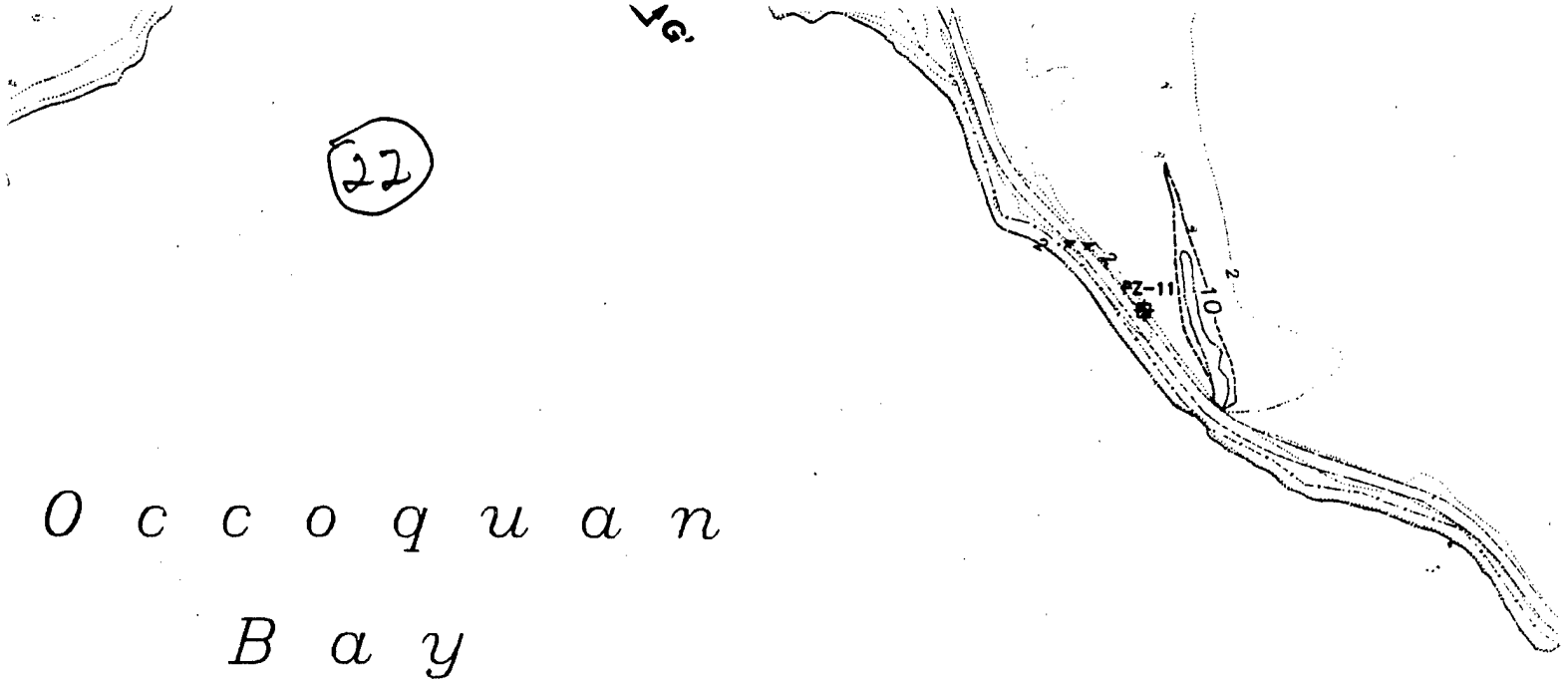
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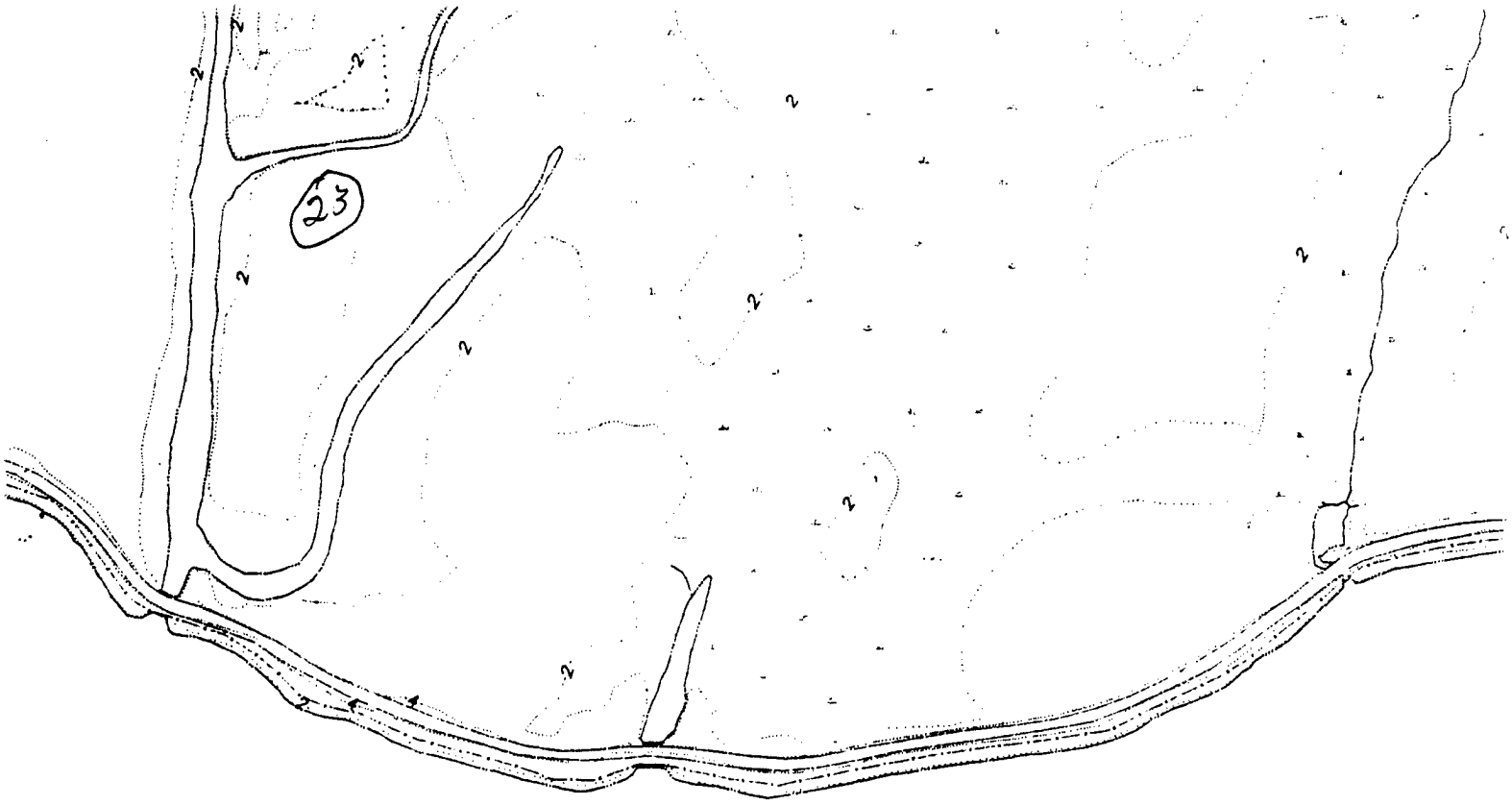
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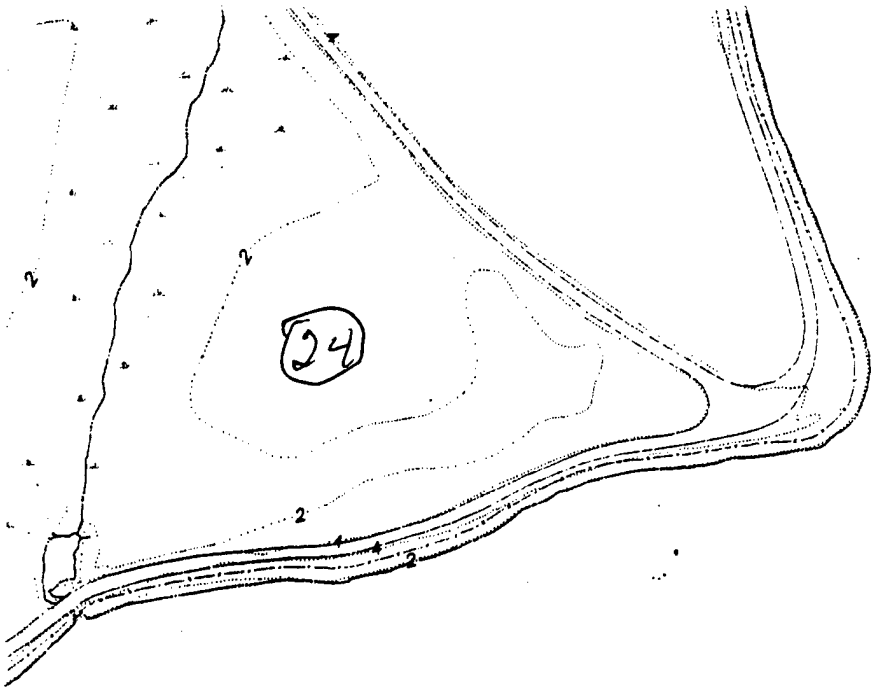
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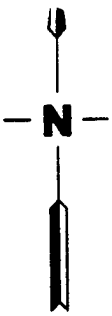


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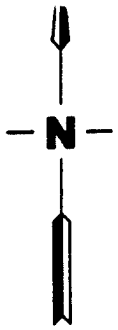
SCALE

US ARMY ENVIRONMENTAL

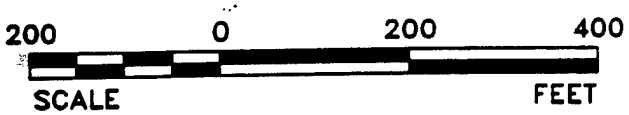
CONTRACT NO. DACA31-94-D-0064

ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: STE-TOPO
DATE 11-14-97	



26



US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

FIGURE 2-2

WOODBRIDGE RESEARCH FACILITY

ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST

CHECKED PT

DATE 11-14-97

TASK NO: 66220

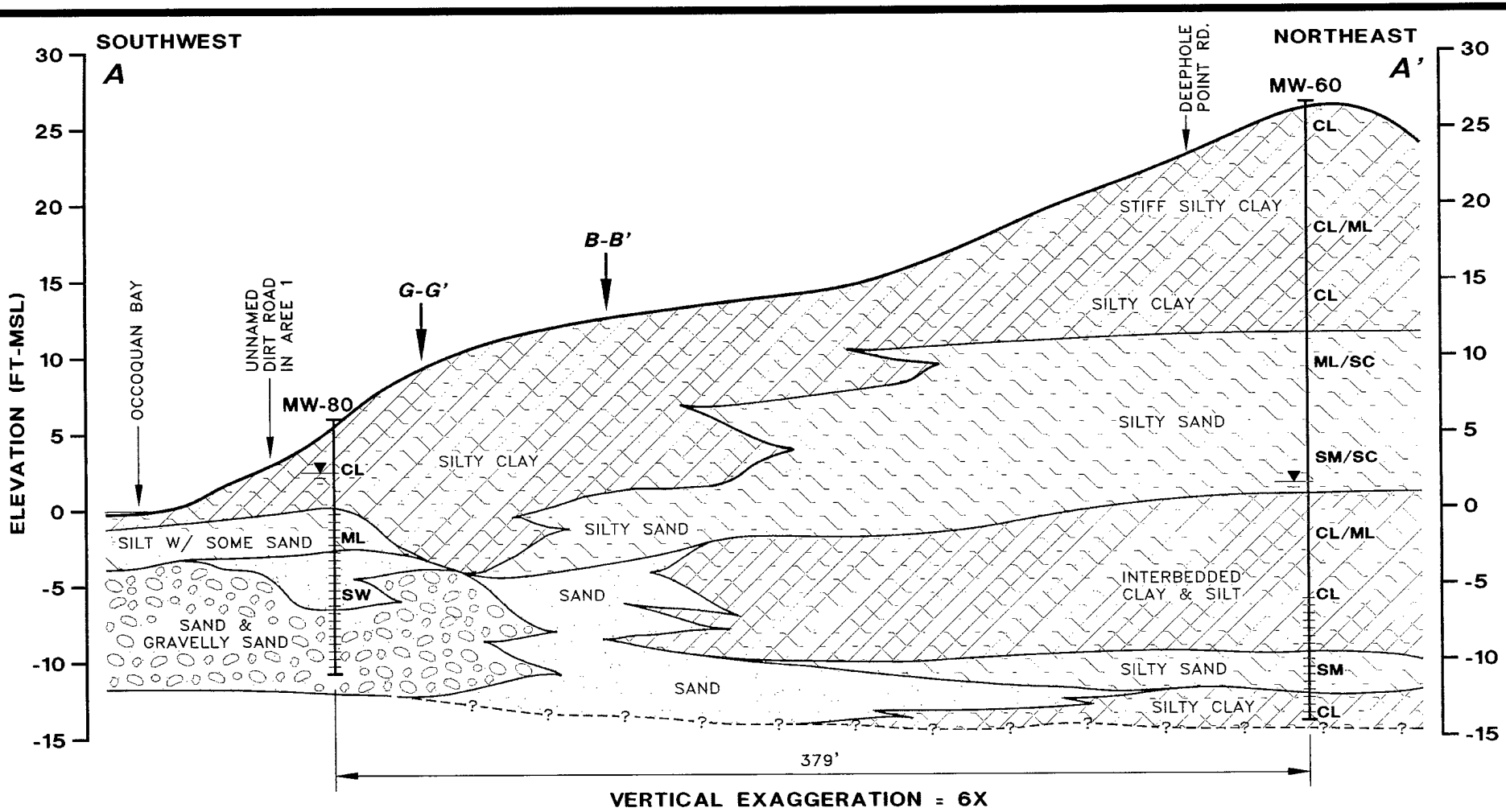
ICF DWG NO:

STE-TOPO

SITE-WIDE TOPOGRAPHIC CONTOUR MAP



FIGURE 2-3 - REGIONAL GEOLOGIC MAP
(Excerpt from Mixon, et al, 1989)
Scale = 1:250,000

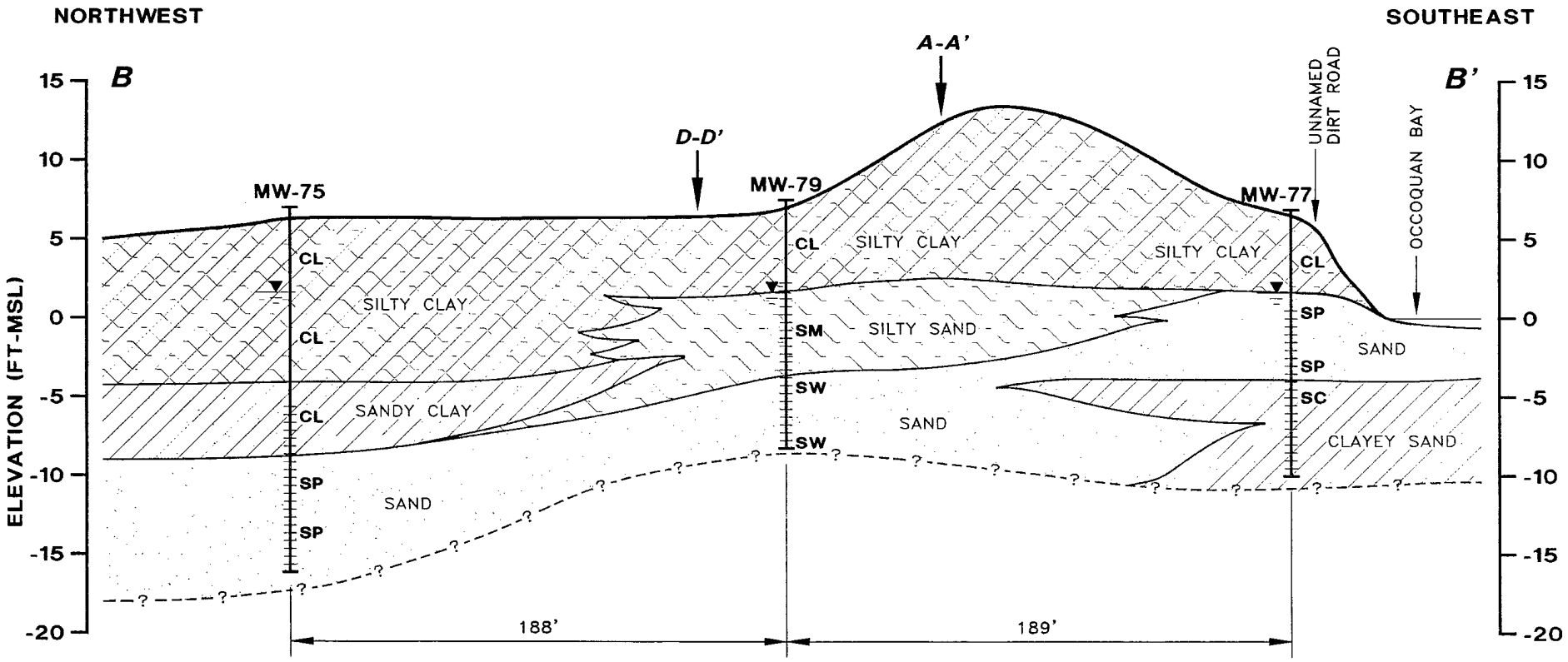


LEGEND:

- ▼ GROUNDWATER ELEVATION MEASURED JAN. 5, 1996
- GRAVEL
- SILT
- SAND
- CLAY

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064	FIGURE 2-4
	WOODBRIDGE RESEARCH FACILITY
ICF KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	GEOLOGIC CROSS SECTION A-A'
PREPARED CST / TASK NO: 66220	
CHECKED PT / ICF DWG NO: WRF-XSA	
DATE 11-14-97	



VERTICAL EXAGGERATION = 6X

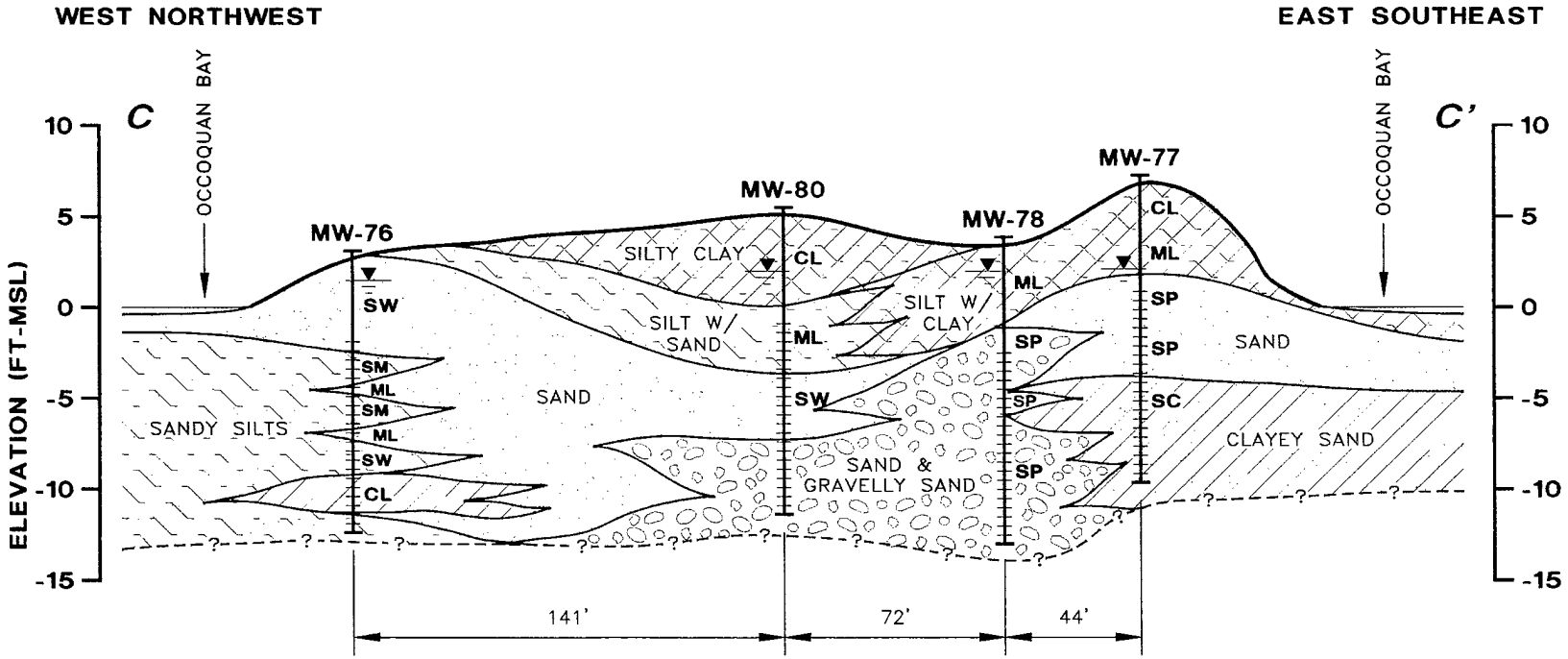
LEGEND:

▼ GROUNDWATER ELEVATION MEASURED JAN. 5, 1996

GRAVEL
SILT
SAND
CLAY

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064	FIGURE 2-5
ICF KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESEARCH FACILITY
PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: WRF-XSB
DATE 11-14-97	GEOLOGIC CROSS SECTION B-B'



VERTICAL EXAGGERATION = 6X

LEGEND:

GROUNDWATER ELEVATION MEASURED JAN. 5, 1996

GRAVEL

SILT

SAND

CLAY

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

FIGURE 2-6

WOODBRIDGE RESEARCH FACILITY

ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST

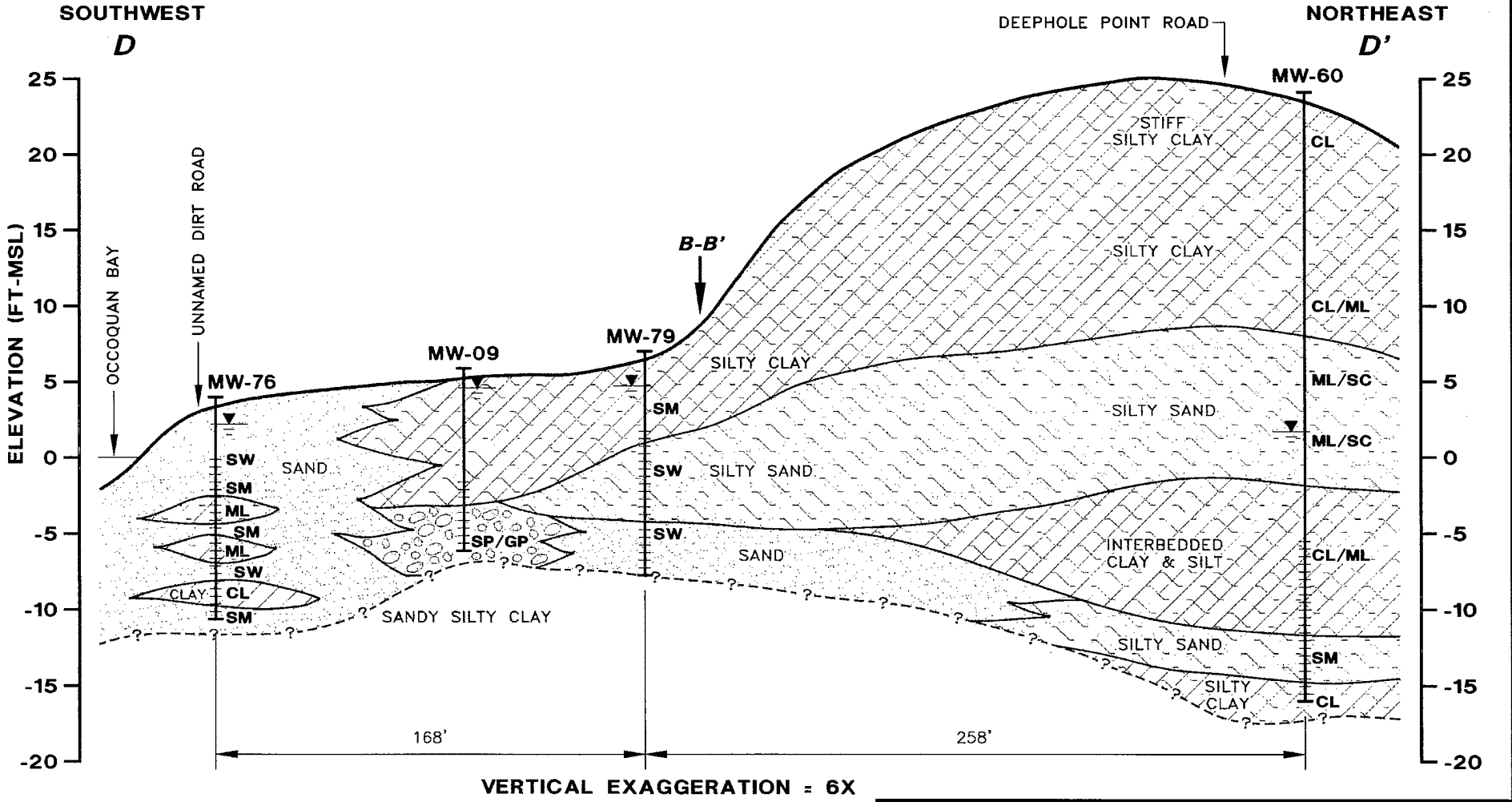
TASK NO: 66220

CHECKED PT

ICF DWG NO: WRF-XSC

DATE 11-14-97

GEOLOGIC CROSS SECTION C-C'



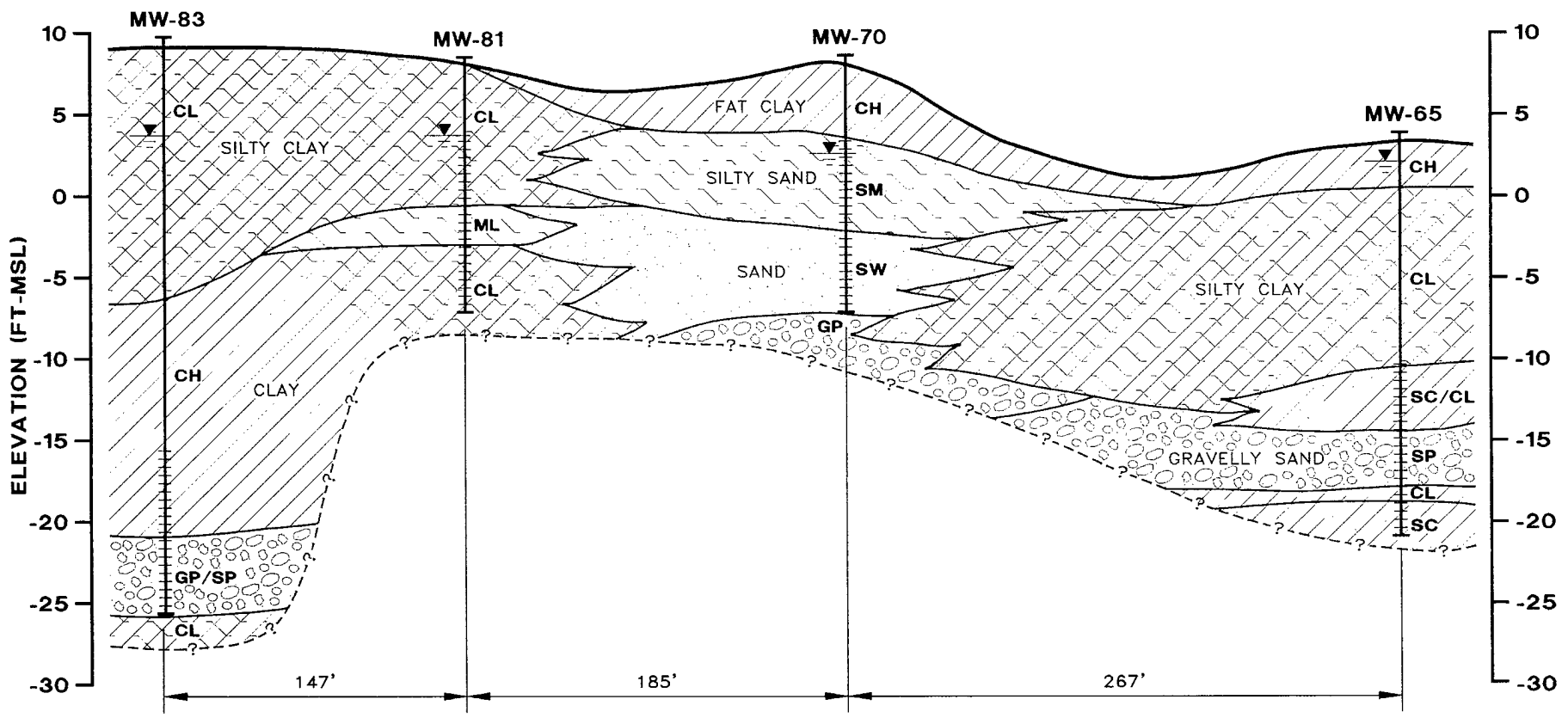
LEGEND:

▼ GROUNDWATER ELEVATION MEASURED JAN. 5, 1996

GRAVEL
SILT
SAND
CLAY

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064	FIGURE 2-7
	WOODBRIDGE RESEARCH FACILITY
ICF KAISER — 2113 Emmorton Park Drive, Suite 100, Edgewood, Maryland 21040, (410) 612-6350	GEOLOGIC CROSS SECTION D-D'
PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: WRF-XSL
DATE 11-14-97	



VERTICAL EXAGGERATION = 8X

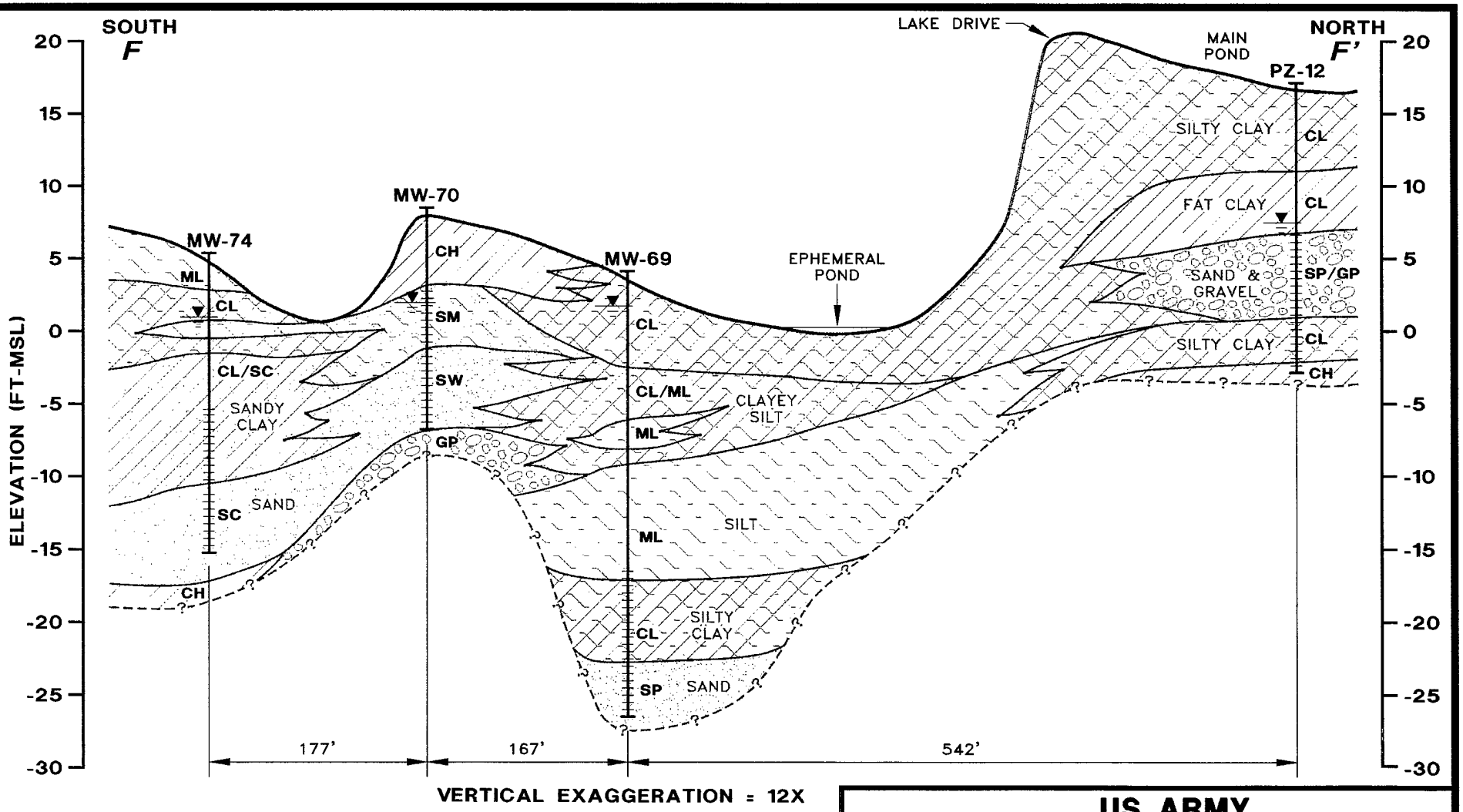
LEGEND:

GROUNDWATER ELEVATION MEASURED JAN. 5, 1996

GRAVEL | SILT | SAND | CLAY

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064	FIGURE 2-8
	WOODBRIDGE RESEARCH FACILITY
ICF KAISER — 2113 Emmorton Park Drive, Suite 100, Edgewood, Maryland 21040, (410) 612-6350	GEOLOGIC CROSS SECTION E-E'
PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: WRF-XSE
DATE 11-14-97	



LEGEND:

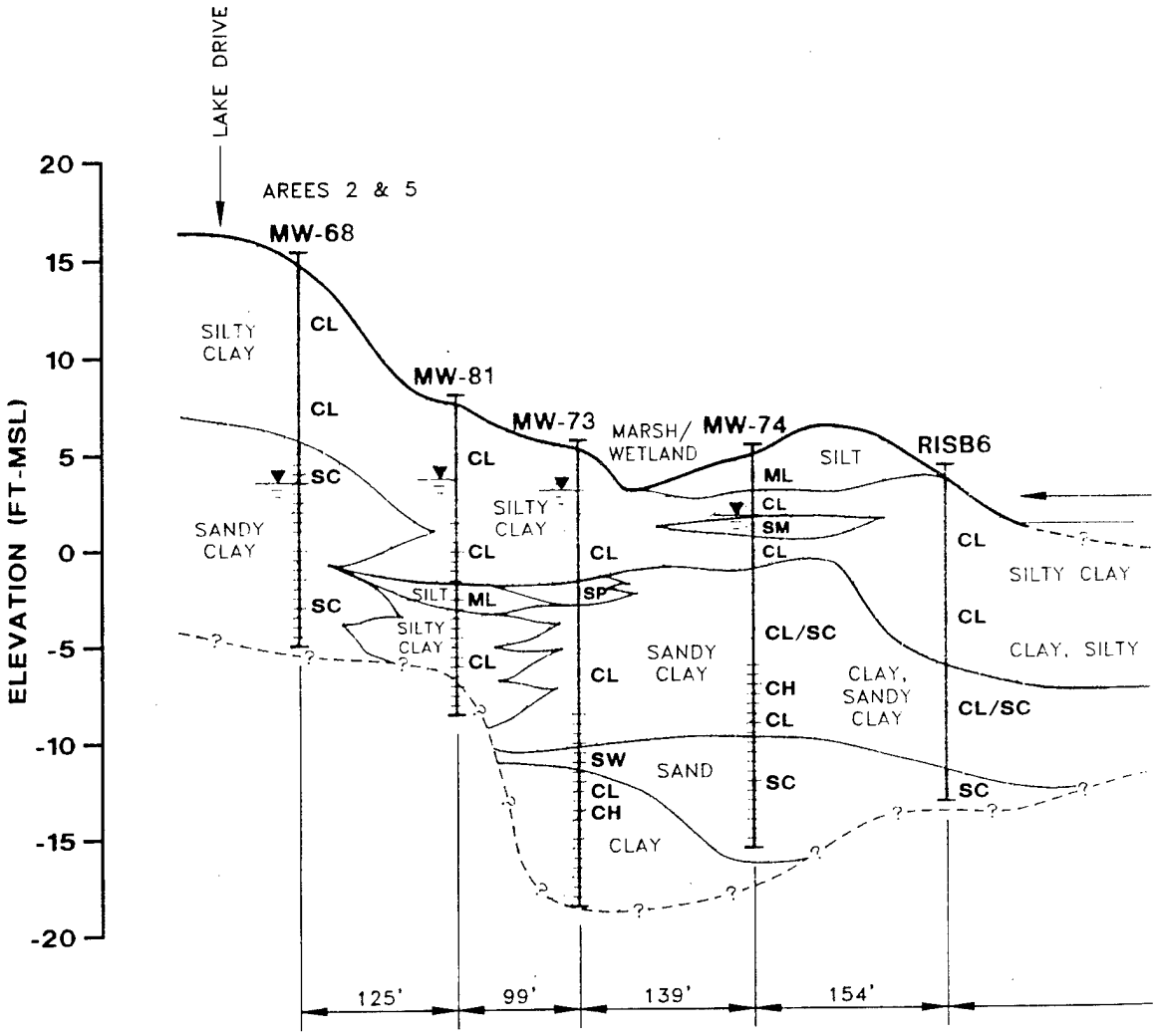
- GROUNDWATER ELEVATION MEASURED JAN. 5, 1996
- GRAVEL
- SILT
- SAND
- CLAY

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064	FIGURE 2-9
ICF KAISER — 2113 Emmorton Park Drive, Suite 100, Edgewood, Maryland 21040, (410) 612-6350	WOODBRIDGE RESEARCH FACILITY
PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: WRF-XSF
DATE 11-14-97	GEOLOGIC CROSS SECTION F-F'

NORTHWEST

G



VERTICAL

LEGEND:

GROUNDWATER ELEVATION MEASURED JAN. 5, 1996

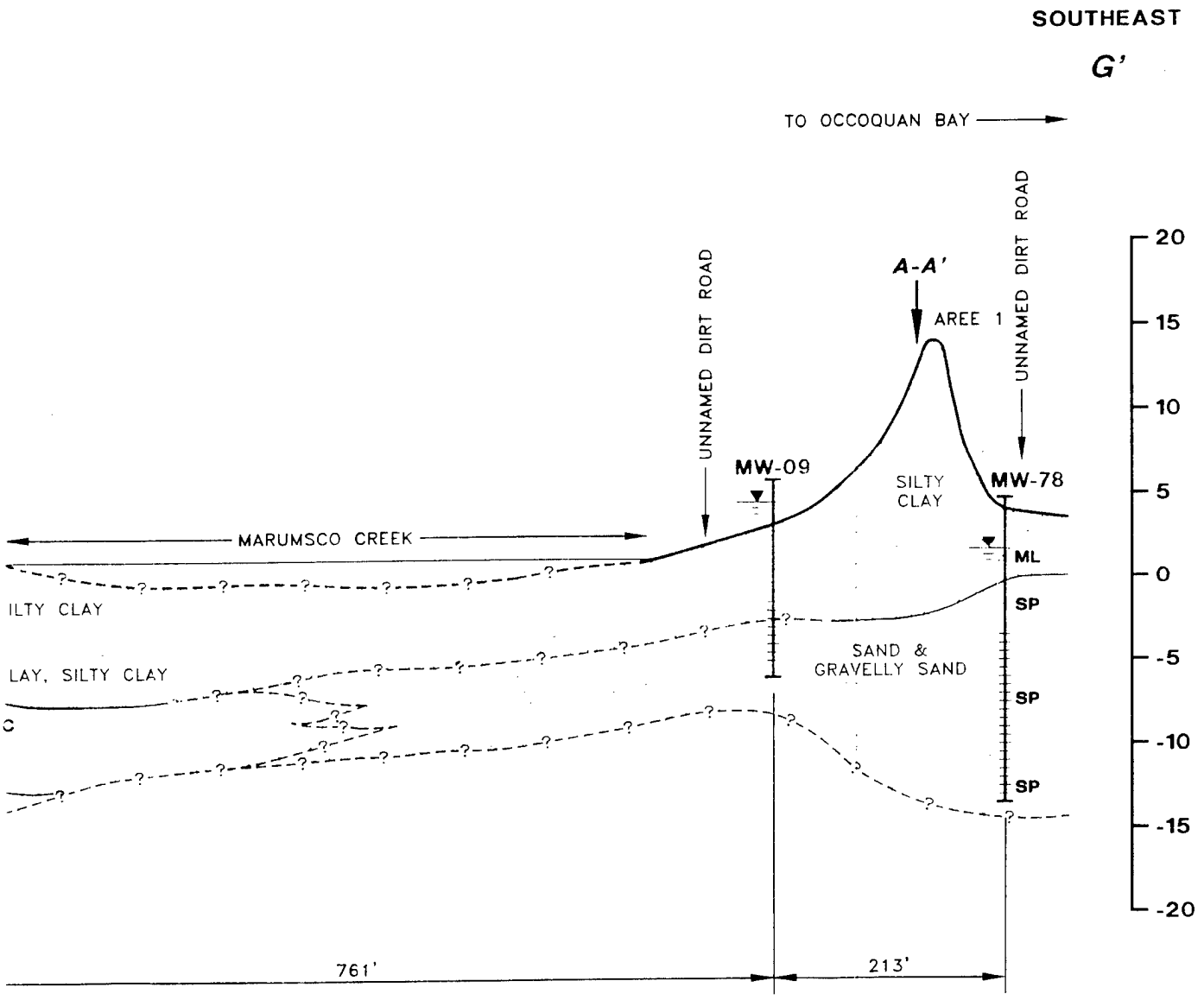
GRAVEL

SILT

SAND

CLAY

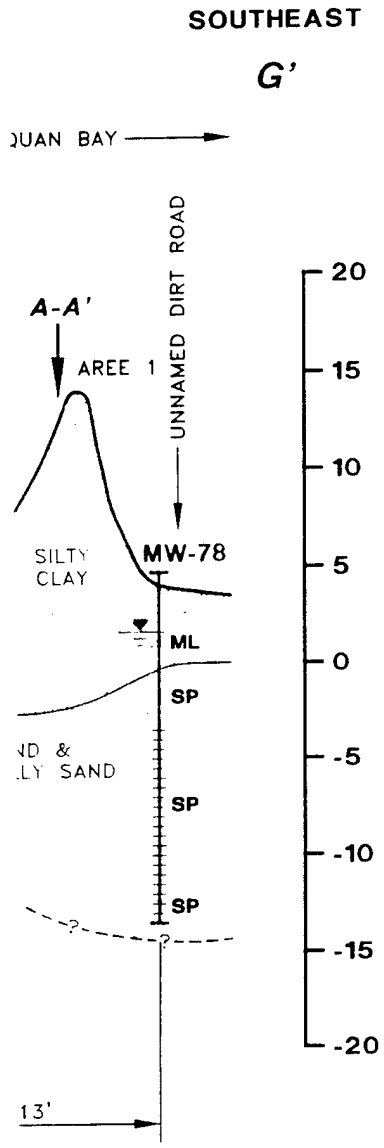
(1)



/ERTICAL EXAGGERATION = 15X

US ARMY ENVIRONMENTAL CENTER		
CONTRACT NO. DACA31-94-D-0064		FIGURE 2- WOODBRIDGE RESEARCH
ICF KAISER	2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	GEOLOGI CROSS SEC G-G'
PREPARED CST	TASK NO: 66220	
CHECKED PT	ICF DWG NO: WRF-XSM	
DATE 11-17-97		

(2)

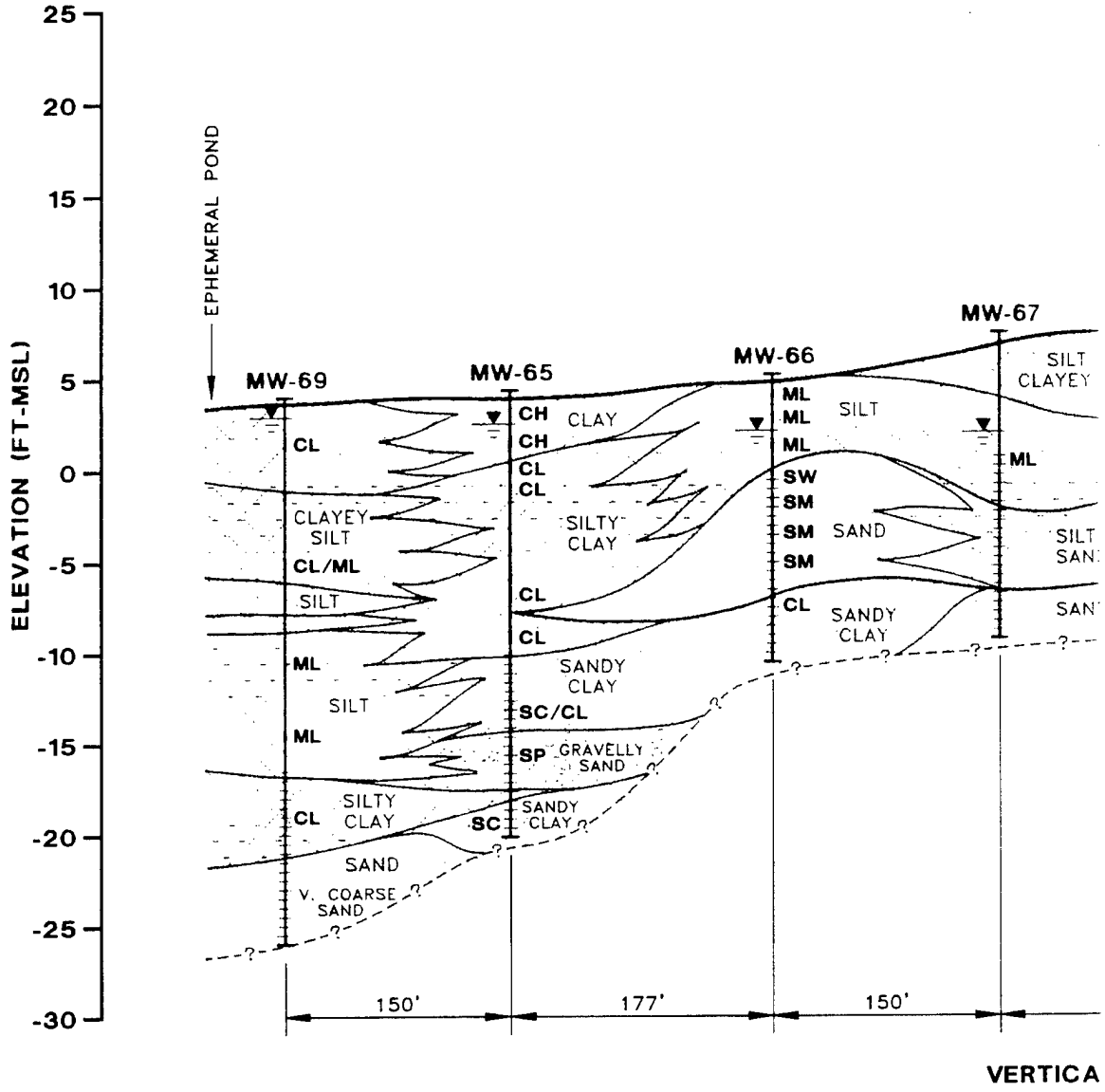


US ARMY
ENVIRONMENTAL CENTER

)O. DACA31-94-D-0064	FIGURE 2-10
	WOODBRIDGE RESEARCH FACILITY
ISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	GEOLOGIC CROSS SECTION G-G'
TASK NO: 66220	
ICF DWG NO: WRF-XSM	
-97	

NORTHWEST

H



LEGEND:

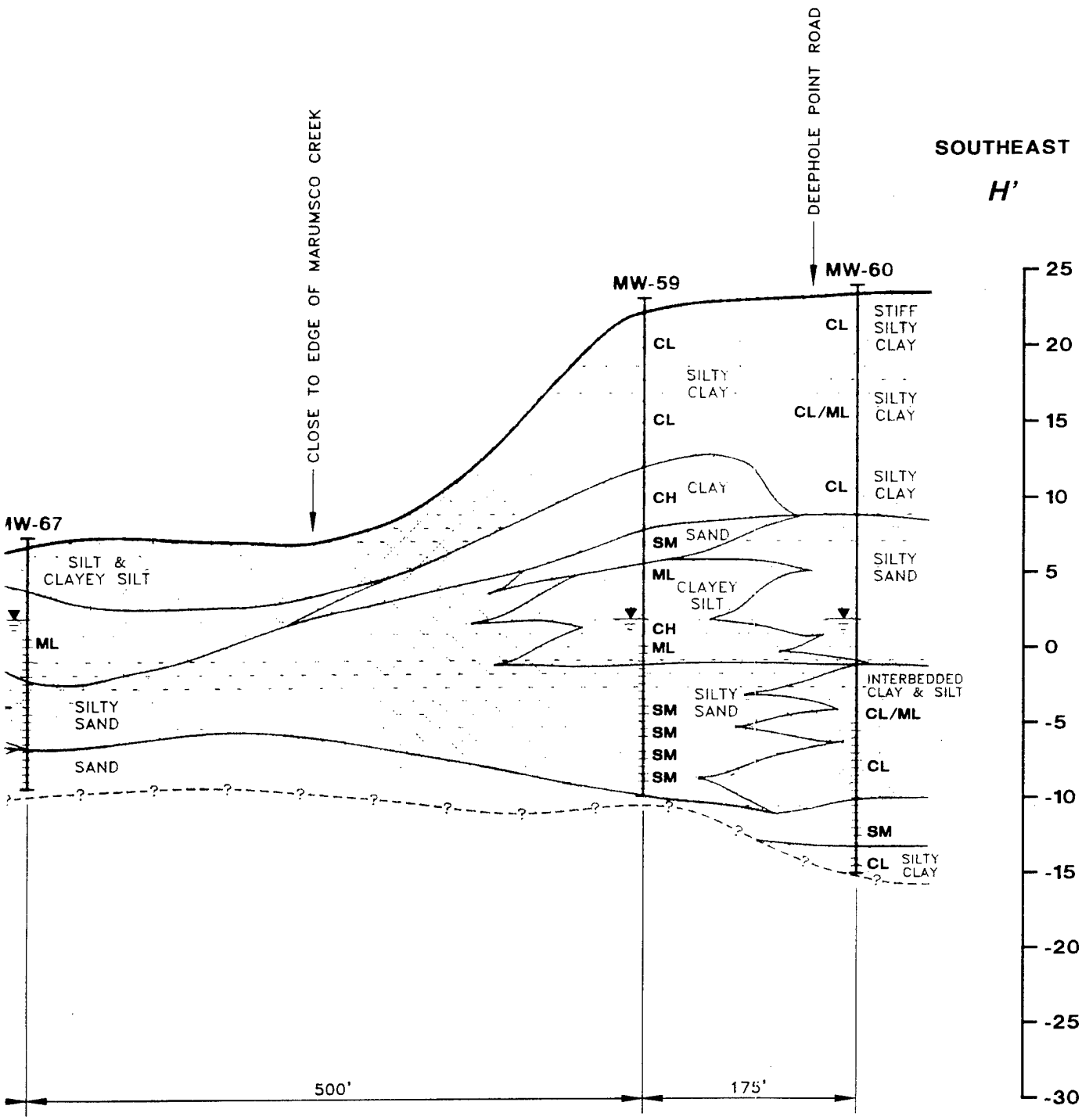
GROUNDWATER ELEVATION MEASURED JAN. 5, 1996

GRAVEL

SILT

SAND

CLAY

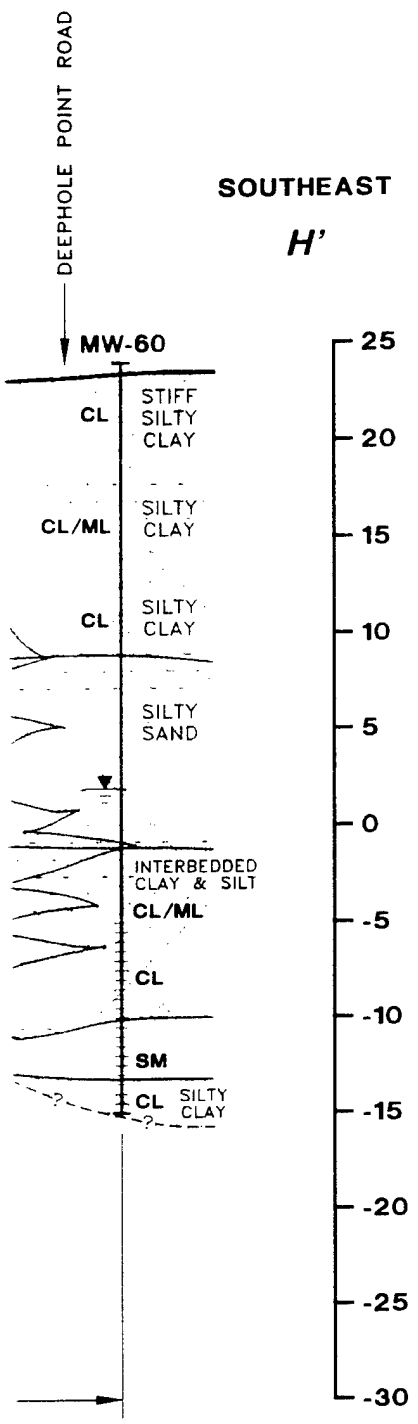


VERTICAL EXAGGERATION = 12X

US ARMY ENVIRONMENTAL CENTER

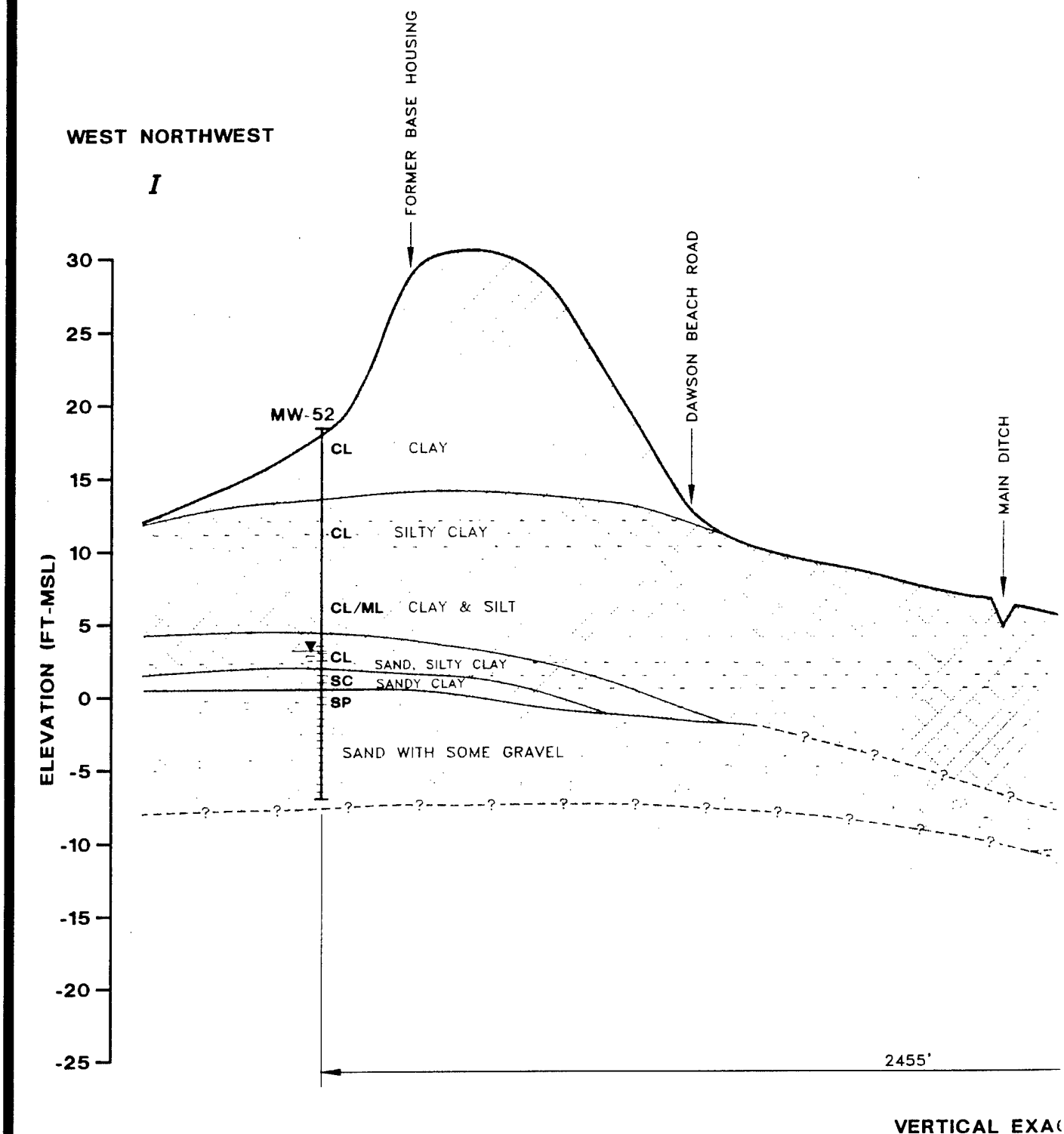
CONTRACT NO. DACA31-94-D-0064	FIGURE 2-1
ICF KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESEARCH
PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: WRF-XSN
DATE 11-14-97	GEOLOGI CROSS SEC H-H'

(2)



US ARMY ENVIRONMENTAL CENTER

T NO. DACA31-94-D-0064	FIGURE 2-11
KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESEARCH FACILITY
CST	TASK NO: 66220
PT	ICF DWG NO: WRF-XSN
14-97	GEOLOGIC CROSS SECTION H-H'



LEGEND:

▼ GROUNDWATER ELEVATION MEASURED JAN. 5, 1996

GRAVEL

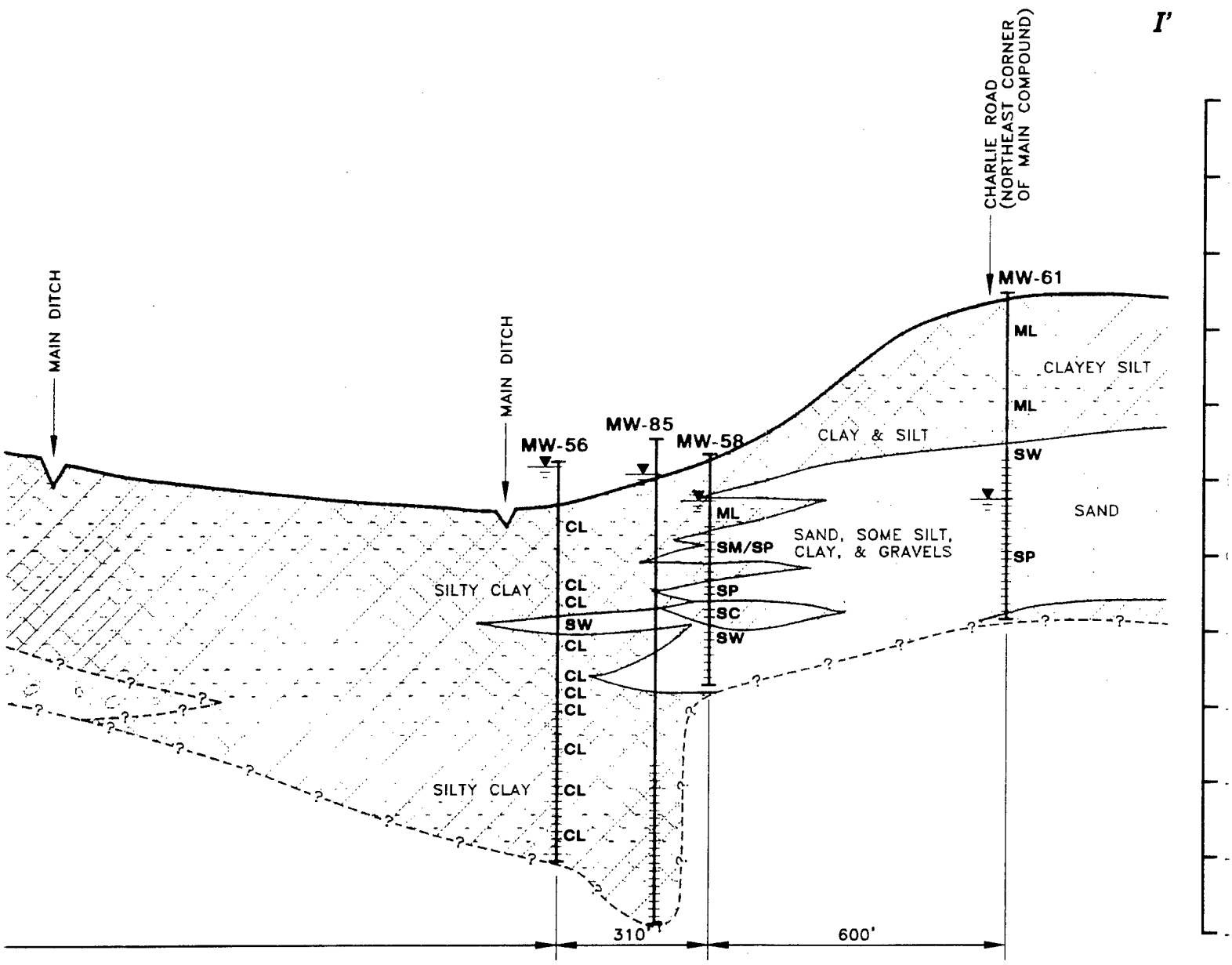
SILT

SAND

CLAY

EAST SOUTHEA

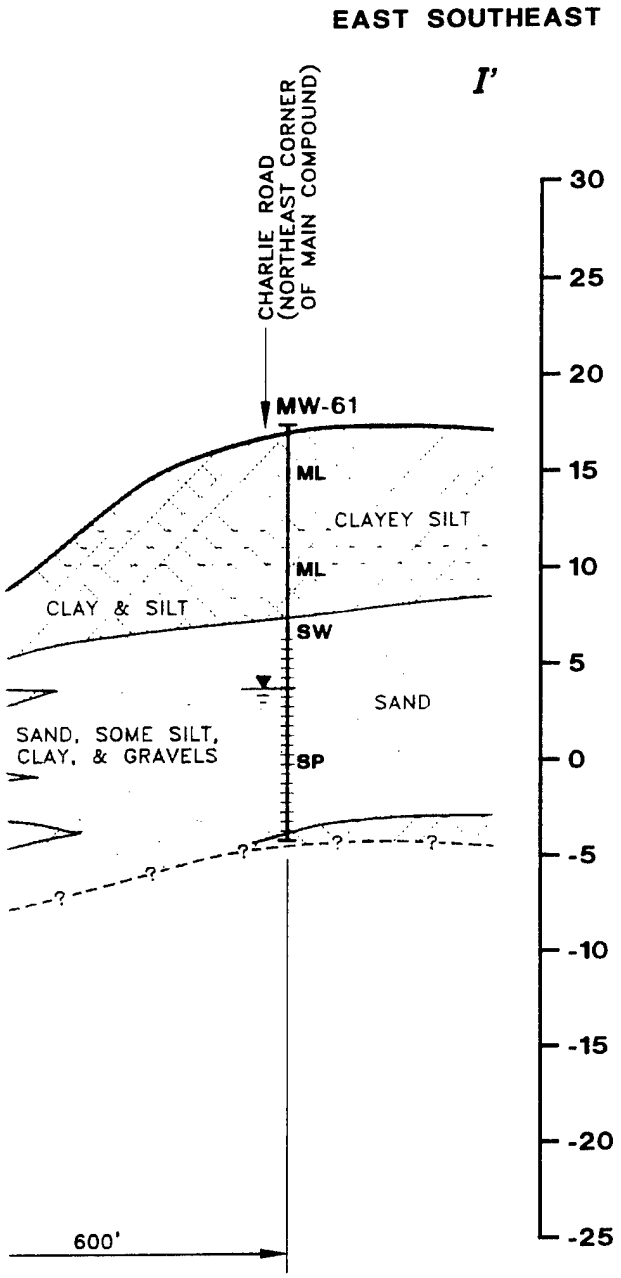
I'



CAL EXAGGERATION = 30X

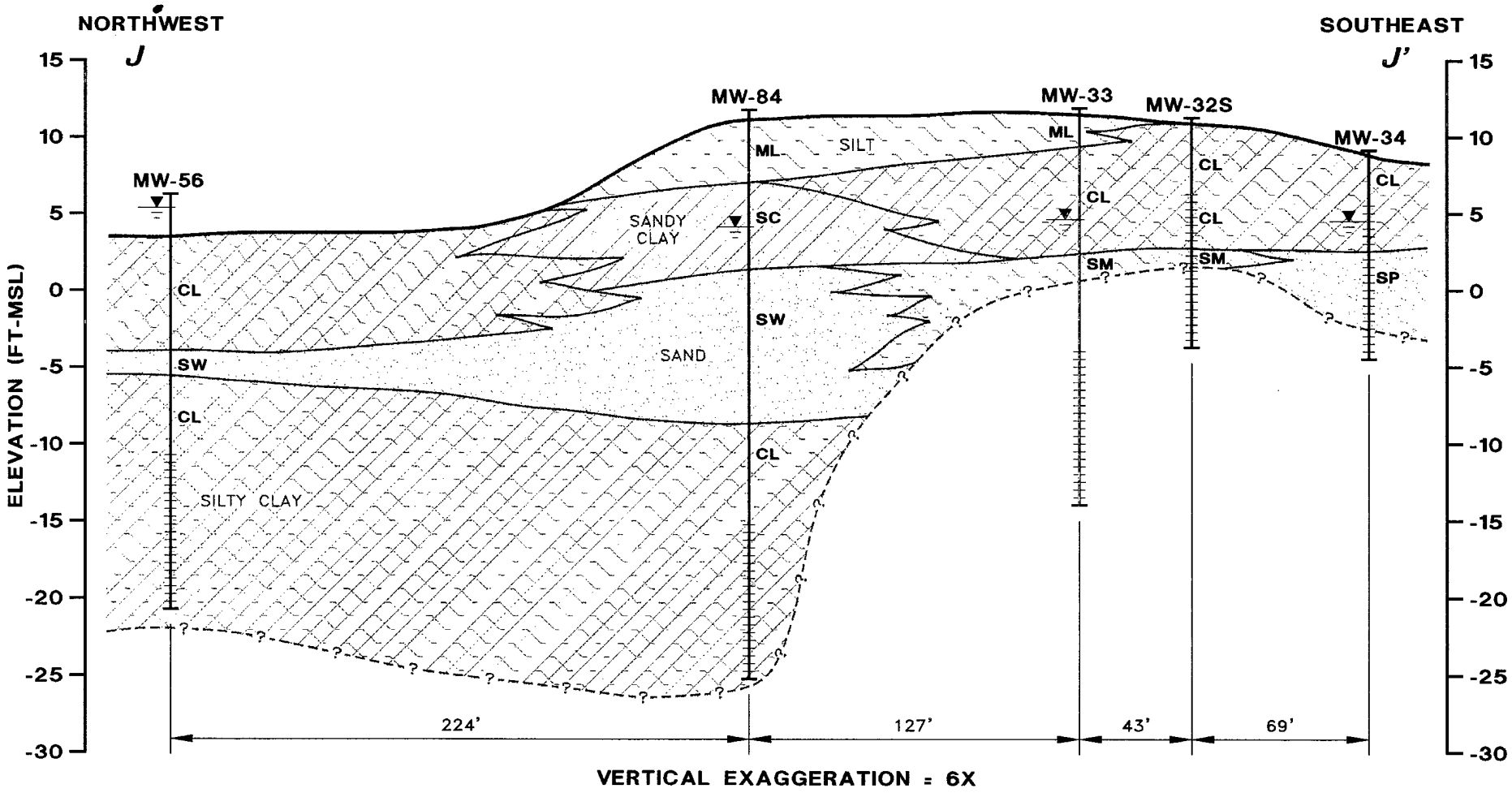
US ARMY ENVIRONMENTAL CENTER		
CONTRACT NO. DACA31-94-D-0064		FIGURE 2-1
ICF KAISER	2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESEARCH
PREPARED CST	TASK NO: 66220	GEOLOGI CROSS SEC I-I'
CHECKED PT	ICF DWG NO: WRF-XSI	
DATE 11-14-97		

(2)



US ARMY ENVIRONMENTAL CENTER

NO. DACA31-94-D-0064	FIGURE 2-12
AISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESEARCH FACILITY
:T TASK NO: 66220	GEOLOGIC CROSS SECTION I-I'
ICF DWG NO:	
4-97 WRF-XSI	



LEGEND:

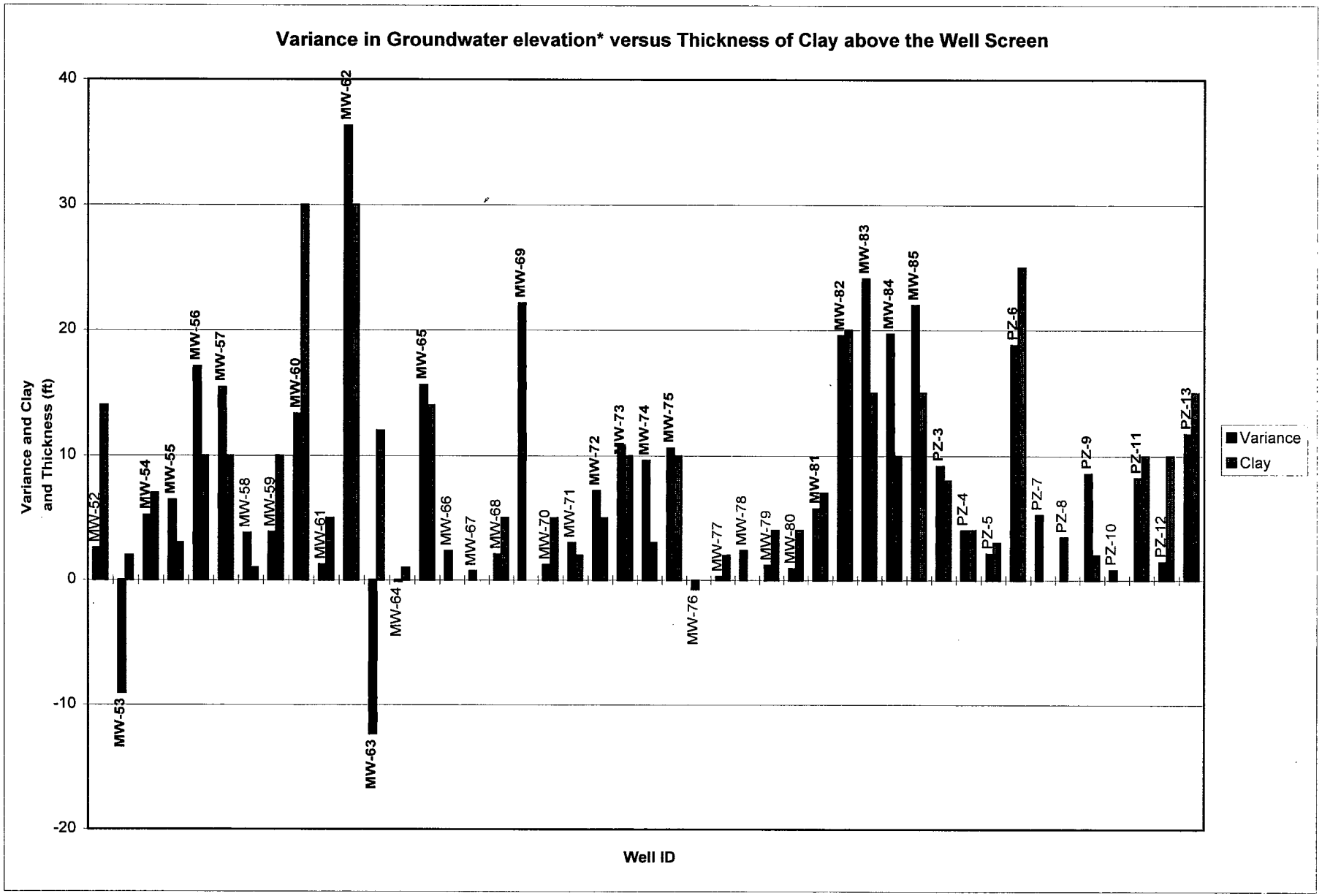
▼ GROUNDWATER ELEVATION
▽ MEASURED JAN. 5, 1996

GRAVEL
SILT
SAND
CLAY

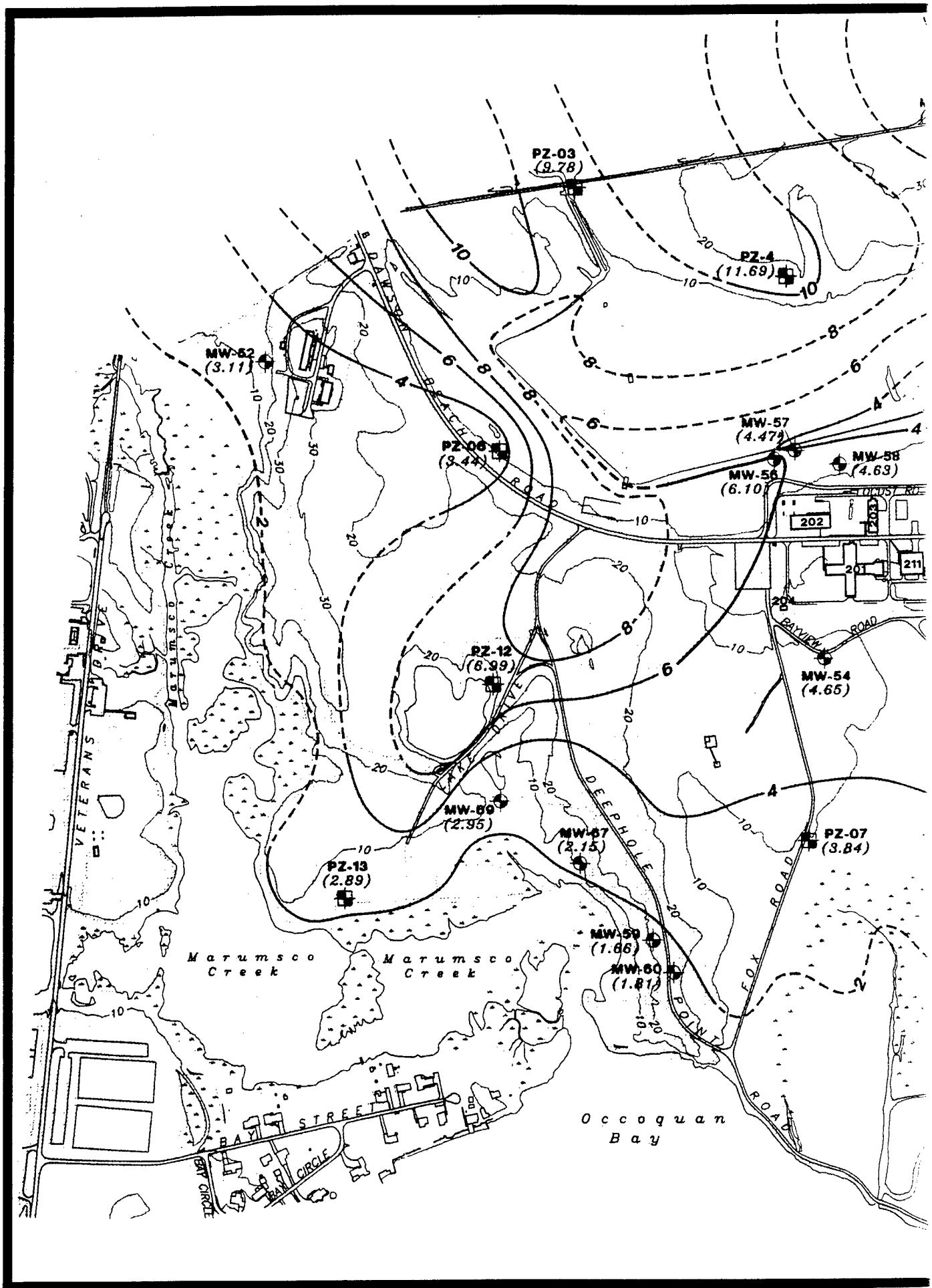
US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064	FIGURE 2-13
	WOODBRIDGE RESEARCH FACILITY
ICF KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	GEOLOGIC CROSS SECTION J-J'
PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: WRF-XSJ
DATE 11-14-97	

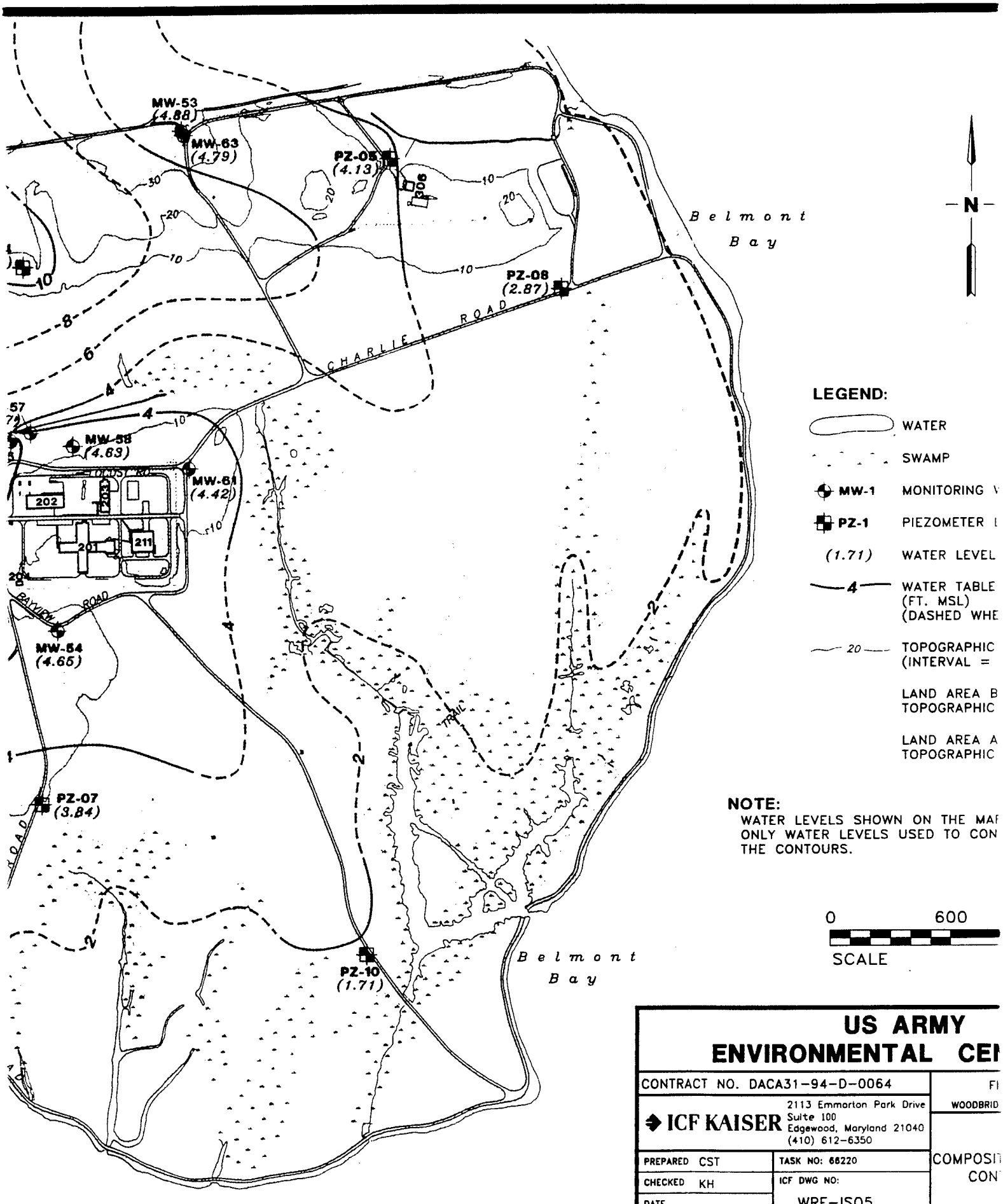
Figure 2-14



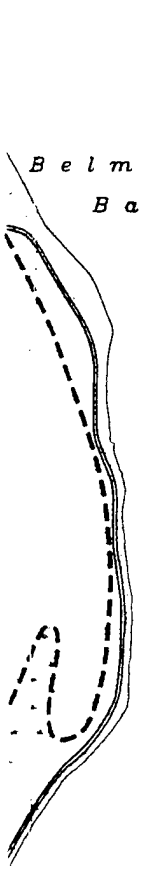
* Variance is the difference in feet between the elevation at which water was first encountered during drilling and the stabilized groundwater elevation after well development.


PZ-03
(9.78)
PZ-4
(11.69)
MW-52
(3.11)
PZ-06
(3.44)
MW-57
(4.47)
MW-58
(4.63)
MW-56
(6.10)
202
201
211
PZ-12
(6.99)
MW-54
(4.65)
MW-55
(2.95)
MW-67
(2.15)
PZ-07
(3.84)
PZ-13
(2.89)
MW-59
(1.66)
MW-60
(1.81)
Marumsco Creek
Marumsco Creek
Occoquan Bay
VETERANS HWY
DAWSON BEACH ROAD
LOCUST RD
RAYVIEW ROAD
LAKE RIDGE DRIVE
DEEPHOLE
FOX POINT ROAD
OCCOQUAN ROAD
BAY STREET
BAY CIRCLE

(1)


MW-53
(4.88)
MW-63
(4.79)
PZ-05
(4.13)
B306
PZ-08
(2.87)
Belmont
Bay
CHARLIE ROAD
MW-58
(4.63)
MW-61
(4.42)
202
203
211
BAYVIEW ROAD
MW-54
(4.65)
PZ-07
(3.84)
PZ-10
(1.71)
Belmont
Bay
TRAIL
N
LEGEND:
WATER
SWAMP
MW-1 MONITORING
PZ-1 PIEZOMETER
(1.71) WATER LEVEL
4 WATER TABLE (FT. MSL) (DASHED WHE
20 TOPOGRAPHIC (INTERVAL =
LAND AREA B TOPOGRAPHIC
LAND AREA A TOPOGRAPHIC
NOTE:
WATER LEVELS SHOWN ON THE MAI
ONLY WATER LEVELS USED TO CON
THE CONTOURS.
0 600
SCALE
US ARMY
ENVIRONMENTAL CEI
CONTRACT NO. DACA31-94-D-0064
ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350
WOODBRID
PREPARED CST
TASK NO: 66220
CHECKED KH
ICF DWG NO:
WRF-ISO5
DATE 08-25-97
COMPOSI
CON

(2)



N

LEGEND:

- WATER
- SWAMP
- MW-1 — MONITORING WELL LOCATION
- PZ-1 — PIEZOMETER LOCATION
- (1.71) — WATER LEVEL (FT. MSL)
- 4 — WATER TABLE CONTOUR (FT. MSL) (DASHED WHERE ESTIMATED)
- 20 — TOPOGRAPHIC CONTOUR (INTERVAL = 10')
- LAND AREA BELOW 10' TOPOGRAPHIC CONTOUR
- LAND AREA ABOVE 10' TOPOGRAPHIC CONTOUR

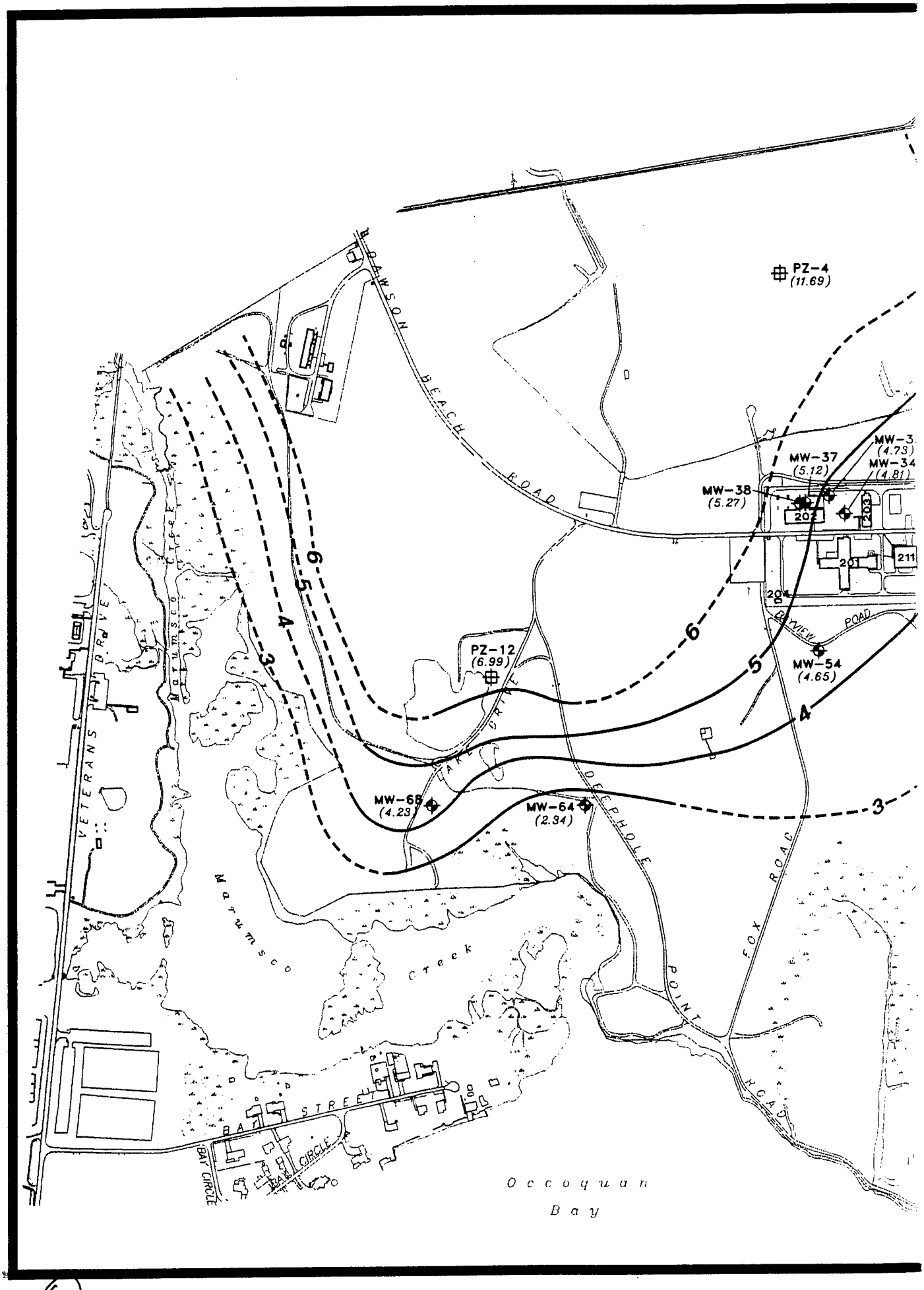
NOTE:
WATER LEVELS SHOWN ON THE MAP ARE THE ONLY WATER LEVELS USED TO CONSTRUCT THE CONTOURS.

0 600 1200
SCALE FEET

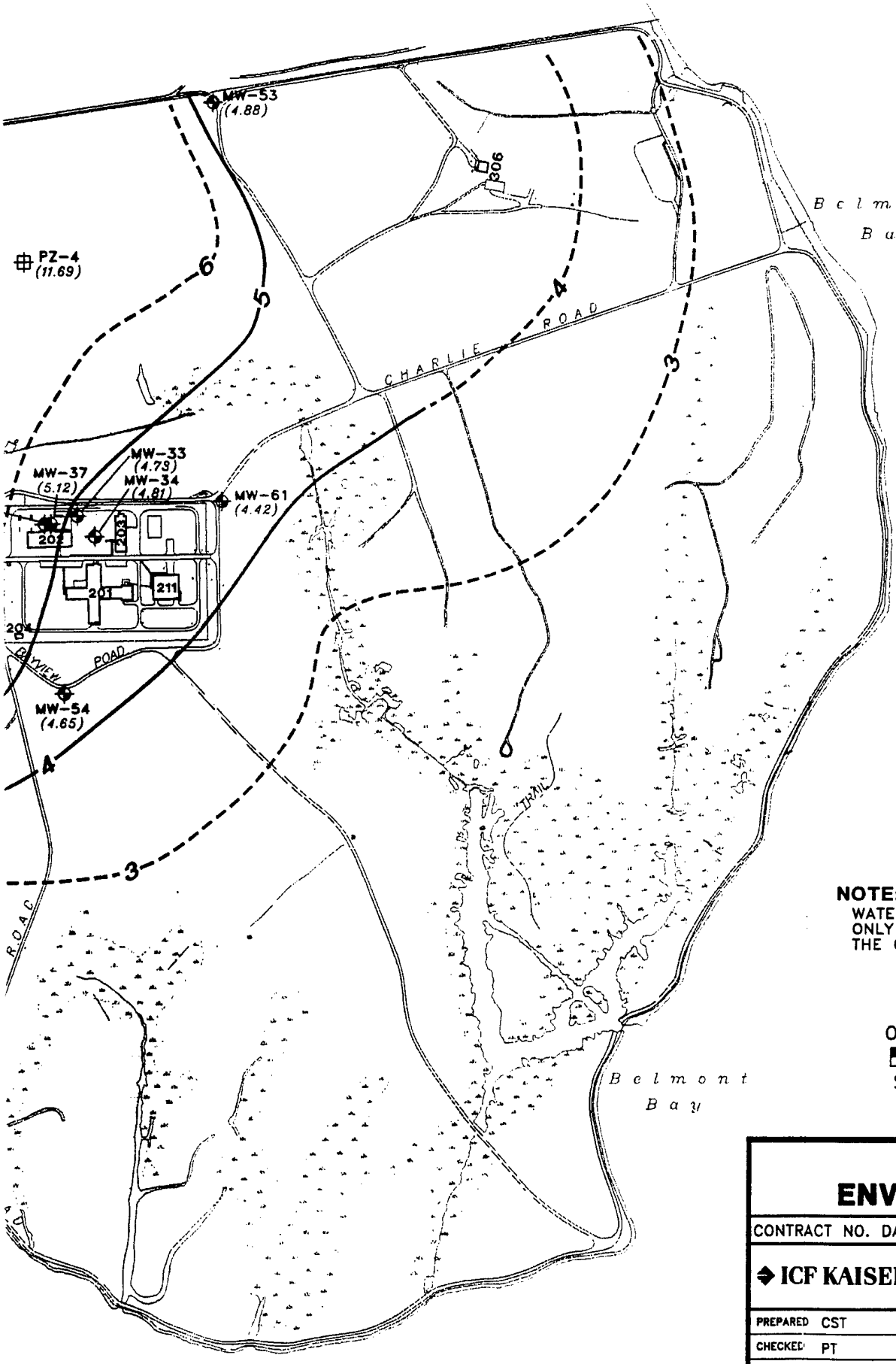
US ARMY ENVIRONMENTAL CENTER

RACT NO. DACA31-94-D-0064	FIGURE 2-15
CF KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESEARCH FACILITY
D CST / TASK NO: 66220	COMPOSITE WATER LEVEL CONTOUR MAP
D KH / ICF DWG NO: WRF-ISO5	
08-25-97	

3


PZ-4
(11.69)
DAWSON BEACH ROAD
MW-37
(5.12)
MW-38
(5.27)
MW-3
(4.73)
MW-34
(4.81)
202
203
201
211
204
RIVIEW ROAD
PZ-12
(6.99)
MW-54
(4.65)
MW-68
(4.23)
MW-64
(2.34)
6
5
4
3
VETERANS DRIVE
Marumsco Creek
DEEPHOLE POINT ROAD
FOX ROAC
BAY STREET
BAY CIRCLE
Occoquan
Bay

(1)



N

LEGEND:

- ROAD
- FENCE
- WATER
- SWAMP
- MW-1 MONITORING WEL
- PZ-1 PIEZOMETER LOC
- (4.23) WATER LEVEL (F
- 5 POTENTIOMETRIC GROUNDWATER C (DASHED WHERE

NOTE:
WATER LEVELS SHOWN ON THE MAP ONLY WATER LEVELS USED TO CONST THE CONTOURS.

0 600 12
SCALE FEET

US ARMY ENVIRONMENTAL CE

CONTRACT NO. DACA31-94-D-0064

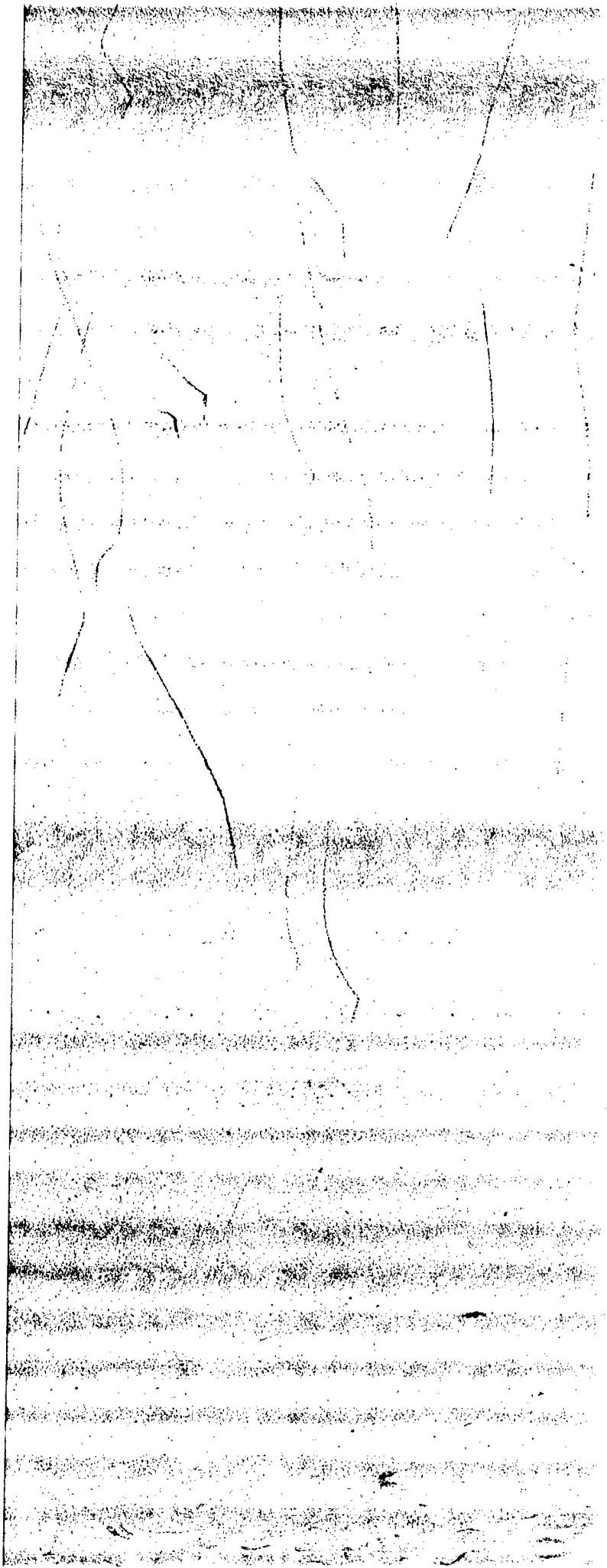
ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: POT-1
DATE 11-14-97	

F
WOODBRID

POTE
CONTO
WITH S
BETWEE
ABOVE M

12



c l m o n t
B a y

N

LEGEND:

- ROAD
- FENCE
- WATER
- SWAMP
- MW-1 — MONITORING WELL LOCATION
- PZ-1 — PIEZOMETER LOCATION
- (4.23) — WATER LEVEL (FT. MSL)
- 5 — POTENTIOMETRIC GROUNDWATER CONTOUR (DASHED WHERE ESTIMATED)

NOTE:
WATER LEVELS SHOWN ON THE MAP ARE THE ONLY WATER LEVELS USED TO CONSTRUCT THE CONTOURS.

0 600 1200
SCALE FEET

US ARMY ENVIRONMENTAL CENTER

NO. DACA31-94-D-0064

FIGURE 2-16
WOODBRIDGE RESEARCH FACILITY

KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

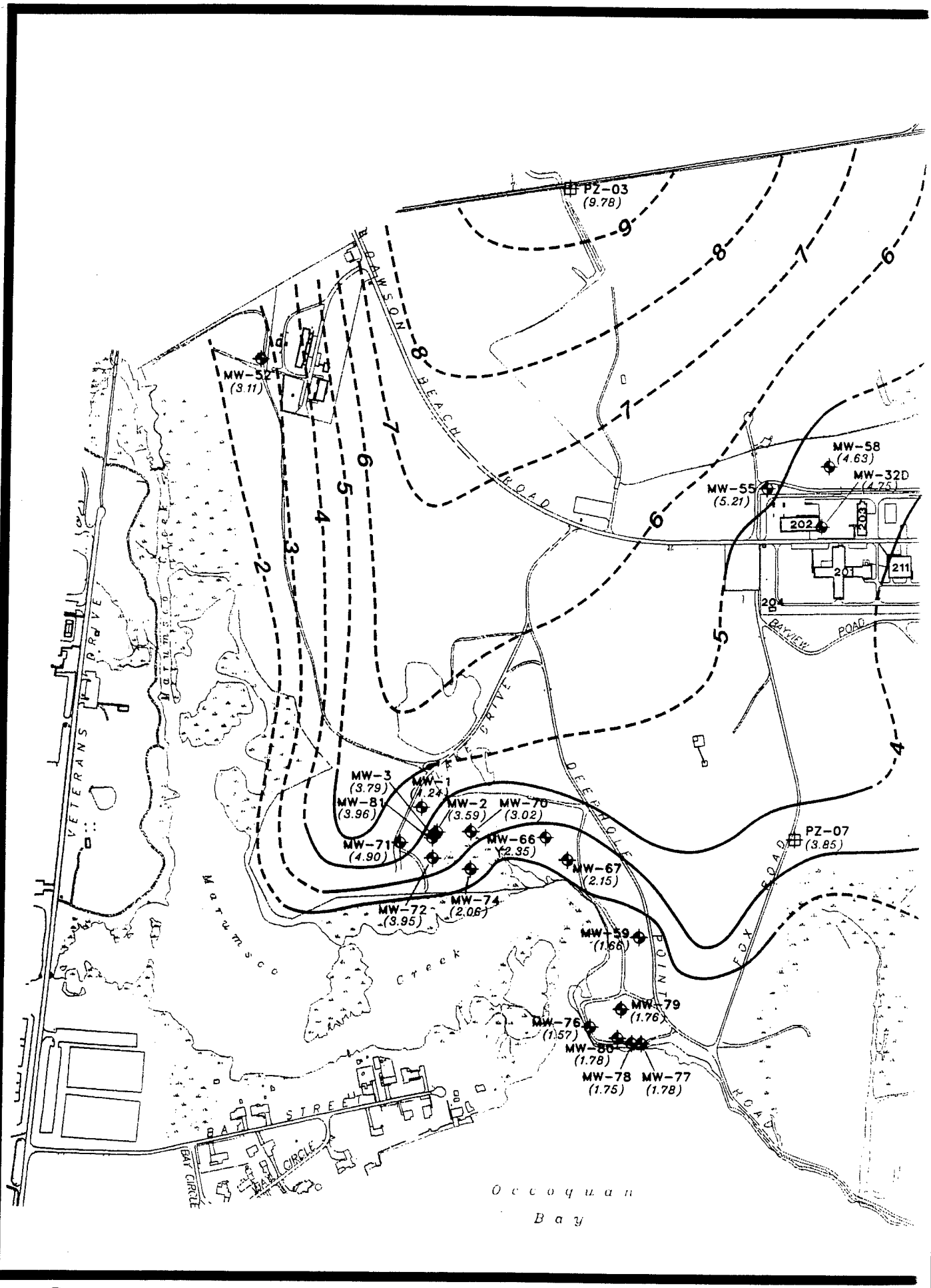
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TASK NO: 66220

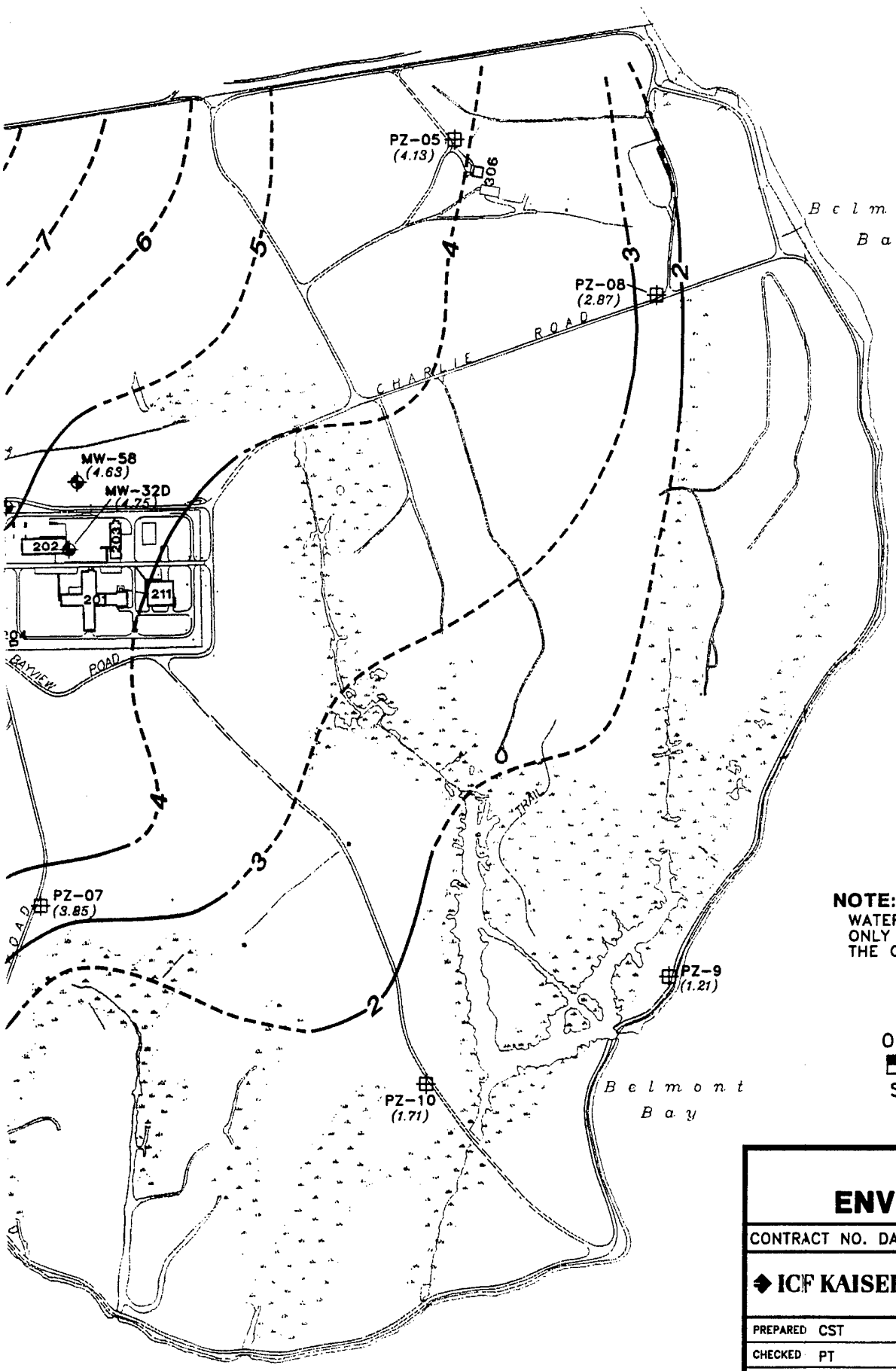
ICF DWG NO:
POT-1

4-97

POTENTIOMETRIC CONTOURS OF WELLS WITH SCREEN MIDPOINT BETWEEN 10 to 0 FEET ABOVE MEAN SEA LEVEL


PZ-03
(9.78)
MW-52
(3.11)
MW-58
(4.63)
MW-32D
(4.75)
MW-55
(5.21)
202
203
201
211
204
BAYVIEW ROAD
DAWSON BEACH ROAD
VETERANS DRIVE
MW-3
(3.79)
MW-1
(1.24)
MW-81
(3.96)
MW-2
(3.59)
MW-70
(3.02)
MW-71
(4.90)
MW-66
(2.35)
MW-67
(2.15)
PZ-07
(3.85)
MW-72
(3.95)
MW-74
(2.06)
MW-59
(1.66)
FOX POINT DRIVE
FOX POINT ROAD
Marumsco Creek
MW-79
(1.76)
MW-76
(1.57)
MW-80
(1.78)
MW-78
(1.75)
MW-77
(1.78)
BAY STREET
BAY CIRCLE
BAY CIRCLE
Occoquan Bay
9
8
7
6
5
4
3
2

(1)



N

LEGEND:

- ROAD
- FENCE
- WATER
- SWAMP
- MW-1 MONITORING WELL
- PZ-1 PIEZOMETER LOCA
- (4.23) WATER LEVEL (FT
- 5 POTENTIOMETRIC GROUNDWATER CO (DASHED WHERE

NOTE:
WATER LEVELS SHOWN ON THE MAP A ONLY WATER LEVELS USED TO CONSTR THE CONTOURS.

0 600 120
SCALE FEET

US ARMY ENVIRONMENTAL CEN

CONTRACT NO. DACA31-94-D-0064

FIC
WOODBRIDG

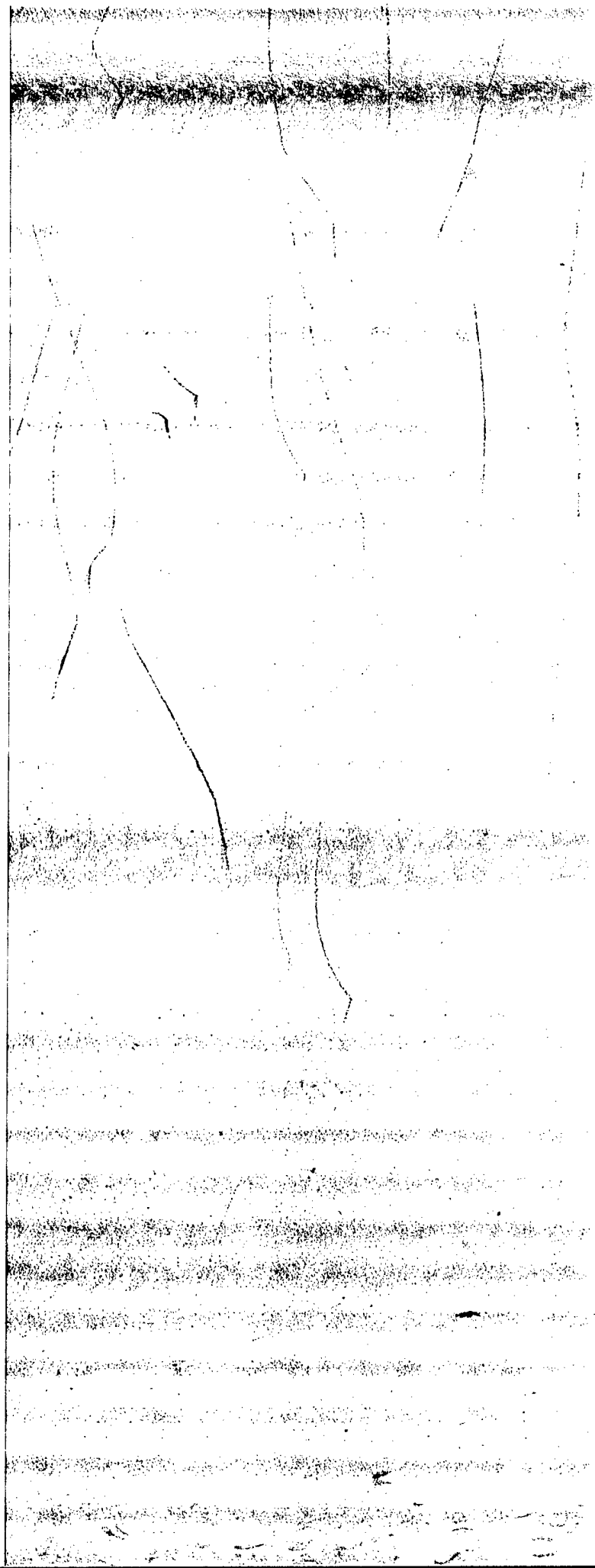
ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST
CHECKED PT
DATE 11-14-97

TASK NO: 66220
ICF DWG NO:
POT-2

POTE CONTOU WITH SC BETWEEN ABOVE M

(2)



c l m o n t

B a y

N

LEGEND:

- ROAD
- FENCE
- WATER
- SWAMP
- MW-1 — MONITORING WELL LOCATION
- PZ-1 — PIEZOMETER LOCATION
- (4.23) — WATER LEVEL (FT. MSL)
- 5 — POTENTIOMETRIC GROUNDWATER CONTOUR (DASHED WHERE ESTIMATED)

NOTE:
WATER LEVELS SHOWN ON THE MAP ARE THE ONLY WATER LEVELS USED TO CONSTRUCT THE CONTOURS.

0 600 1200

SCALE FEET

US ARMY ENVIRONMENTAL CENTER

NO. DACA31-94-D-0064

FIGURE 2-17

WOODBRIDGE RESEARCH FACILITY

KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

ST

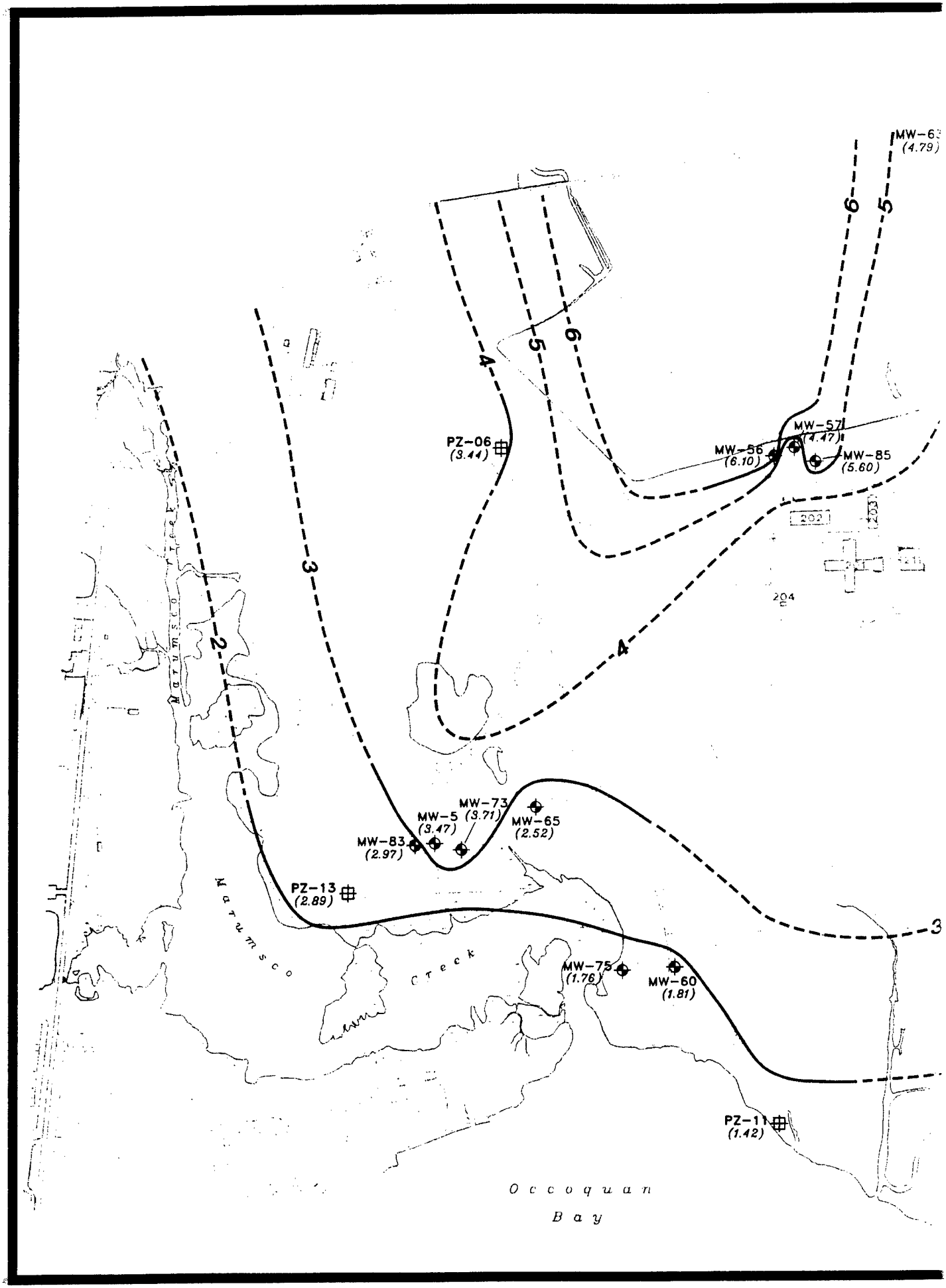
T

14-97

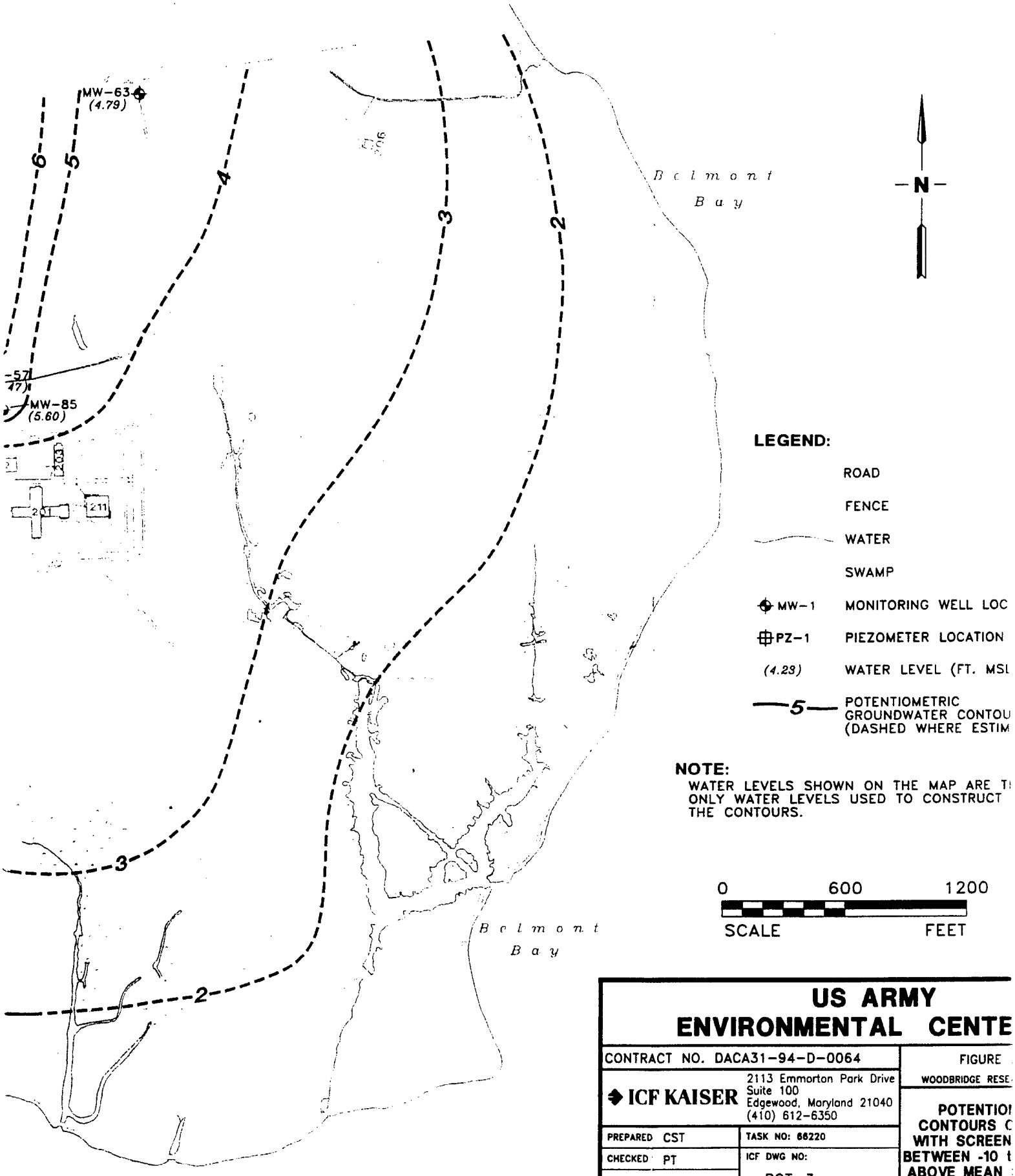
TASK NO: 66220

ICF DWG NO:
POT-2

POTENTIOMETRIC CONTOURS OF WELLS WITH SCREEN MIDPOINT BETWEEN 0 to -10 FEET ABOVE MEAN SEA LEVEL


MW-63
(4.79)
6
5
4
5
6
PZ-06
(3.44)
MW-57
(4.47)
MW-56
(6.10)
MW-85
(5.60)
202
253
21
204
3
2
4
MW-73
(3.71)
MW-5
(3.47)
MW-65
(2.52)
MW-83
(2.97)
PZ-13
(2.89)
Marumsco
Creek
MW-75
(1.76)
MW-60
(1.81)
3
PZ-11
(1.42)
Occoquan
Bay

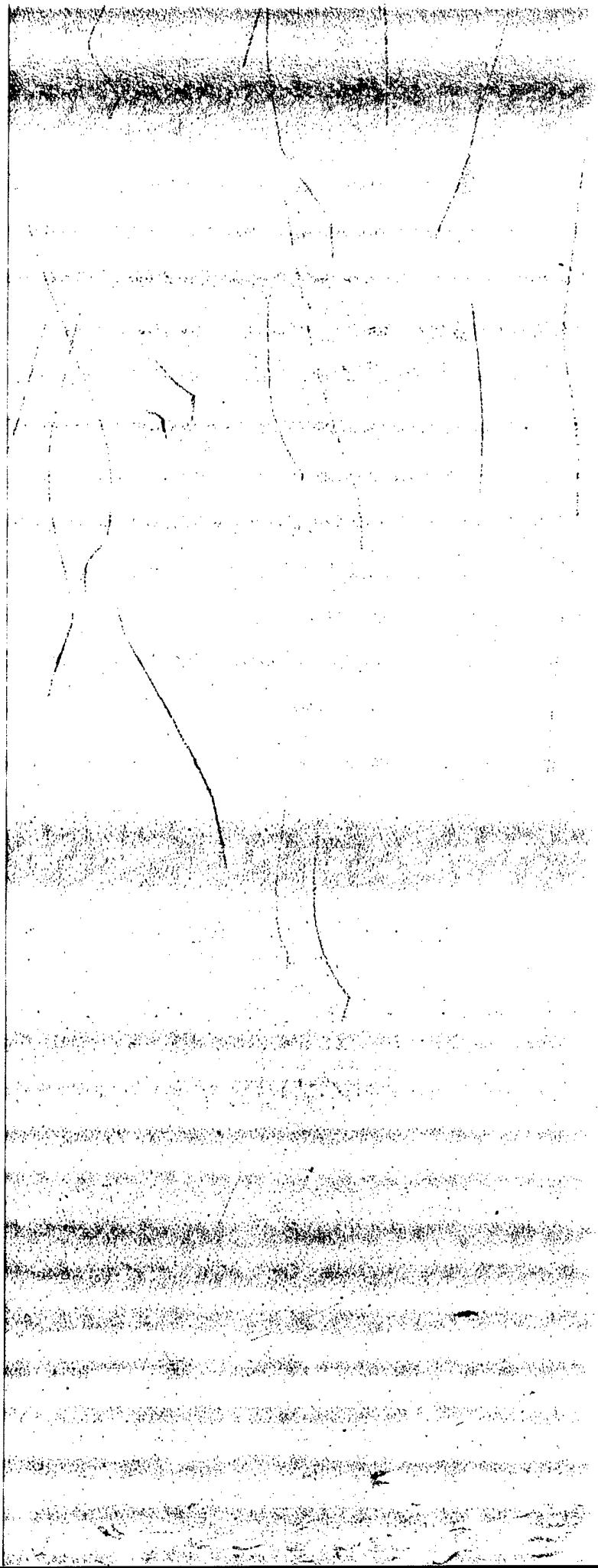
(1)



US ARMY ENVIRONMENTAL CENTE

CONTRACT NO. DACA31-94-D-0064	FIGURE
ICF KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESE
PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: POT-3
DATE 11-14-97	POTENTIO CONTOURS C WITH SCREEN BETWEEN -10 t ABOVE MEAN

(2)



c l m o n t

B a y

N

LEGEND:

	ROAD
	FENCE
	WATER
	SWAMP
⊕ MW-1	MONITORING WELL LOCATION
⊞ PZ-1	PIEZOMETER LOCATION
(4.23)	WATER LEVEL (FT. MSL)
—5—	POTENTIOMETRIC GROUNDWATER CONTOUR (DASHED WHERE ESTIMATED)

NOTE:
WATER LEVELS SHOWN ON THE MAP ARE THE ONLY WATER LEVELS USED TO CONSTRUCT THE CONTOURS.

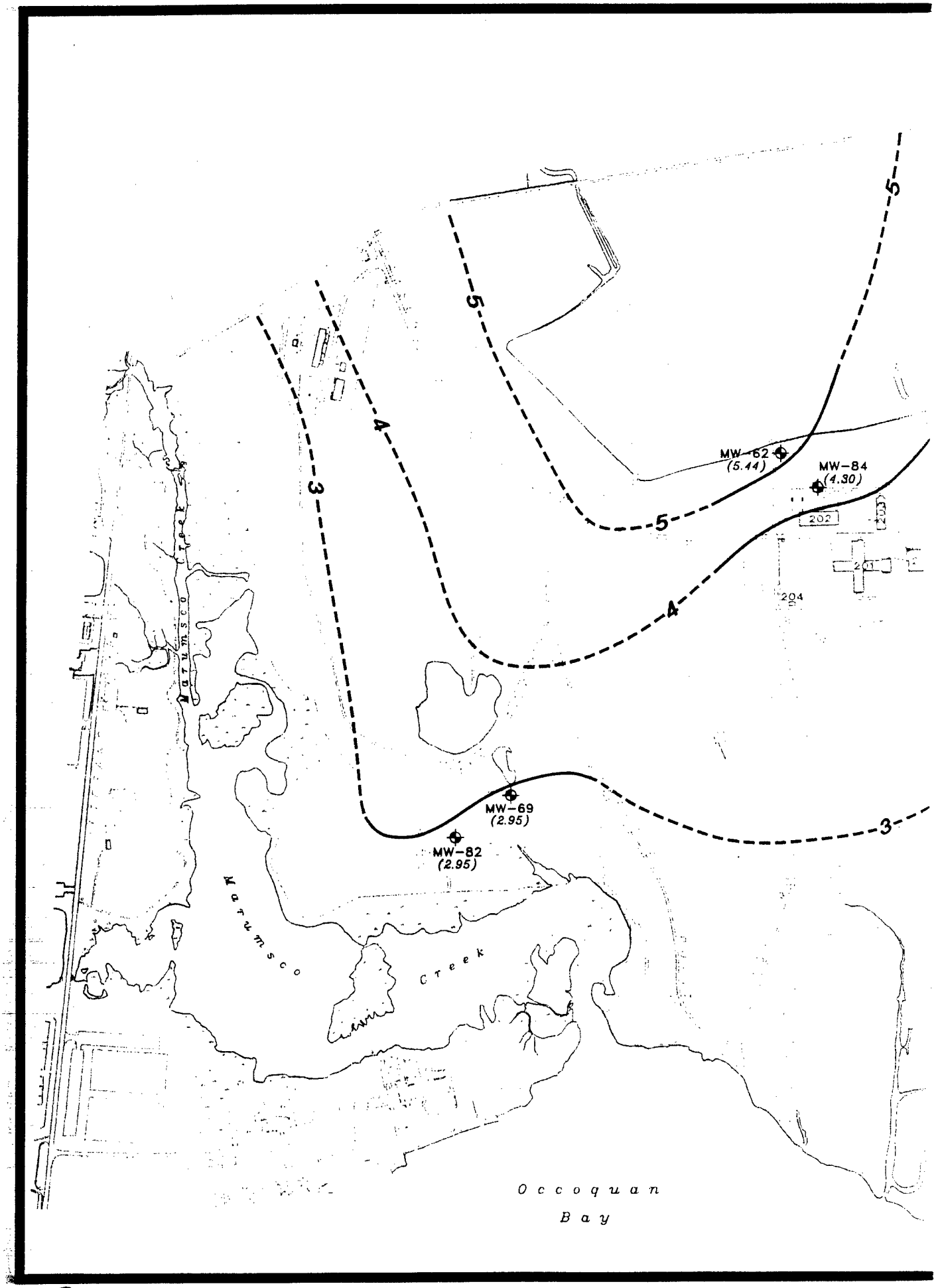
0 600 1200

SCALE FEET

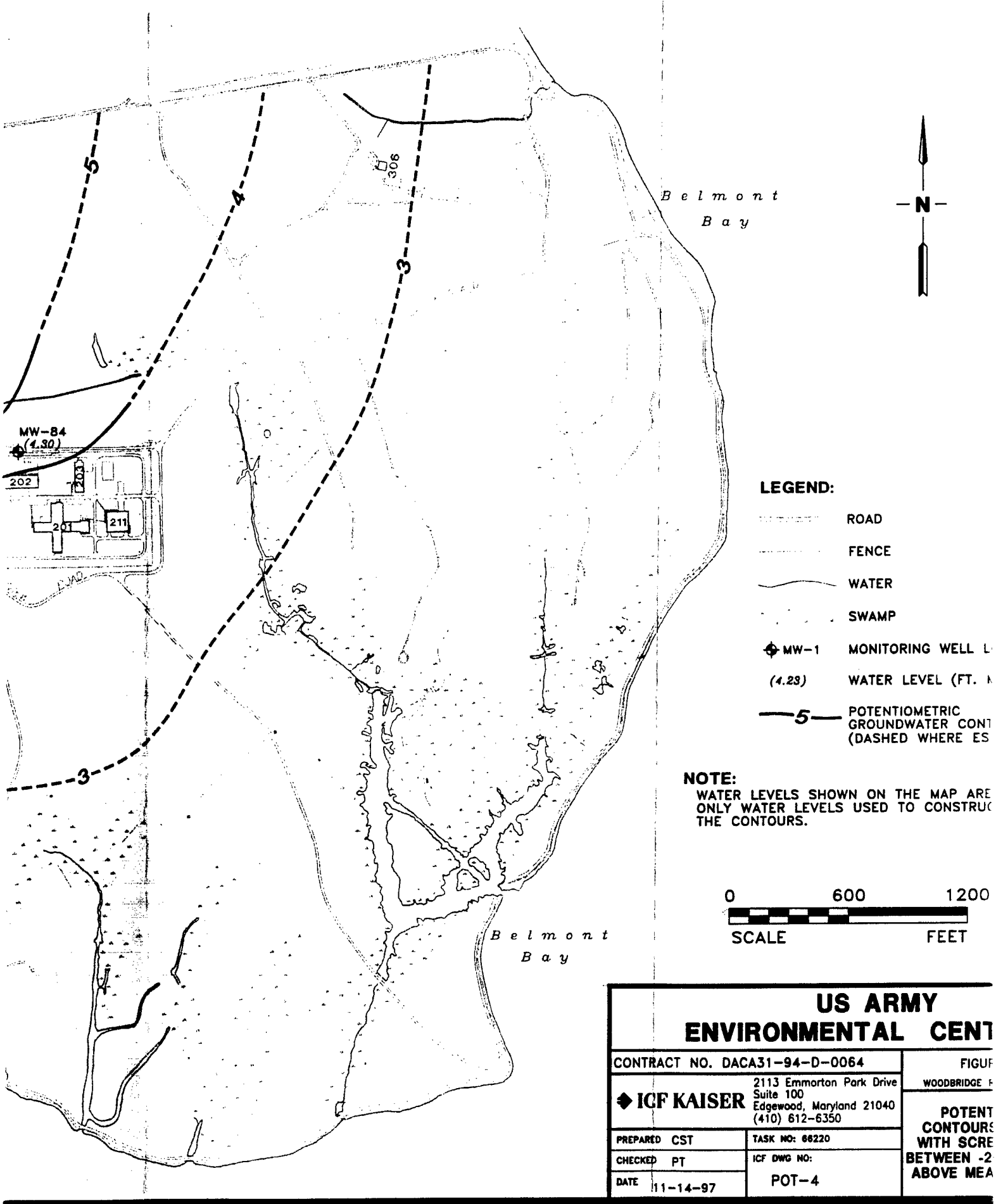
US ARMY ENVIRONMENTAL CENTER

T NO. DACA31-94-D-0064	FIGURE 2-18
KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESEARCH FACILITY
CST / TASK NO: 66220	POTENTIOMETRIC CONTOURS OF WELLS WITH SCREEN MIDPOINT BETWEEN -10 to -20 FEET ABOVE MEAN SEA LEVEL
T / ICF DWG NO: POT-3	
14-97	

(3)


5
5
4
3
5
4
3
MW-62
(5.14)
MW-84
(4.30)
202
204
MW-69
(2.95)
MW-82
(2.95)
Katumsco Creek
Occoquan
Bay

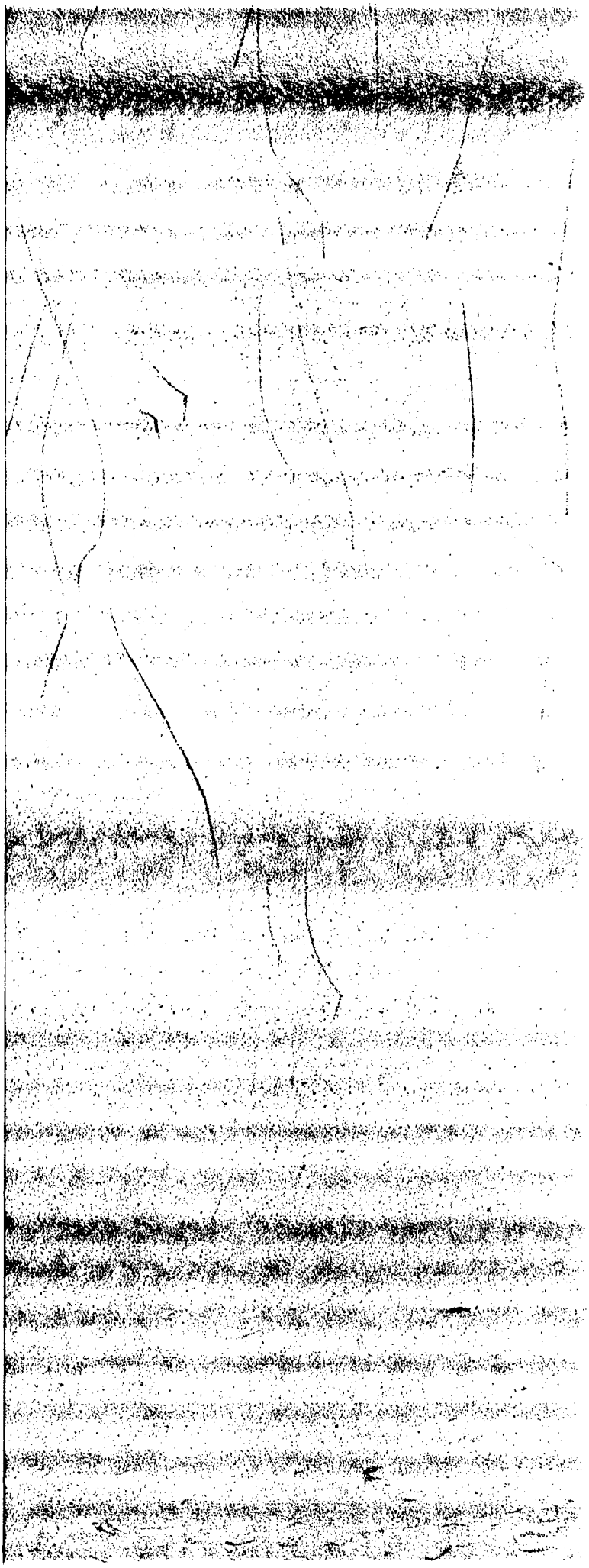
(1)



US ARMY ENVIRONMENTAL CENT

CONTRACT NO. DACA31-94-D-0064	FIGUR
ICF KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE F
PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: POT-4
DATE 11-14-97	POTENT CONTOURS WITH SCRE BETWEEN -2 ABOVE MEA

(2)



elmont

Bay

N

LEGEND:

- ROAD
- FENCE
- WATER
- SWAMP
- MW-1 — MONITORING WELL LOCATION
- (4.23) — WATER LEVEL (FT. MSL)
- 5 — POTENTIOMETRIC GROUNDWATER CONTOUR (DASHED WHERE ESTIMATED)

NOTE:
WATER LEVELS SHOWN ON THE MAP ARE THE ONLY WATER LEVELS USED TO CONSTRUCT THE CONTOURS.

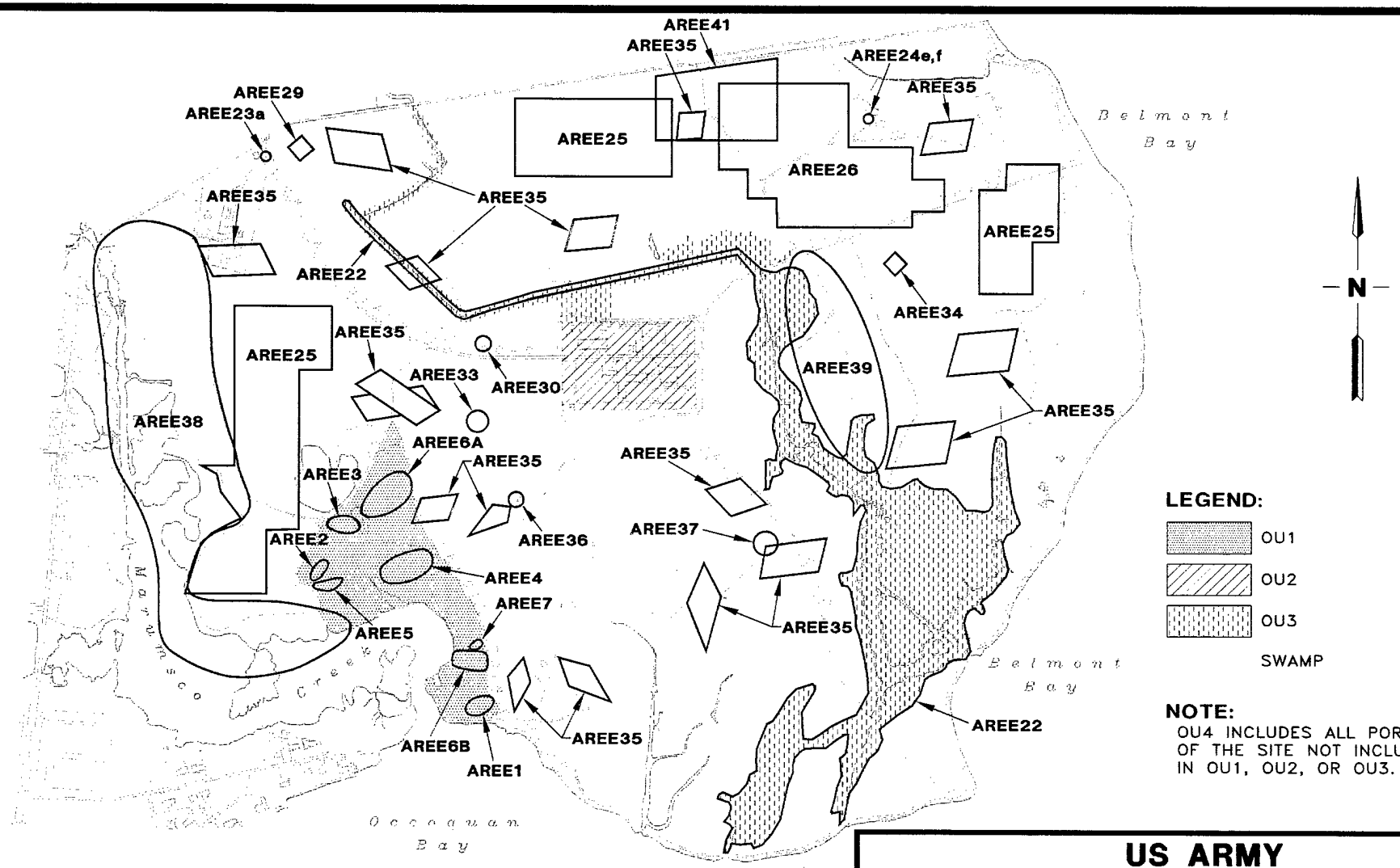
0 600 1200

SCALE FEET

US ARMY ENVIRONMENTAL CENTER

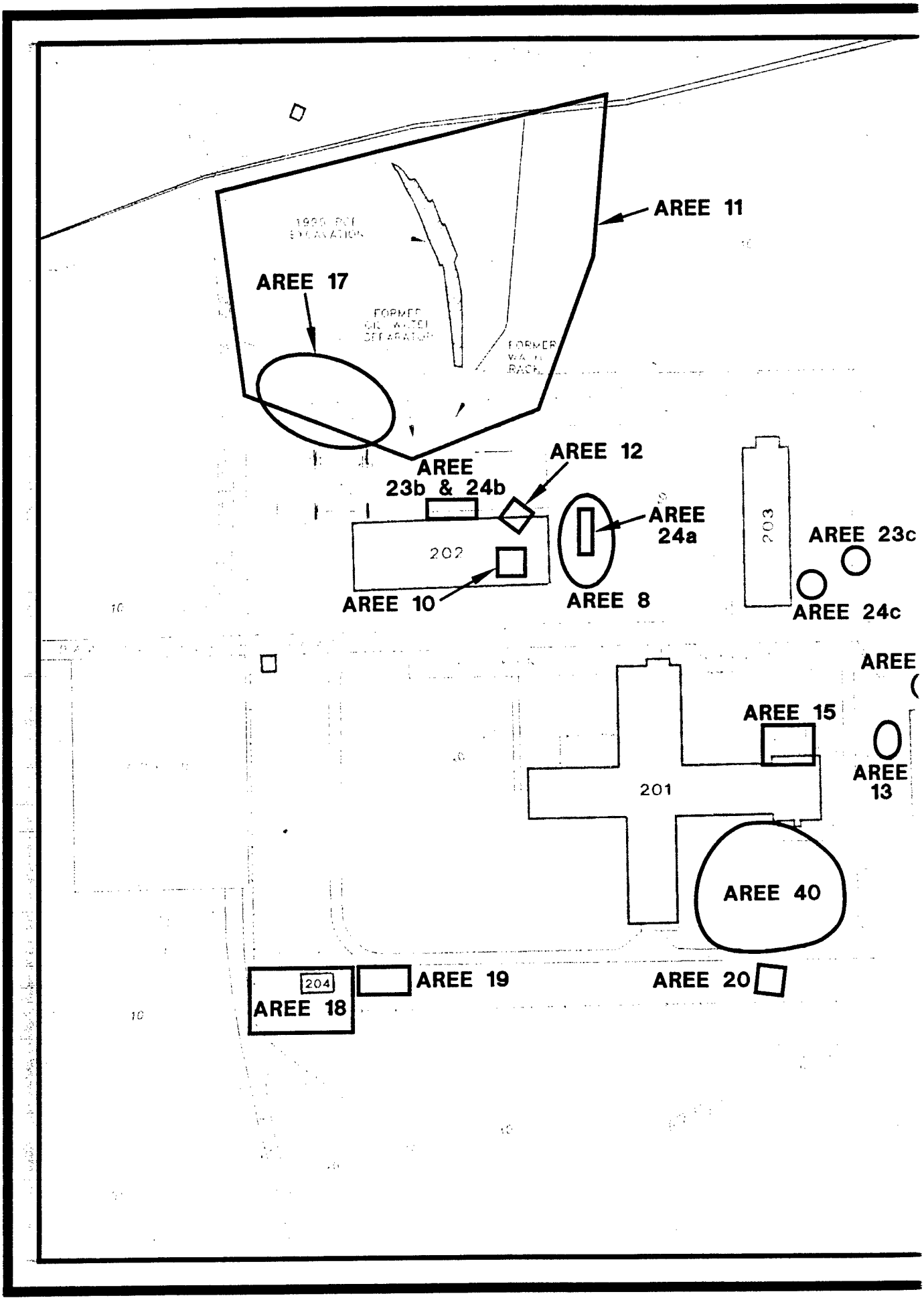
T NO. DACA31-94-D-0064	FIGURE 2-19
KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESEARCH FACILITY
CST / TASK NO: 66220	POTENTIOMETRIC CONTOURS OF WELLS WITH SCREEN MIDPOINT BETWEEN -20 to -30 FEET ABOVE MEAN SEA LEVEL
PT / ICF DWG NO: POT-4	
-14-97	

3

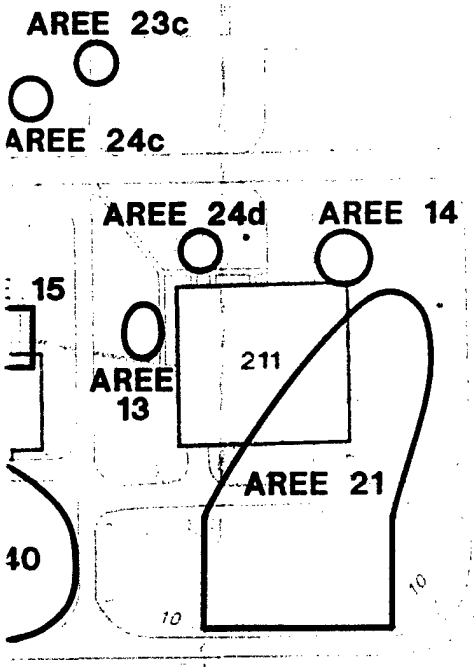


US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064	FIGURE 2-20
ICF KAISER 1301 Continental Drive Suite 101 Abingdon, Maryland 21009 (410) 612-6350	WOODBRIDGE RESEARCH FACILITY
PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: AR-OULOC
DATE 11-17-97	LOCATIONS OF AREES AND OPERABLE UNITS AT WRF


AREE 11
AREE 17
AREE 12
AREE 23b & 24b
AREE 24a
AREE 23c
AREE 24c
AREE 10
AREE 8
202
203
AREE 15
AREE 13
201
AREE 40
204
AREE 18
AREE 19
AREE 20

1



LEGEND:

ROAD

FENCE

WATER

TREE LINE

TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT

N

0 120 240

SCALE FEET

US ARMY ENVIRONMENTAL CENT

CONTRACT NO. DACA31-94-D-0064		FIGUF
ICF KAISER	2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE R
PREPARED CST	TASK NO: 66220	LOCATI AREEs FACILITY
CHECKED PT	ICF DWG NO: FACAREE	
DATE 11-17-97		

(2)

LEGEND:

ROAD

FENCE

WATER

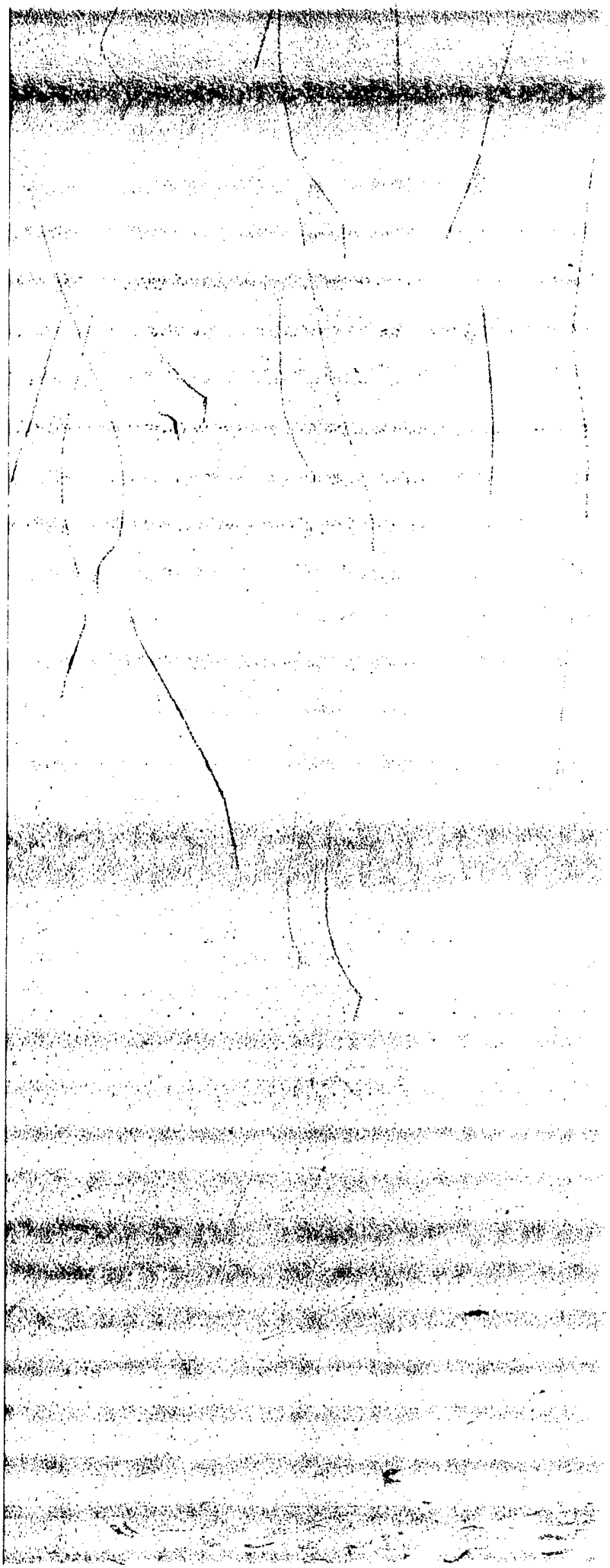
TREE LINE

TOPOGRAPHIC CONTOUR
(CONTOUR INTERVAL = 10 FT.)

N

0 120 240

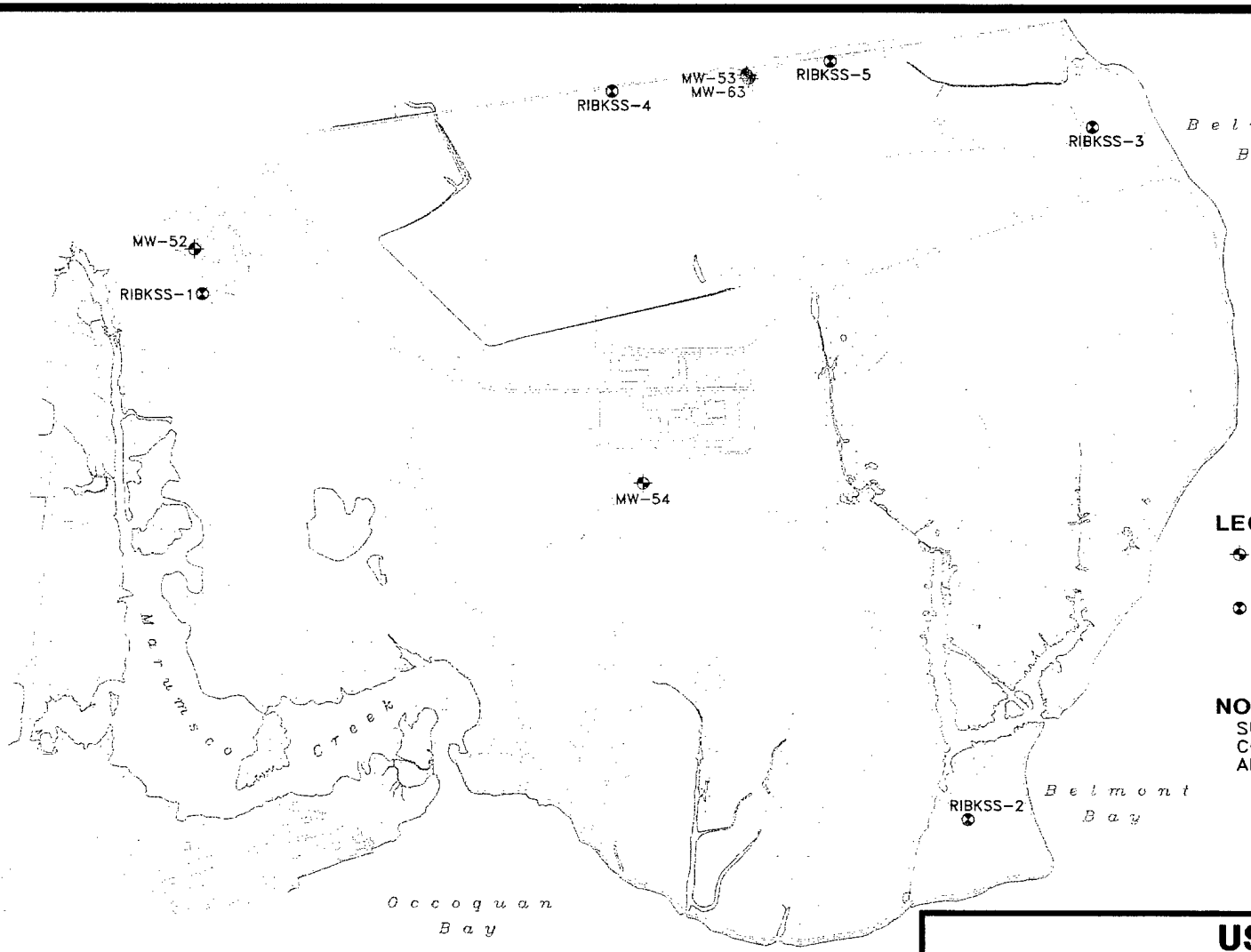
SCALE FEET



US ARMY ENVIRONMENTAL CENTER

NO. DACA31-94-D-0064	FIGURE 2-21
AISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESEARCH FACILITY
:T TASK NO: 66220	LOCATIONS OF AREEs AT MAIN FACILITY COMPUND
ICF DWG NO:	
7-97 FACAREE	

(3)



LEGEND:

- BACKGROUND GROUNDWATER SAMPLE LOCATION
- BACKGROUND SURFACE SOIL SAMPLE LOCATION
- SWAMP

NOTE:

SUBSURFACE SOIL SAMPLES WERE COLLECTED FROM MW-52, MW-53, AND MW-54 SOIL BORINGS.

0 1000 2000

SCALE FEET

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

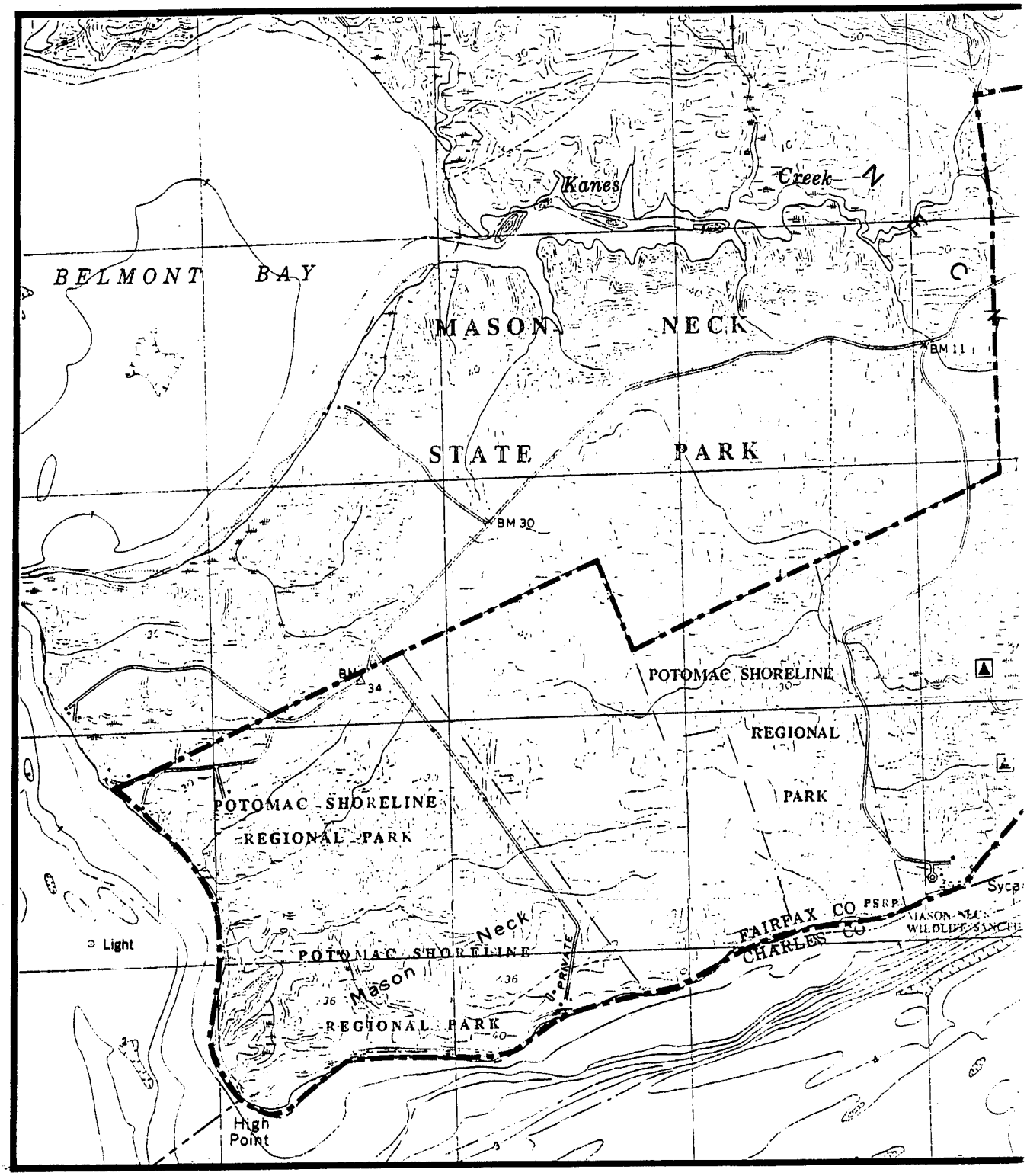
FIGURE 2-22

WOODBRIDGE RESEARCH FACILITY

ICF KAISER
1301 Continental Drive
Suite 101
Abingdon, Maryland 21009
(410) 612-6350

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: STESMP6
DATE 11-17-97	

BACKGROUND SAMPLE LOCATIONS

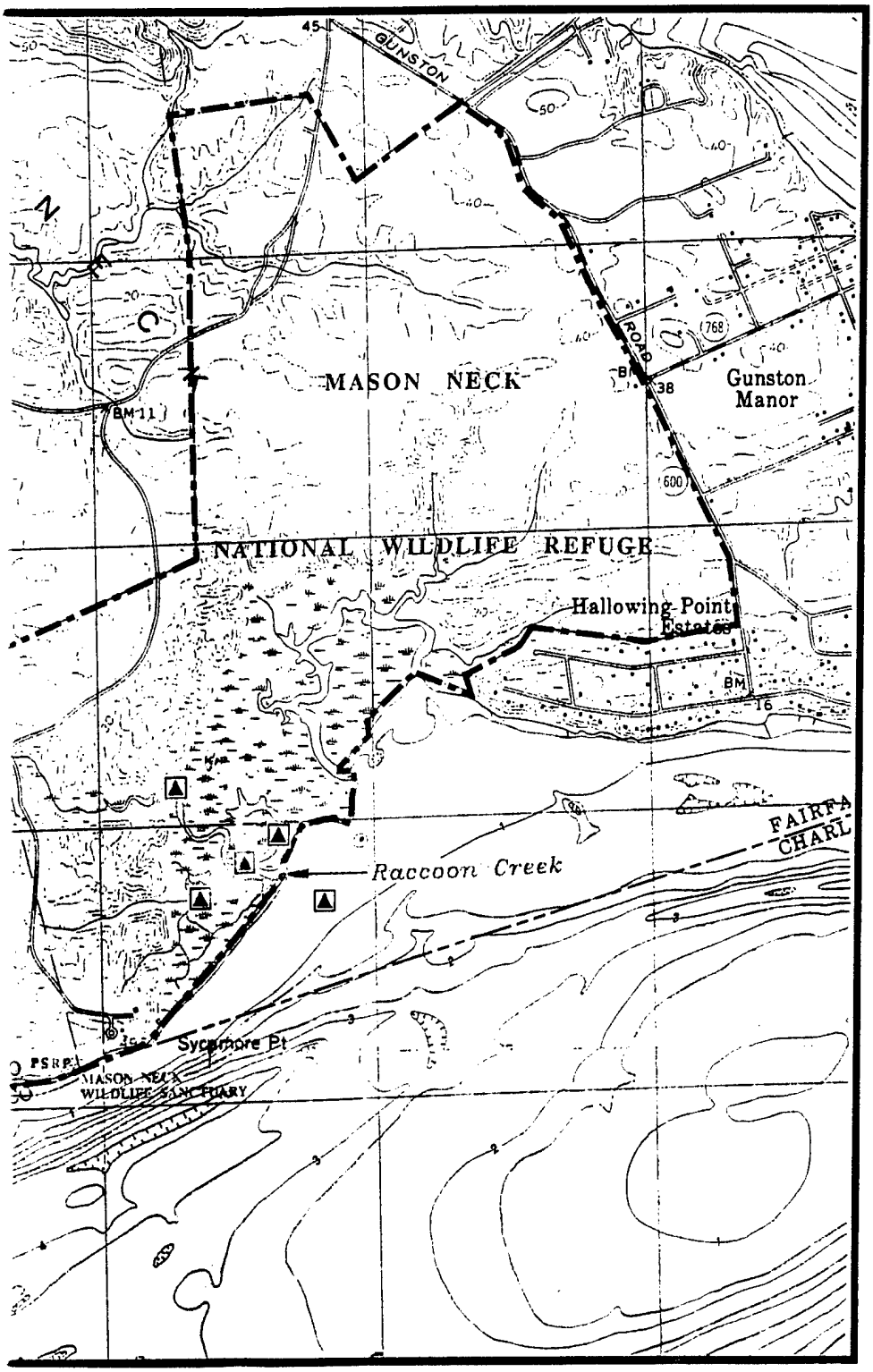


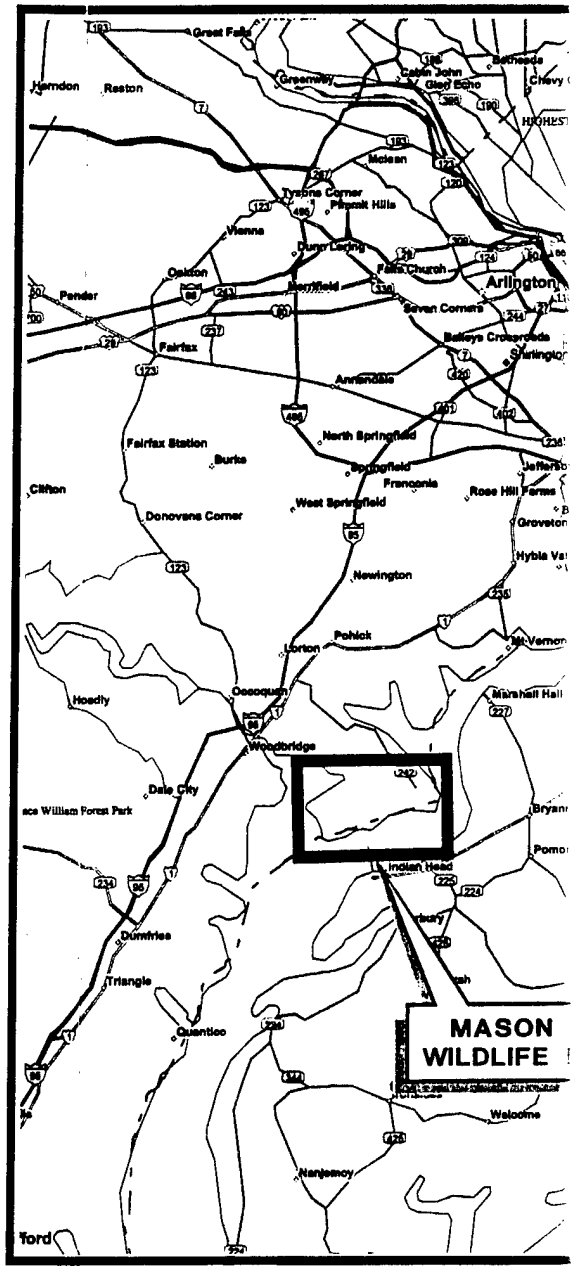
LEGEND:

▲ SURFACE WATER/SEDIMENT SAMPLE LOCATION

▬ ▪ ▬ ▪ ▬ REFUGE BOUNDARY

1





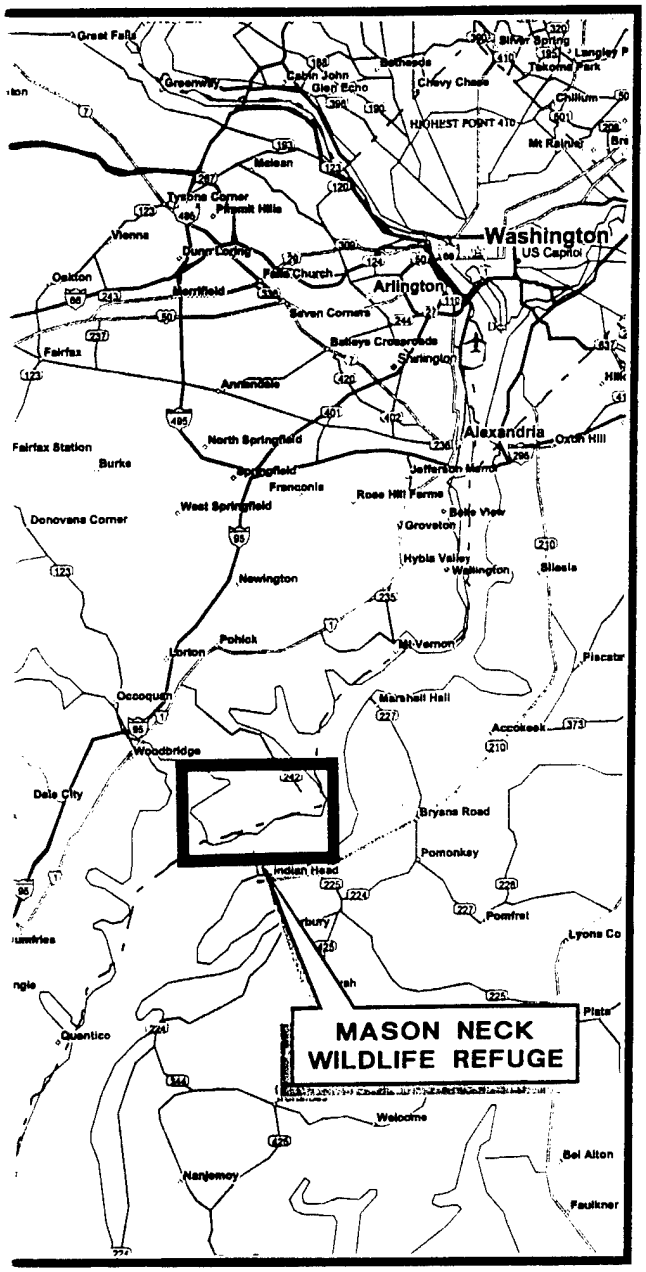
KEY PLAN

US ARMY ENVIRONMENTAL CE

CONTRACT NO. DACA31-94-D-0064	
ICF KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRI
PREPARED CST	TASK NO: 86220
CHECKED PT	ICF DWG NO: MNECKCP1
DATE 11-17-97	

LO
BA
SURFAC
SEDIM
FROM
WILD

(2)

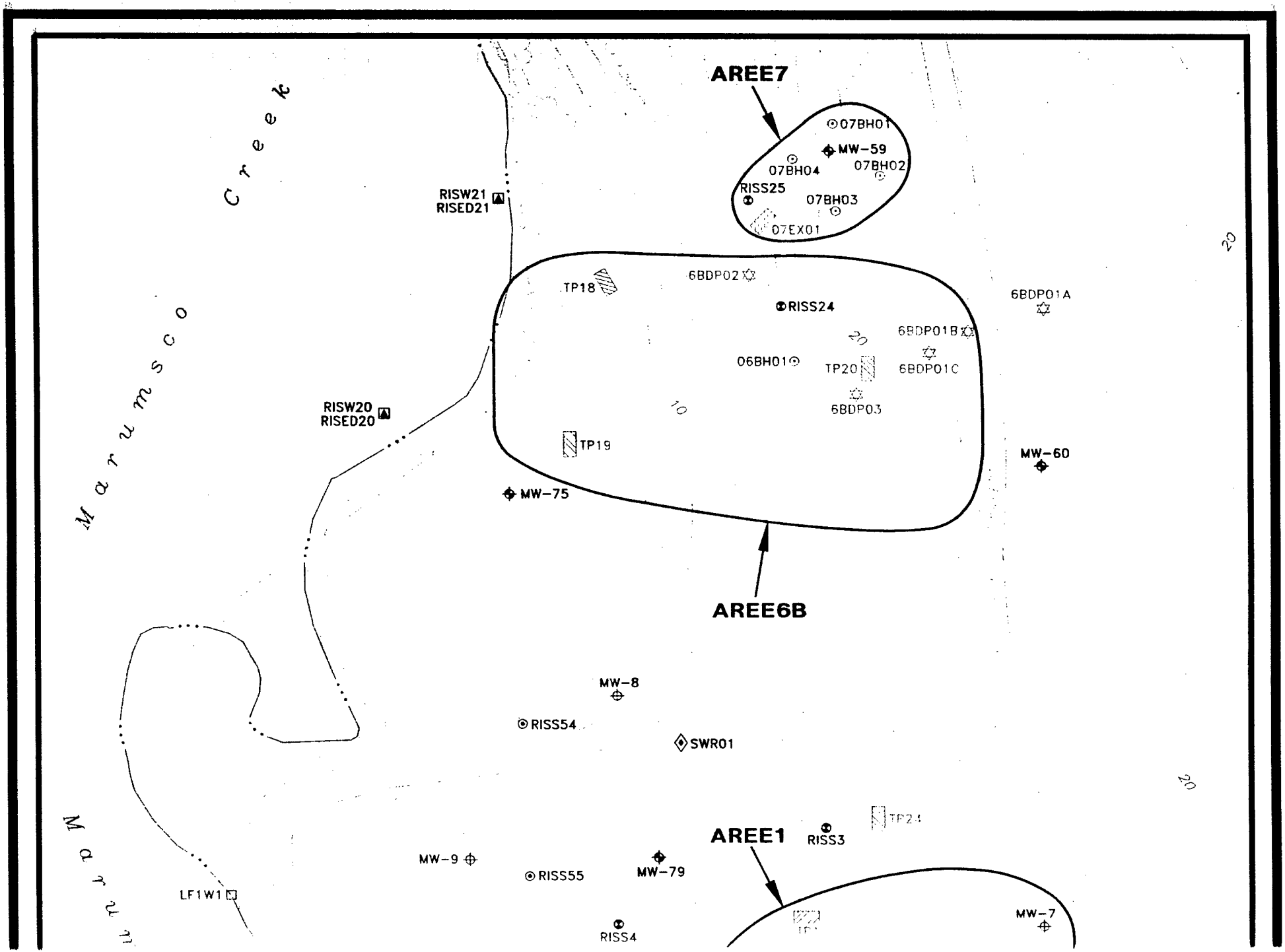


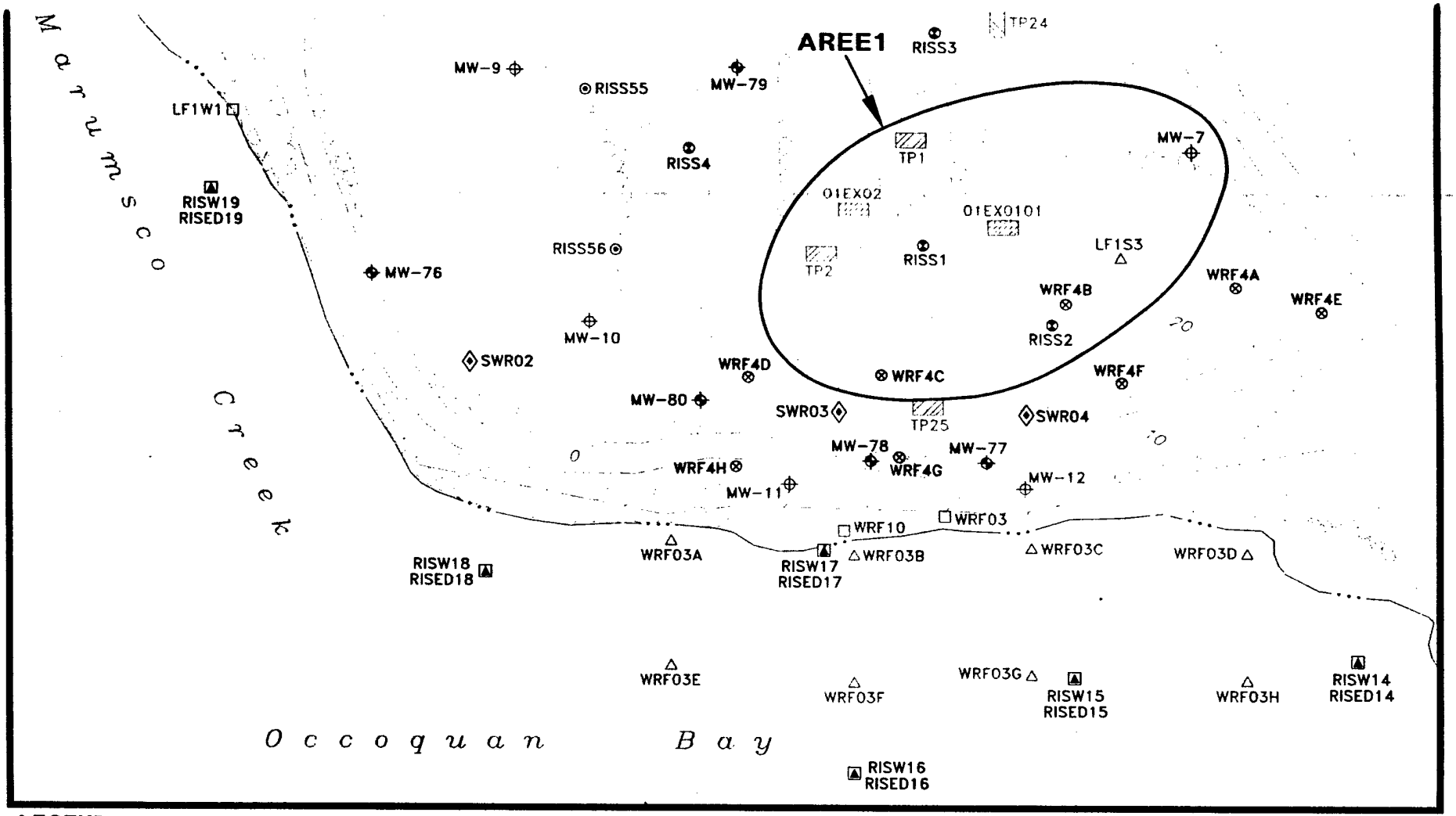
KEY PLAN

US ARMY ENVIRONMENTAL CENTER

NO. DACA31-94-D-0064	FIGURE 2-23
	WOODBRIDGE RESEARCH FACILITY
AISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	LOCATION OF BACKGROUND SURFACE WATER AND SEDIMENT SAMPLES FROM MASON NECK WILDLIFE REFUGE
TASK NO: 66220	
ICF DWG NO: MNECKCP1	
-97	

3


AREE7
07BH01
MW-59
07BH04
07BH02
RISS25
07BH03
07EX01
RISW21
RISED21
Marumsco Creek
TP18
6BDP02
RISS24
6BDP01A
6BDP01B
6BDP01C
06BH01
TP20
6BDP03
RISW20
RISED20
TP19
MW-60
MW-75
AREE6B
MW-8
RISS54
SWR01
TP24
AREE1
RISS3
MW-9
RISS55
MW-79
LF1W1
MW-7
RISS4
20
10



LEGEND:

- PRIOR MONITORING WELL LOCATION
- 1995 RI MONITORING WELL LOCATION
- PRIOR SOIL BORING LOCATION
- 1995 RI SOIL BORING LOCATION
- PRIOR SURFACE WATER SAMPLE LOCATION
- PRIOR SEDIMENT SAMPLE LOCATION
- 1995 RI SURFACE WATER/SEDIMENT SAMPLE LOCATION
- PRIOR SURFACE SOIL SAMPLE LOCATION
- 1995 RI SURFACE SOIL SAMPLE LOCATION
- PRIOR DEEP PUNCH LOCATION
- 1995 RI STORMWATER RUNOFF SAMPLE LOCATION
- PRIOR EXCAVATION LOCATION
- 1995 RI TEST PIT LOCATION
- AREE LOCATION

0 60 120
SCALE FEET

N

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

FIGURE 2-24

PRIOR MONITORING WELL LOCATION
1995 RI MONITORING WELL LOCATION
PRIOR SOIL BORING LOCATION
1995 RI SOIL BORING LOCATION
PRIOR SURFACE WATER SAMPLE LOCATION
PRIOR SEDIMENT SAMPLE LOCATION
1995 RI SURFACE WATER/SEDIMENT SAMPLE LOCATION
PRIOR SURFACE SOIL SAMPLE LOCATION
1995 RI SURFACE SOIL SAMPLE LOCATION
PRIOR DEEP PUNCH LOCATION
1995 RI STORMWATER RUNOFF SAMPLE LOCATION
PRIOR EXCAVATION LOCATION
1995 RI TEST PIT LOCATION
AREE LOCATION
SHORELINE
20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 2 FT.)
FENCE LINE
TREE LINE

0 60 120
SCALE FEET

N

US ARMY ENVIRONMENTAL CENTER

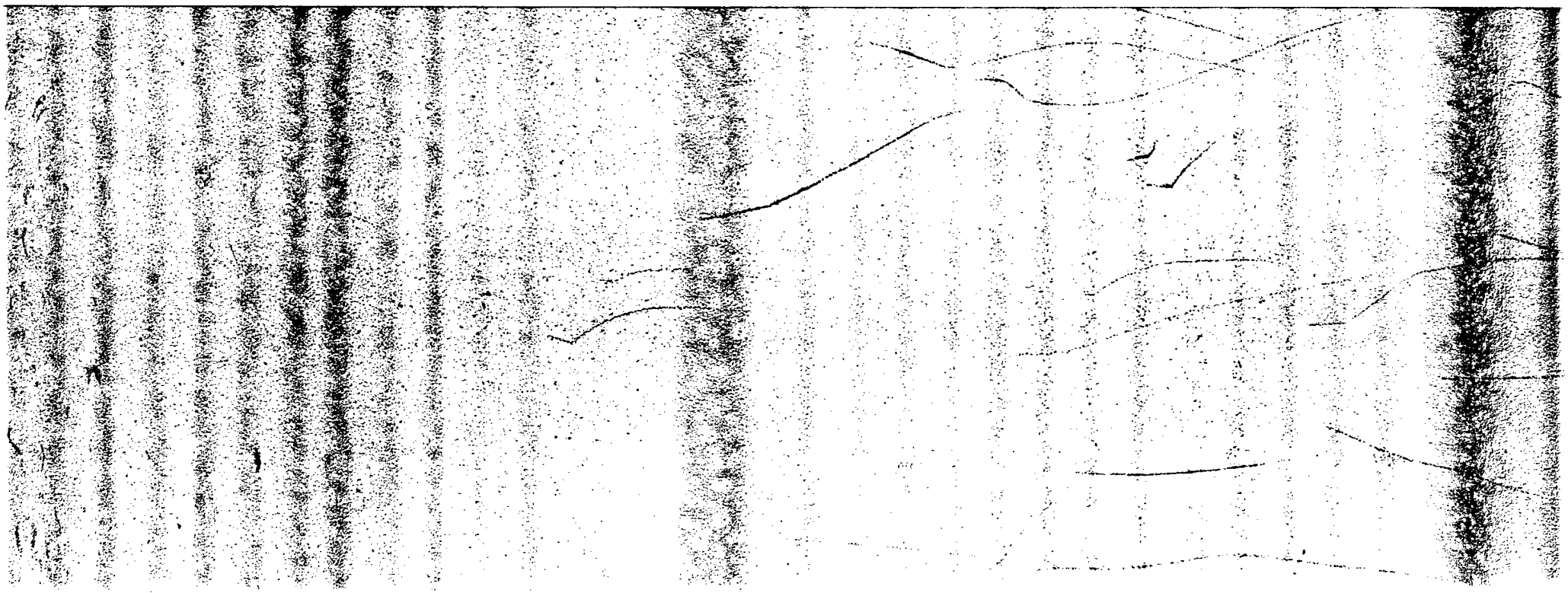
CONTRACT NO. DACA31-94-D-0064

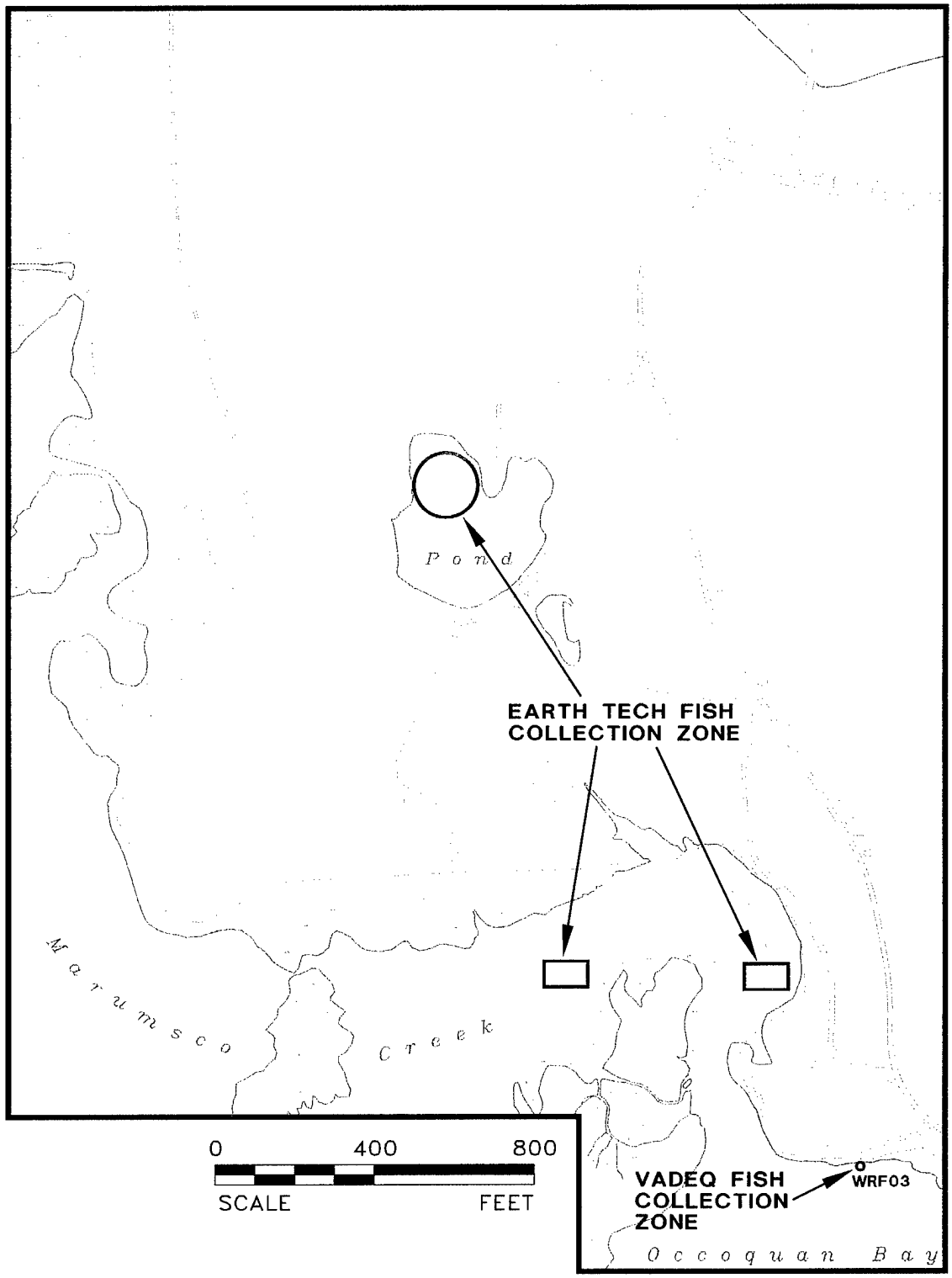
ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

FIGURE 2-24
WOODBRIDGE RESEARCH FACILITY

PREPARED CST
CHECKED PT
DATE 11-17-97
TASK NO: 66220
ICF DWG NO: A16B7SMP

PRIOR AND 1995 RI SAMPLING LOCATIONS FOR AREES 1, 6B, & 7





LEGEND:

ROAD

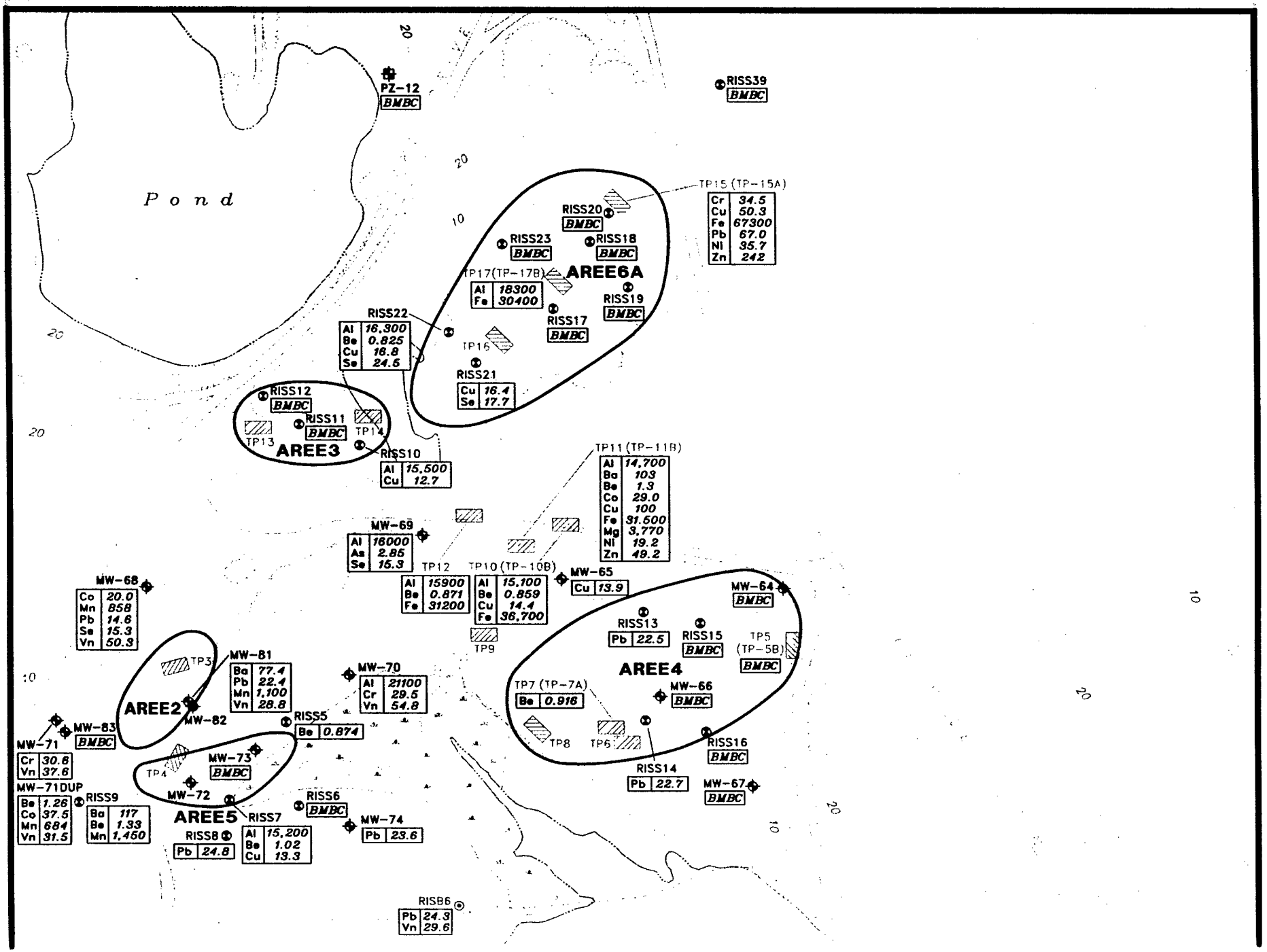
FENCE

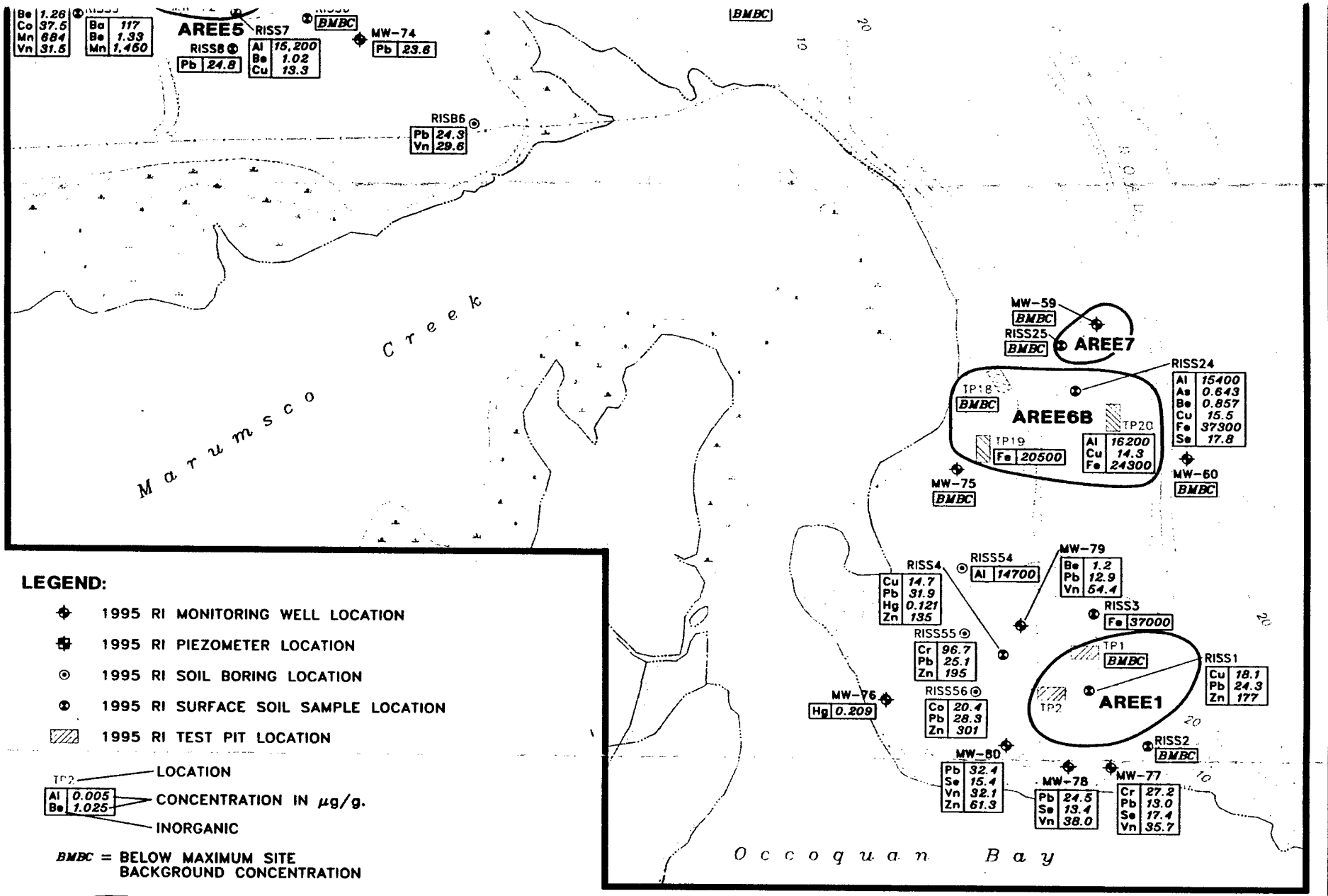
WATER

SWAMP

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064	FIGURE 2-25
ICF KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350	WOODBRIDGE RESEARCH FACILITY
PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: SW-FISH
DATE 11-17-97	EARTH TECH AND VADEQ FISH COLLECTION ZONES


Pond
PZ-12
BMBC
RISS39
BMBC
TP15 (TP-15A)
Cr 34.5
Cu 50.3
Fe 67300
Pb 67.0
Ni 35.7
Zn 242
RISS20
BMBC
RISS23
BMBC
RISS18
BMBC
AREE6A
TP17(TP-17B)
Al 18300
Fe 30400
RISS19
BMBC
RISS17
BMBC
RISS22
Al 16,300
Be 0.825
Cu 16.8
Se 24.6
TP16
RISS21
Cu 16.4
Se 17.7
RISS12
BMBC
RISS11
BMBC
TP13
TP14
AREE3
RISS10
Al 15,500
Cu 12.7
TP11 (TP-11B)
Al 14,700
Ba 103
Be 1.3
Co 29.0
Cu 100
Fe 31,500
Mg 3,770
Ni 19.2
Zn 49.2
MW-69
Al 16000
As 2.85
Se 15.3
TP12
Al 15900
Be 0.871
Fe 31200
TP10 (TP-10B)
Al 15,100
Be 0.859
Cu 14.4
Fe 36,700
TP9
MW-65
Cu 13.9
MW-64
BMBC
RISS13
Pb 22.5
RISS15
BMBC
TP5
(TP-5B)
BMBC
AREE4
MW-66
BMBC
TP7 (TP-7A)
Be 0.916
TP8
TP6
RISS16
BMBC
RISS14
Pb 22.7
MW-67
BMBC
MW-68
Co 20.0
Mn 858
Pb 14.6
Se 15.3
Vn 50.3
TP3
MW-81
Ba 77.4
Pb 22.4
Mn 1,100
Vn 28.8
MW-70
Al 21100
Cr 29.5
Vn 54.8
AREE2
MW-82
RISS5
Be 0.874
MW-83
BMBC
MW-71
Cr 30.6
Vn 37.6
MW-71DUP
Be 1.26
Co 37.5
Mn 684
Vn 31.5
TP4
MW-73
BMBC
MW-72
RISS9
Ba 117
Be 1.33
Mn 1,450
AREE5
RISS7
RISS8
Pb 24.8
Al 15,200
Be 1.02
Cu 13.3
RISS6
BMBC
MW-74
Pb 23.6
RISB6
Pb 24.3
Vn 29.6



LEGEND:

- 1995 RI MONITORING WELL LOCATION
- 1995 RI PIEZOMETER LOCATION
- 1995 RI SOIL BORING LOCATION
- 1995 RI SURFACE SOIL SAMPLE LOCATION
- 1995 RI TEST PIT LOCATION

TP2 — LOCATION
Al 0.005
Be 1.025 — CONCENTRATION IN µg/g.
INORGANIC

BMBC = BELOW MAXIMUM SITE BACKGROUND CONCENTRATION

AREE LOCATION

20 — TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP

0 150 300
SCALE FEET

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064 | FIGURE 2-26

TP2 — LOCATION

Al	0.005
Be	1.025

CONCENTRATION IN µg/g.

INORGANIC

BMBC = BELOW MAXIMUM SITE BACKGROUND CONCENTRATION

AREE LOCATION

20 — TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP

Se	15.4
Vn	32.1
Zn	61.3

MW-7B

Pb	24.5
Se	13.4
Vn	38.0

MW-7?

Cr	27.2
Pb	13.0
Se	17.4
Vn	35.7

Occoquan Bay

0 150 300

SCALE FEET

N

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

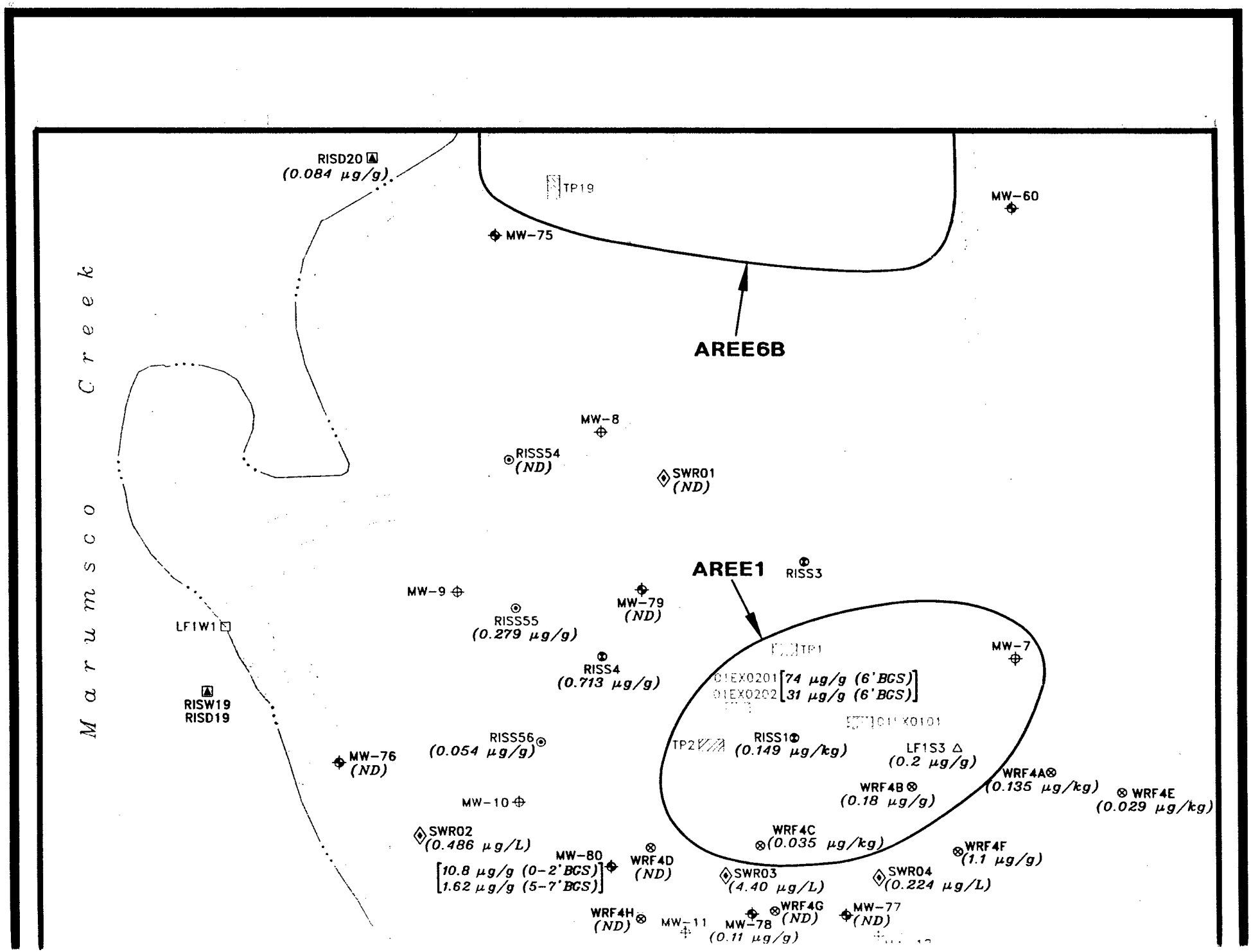
FIGURE 2-26

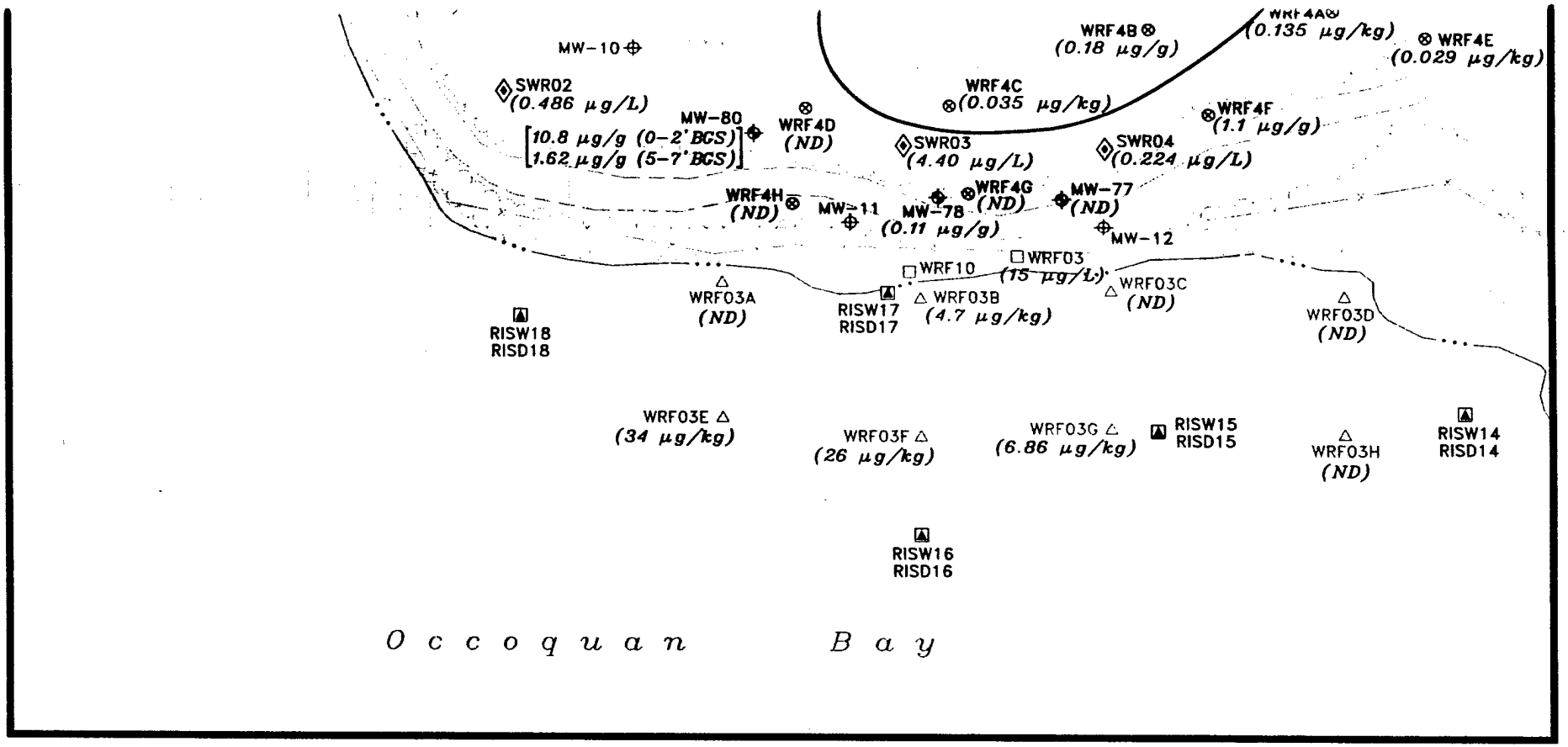
WOODBRIDGE RESEARCH FACILITY

ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: OU1-RES6
DATE 11-17-97	

INORGANICS DETECTED IN SURFACE SOILS ABOVE BACKGROUND - OU1 AREA


Marumsco Creek
RISD20
(0.084 µg/g)
TP19
MW-60
MW-75
AREE6B
MW-8
RISS54
(ND)
SWR01
(ND)
AREE1
RISS3
MW-9
MW-79
(ND)
RISS55
(0.279 µg/g)
LF1W1
TP1
MW-7
RISS4
(0.713 µg/g)
01EX0201 [74 µg/g (6'BGS)]
01EX0202 [31 µg/g (6'BGS)]
RISW19
RISD19
RISS56
(0.054 µg/g)
TP2
RISS1
(0.149 µg/kg)
LF1S3
(0.2 µg/g)
MW-76
(ND)
WRF4A
(0.135 µg/kg)
WRF4B
(0.18 µg/g)
WRF4E
(0.029 µg/kg)
MW-10
SWR02
(0.486 µg/L)
WRF4C
(0.035 µg/kg)
WRF4F
(1.1 µg/g)
MW-80
[10.8 µg/g (0-2'BGS)
1.62 µg/g (5-7'BGS)]
WRF4D
(ND)
SWR03
(4.40 µg/L)
SWR04
(0.224 µg/L)
WRF4H
(ND)
MW-11
MW-78
(0.11 µg/g)
WRF4G
(ND)
MW-77
(ND)



LEGEND:

- PRIOR MONITORING WELL LOCATION
- 1995 RI MONITORING WELL LOCATION
- 1995 RI SOIL BORING LOCATION
- PRIOR SURFACE WATER SAMPLE LOCATION
- PRIOR SEDIMENT SAMPLE LOCATION
- 1995 RI SURFACE WATER/SEDIMENT SAMPLE LOCATION
- PRIOR SURFACE SOIL SAMPLE LOCATION
- 1995 RI SURFACE SOIL SAMPLE LOCATION
- 1995 RI STORMWATER RUNOFF SAMPLE LOCATION
- PRIOR EXCAVATION LOCATION
- 1995 RI TEST PIT LOCATION
- AREE LOCATION

0 60 120
SCALE FEET

N

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064 FIGURE 2-27

- 1995 RI SOIL BORING LOCATION
- PRIOR SURFACE WATER SAMPLE LOCATION
- PRIOR SEDIMENT SAMPLE LOCATION
- 1995 RI SURFACE WATER/SEDIMENT SAMPLE LOCATION
- PRIOR SURFACE SOIL SAMPLE LOCATION
- 1995 RI SURFACE SOIL SAMPLE LOCATION
- 1995 RI STORMWATER RUNOFF SAMPLE LOCATION
- PRIOR EXCAVATION LOCATION
- 1995 RI TEST PIT LOCATION
- AREE LOCATION
- SHORELINE
- FENCE LINE
- TREE LINE

0 60 120
SCALE FEET

N

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

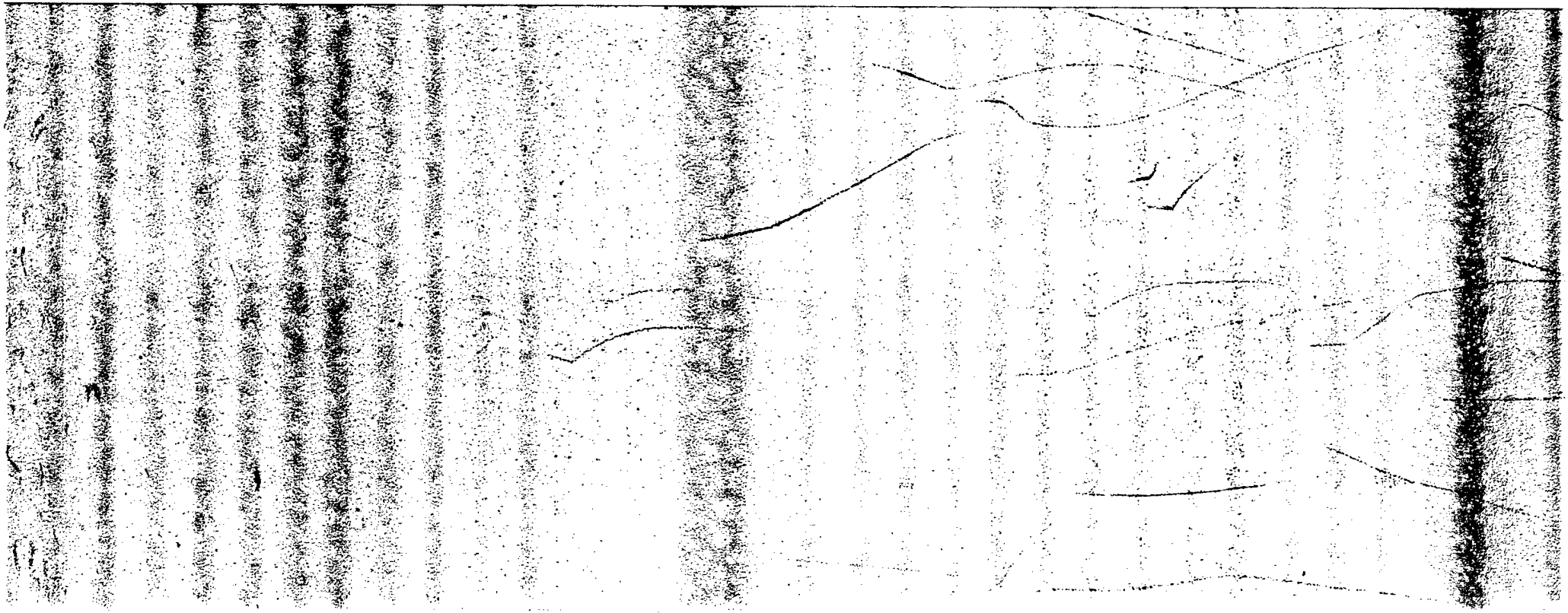
FIGURE 2-27

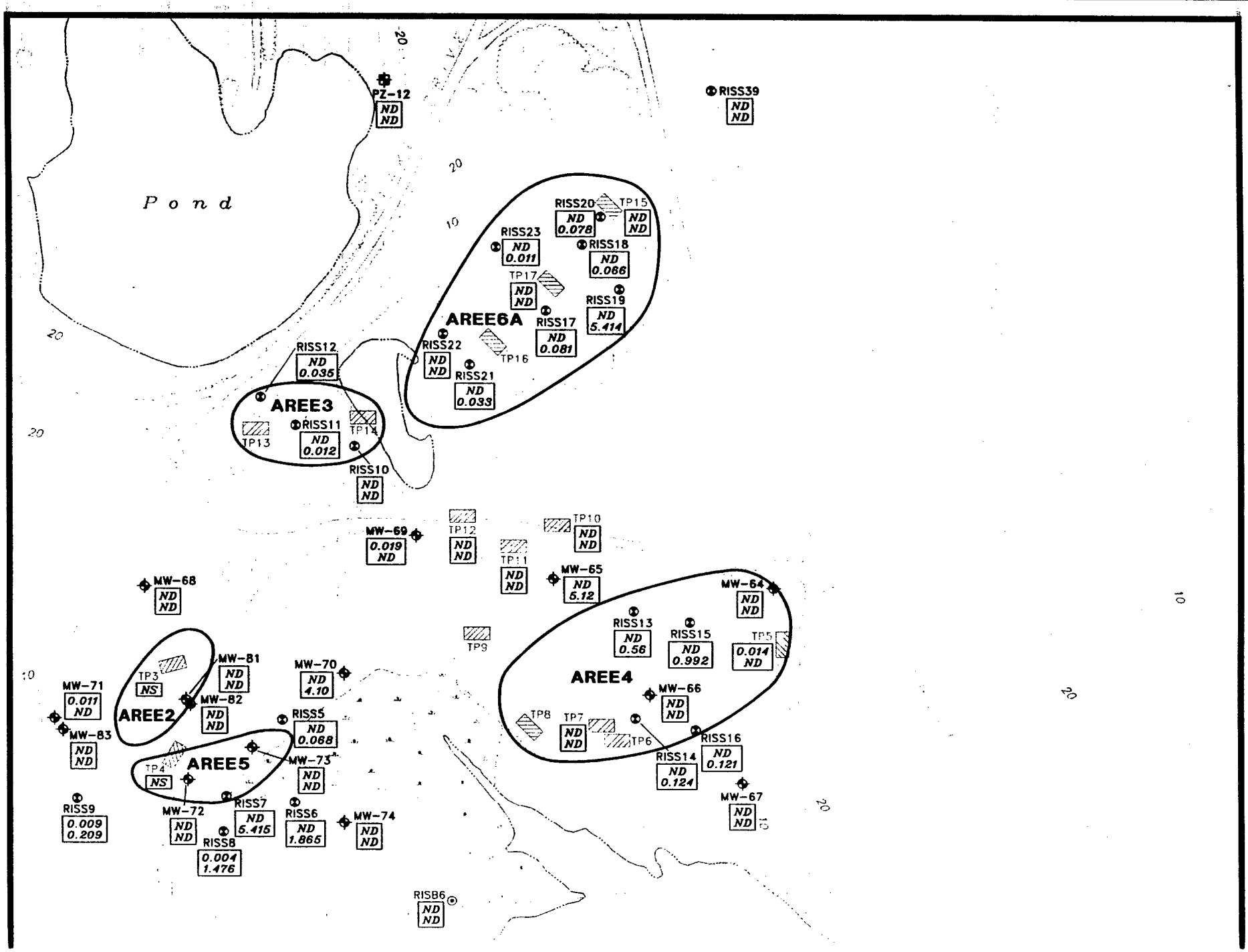
WOODBRIDGE RESEARCH FACILITY

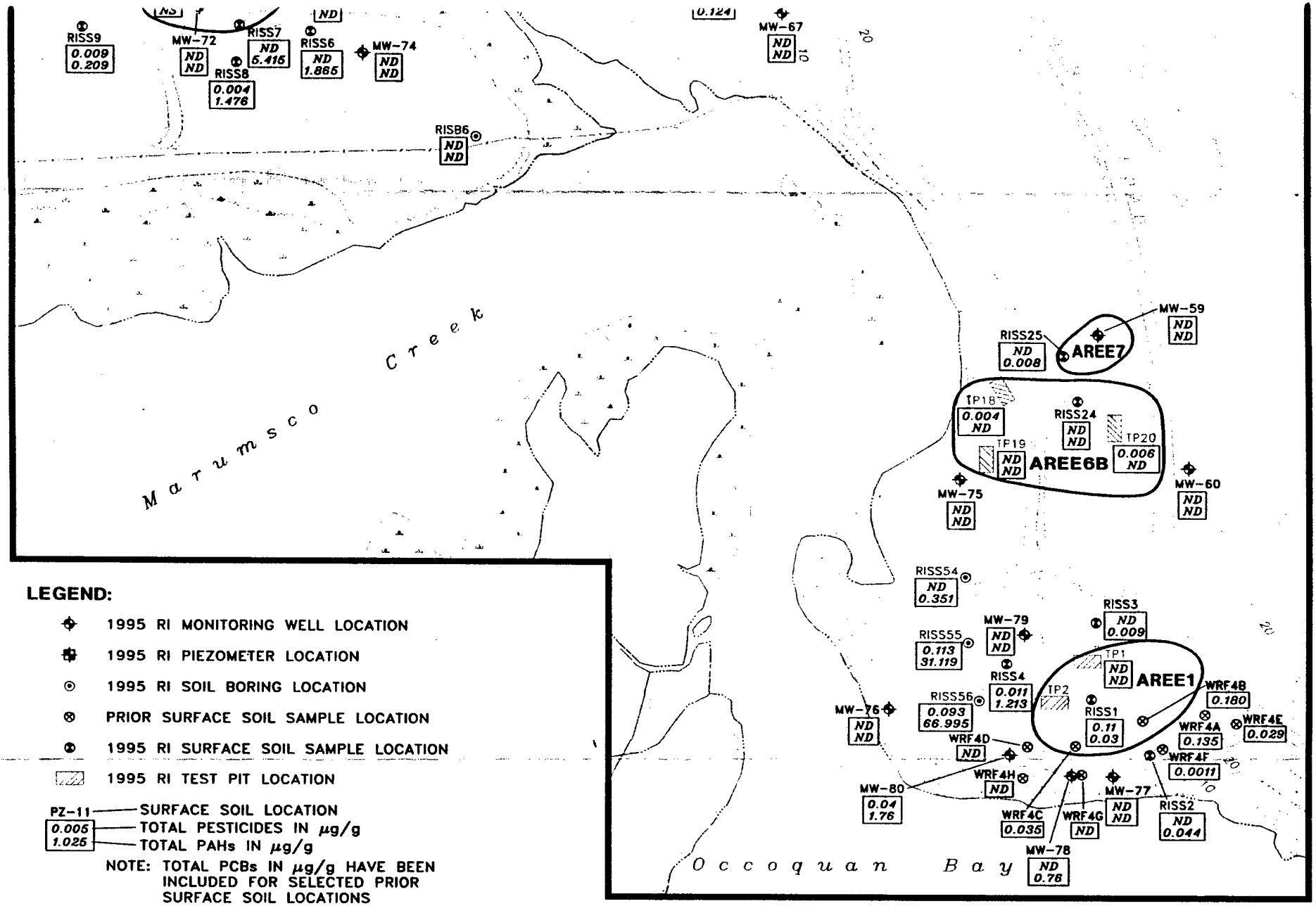
ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: A1-RES2
DATE 11-17-97	

AREE 1 PCB CONCENTRATIONS IN SURFACE SOIL, SUBSURFACE SOIL, TEST PITS, SURFACE WATER RUNOFF, & SEDIMENT SAMPLES




Pond
PZ-12
ND
ND
RISS39
ND
ND
RISS20
ND
0.078
TP15
ND
ND
RISS23
ND
0.011
RISS18
ND
0.066
TP17
ND
ND
RISS19
ND
5.414
AREE6A
RISS17
ND
0.081
RISS22
ND
ND
TP16
RISS21
ND
0.033
RISS12
ND
0.036
AREE3
TP13
RISS11
ND
0.012
TP14
RISS10
ND
ND
MW-69
0.019
ND
TP12
ND
ND
TP10
ND
ND
TP11
ND
ND
MW-65
ND
5.12
MW-64
ND
ND
MW-68
ND
ND
TP9
RISS13
ND
0.56
RISS15
ND
0.992
TP5
0.014
ND
AREE4
MW-66
ND
ND
TP8
TP7
ND
ND
TP6
RISS16
ND
0.121
RISS14
ND
0.124
MW-67
ND
ND
TP3
NS
AREE2
MW-81
ND
ND
MW-70
ND
4.10
MW-71
0.011
ND
MW-82
ND
ND
RISS5
ND
0.068
MW-83
ND
ND
TP4
NS
AREE5
MW-73
ND
ND
RISS9
0.009
0.209
MW-72
ND
ND
RISS7
ND
5.415
RISS6
ND
1.865
MW-74
ND
ND
RISS8
0.004
1.476
RISB6
ND
ND



LEGEND:

- 1995 RI MONITORING WELL LOCATION
- 1995 RI PIEZOMETER LOCATION
- 1995 RI SOIL BORING LOCATION
- PRIOR SURFACE SOIL SAMPLE LOCATION
- 1995 RI SURFACE SOIL SAMPLE LOCATION
- 1995 RI TEST PIT LOCATION

PZ-11 — SURFACE SOIL LOCATION
0.005 — TOTAL PESTICIDES IN µg/g
1.025 — TOTAL PAHs IN µg/g

NOTE: TOTAL PCBs IN µg/g HAVE BEEN INCLUDED FOR SELECTED PRIOR SURFACE SOIL LOCATIONS

ND = NOT DETECTED
NS = NOT SAMPLED

AREE LOCATION

20 — TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

0 150 300
SCALE FEET

US ARMY ENVIRONMENTAL CENTER

1995 RI TEST PIT LOCATION

PZ-11 — SURFACE SOIL LOCATION
0.005 — TOTAL PESTICIDES IN µg/g
1.025 — TOTAL PAHs IN µg/g

NOTE: TOTAL PCBs IN µg/g HAVE BEEN INCLUDED FOR SELECTED PRIOR SURFACE SOIL LOCATIONS

ND = NOT DETECTED
NS = NOT SAMPLED

AREE LOCATION

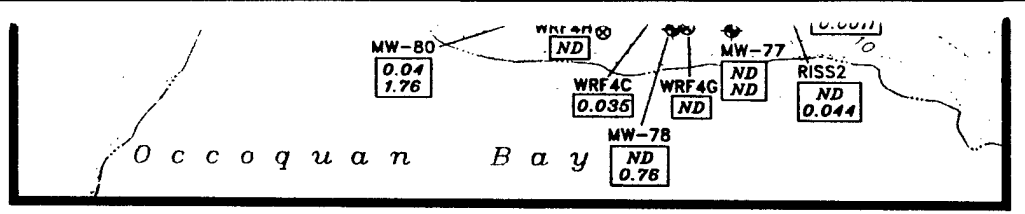
20 — TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP



0 150 300
SCALE FEET

N

US ARMY ENVIRONMENTAL CENTER

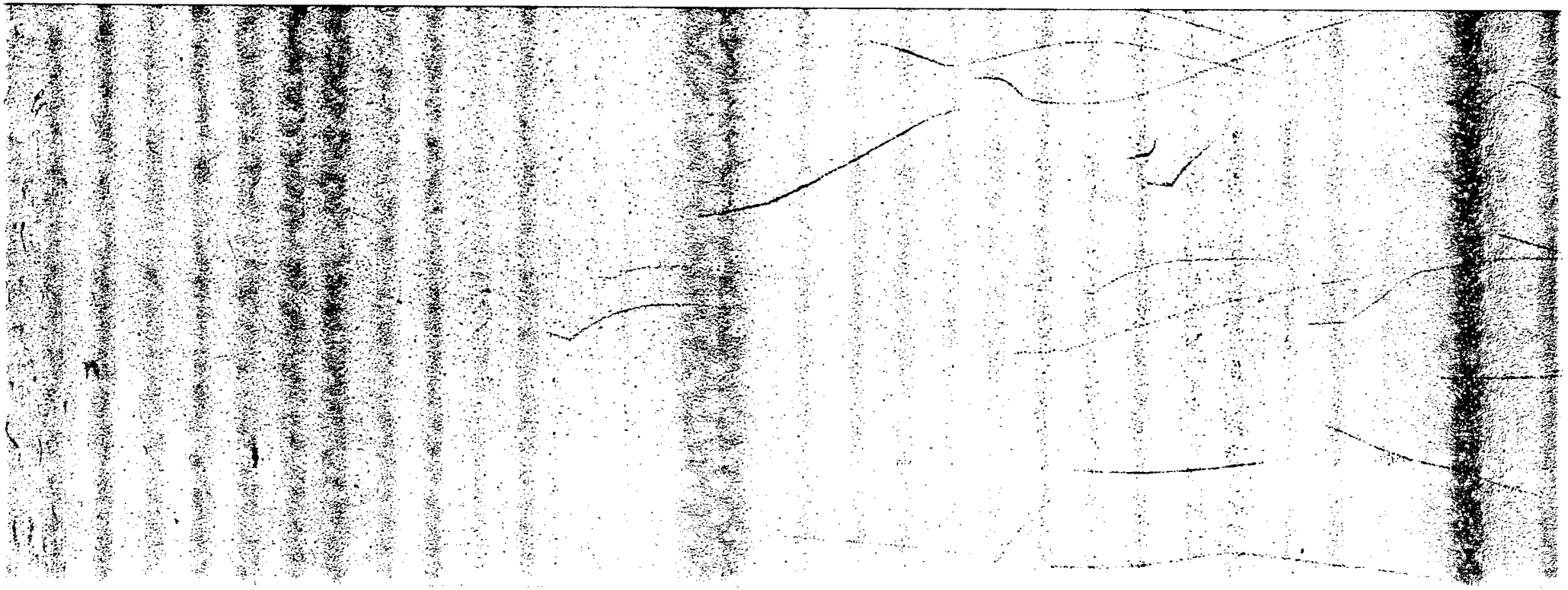
CONTRACT NO. DACA31-94-D-0064

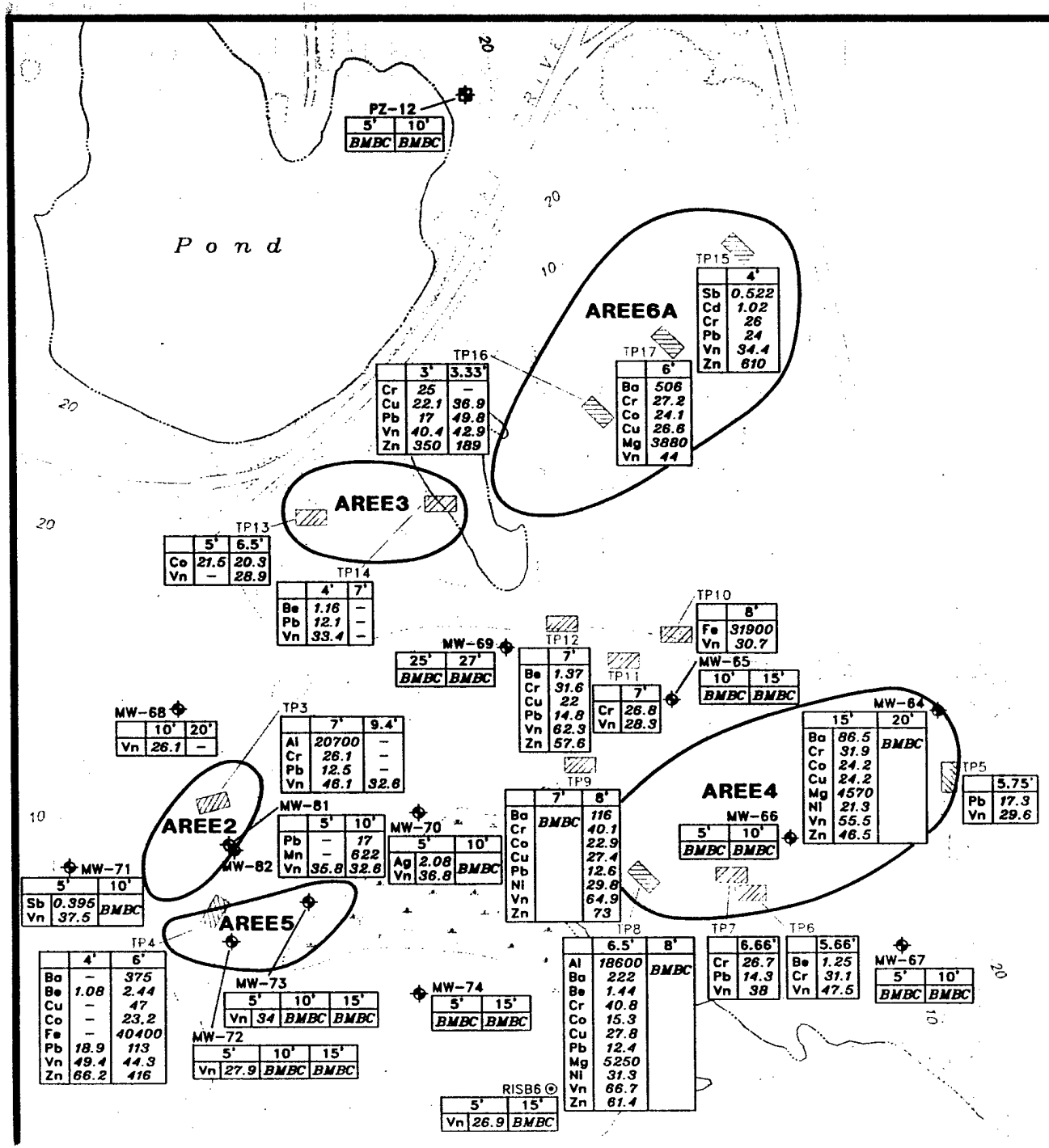
FIGURE 2-28
WOODBRIDGE RESEARCH FACILITY

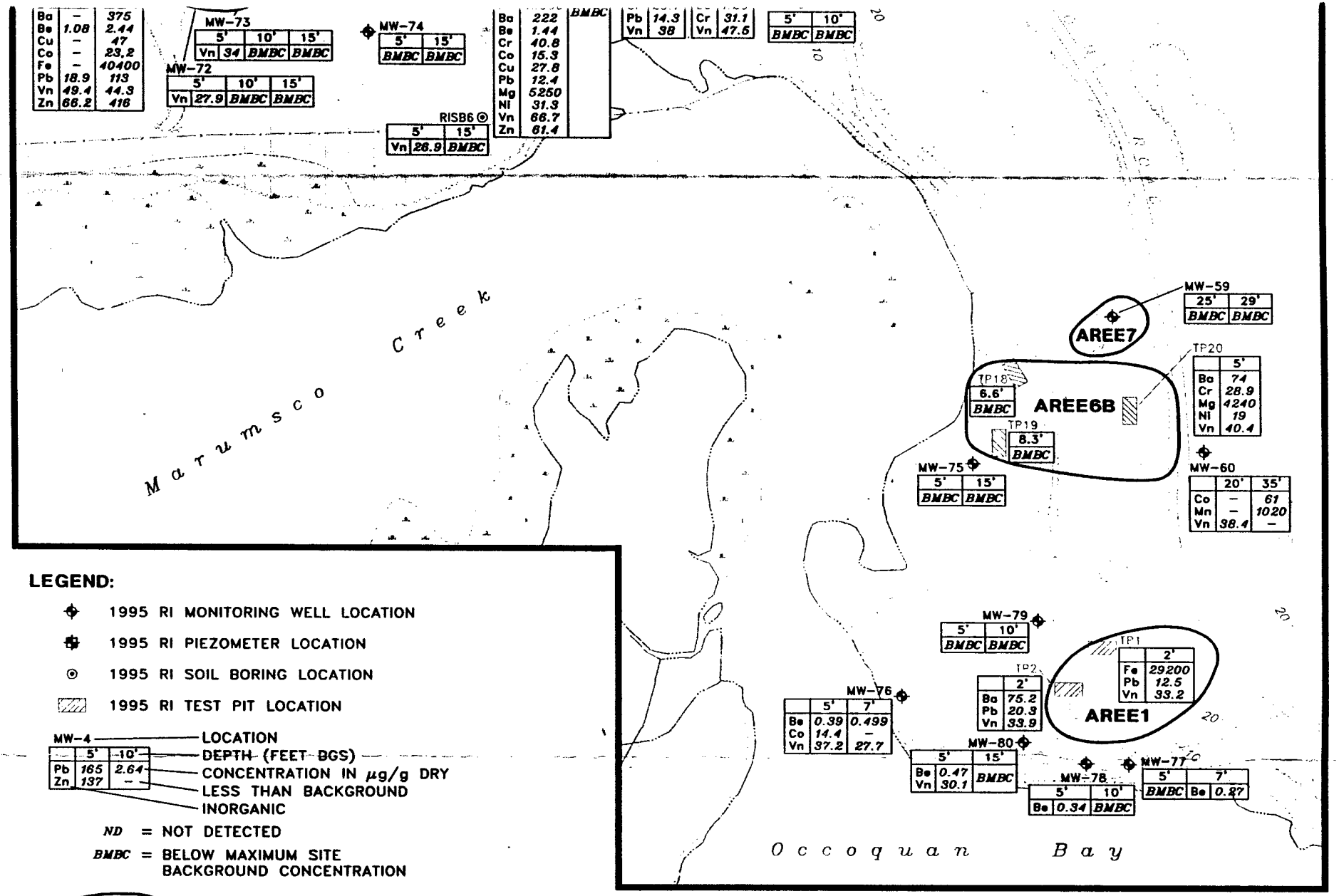
ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: OU1-RES3
DATE 11-17-97	

TOTAL PESTICIDES AND TOTAL PAHs DETECTED IN SURFACE SOILS - OU1 AREA




Pond
AREE2
AREE3
AREE4
AREE5
AREE6A
PZ-12
5' 10'
BMBC BMBC
TP15
4'
Sb 0.522
Cd 1.02
Cr 26
Pb 24
Vn 34.4
Zn 610
TP16
3' 3.33'
Cr 25 –
Cu 22.1 36.9
Pb 17 49.8
Vn 40.4 42.9
Zn 350 189
TP17
6'
Ba 506
Cr 27.2
Co 24.1
Cu 26.6
Mg 3880
Vn 44
TP13
5' 6.5'
Co 21.5 20.3
Vn – 28.9
TP14
4' 7'
Be 1.16 –
Pb 12.1 –
Vn 33.4 –
TP10
8'
Fe 31900
Vn 30.7
MW-69
25' 27'
BMBC BMBC
TP12
7'
Be 1.37
Cr 31.6
Cu 22
Pb 14.8
Vn 62.3
Zn 57.6
TP11
7'
Cr 26.8
Vn 28.3
MW-65
10' 15'
BMBC BMBC
MW-64
15' 20'
Ba 86.5 BMBC
Cr 31.9
Co 24.2
Cu 24.2
Mg 4570
Ni 21.3
Vn 55.5
Zn 46.5
TP5
5.75'
Pb 17.3
Vn 29.6
MW-68
10' 20'
Vn 26.1 –
TP3
7' 9.4'
Al 20700 –
Cr 26.1 –
Pb 12.5 –
Vn 46.1 32.6
MW-81
5' 10'
Pb – 17
Mn – 622
Vn 35.8 32.6
MW-70
5' 10'
Ag 2.08 BMBC
Vn 36.8 BMBC
TP9
7' 8'
Ba BMBC 116
Cr 40.1
Co 22.9
Cu 27.4
Pb 12.6
Ni 29.8
Vn 64.9
Zn 73
MW-66
5' 10'
BMBC BMBC
MW-71
5' 10'
Sb 0.395 BMBC
Vn 37.5
MW-82
TP4
4' 6'
Ba – 375
Be 1.08 2.44
Cu – 47
Co – 23.2
Fe – 40400
Pb 18.9 113
Vn 49.4 44.3
Zn 66.2 416
MW-73
5' 10' 15'
Vn 34 BMBC BMBC
MW-72
5' 10' 15'
Vn 27.9 BMBC BMBC
MW-74
5' 15'
BMBC BMBC
RISB6
5' 15'
Vn 26.9 BMBC
TP8
6.5' 8'
Al 18600 BMBC
Ba 222
Be 1.44
Cr 40.8
Co 15.3
Cu 27.8
Pb 12.4
Mg 5250
Ni 31.3
Vn 66.7
Zn 61.4
TP7
6.66'
Cr 26.7
Pb 14.3
Vn 38
TP6
5.66'
Be 1.25
Cr 31.1
Vn 47.5
MW-67
5' 10'
BMBC BMBC
20
10



LEGEND:

- 1995 RI MONITORING WELL LOCATION
- 1995 RI PIEZOMETER LOCATION
- 1995 RI SOIL BORING LOCATION
- 1995 RI TEST PIT LOCATION

MW-4 — LOCATION

	5'	10'
Pb	165	2.64
Zn	137	–

5' — DEPTH (FEET BGS)
165 — CONCENTRATION IN µg/g DRY
– — LESS THAN BACKGROUND
Pb, Zn — INORGANIC

ND = NOT DETECTED

BMBC = BELOW MAXIMUM SITE BACKGROUND CONCENTRATION

AREE LOCATION

20 — TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP

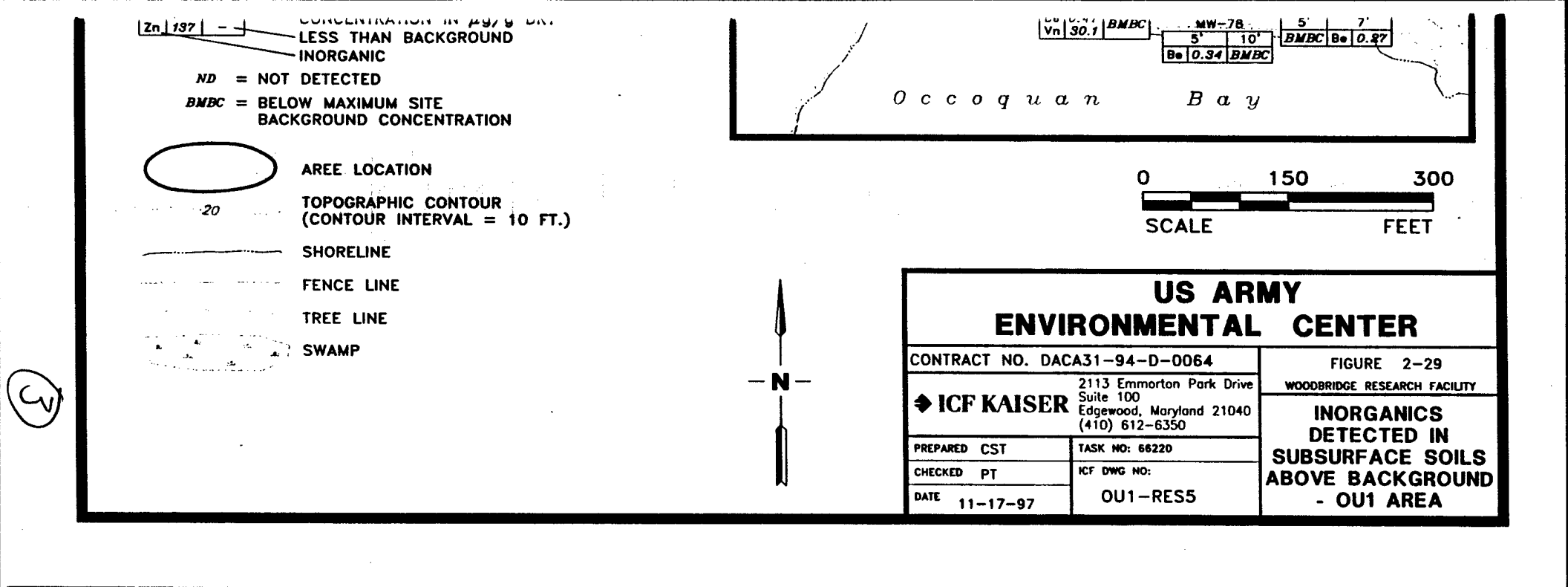
0 150 300

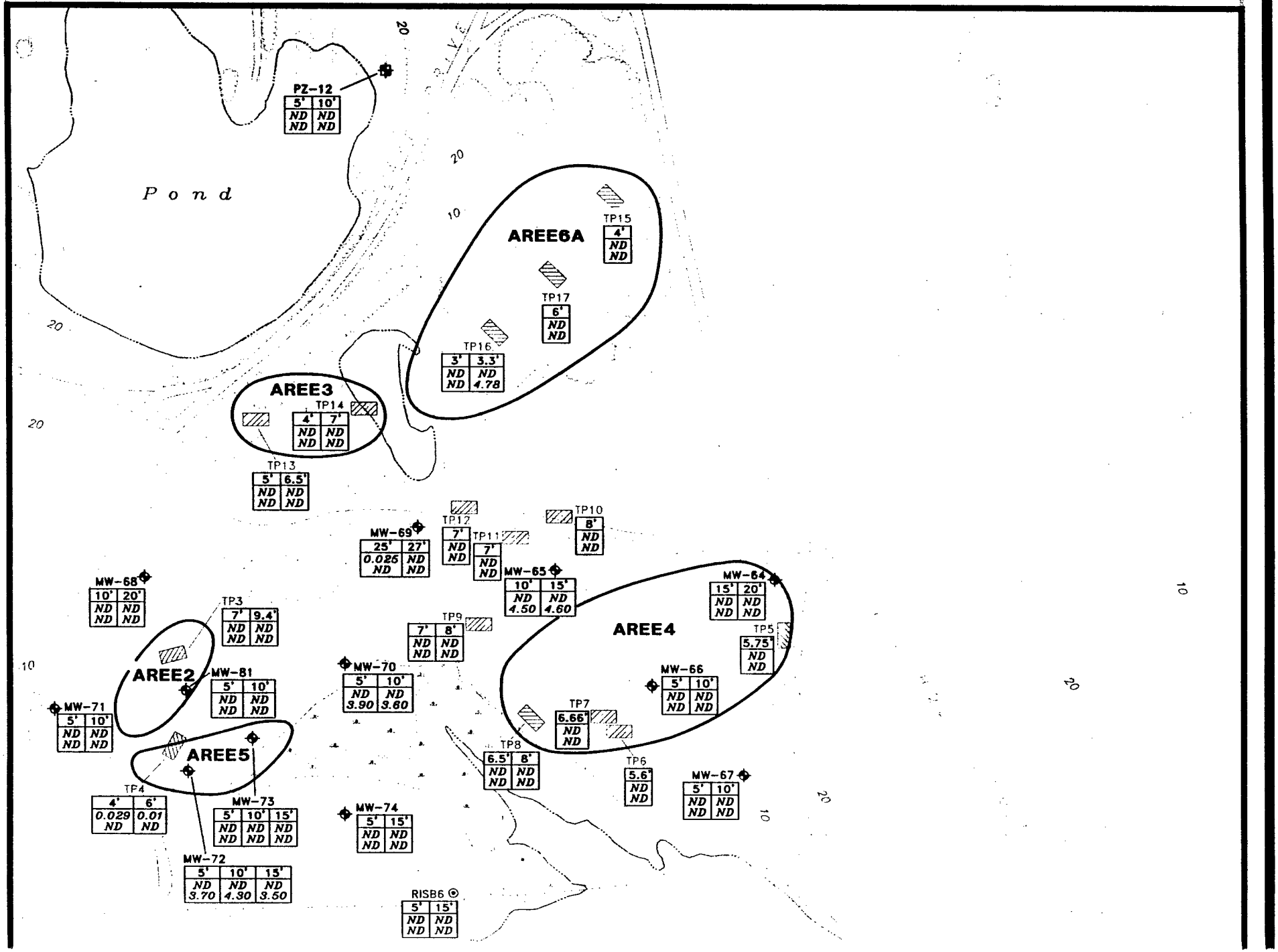
SCALE FEET

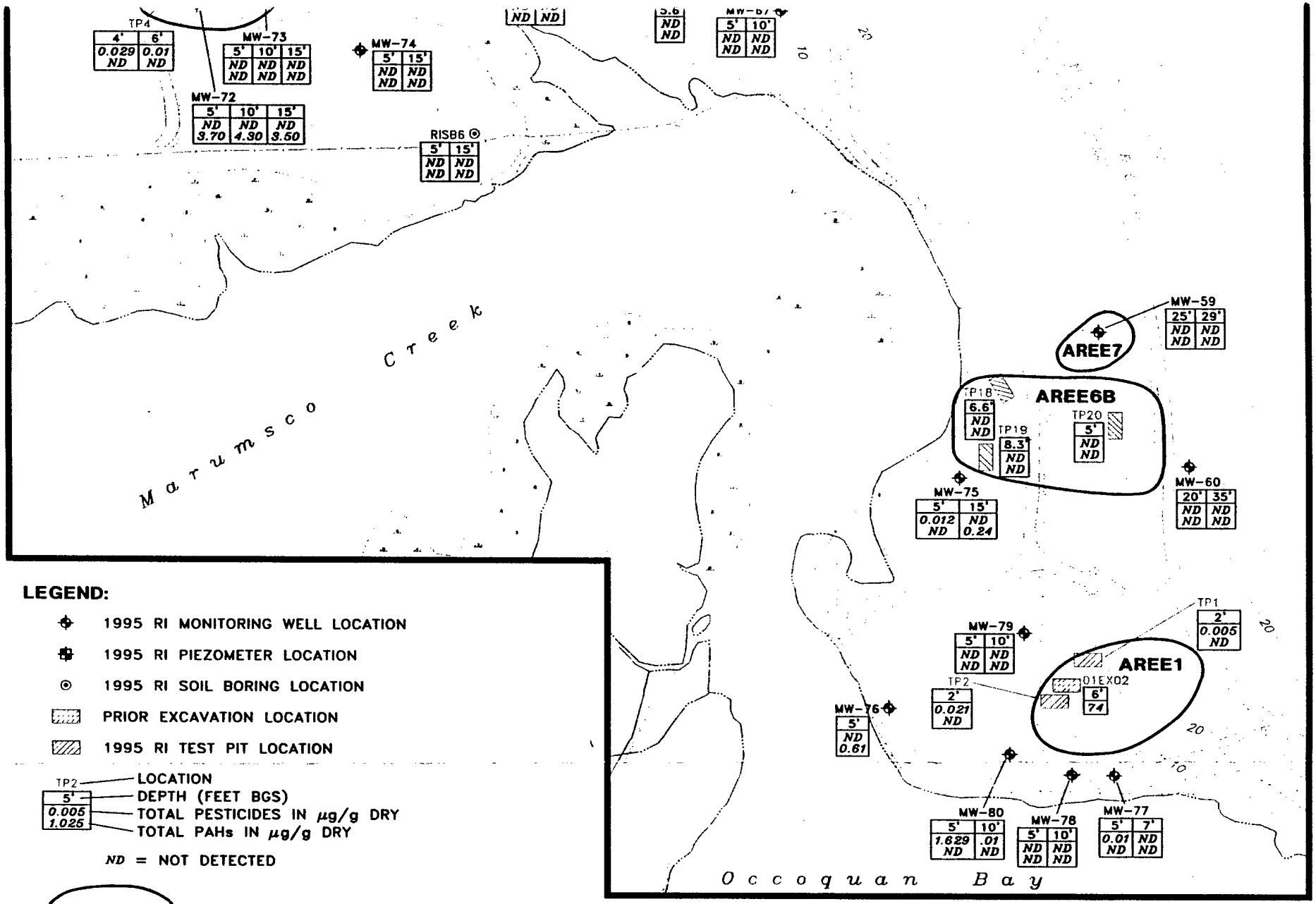
US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

FIGURE 2-29


Zn 137 –
CONCENTRATION IN µg/g DRY
LESS THAN BACKGROUND INORGANIC
ND = NOT DETECTED
BMBC = BELOW MAXIMUM SITE BACKGROUND CONCENTRATION
AREE LOCATION
20
TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)
SHORELINE
FENCE LINE
TREE LINE
SWAMP
Occoquan Bay
Vn 30.1 BMBC
MW-78
5' 10'
Be 0.34 BMBC
5' 7'
BMBC Be 0.87
0 150 300
SCALE FEET
N
US ARMY
ENVIRONMENTAL CENTER
CONTRACT NO. DACA31-94-D-0064
ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350
PREPARED CST
CHECKED PT
DATE 11-17-97
TASK NO: 66220
ICF DWG NO:
OU1-RES5
FIGURE 2-29
WOODBRIDGE RESEARCH FACILITY
INORGANICS DETECTED IN SUBSURFACE SOILS ABOVE BACKGROUND - OU1 AREA


PZ-12
5' | 10'
ND | ND
ND | ND
Pond
AREE6A
TP15
4'
ND
ND
TP17
6'
ND
ND
TP16
3' | 3.3'
ND | ND
ND | 4.78
AREE3
TP14
4' | 7'
ND | ND
ND | ND
TP13
5' | 6.5'
ND | ND
ND | ND
TP12
7'
ND
ND
TP11
7'
ND
ND
TP10
8'
ND
ND
MW-69
25' | 27'
0.025 | ND
ND | ND
MW-65
10' | 15'
ND | ND
4.50 | 4.60
MW-64
15' | 20'
ND | ND
ND | ND
MW-68
10' | 20'
ND | ND
ND | ND
TP3
7' | 9.4'
ND | ND
ND | ND
TP9
7' | 8'
ND | ND
ND | ND
AREE4
TP5
5.75'
ND
ND
AREE2
MW-81
5' | 10'
ND | ND
ND | ND
MW-70
5' | 10'
ND | ND
3.90 | 3.60
MW-66
5' | 10'
ND | ND
ND | ND
MW-71
5' | 10'
ND | ND
ND | ND
TP7
6.66'
ND
ND
AREE5
TP8
6.5' | 8'
ND | ND
ND | ND
TP6
5.6'
ND
ND
MW-67
5' | 10'
ND | ND
ND | ND
TP4
4' | 6'
0.029 | 0.01
ND | ND
MW-73
5' | 10' | 15'
ND | ND | ND
ND | ND | ND
MW-74
5' | 15'
ND | ND
ND | ND
MW-72
5' | 10' | 15'
ND | ND | ND
3.70 | 4.30 | 3.50
RISB6
5' | 15'
ND | ND
ND | ND
20
10



LEGEND:

- 1995 RI MONITORING WELL LOCATION
- 1995 RI PIEZOMETER LOCATION
- 1995 RI SOIL BORING LOCATION
- PRIOR EXCAVATION LOCATION
- 1995 RI TEST PIT LOCATION

TP2 — LOCATION
5' — DEPTH (FEET BGS)
0.005 — TOTAL PESTICIDES IN µg/g DRY
1.025 — TOTAL PAHs IN µg/g DRY

ND = NOT DETECTED

AREE LOCATION

20 — TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064 FIGURE 2-30

LOCATION
5' — DEPTH (FEET BGS)
0.005 — TOTAL PESTICIDES IN µg/g DRY
1.025 — TOTAL PAHs IN µg/g DRY

ND = NOT DETECTED

AREE LOCATION

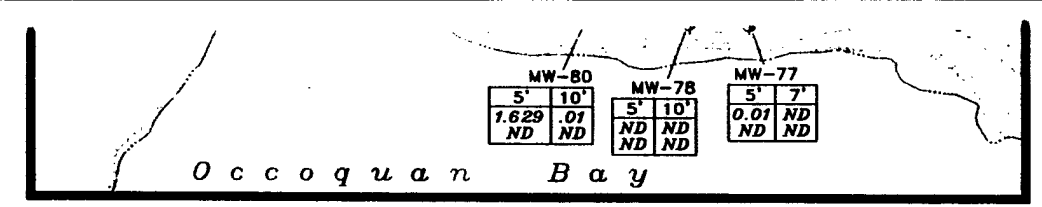
20 — TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP



0 150 300
SCALE FEET

N

US ARMY ENVIRONMENTAL CENTER

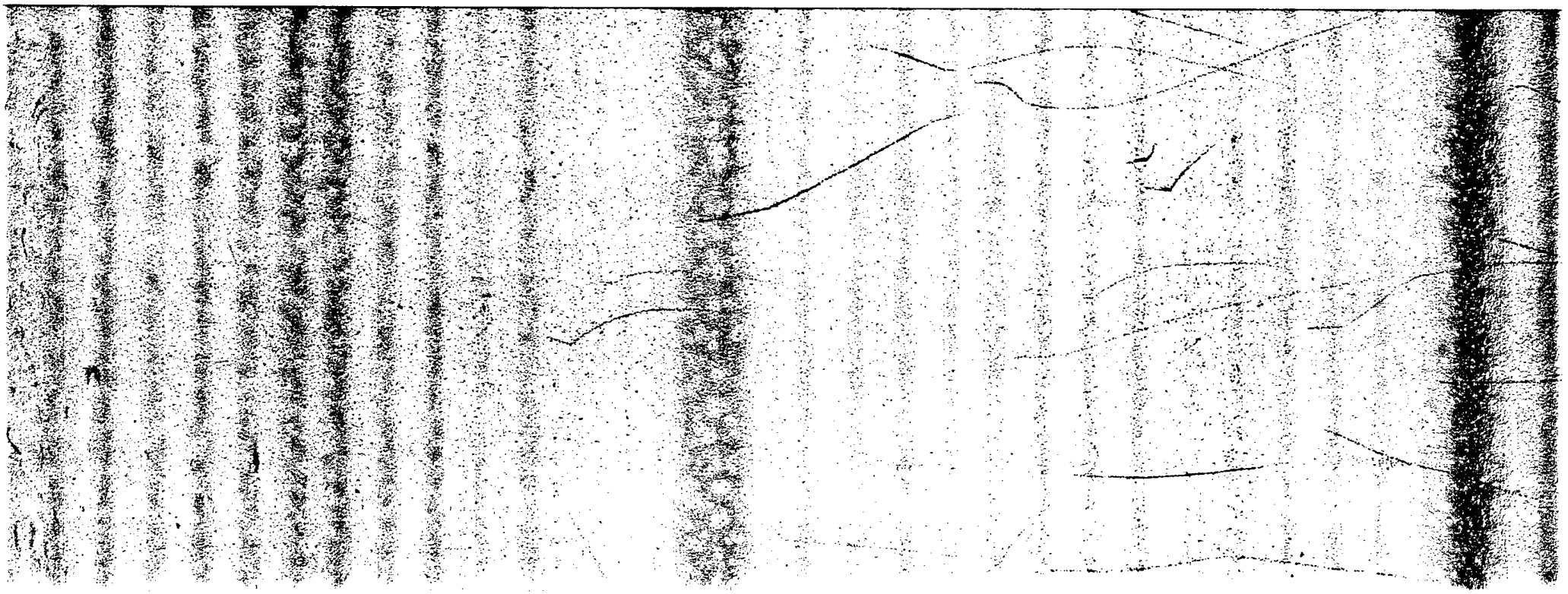
CONTRACT NO. DACA31-94-D-0064

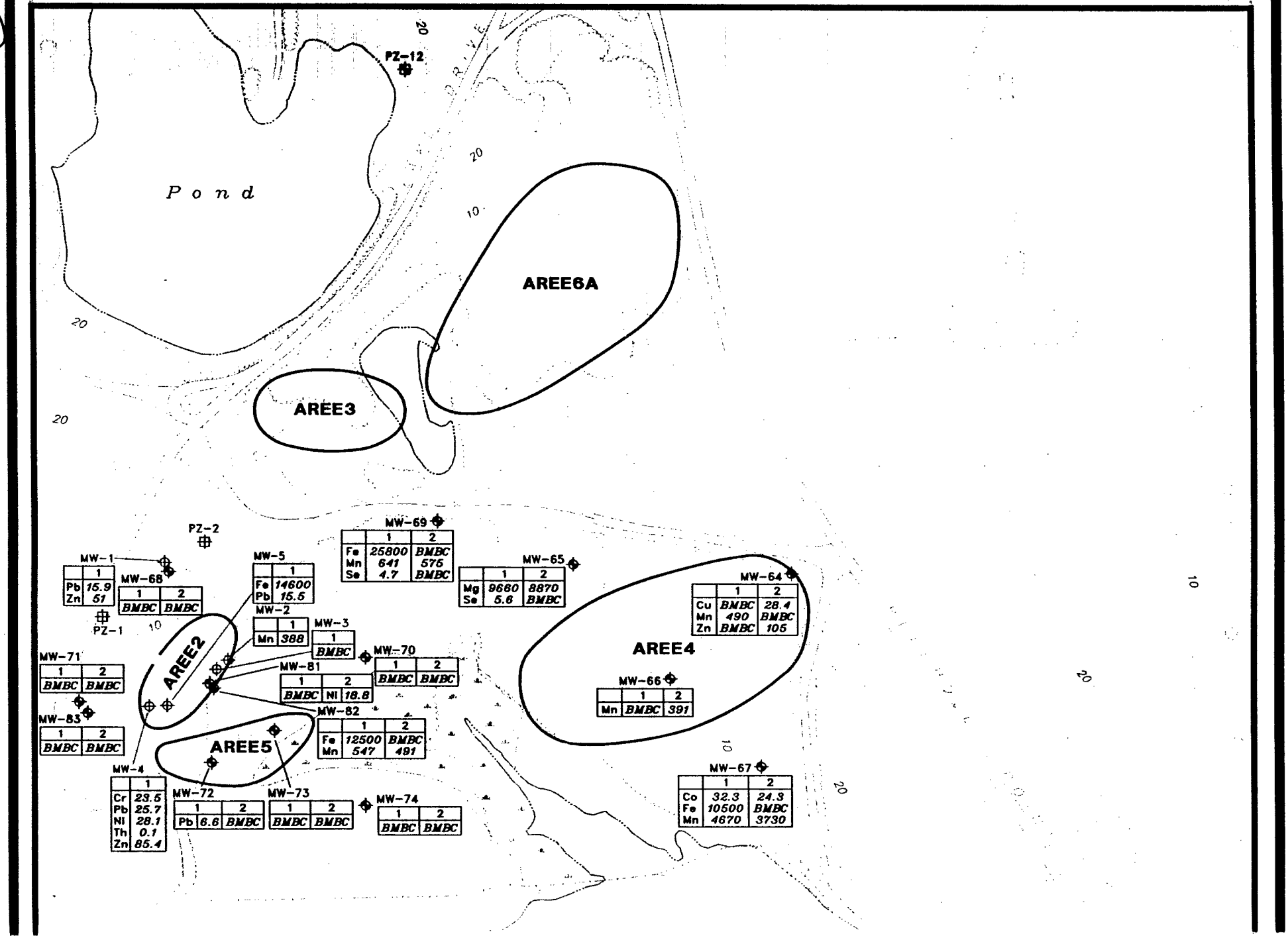
FIGURE 2-30
WOODBRIDGE RESEARCH FACILITY

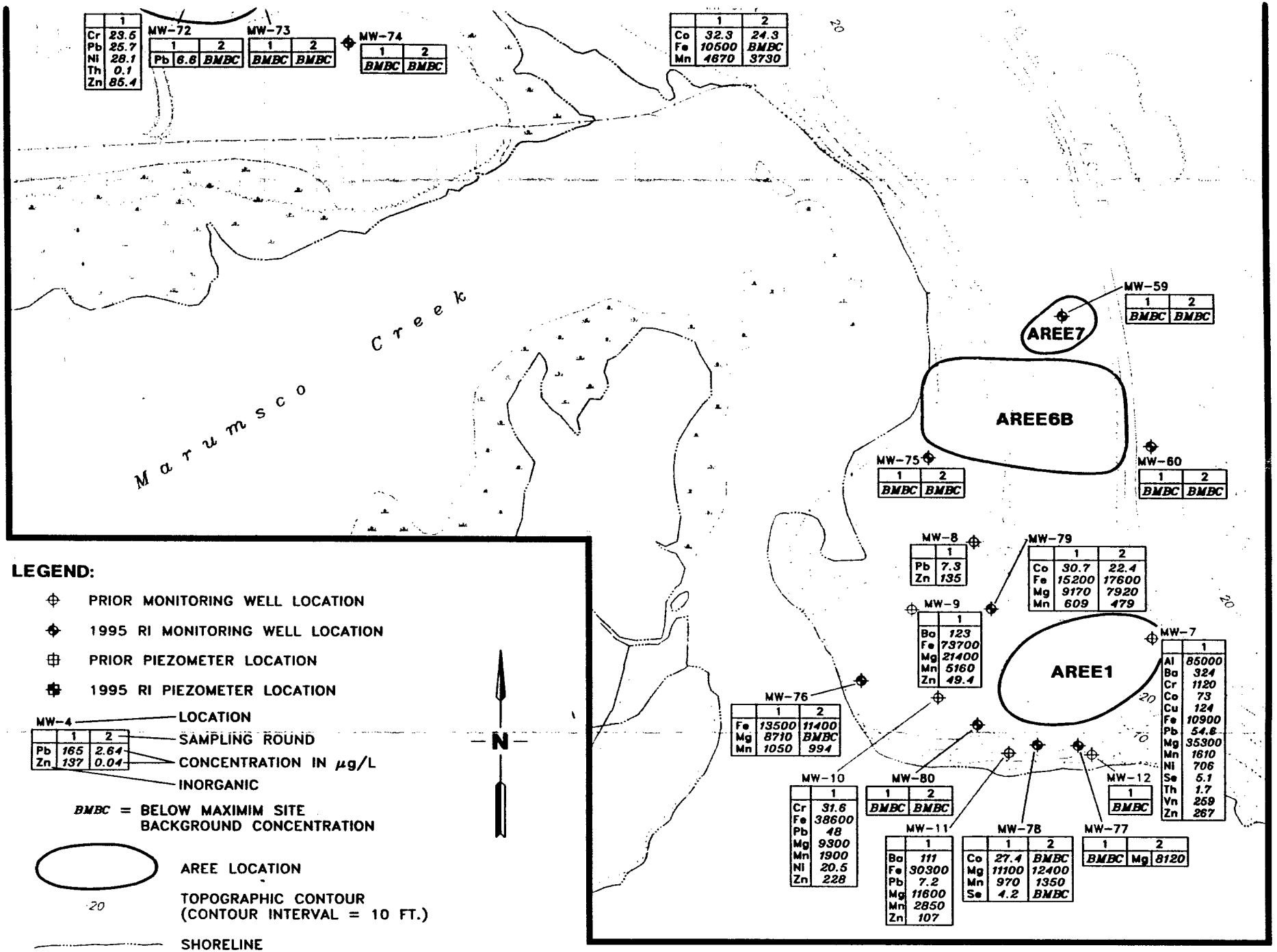
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2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: OU1-RES1
DATE 11-17-97	

TOTAL PESTICIDES AND TOTAL PAHs DETECTED IN SUBSURFACE SOILS - OU1 AREA




PZ-12
Pond
AREE6A
AREE3
AREE2
AREE4
AREE5
PZ-2
PZ-1
MW-1
Pb 15.9
Zn 51
MW-68
1 2
BMBC BMBC
MW-5
Fe 14600
Pb 15.6
MW-2
Mn 388
MW-3
BMBC
MW-69
Fe 25800 BMBC
Mn 641 575
Se 4.7 BMBC
MW-65
Mg 9660 8870
Se 6.8 BMBC
MW-64
Cu BMBC 28.4
Mn 490 BMBC
Zn BMBC 105
MW-71
BMBC BMBC
MW-83
BMBC BMBC
MW-81
BMBC Ni 18.8
MW-70
BMBC BMBC
MW-82
Fe 12500 BMBC
Mn 547 491
MW-66
Mn BMBC 391
MW-4
Cr 23.5
Pb 25.7
Ni 28.1
Th 0.1
Zn 85.4
MW-72
Pb 6.6 BMBC
MW-73
BMBC BMBC
MW-74
BMBC BMBC
MW-67
Co 32.3 24.3
Fe 10500 BMBC
Mn 4670 3730



US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

FIGURE 2-31

Pb	165	2.64
Zn	137	0.04

CONCENTRATION IN µg/L

INORGANIC

BMBC = BELOW MAXIMIM SITE BACKGROUND CONCENTRATION

AREE LOCATION

20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

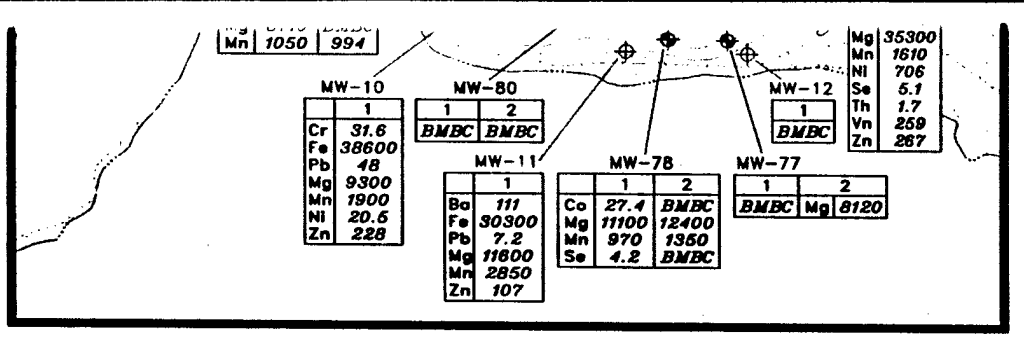
FENCE LINE

TREE LINE

SWAMP

0 150 300

SCALE FEET



NOTE:
MONITORING WELLS MW-1 THROUGH MW-5, AND MW-7 THROUGH MW-12 WERE NOT SAMPLED FOR ROUND 2.

US ARMY ENVIRONMENTAL CENTER

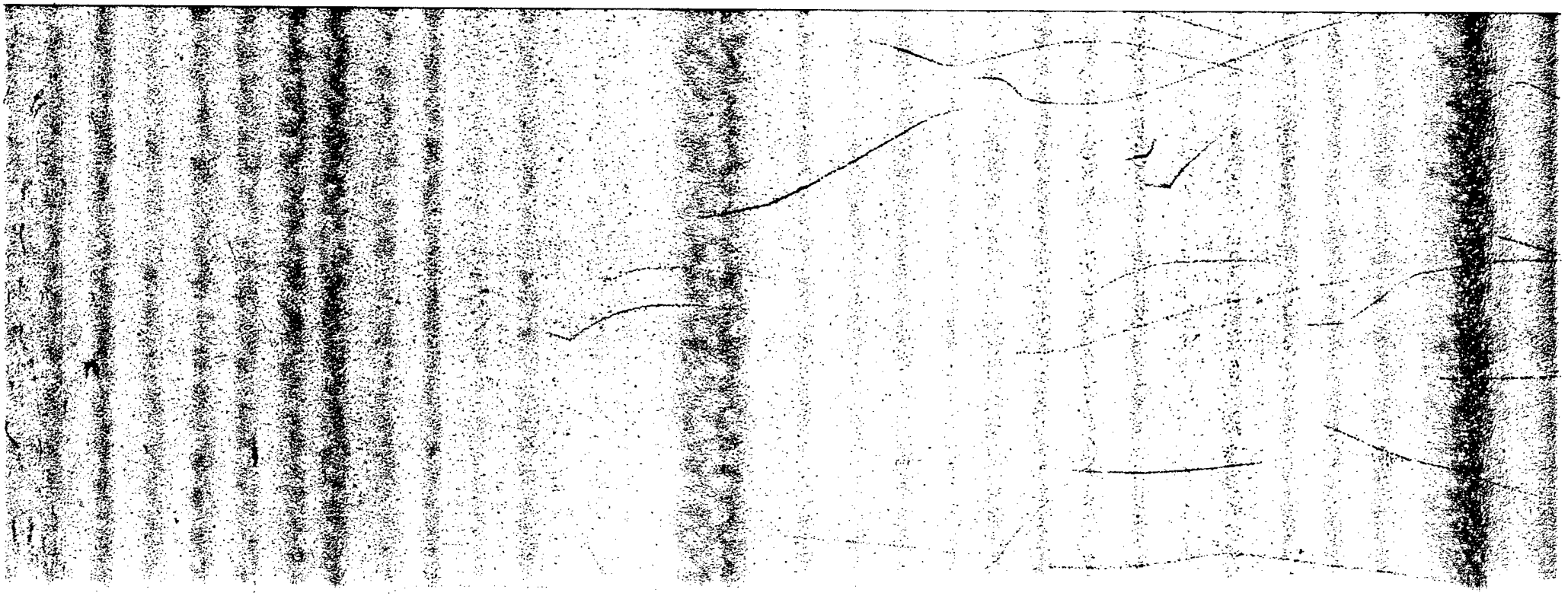
CONTRACT NO. DACA31-94-D-0064

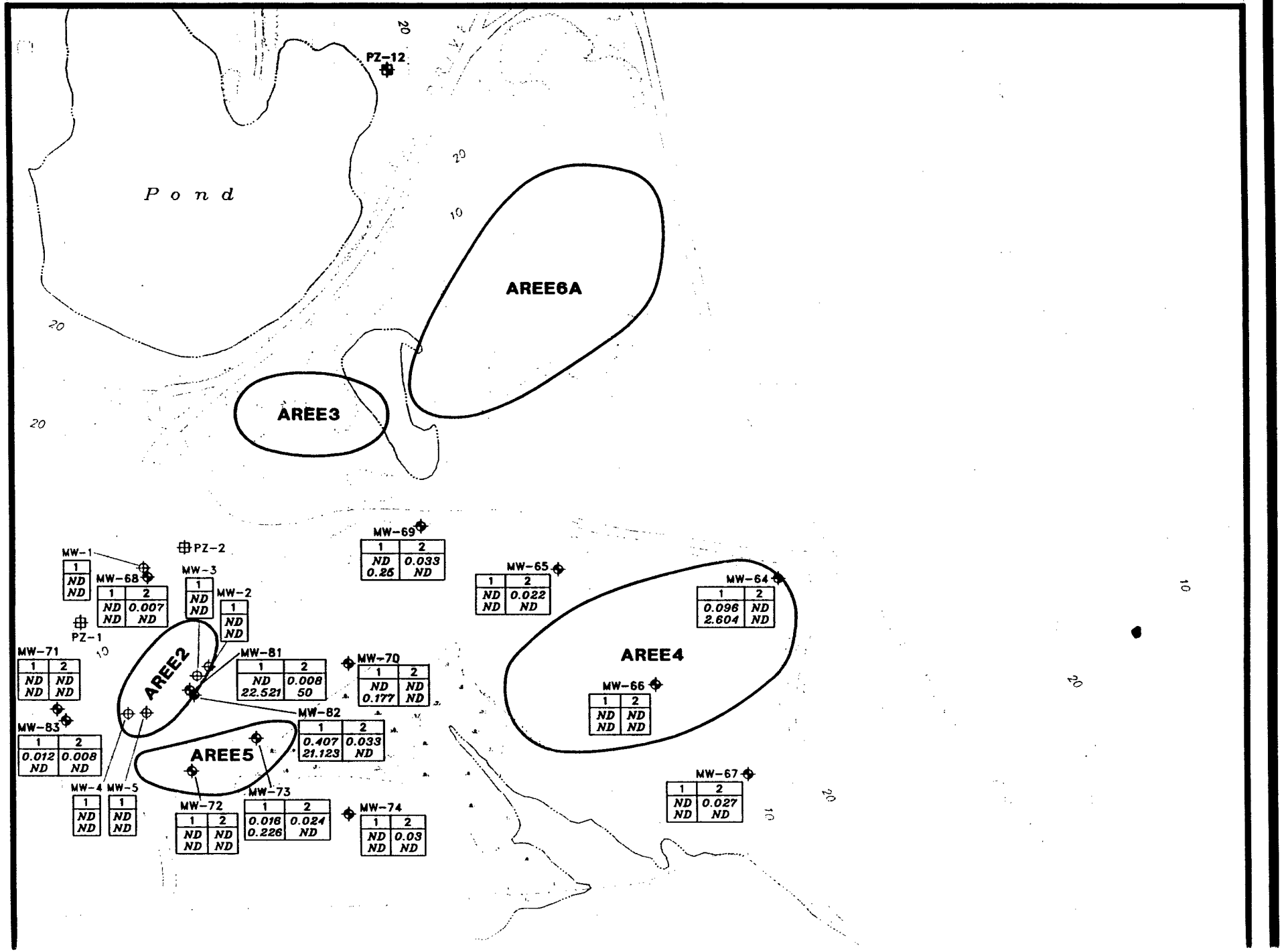
FIGURE 2-31
WOODBRIDGE RESEARCH FACILITY

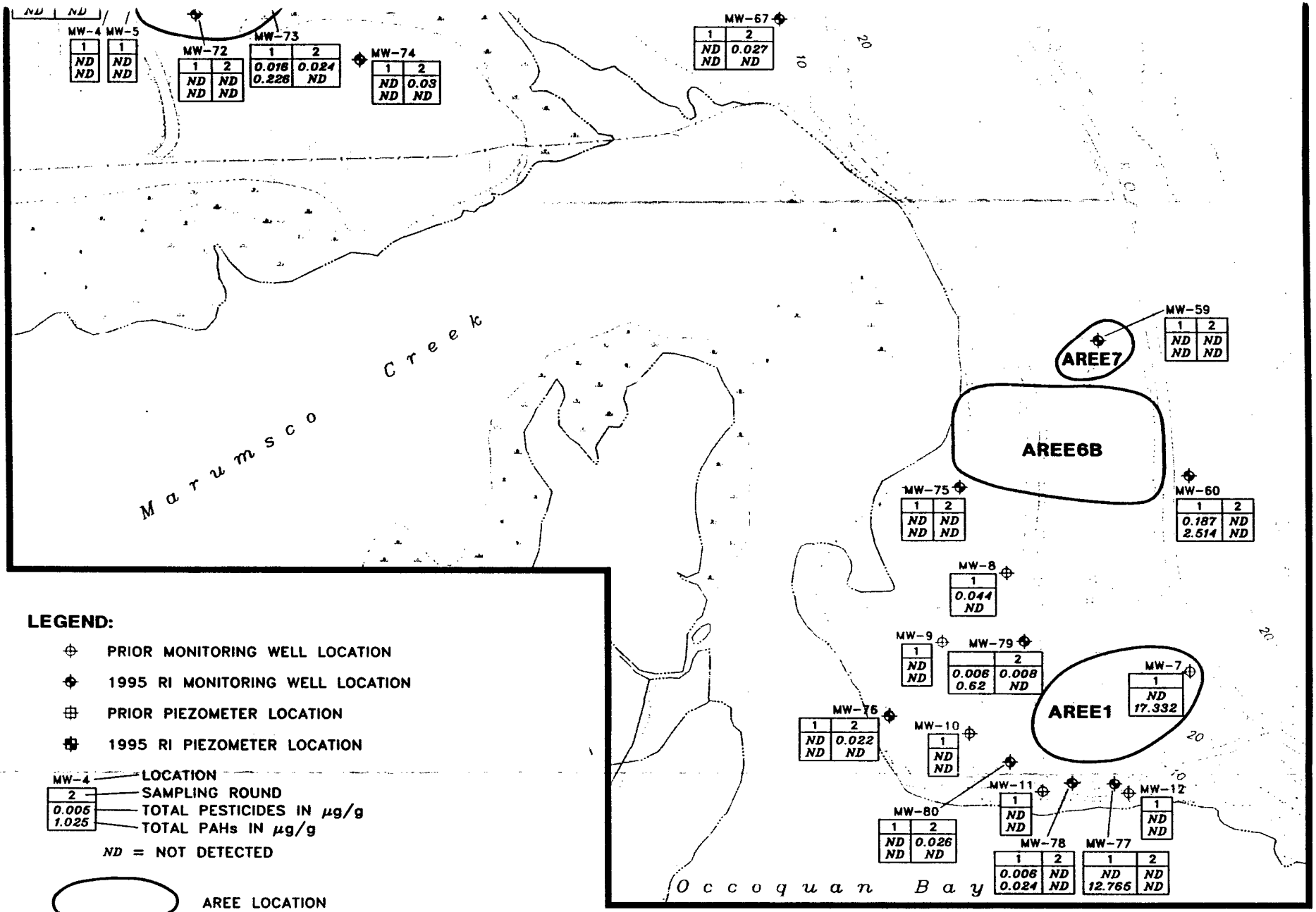
ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: OU1-RES4
DATE 11-17-97	

INORGANICS DETECTED IN GROUNDWATER ABOVE BACKGROUND - OU1 AREA




PZ-12
Pond
AREE6A
AREE3
AREE2
AREE4
AREE5
PZ-2
PZ-1
MW-1
MW-68
MW-3
MW-2
MW-69
MW-65
MW-64
MW-71
MW-81
MW-70
MW-66
MW-82
MW-83
MW-4
MW-5
MW-72
MW-73
MW-74
MW-67
20
10



LEGEND:

- PRIOR MONITORING WELL LOCATION
- 1995 RI MONITORING WELL LOCATION
- PRIOR PIEZOMETER LOCATION
- 1995 RI PIEZOMETER LOCATION

MW-4 — LOCATION
2 — SAMPLING ROUND
0.005 — TOTAL PESTICIDES IN µg/g
1.025 — TOTAL PAHs IN µg/g

ND = NOT DETECTED

AREE LOCATION

20 — TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP

US ARMY ENVIRONMENTAL CENTER

2	SAMPLING ROUND
0.005	TOTAL PESTICIDES IN µg/g
1.025	TOTAL PAHs IN µg/g

ND = NOT DETECTED

AREE LOCATION

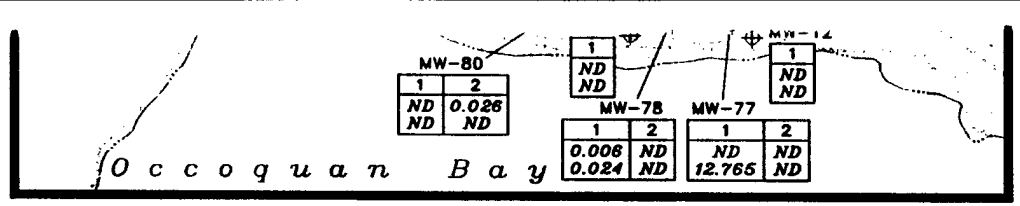
20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP



0 150 300

SCALE FEET

N

NOTE:
MONITORING WELLS MW-1 THROUGH MW-5, AND MW-7 THROUGH MW-12 WERE NOT SAMPLED FOR ROUND 2.

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

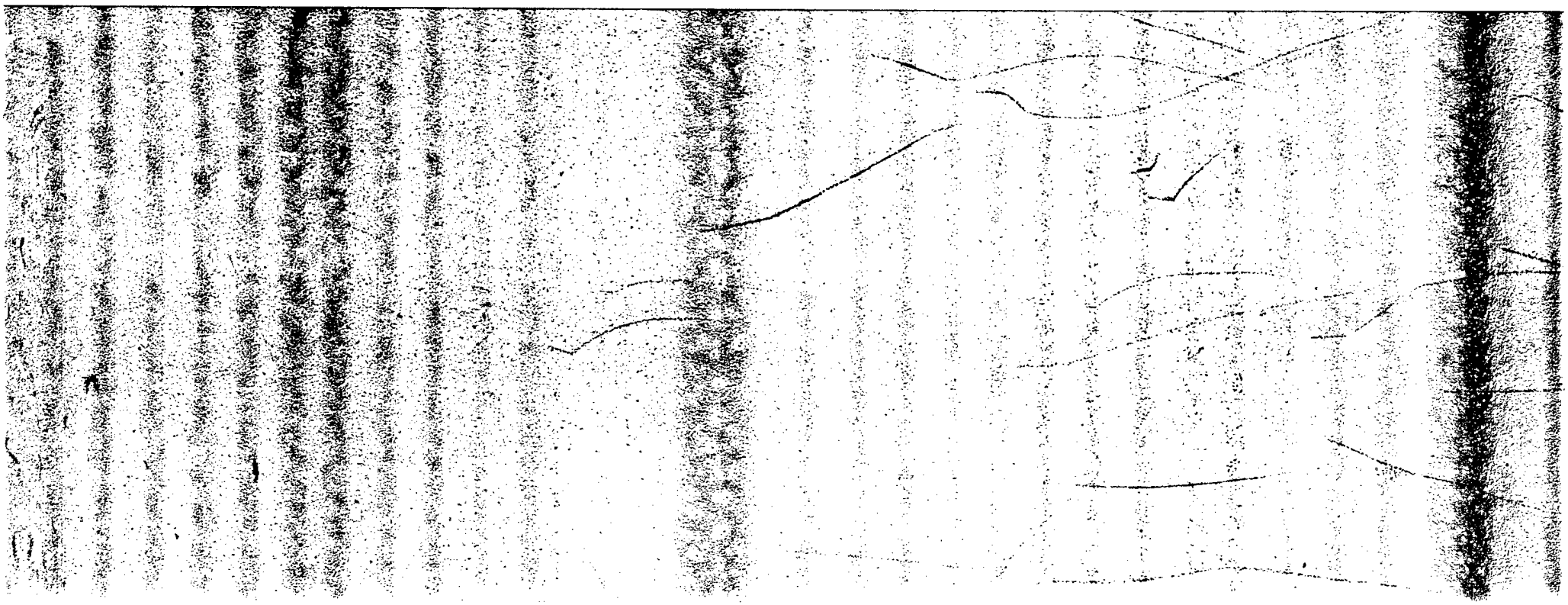
FIGURE 2-32

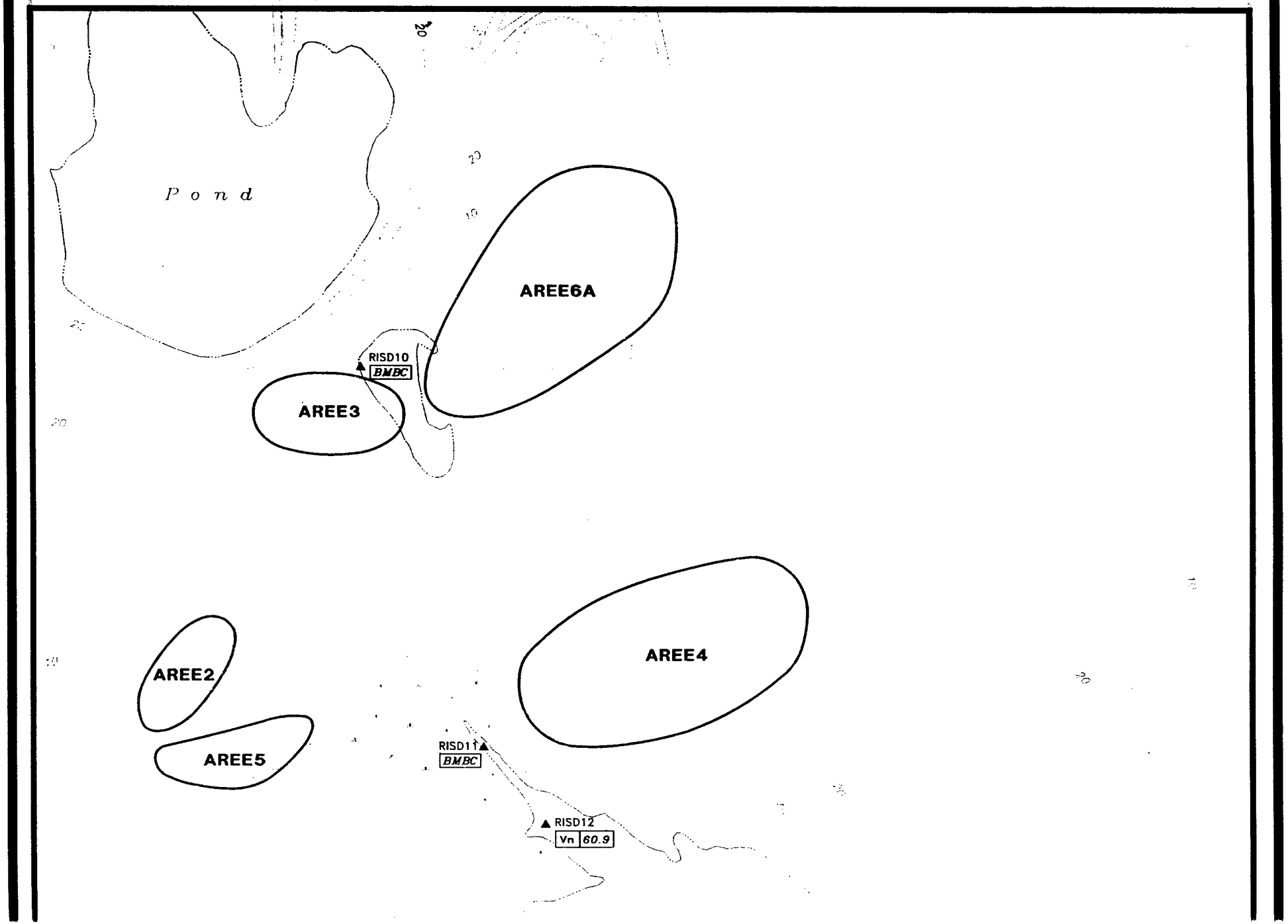
WOODBRIDGE RESEARCH FACILITY

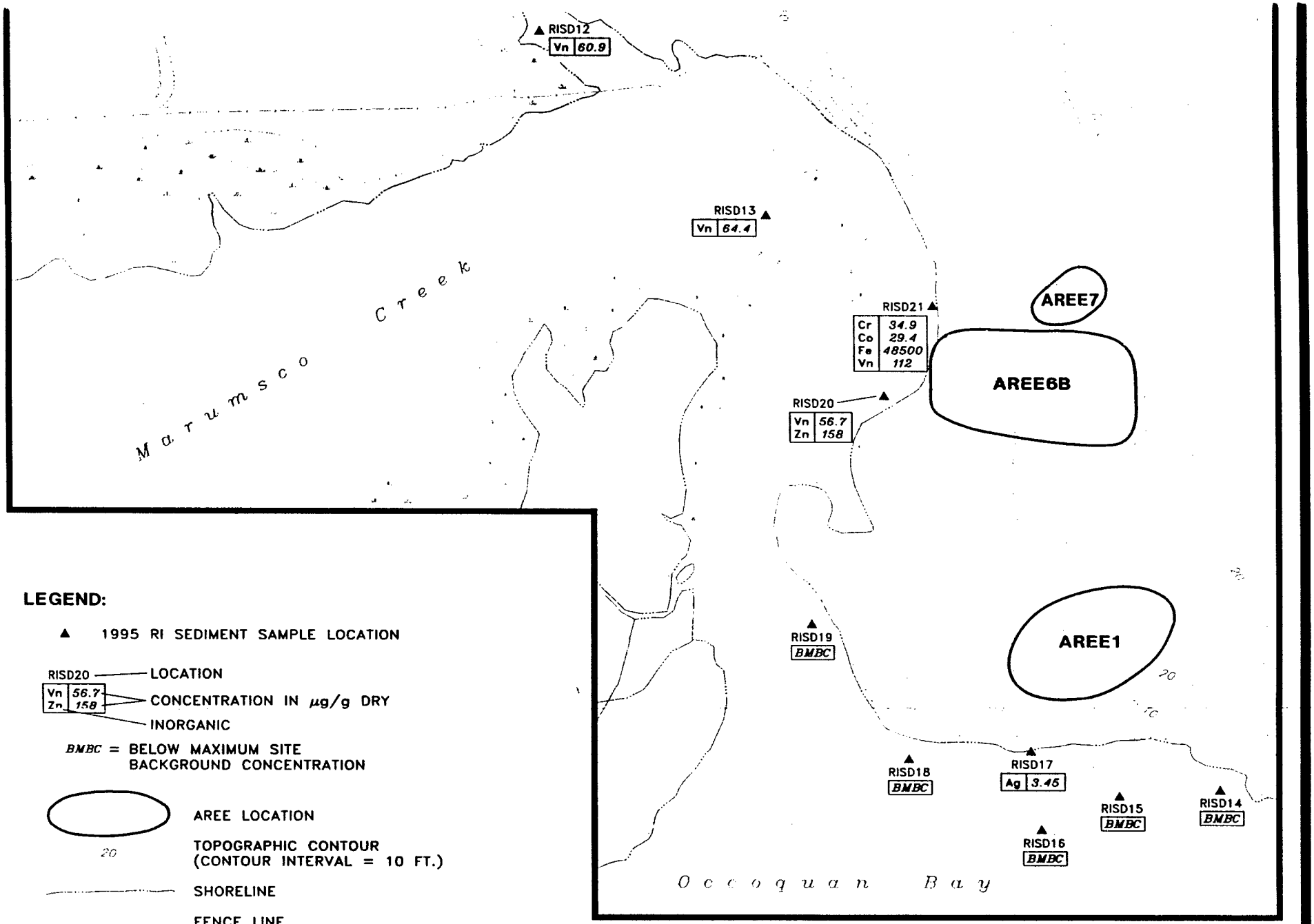
ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: OU1-RES2
DATE 11-17-97	

TOTAL PESTICIDES AND TOTAL PAHs DETECTED IN GROUNDWATER - OU1 AREA




Pond
AREE6A
RISD10
BMBC
AREE3
AREE4
AREE2
AREE5
RISD11
BMBC
RISD12
Vn
60.9



US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

FIGURE 2-33

WOODBRIDGE RESEARCH FACILITY

2113 Emmorton Park Drive
Suite 100

BMBC = BELOW MAXIMUM SITE BACKGROUND CONCENTRATION

AREE LOCATION

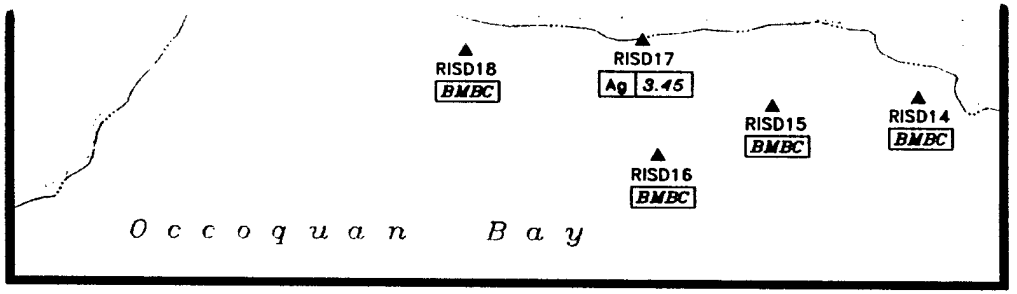
20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP



0 150 300
SCALE FEET

N

(3)

US ARMY ENVIRONMENTAL CENTER

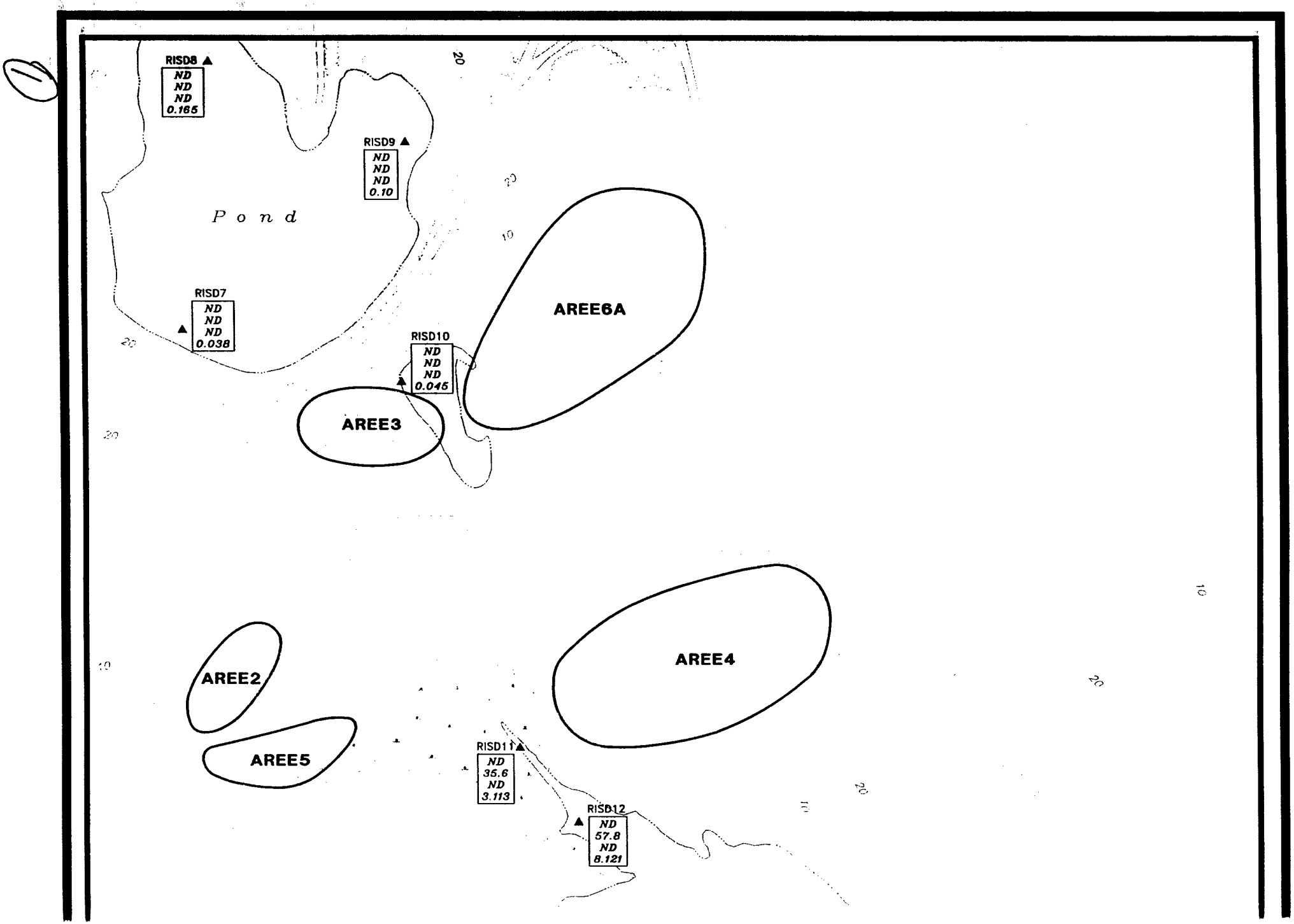
CONTRACT NO. DACA31-94-D-0064

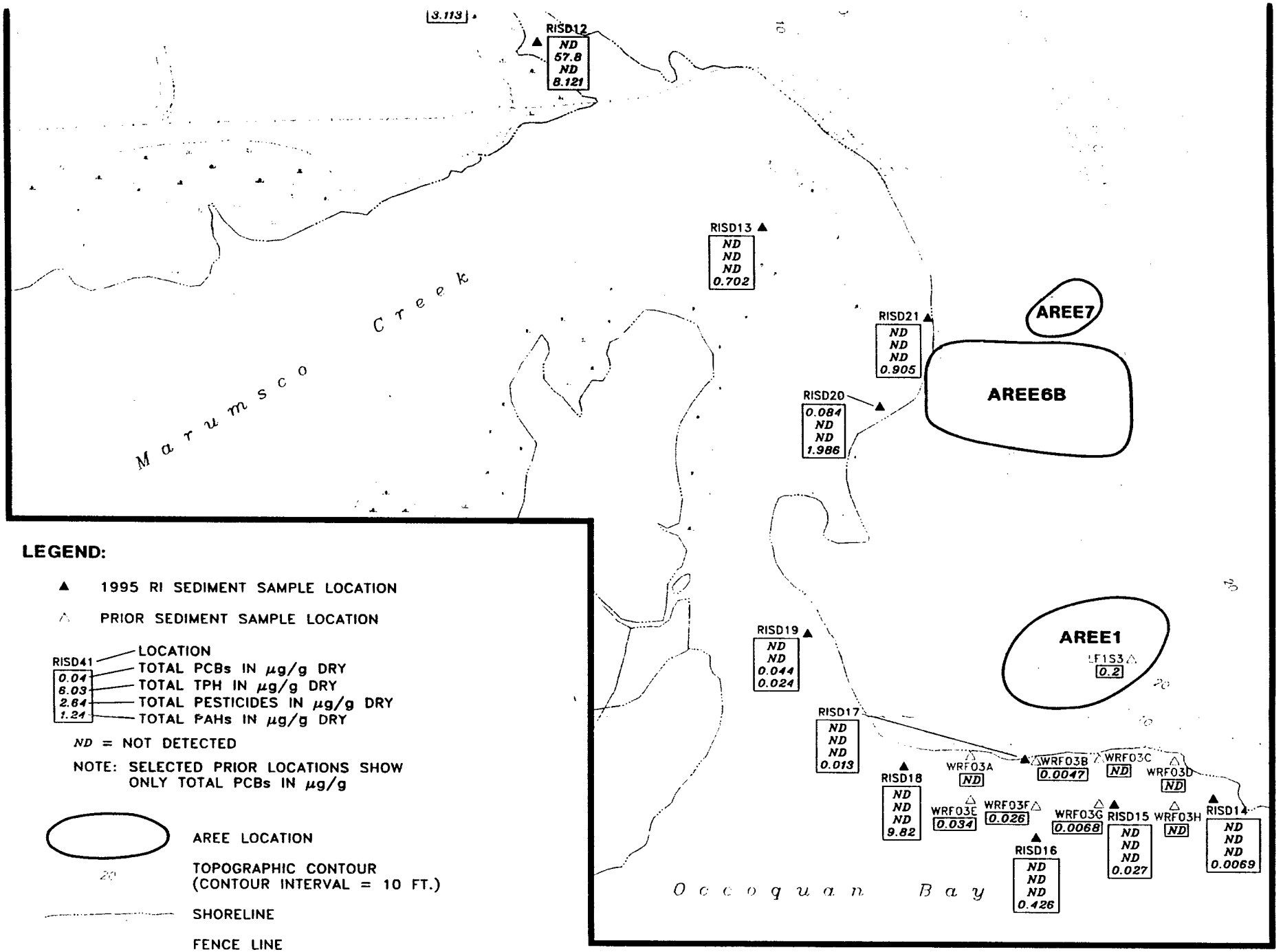
FIGURE 2-33
WOODBRIDGE RESEARCH FACILITY

ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: OU1-RES7
DATE 11-17-97	

INORGANICS DETECTED ABOVE BACKGROUND IN SEDIMENT SAMPLES - OU1 AREA


RISD8
ND
ND
ND
0.165
RISD9
ND
ND
ND
0.10
Pond
RISD7
ND
ND
ND
0.038
RISD10
ND
ND
ND
0.045
AREE6A
AREE3
AREE2
AREE5
AREE4
RISD11
ND
35.6
ND
3.113
RISD12
ND
57.8
ND
8.121



US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

2113 Emmerton Park Drive

FIGURE 2-34

WOODBRIDGE RESEARCH FACILITY

ND = NOT DETECTED

NOTE: SELECTED PRIOR LOCATIONS SHOW ONLY TOTAL PCBs IN µg/g

AREE LOCATION

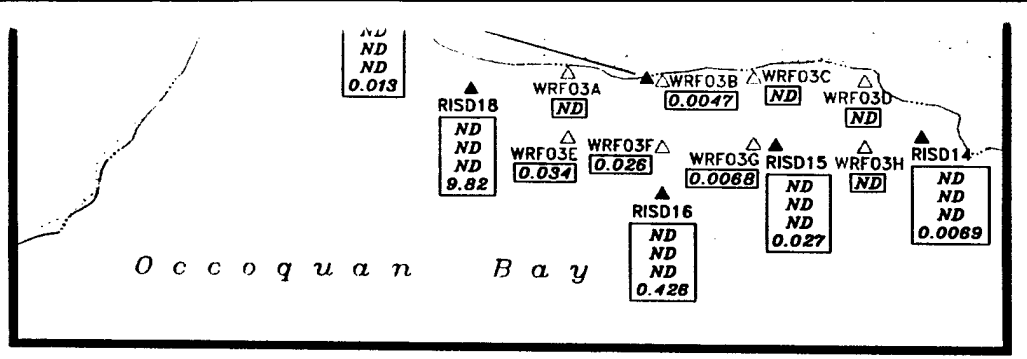
20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP



0 150 300

SCALE FEET

N

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST

CHECKED PT

DATE 11-17-97

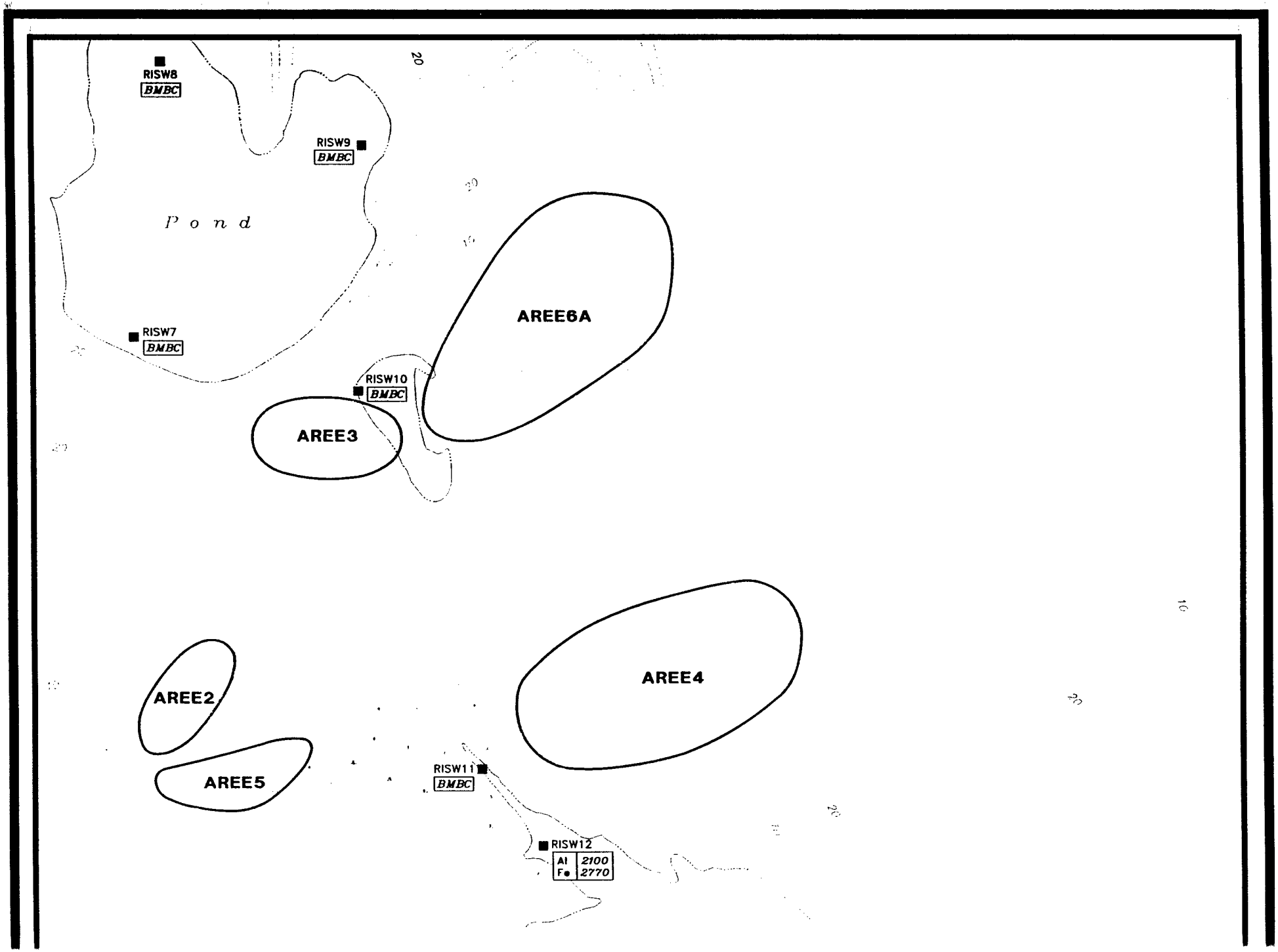
TASK NO: 66220

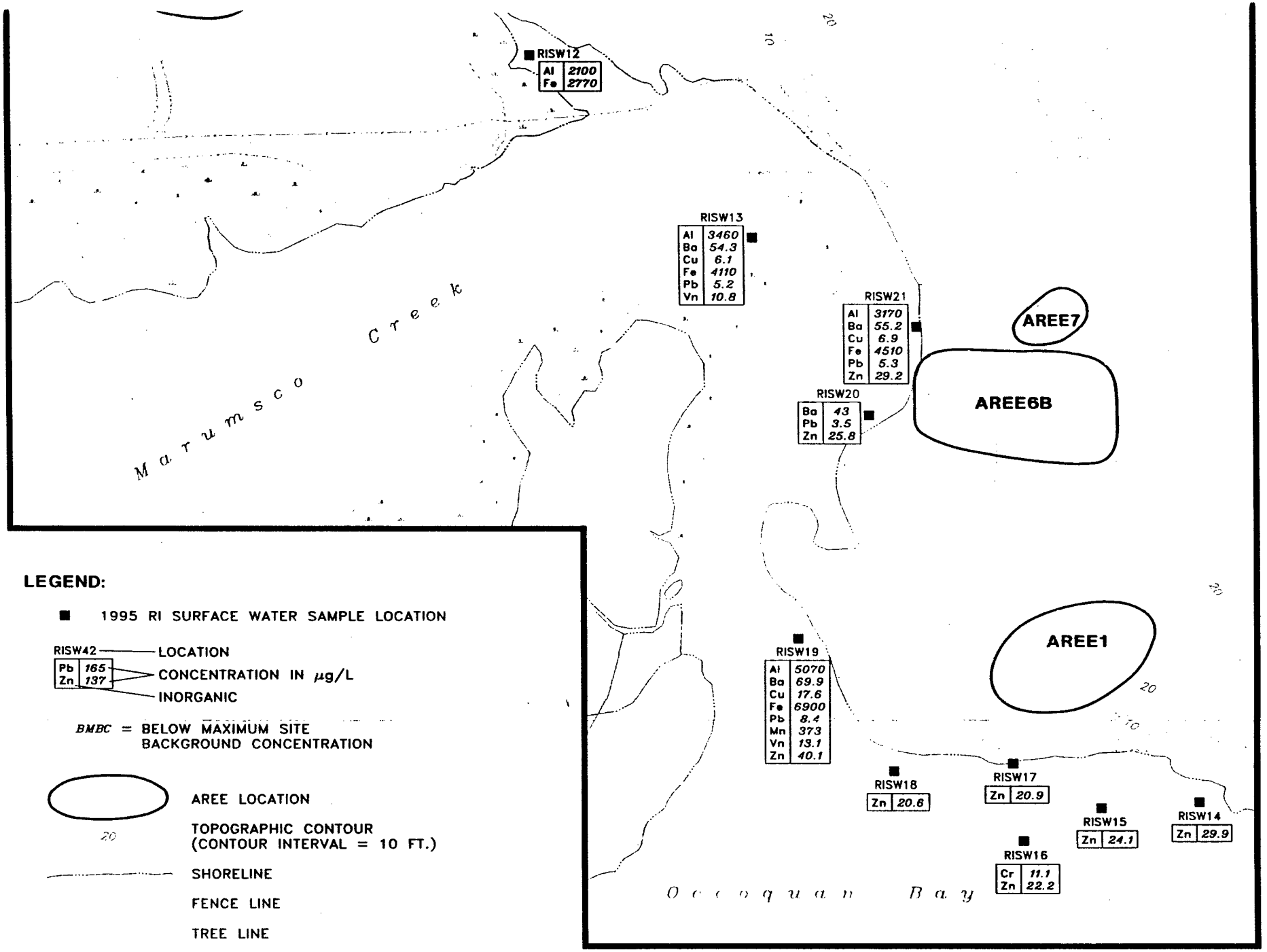
ICF DWG NO: OU1-RES8

FIGURE 2-34

WOODBRIDGE RESEARCH FACILITY

TOTAL PCBs, TOTAL TPH, TOTAL PESTICIDES, AND TOTAL PAHs DETECTED IN SEDIMENT SAMPLES - OU1 AREA


RISW8
BMBC
RISW9
BMBC
Pond
RISW7
BMBC
AREE6A
RISW10
BMBC
AREE3
AREE2
AREE5
AREE4
RISW11
BMBC
RISW12
Al 2100
Fe 2770



LEGEND:

■ 1995 RI SURFACE WATER SAMPLE LOCATION

RISW42 — LOCATION
Pb 165
Zn 137 — CONCENTRATION IN µg/L
— INORGANIC

BMBC = BELOW MAXIMUM SITE BACKGROUND CONCENTRATION

AREE LOCATION

20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

FIGURE 2-35

BACKGROUND CONCENTRATION

AREE LOCATION

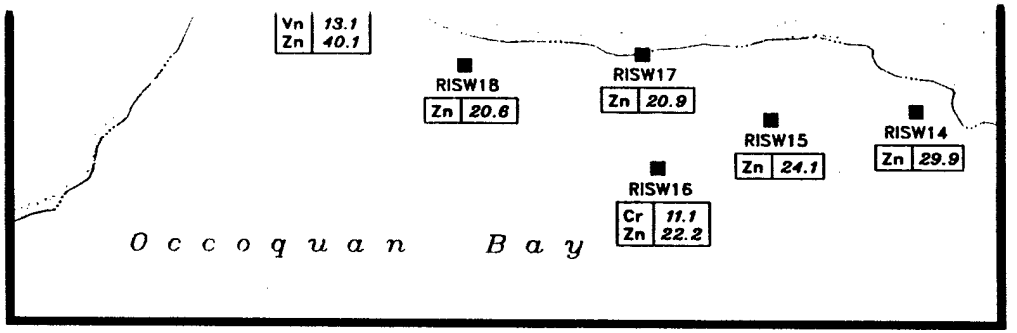
20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 10 FT.)

SHORELINE

FENCE LINE

TREE LINE

SWAMP



0 150 300

SCALE FEET

N

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

FIGURE 2-35

WOODBRIDGE RESEARCH FACILITY

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Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST

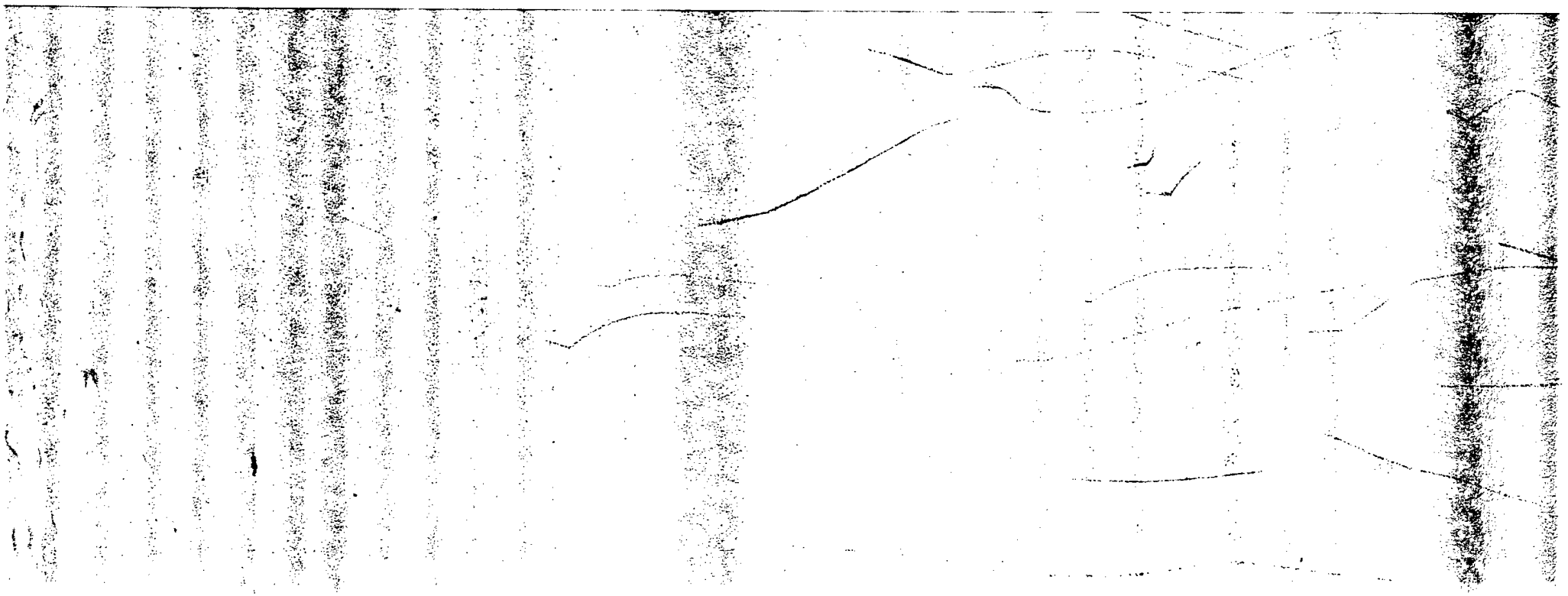
TASK NO: 66220

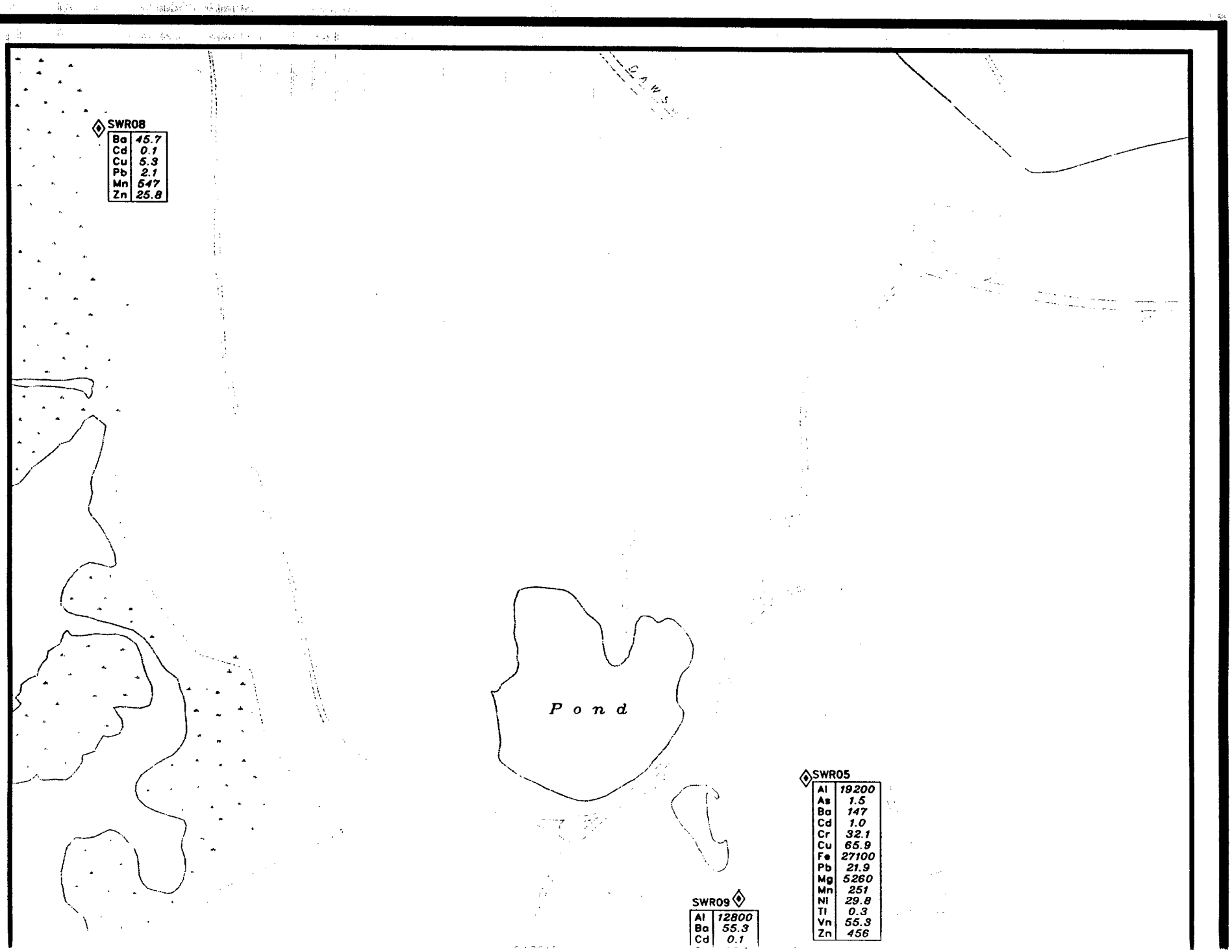
CHECKED PT

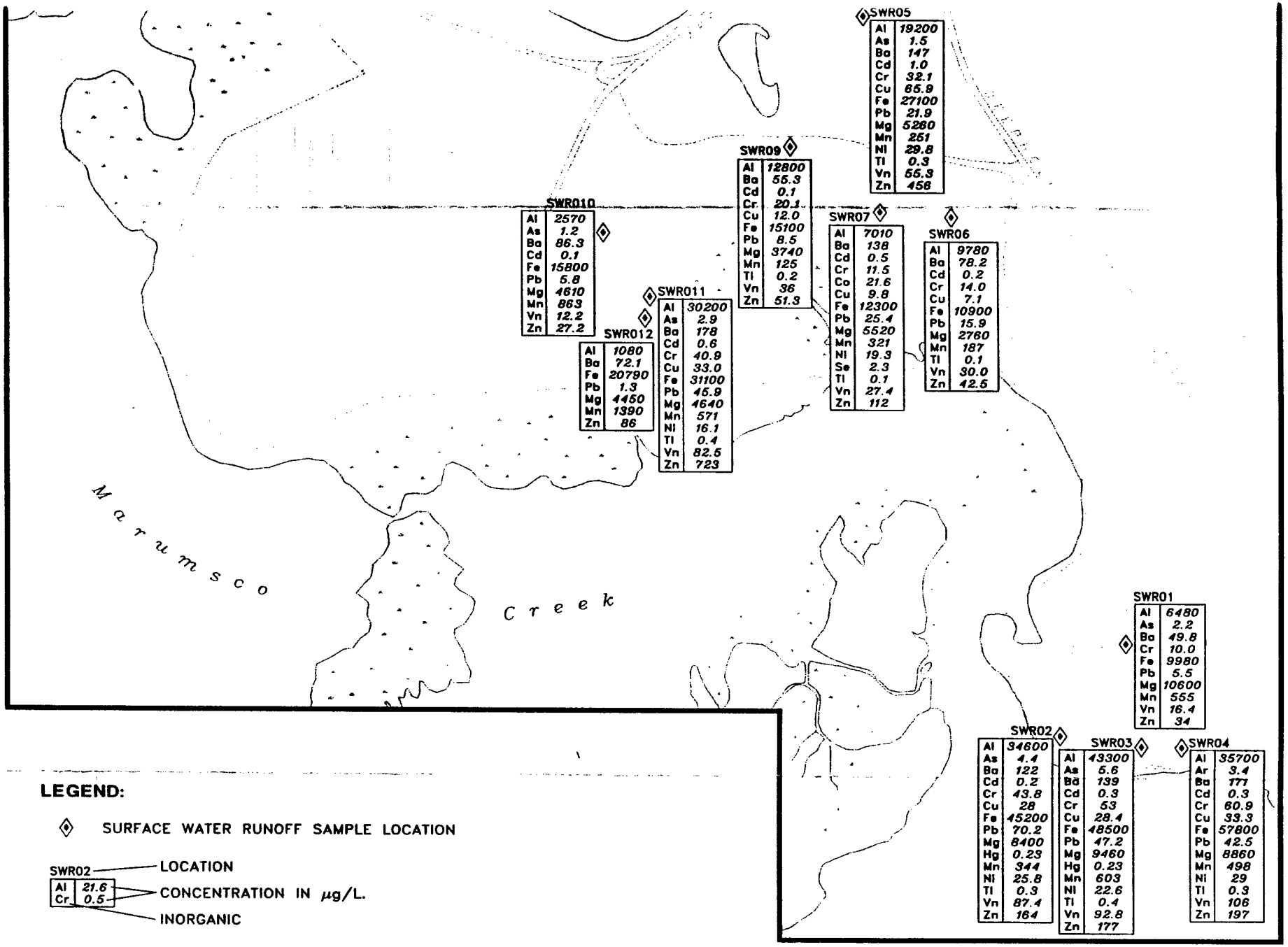
ICF DWG NO: OU1-RES9

DATE 11-17-97

TOTAL PESTICIDES AND INORGANICS DETECTED ABOVE BACKGROUND IN SURFACE WATER SAMPLES - OU1 AREA




SWR08
Ba 45.7
Cd 0.1
Cu 5.3
Pb 2.1
Mn 547
Zn 25.8
Pond
SWR09
Al 12800
Ba 55.3
Cd 0.1
SWR05
Al 19200
As 1.5
Ba 147
Cd 1.0
Cr 32.1
Cu 65.9
Fe 27100
Pb 21.9
Mg 5260
Mn 251
Ni 29.8
Tl 0.3
Vn 55.3
Zn 456


SWR05
Al 19200
As 1.5
Ba 147
Cd 1.0
Cr 32.1
Cu 65.9
Fe 27100
Pb 21.9
Mg 5260
Mn 251
Ni 29.8
Tl 0.3
Vn 55.3
Zn 458
SWR09
Al 12800
Ba 55.3
Cd 0.1
Cr 20.1
Cu 12.0
Fe 15100
Pb 8.5
Mg 3740
Mn 125
Tl 0.2
Vn 36
Zn 51.3
SWR010
Al 2570
As 1.2
Ba 86.3
Cd 0.1
Fe 15800
Pb 5.8
Mg 4610
Mn 863
Vn 12.2
Zn 27.2
SWR07
Al 7010
Ba 138
Cd 0.5
Cr 11.5
Co 21.6
Cu 9.8
Fe 12300
Pb 25.4
Mg 5520
Mn 321
Ni 19.3
Se 2.3
Tl 0.1
Vn 27.4
Zn 112
SWR06
Al 9780
Ba 78.2
Cd 0.2
Cr 14.0
Cu 7.1
Fe 10900
Pb 15.9
Mg 2760
Mn 187
Tl 0.1
Vn 30.0
Zn 42.5
SWR011
Al 30200
As 2.9
Ba 178
Cd 0.6
Cr 40.9
Cu 33.0
Fe 31100
Pb 45.9
Mg 4640
Mn 571
Ni 16.1
Tl 0.4
Vn 82.5
Zn 723
SWR012
Al 1080
Ba 72.1
Fe 20790
Pb 1.3
Mg 4450
Mn 1390
Zn 86
Marumsco Creek
SWR01
Al 6480
As 2.2
Ba 49.8
Cr 10.0
Fe 9980
Pb 5.5
Mg 10600
Mn 555
Vn 16.4
Zn 34
SWR02
Al 34600
As 4.4
Ba 122
Cd 0.2
Cr 43.8
Cu 28
Fe 45200
Pb 70.2
Mg 8400
Hg 0.23
Mn 344
Ni 25.8
Tl 0.3
Vn 87.4
Zn 164
SWR03
Al 43300
As 5.6
Ba 139
Cd 0.3
Cr 53
Cu 28.4
Fe 48500
Pb 47.2
Mg 9460
Hg 0.23
Mn 603
Ni 22.6
Tl 0.4
Vn 92.8
Zn 177
SWR04
Al 35700
Ar 3.4
Ba 171
Cd 0.3
Cr 60.9
Cu 33.3
Fe 57800
Pb 42.5
Mg 8860
Mn 498
Ni 29
Tl 0.3
Vn 106
Zn 197
LEGEND:
SURFACE WATER RUNOFF SAMPLE LOCATION
SWR02
Al 21.6
Cr 0.5
LOCATION
CONCENTRATION IN µg/L.
INORGANIC
ROAD
FENCE
WATER
SWAMP
0 250 500
SCALE FEET
US ARMY
ENVIRONMENTAL CENTER

◈ SURFACE WATER RUNOFF SAMPLE LOCATION

SWR02 — LOCATION

Al	21.6
Cr	0.5

CONCENTRATION IN µg/L.

INORGANIC

ROAD

FENCE

WATER

SWAMP

Cu	28
Fe	45200
Pb	70.2
Mg	8400
Hg	0.23
Mn	344
Ni	25.8
Tl	0.3
Vn	87.4
Zn	184

Cr	53
Cu	28.4
Fe	48500
Pb	47.2
Mg	9460
Hg	0.23
Mn	603
Ni	22.6
Tl	0.4
Vn	92.8
Zn	177

Cr	60.9
Cu	33.3
Fe	57800
Pb	42.5
Mg	8860
Mn	498
Ni	29
Tl	0.3
Vn	106
Zn	197

0 250 500

SCALE FEET

N

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

FIGURE 2-36

WOODBRIDGE RESEARCH FACILITY

ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

PREPARED CST

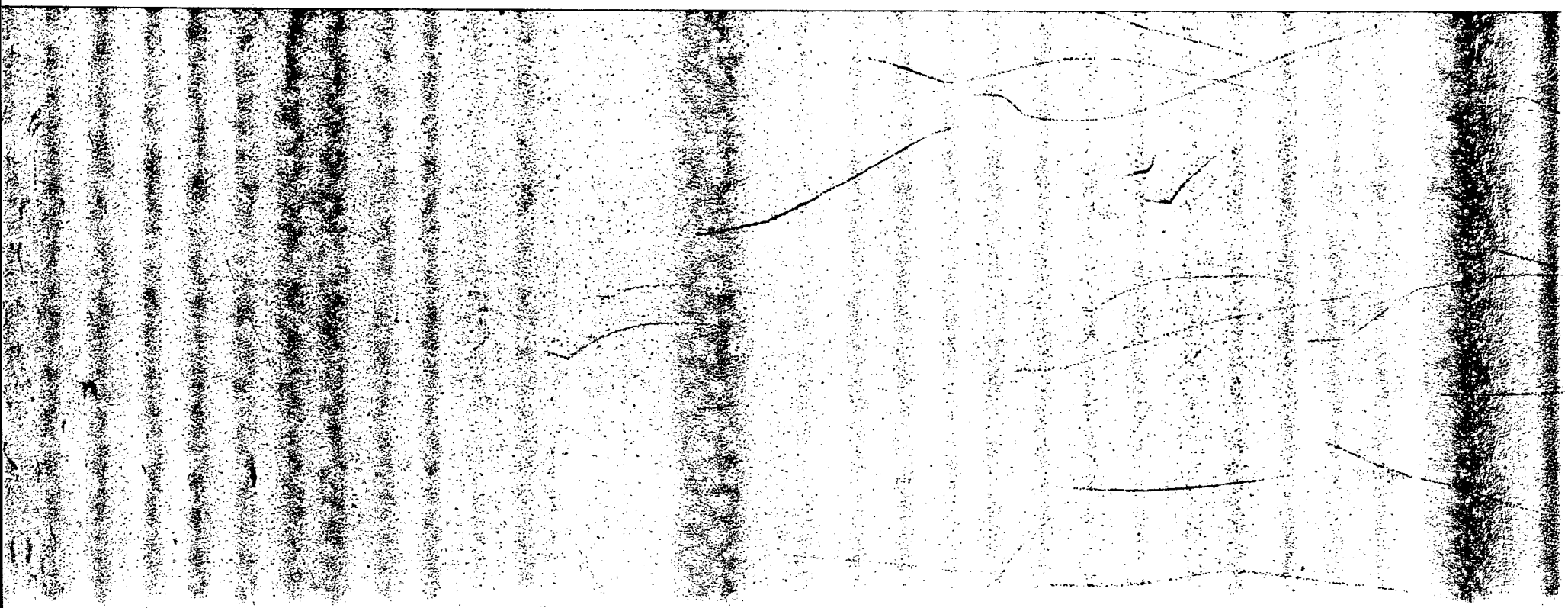
TASK NO: 66220

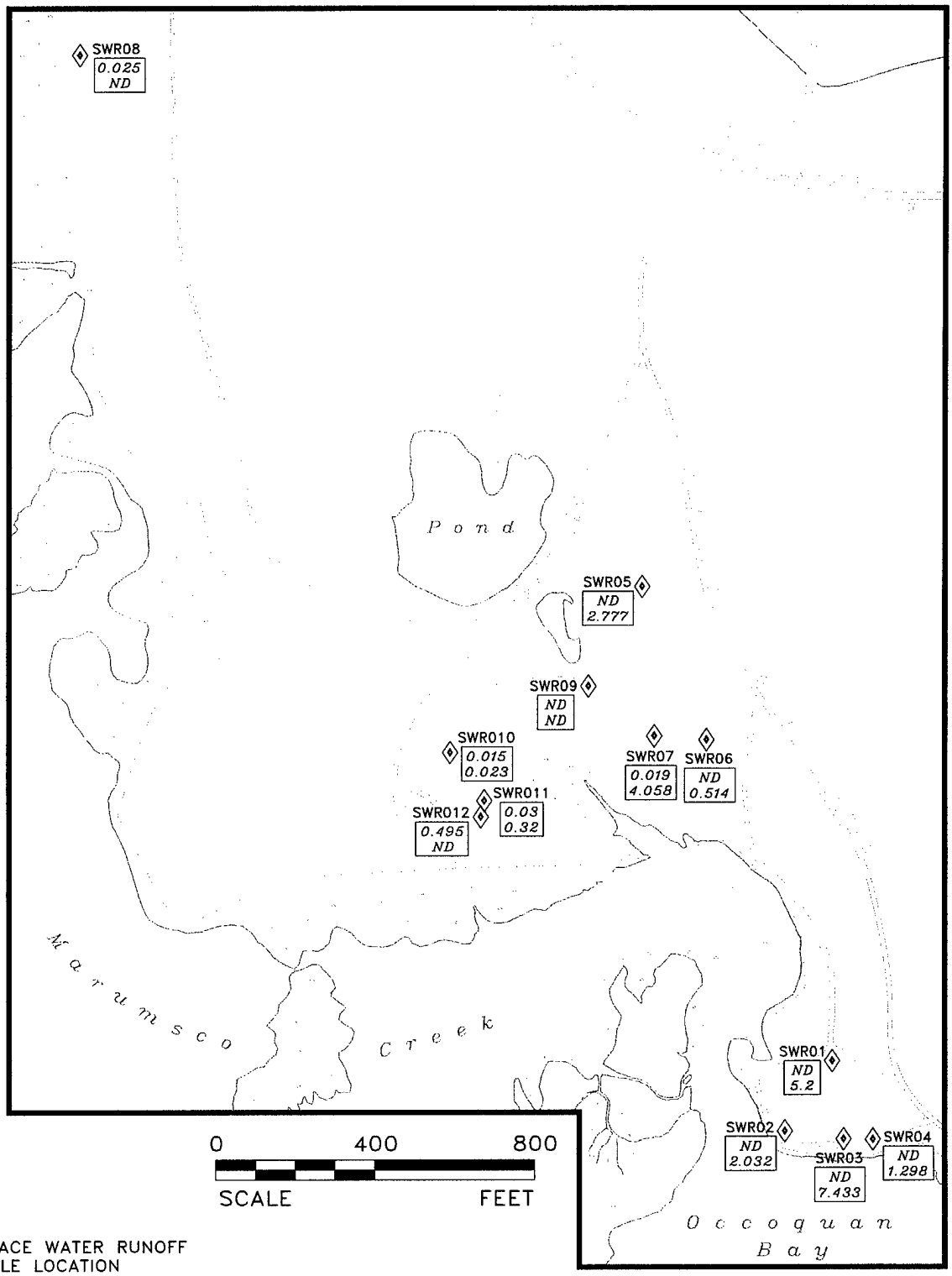
CHECKED PT

ICF DWG NO: SW-RES1

DATE 11-17-97

INORGANICS DETECTED IN SURFACE WATER RUNOFF ABOVE BACKGROUND





LEGEND:

◈ SURFACE WATER RUNOFF SAMPLE LOCATION

SWR02 — LOCATION
21.6 — TOTAL PESTICIDES IN µg/L
0.5 — TOTAL PAHs IN µg/L

ND = NOT DETECTED

ROAD

FENCE

WATER

SWAMP

US ARMY ENVIRONMENTAL CENTER

CONTRACT NO. DACA31-94-D-0064

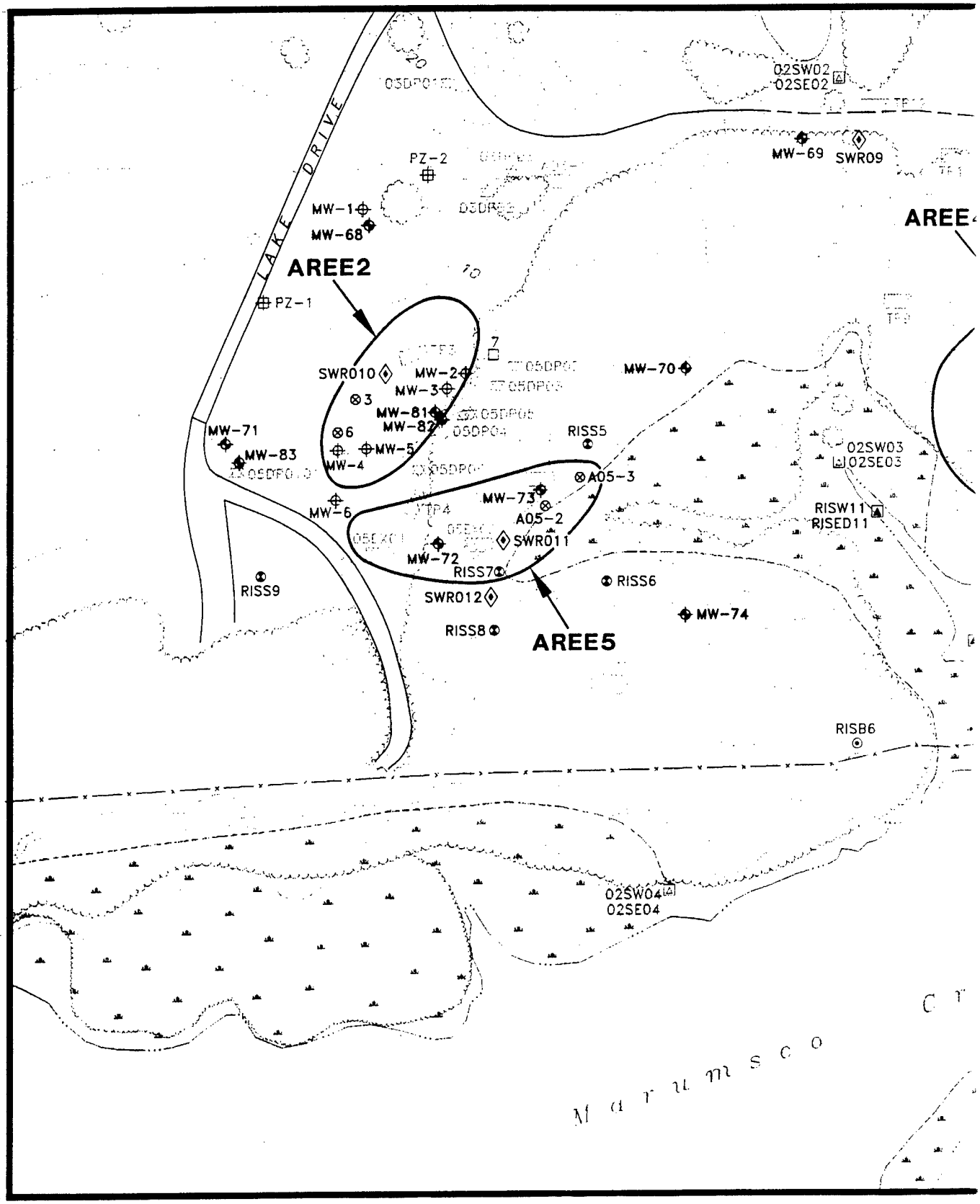
FIGURE 2-37

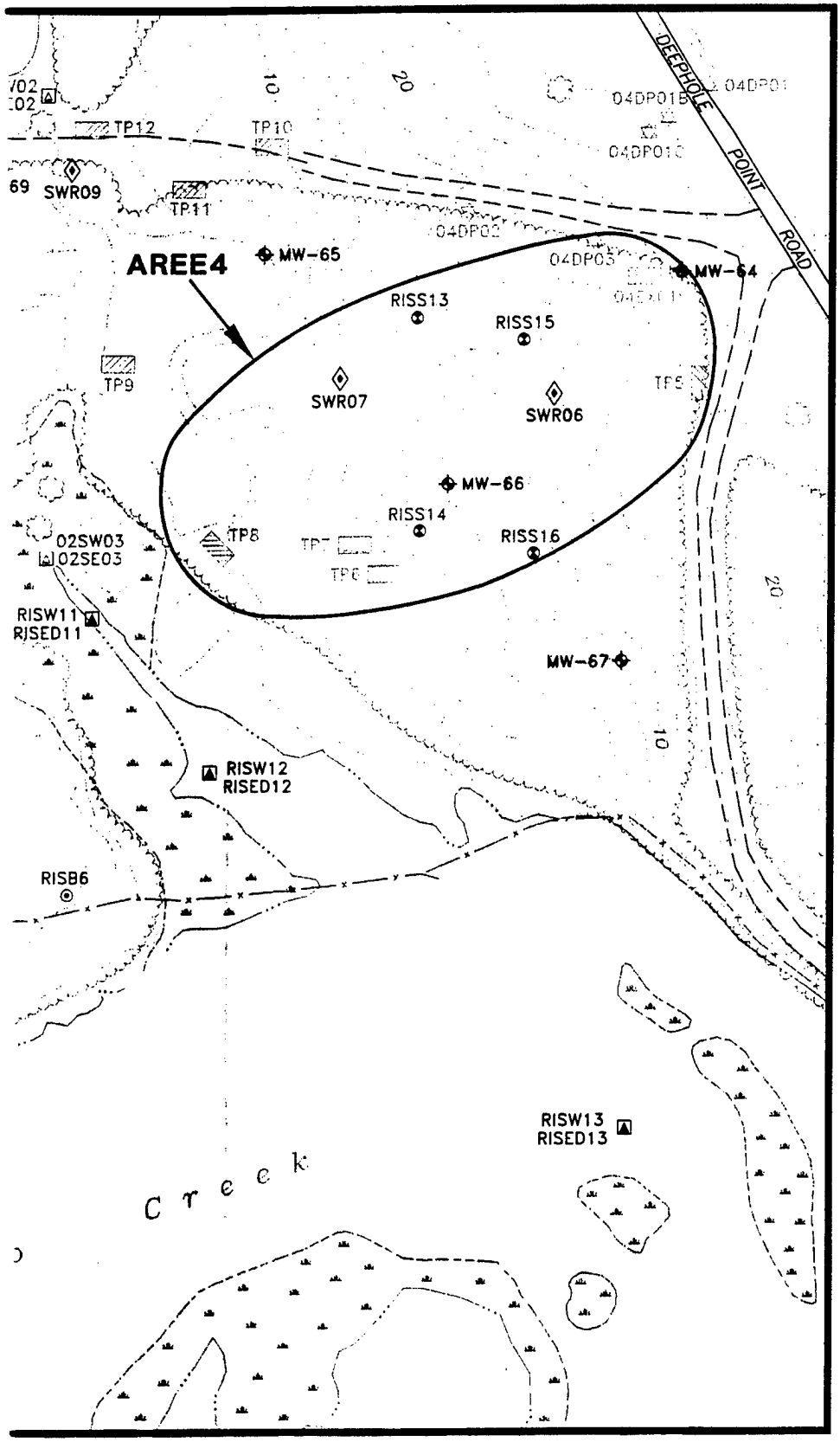
WOODBRIDGE RESEARCH FACILITY

ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

TOTAL PESTICIDES AND TOTAL PAHs DETECTED IN SURFACE WATER RUNOFF SAMPLES FROM OU1

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: SW-RES2
DATE 11-17-97	


LAKE DRIVE
AREE2
AREE5
PZ-2
MW-1
MW-68
PZ-1
SWR010
MW-2
MW-3
MW-81
MW-82
MW-71
MW-83
MW-5
MW-4
MW-6
MW-73
A05-3
A05-2
SWR011
MW-72
RISS7
SWR012
RISS8
RISS9
RISS5
RISS6
MW-70
MW-74
MW-69
SWR09
02SW02
02SE02
02SW03
02SE03
RISW11
RISED11
RISB6
02SW04
02SE04



LEGEND:

- PRIOR MONITORING WELL LOCATION
- 1995 RI MONITORING WELL LOCATION
- 1995 RI SOIL BORING LOCATION
- PRIOR PIEZOMETER LOCATION
- PRIOR SEDIMENT SAMPLE LOCATION
- PRIOR SURFACE WATER/SEDIMENT SAMPLE
- 1995 RI SURFACE WATER/SEDIMENT SAMPL
- PRIOR SURFACE SOIL SAMPLE LOCATION
- 1995 RI SURFACE SOIL SAMPLE LOCATION
- PRIOR DEEP PUNCH LOCATION
- 1995 RI STORMWATER RUNOFF SAMPLE LO
- PRIOR EXCAVATION LOCATION
- 1995 RI TEST PIT LOCATION
- AREE LOCATION
- SWAMP
- SHORELINE
- 20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 2
- FENCE LINE
- TREE LINE

N

0 100 20

SCALE FEET

US ARMY ENVIRONMENTAL CEN

CONTRACT NO. DACA31-94-D-0064

FIG

WOODBRIDG

ICF KAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350

PREPARED CST

TASK NO: 66220

CHECKED PT

ICF DWG NO: A245-SMP

DATE 11-17-97

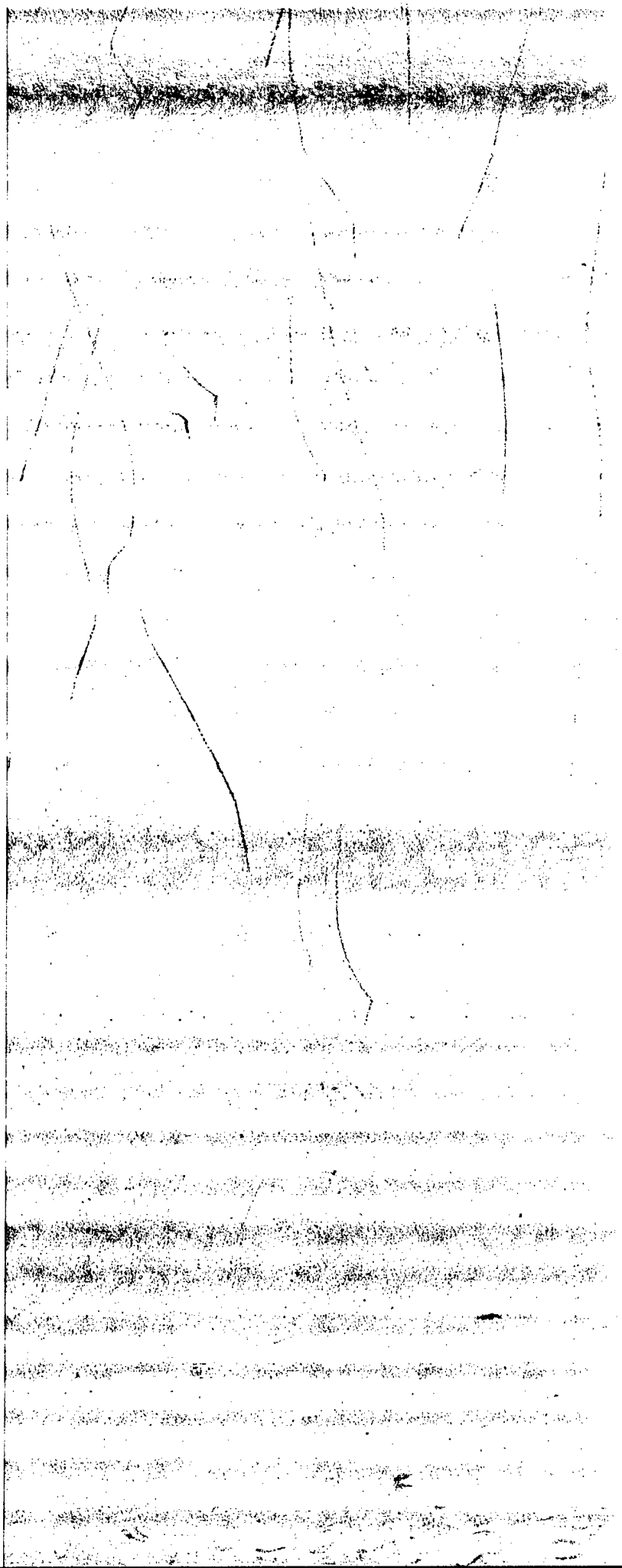
PRI

1995 R

LOCA

AREES

(2)



ID:
OR MONITORING WELL LOCATION
95 RI MONITORING WELL LOCATION
95 RI SOIL BORING LOCATION
OR PIEZOMETER LOCATION
OR SEDIMENT SAMPLE LOCATION
OR SURFACE WATER/SEDIMENT SAMPLE LOCATION
95 RI SURFACE WATER/SEDIMENT SAMPLE LOCATION
OR SURFACE SOIL SAMPLE LOCATION
95 RI SURFACE SOIL SAMPLE LOCATION
OR DEEP PUNCH LOCATION
95 RI STORMWATER RUNOFF SAMPLE LOCATION
OR EXCAVATION LOCATION
95 RI TEST PIT LOCATION

AREE LOCATION

SWAMP

SHORELINE

20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 2 FT.)

FENCE LINE

TREE LINE

N

0 100 200

SCALE FEET

US ARMY ENVIRONMENTAL CENTER

NO. DACA31-94-D-0064

NISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350

TASK NO: 66220

ICF DWG NO: A245-SMP

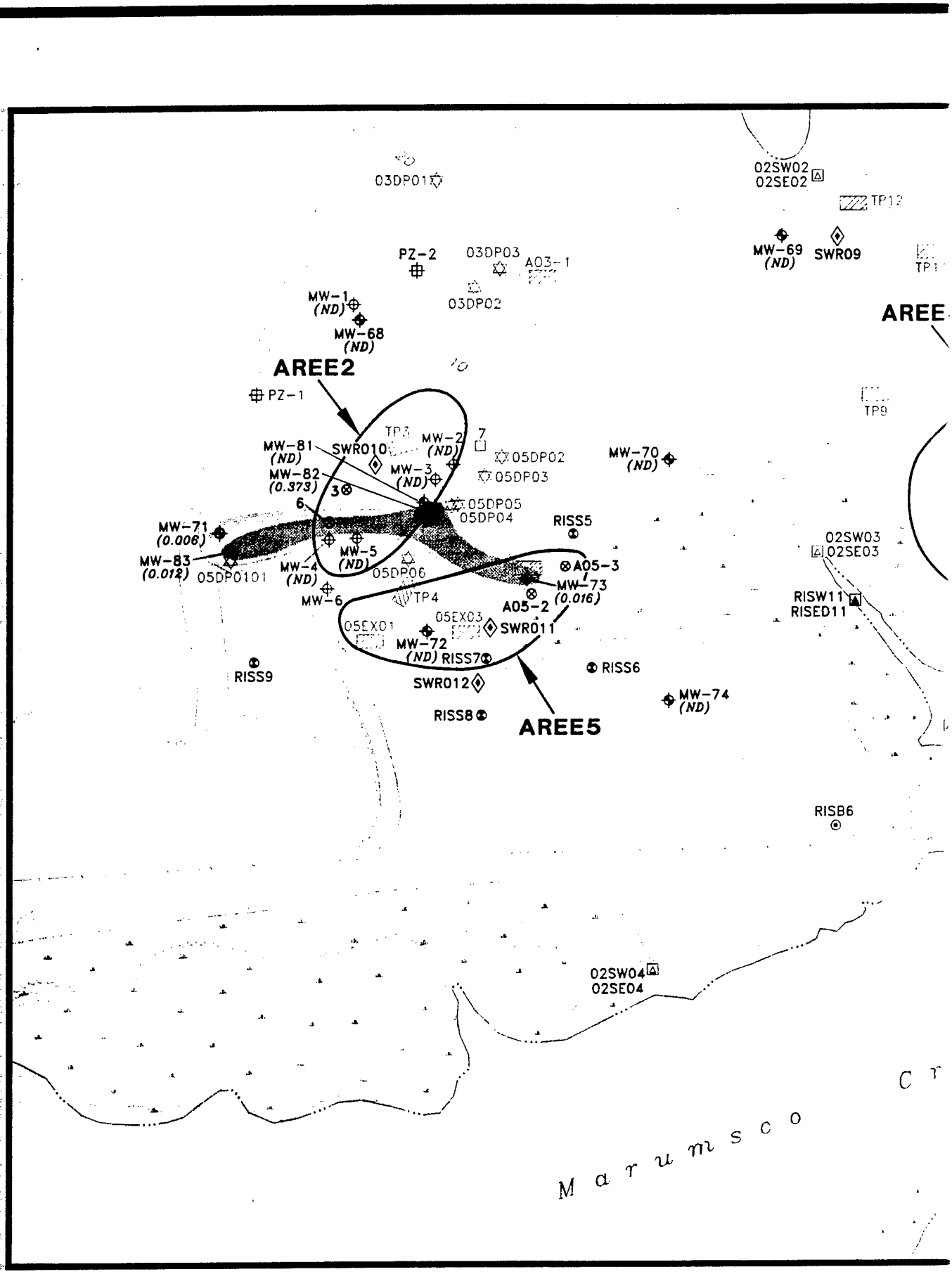
-97

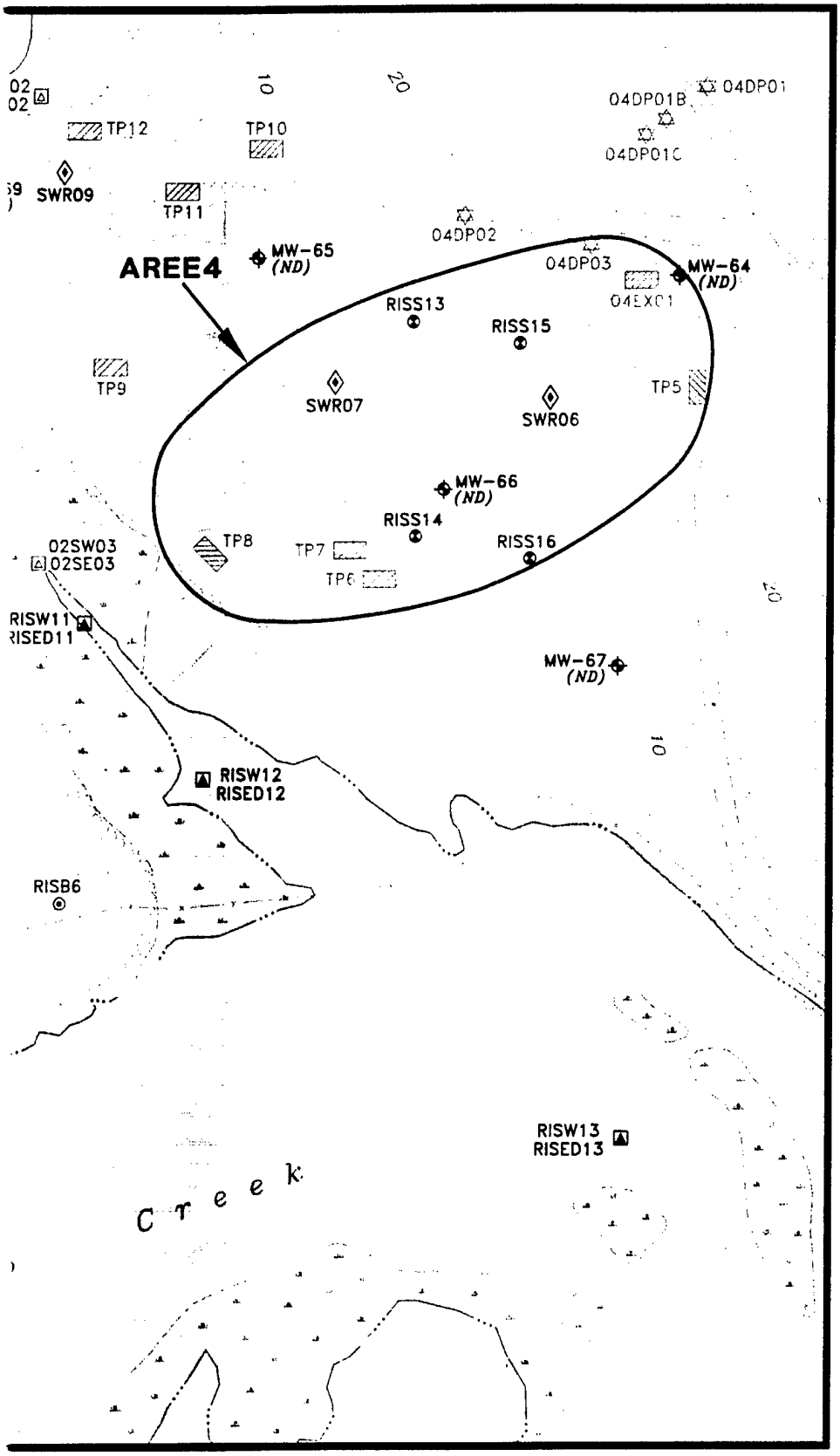
FIGURE 2-38

WOODBRIDGE RESEARCH FACILITY

PRIOR AND 1995 RI SAMPLING LOCATIONS FOR AREES 2, 4, & 5

(3)


03DP01
02SW02
02SE02
TP12
PZ-2
03DP03
A03-1
MW-69
(ND)
SWR09
03DP02
MW-1
(ND)
MW-68
(ND)
AREE
AREE2
PZ-1
TP9
TP3
MW-2
(ND)
MW-81
(ND)
SWR010
MW-3
(ND)
05DP02
MW-70
(ND)
MW-82
(0.373)
05DP03
3
6
05DP05
05DP04
RISS5
MW-71
(0.006)
MW-83
(0.012)
05DP0101
MW-5
(ND)
MW-4
(ND)
05DP06
A05-3
MW-73
(0.016)
02SW03
02SE03
MW-6
TP4
A05-2
RISW11
RISED11
05EX01
05EX03
SWR011
MW-72
(ND)
RISS7
RISS9
RISS6
SWR012
MW-74
(ND)
RISS8
AREE5
RISB6
02SW04
02SE04
Marumsco



LEGEND:

- PRIOR MONITORING WELL LOCATION
- 1995 RI MONITORING WELL LOCATION
- 1995 RI SOIL BORING LOCATION
- PRIOR PIEZOMETER LOCATION
- PRIOR SEDIMENT SAMPLE LOCATION
- PRIOR SURFACE WATER/SEDIMENT SAMPLE
- 1995 RI SURFACE WATER/SEDIMENT SAMPL
- PRIOR SURFACE SOIL SAMPLE LOCATION
- 1995 RI SURFACE SOIL SAMPLE LOCATION
- PRIOR DEEP PUNCH LOCATION
- 1995 RI STORMWATER RUNOFF SAMPLE LO
- PRIOR EXCAVATION LOCATION
- 1995 RI TEST PIT LOCATION
- AREE LOCATION
- SWAMP
- SHORELINE
- TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 2 F
- FENCE LINE
- TREE LINE

TOTAL PESTICIDE GROUNDWATER PLUME:

- 0.1 µg/L
- 0.01 µg/L
- 0.001 µg/L

NOTE:

RESULTS ARE REPORTED IN µg/L.
ND = NON-DETECT

0 100 200
SCALE FEET

US ARMY ENVIRONMENTAL CEN

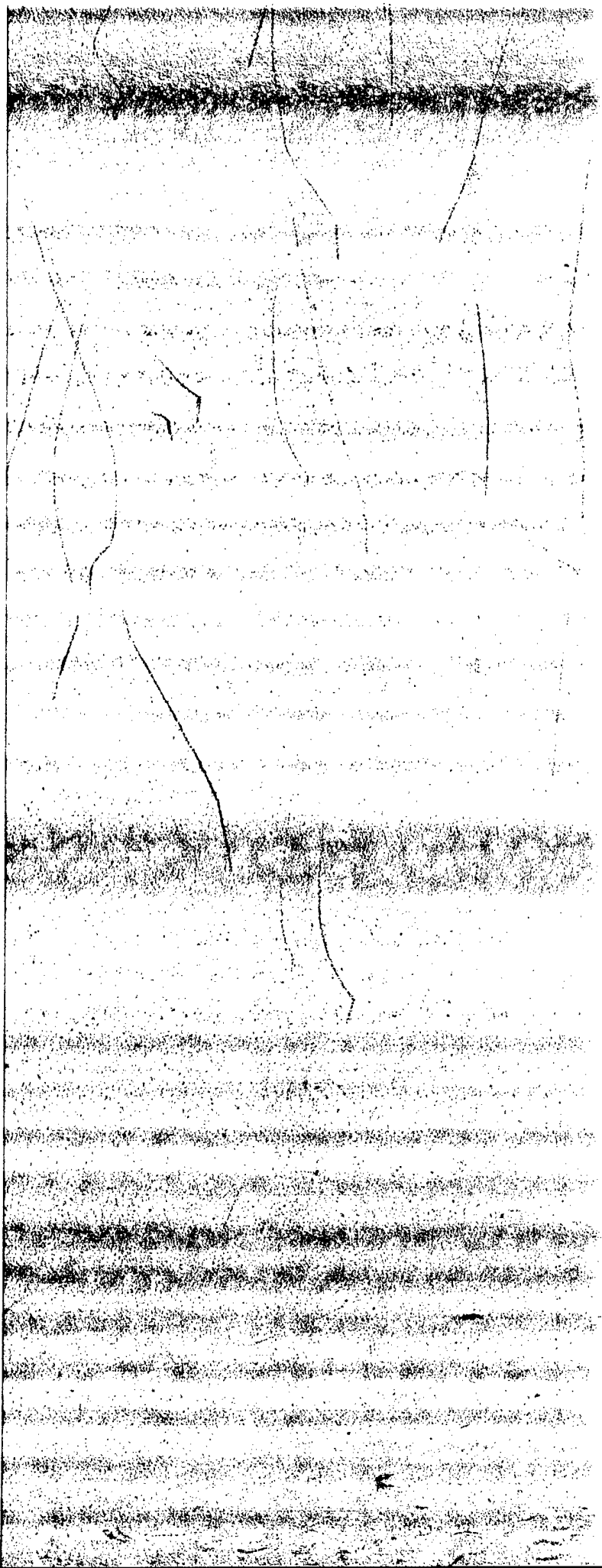
CONTRACT NO. DACA31-94-D-0064

FIG
WOODBRIDGE

ICF KAISER
2113 Emmorton Park Drive
Suite 100
Edgewood, Maryland 21040
(410) 612-6350

AREES
TOTAL
GROU
P

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: A245PEST
DATE 11-17-97	



ND:

RIOR MONITORING WELL LOCATION
995 RI MONITORING WELL LOCATION
995 RI SOIL BORING LOCATION
RIOR PIEZOMETER LOCATION
RIOR SEDIMENT SAMPLE LOCATION
RIOR SURFACE WATER/SEDIMENT SAMPLE LOCATION
995 RI SURFACE WATER/SEDIMENT SAMPLE LOCATION
RIOR SURFACE SOIL SAMPLE LOCATION
995 RI SURFACE SOIL SAMPLE LOCATION
RIOR DEEP PUNCH LOCATION
995 RI STORMWATER RUNOFF SAMPLE LOCATION
RIOR EXCAVATION LOCATION
995 RI TEST PIT LOCATION
AREE LOCATION
SWAMP
SHORELINE
20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 2 FT.)
FENCE LINE
TREE LINE

L PESTICIDE NDWATER PLUME:

0.1 μg/L
0.01 μg/L
0.001 μg/L

LTS ARE REPORTED IN μg/L.
NON-DETECT

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100 200
ALE FEET

US ARMY ENVIRONMENTAL CENTER

NO. DACA31-94-D-0064

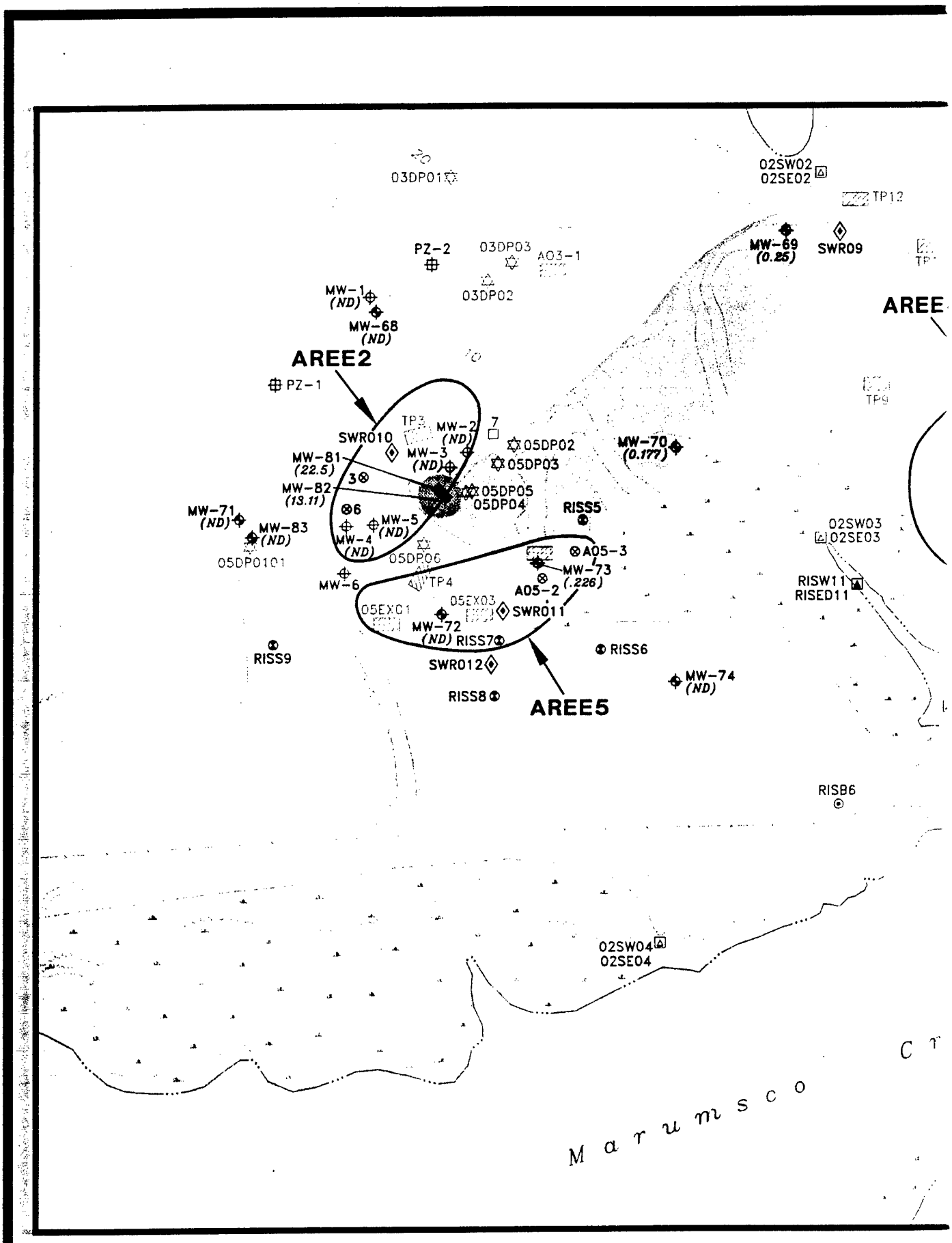
FIGURE 2-39
WOODBRIDGE RESEARCH FACILITY

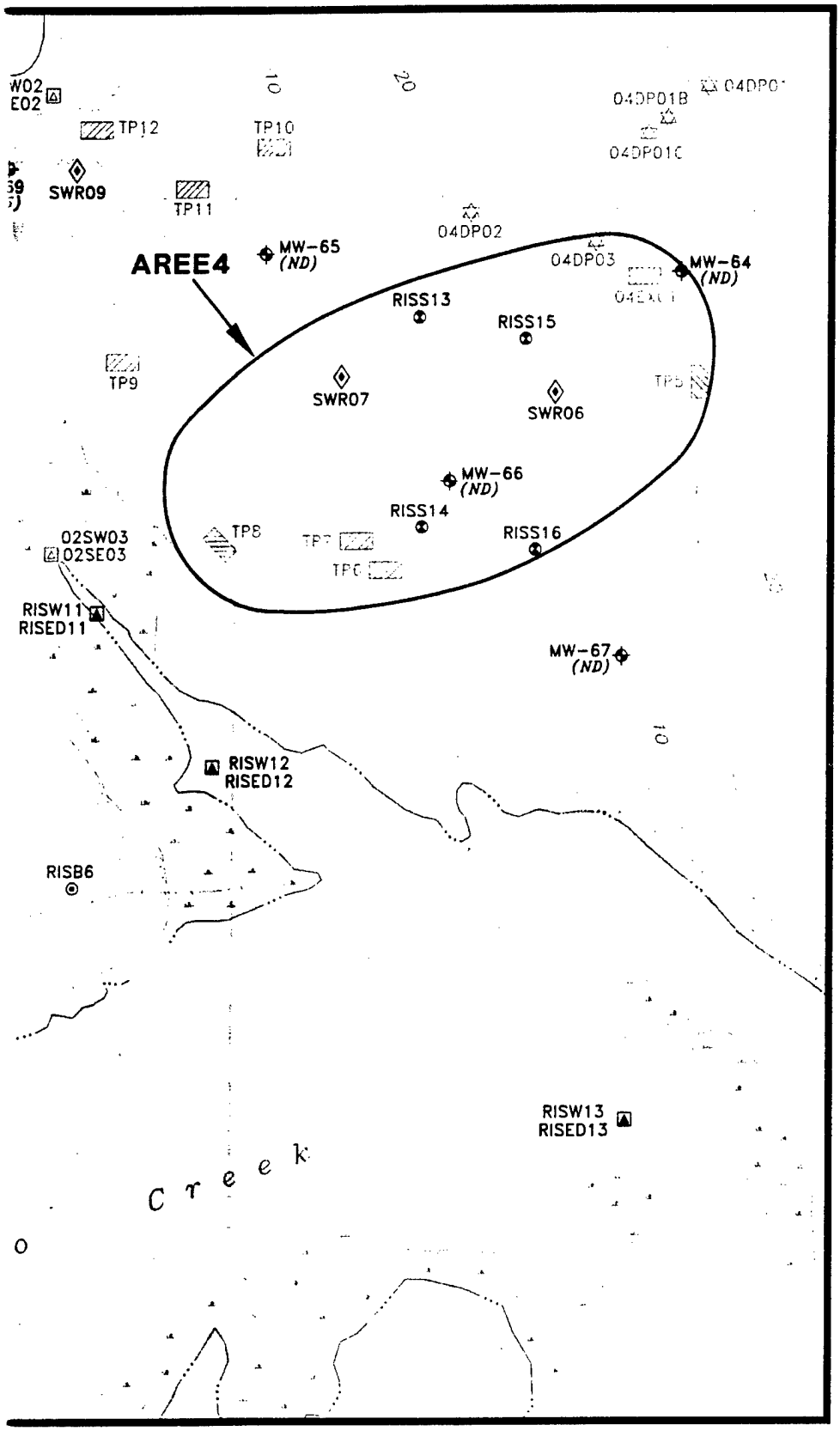
CAISER 2113 Emmorton Park Drive Suite 100 Edgewood, Maryland 21040 (410) 612-6350

ST | TASK NO: 66220
T | ICF DWG NO: A245PEST
7-97

AREES 2, 4, & 5 TOTAL PESTICIDE GROUNDWATER PLUME

3


03DP01
02SW02
02SE02
TP12
PZ-2
03DP03
AO3-1
03DP02
MW-69
(0.25)
SWR09
AREE
MW-1
(ND)
MW-68
(ND)
AREE2
PZ-1
TP3
MW-2
(ND)
SWR010
MW-3
(ND)
05DP02
MW-70
(0.177)
MW-81
(22.5)
05DP03
MW-82
(13.11)
05DP05
05DP04
RISS5
MW-71
(ND)
MW-83
(ND)
MW-5
(ND)
MW-4
(ND)
05DP01
05DP06
A05-3
MW-73
(.226)
MW-6
TP4
A05-2
02SW03
02SE03
RISW11
RISED11
05EX01
05EX03
SWR011
MW-72
(ND)
RISS7
RISS9
RISS6
SWR012
MW-74
(ND)
RISS8
AREE5
RISB6
02SW04
02SE04
Marumsco



LEGEND:

- PRIOR MONITORING WELL LOCATION
- 1995 RI MONITORING WELL LOCATION
- 1995 RI SOIL BORING LOCATION
- PRIOR PIEZOMETER LOCATION
- PRIOR SEDIMENT SAMPLE LOCATION
- PRIOR SURFACE WATER/SEDIMENT SAMPLE
- 1995 RI SURFACE WATER/SEDIMENT SAMPL
- PRIOR SURFACE SOIL SAMPLE LOCATION
- 1995 RI SURFACE SOIL SAMPLE LOCATION
- PRIOR DEEP PUNCH LOCATION
- 1995 RI STORMWATER RUNOFF SAMPLE LO
- PRIOR EXCAVATION LOCATION
- 1995 RI TEST PIT LOCATION
- AREE LOCATION
- SWAMP
- SHORELINE
- TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 2
- FENCE LINE
- TREE LINE

TOTAL SEMI-VOLATILE GROUNDWATER PLUME:

- >1.0 µg/L
- 0.1 to 0.99 µg/L

NOTE:

RESULTS ARE REPORTED IN µg/L.
ND = NON-DETECT

0 100 200
SCALE FEET

US ARMY ENVIRONMENTAL CEN

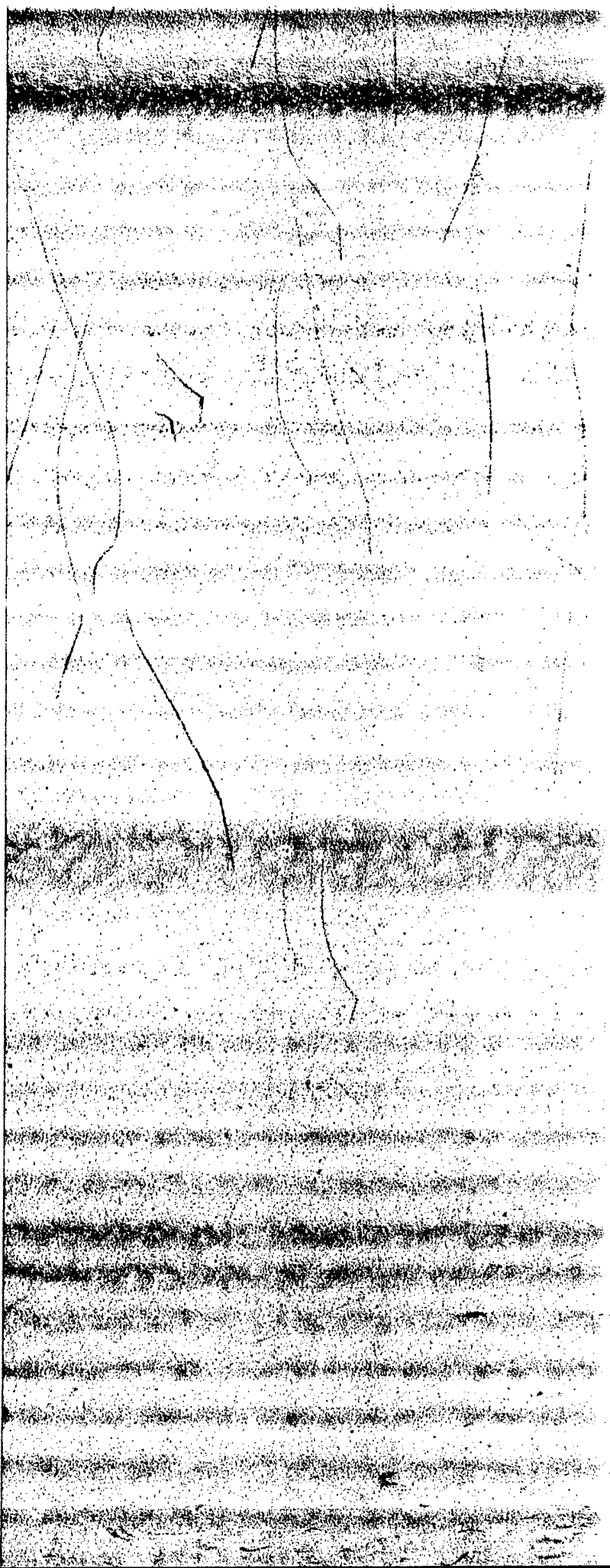
CONTRACT NO. DACA31-94-D-0064

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PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: A245SVOL
DATE 11-17-97	

FI
WOODBRIDG
AREES
T
SEMI-
GROU
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(2)



ND:

- RIOR MONITORING WELL LOCATION
- 995 RI MONITORING WELL LOCATION
- 995 RI SOIL BORING LOCATION
- RIOR PIEZOMETER LOCATION
- RIOR SEDIMENT SAMPLE LOCATION
- RIOR SURFACE WATER/SEDIMENT SAMPLE LOCATION
- 995 RI SURFACE WATER/SEDIMENT SAMPLE LOCATION
- RIOR SURFACE SOIL SAMPLE LOCATION
- 995 RI SURFACE SOIL SAMPLE LOCATION
- RIOR DEEP PUNCH LOCATION
- 995 RI STORMWATER RUNOFF SAMPLE LOCATION
- RIOR EXCAVATION LOCATION
- 995 RI TEST PIT LOCATION
- AREE LOCATION
- SWAMP
- SHORELINE
- 20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 2 FT.)
- FENCE LINE
- TREE LINE

L SEMI-VOLATILE NDWATER PLUME:

- >1.0 µg/L
- 0.1 to 0.99 µg/L

LTS ARE REPORTED IN µg/L.
NON-DETECT

N

100 200

LE FEET

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NO. DACA31-94-D-0064

FIGURE 2-40

WOODBRIDGE RESEARCH FACILITY

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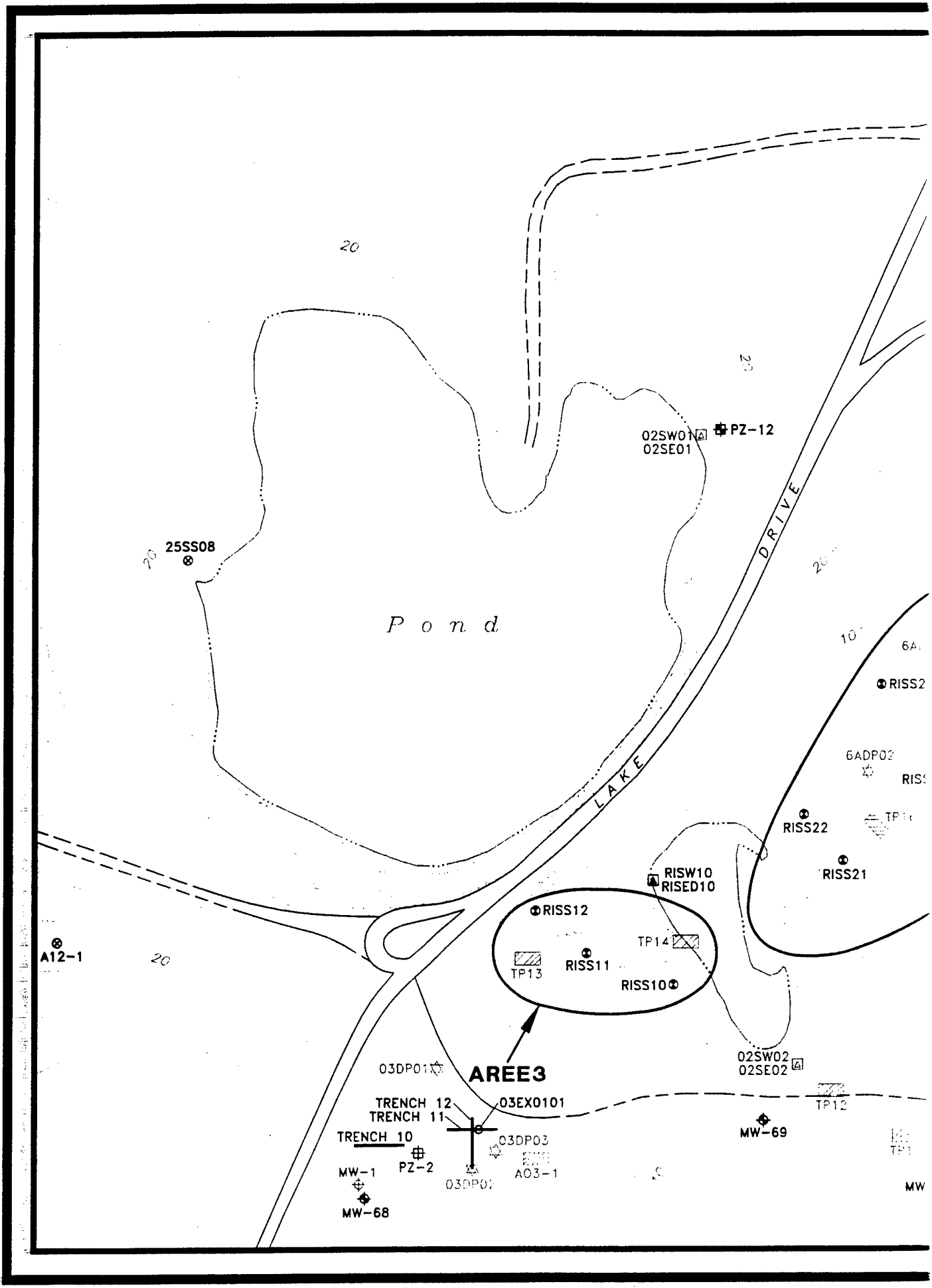
T | TASK NO: 66220

ICF DWG NO: A245SVOL

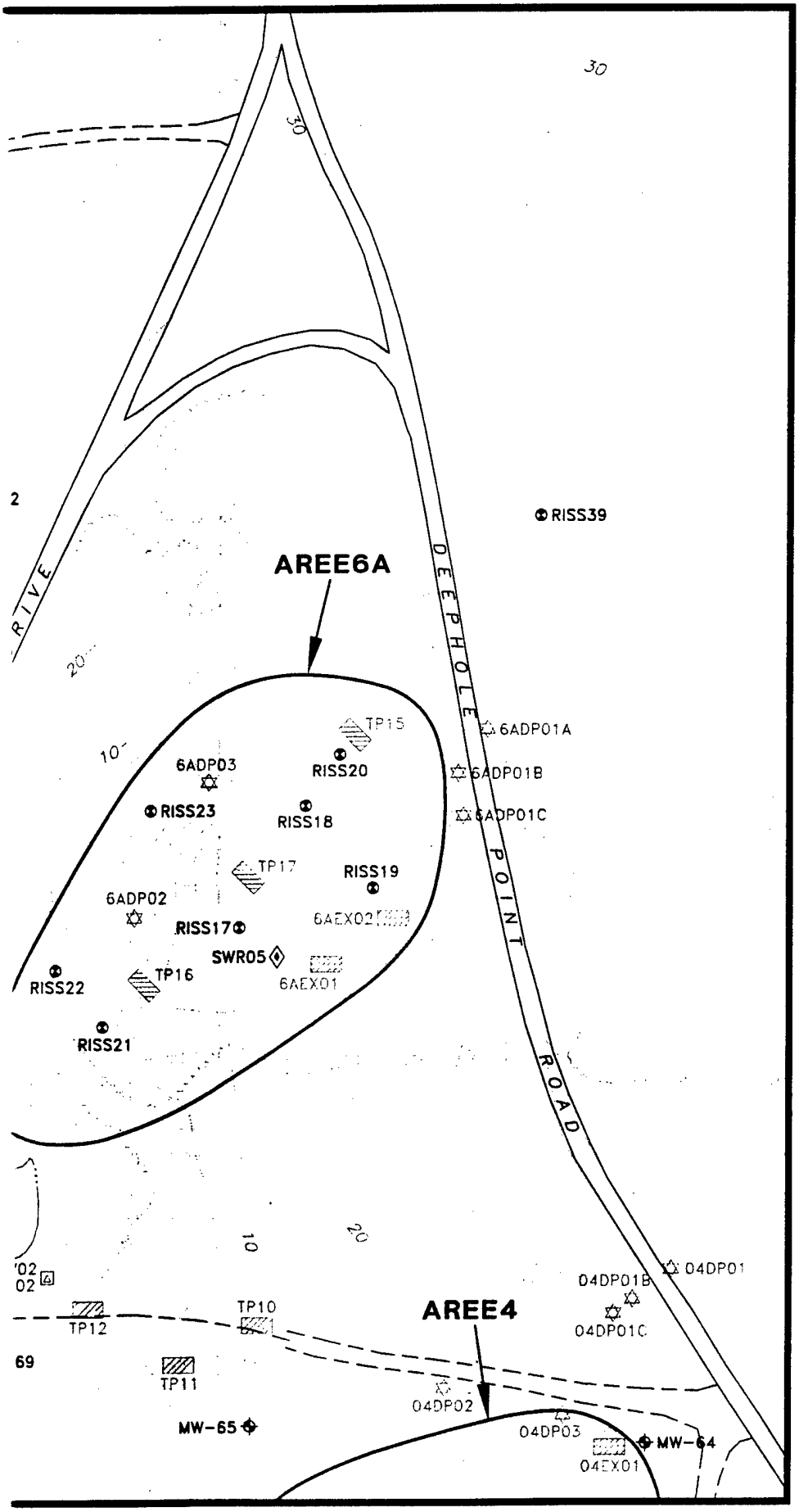
7-97

AREES 2, 4, & 5 TOTAL SEMI-VOLATILE GROUNDWATER PLUME

3


20
Pond
LAKE
DRIVE
02SW01
02SE01
PZ-12
25SS08
A12-1
RISS2
6ADP02
RISS22
RISS21
RISW10
RISED10
RISS12
TP14
TP13
RISS11
RISS10
02SW02
02SE02
03DP01
AREE3
TRENCH 12
TRENCH 11
03EX0101
TRENCH 10
03DP03
PZ-2
MW-1
MW-68
03DP02
AO3-1
TP12
MW-69
MW

(1)



LEGEND:

- PRIOR MONITORING WELL LOCATION
- 1995 RI MONITORING WELL LOCATION
- PRIOR PIEZOMETER LOCATION
- 1995 RI PIEZOMETER LOCATION
- PRIOR SURFACE WATER/SEDIMENT SAMPLE
- 1995 RI SURFACE WATER/SEDIMENT SAMP
- PRIOR SURFACE SOIL SAMPLE LOCATION
- 1995 RI SURFACE SOIL SAMPLE LOCATION
- PRIOR DEEP PUNCH LOCATION
- 1995 RI STORMWATER RUNOFF SAMPLE LC
- PRIOR EXCAVATION LOCATION
- 1995 RI TEST PIT LOCATION
- AREE LOCATION
- SHORELINE
- TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 2
- FENCE LINE
- TREE LINE

N

0 100 2(

SCALE FEET

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CONTRACT NO. DACA31-94-D-0064

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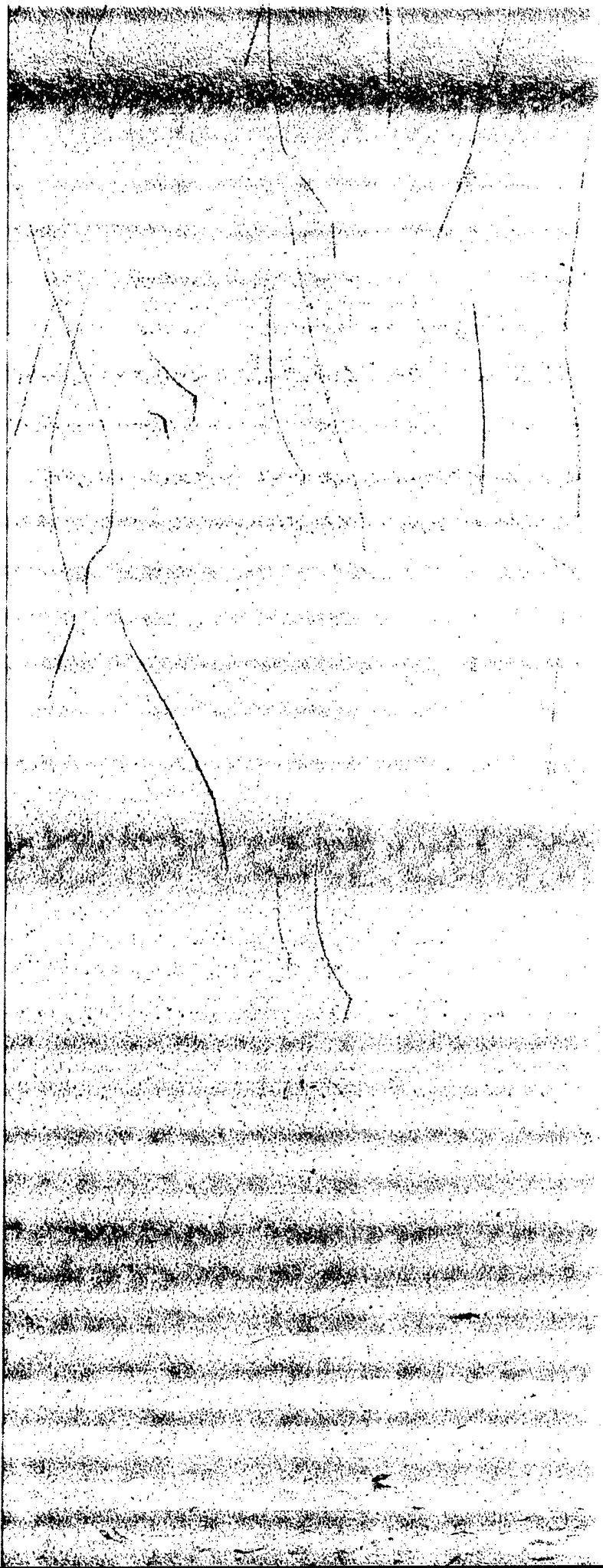
1995 R

LOCA

AREES

PREPARED CST	TASK NO: 66220
CHECKED PT	ICF DWG NO: A36A-SMP
DATE 11-17-97	

(2)



END:

PRIOR MONITORING WELL LOCATION

1995 RI MONITORING WELL LOCATION

PRIOR PIEZOMETER LOCATION

1995 RI PIEZOMETER LOCATION

PRIOR SURFACE WATER/SEDIMENT SAMPLE LOCATION

1995 RI SURFACE WATER/SEDIMENT SAMPLE LOCATION

PRIOR SURFACE SOIL SAMPLE LOCATION

995 RI SURFACE SOIL SAMPLE LOCATION

PRIOR DEEP PUNCH LOCATION

995 RI STORMWATER RUNOFF SAMPLE LOCATION

PRIOR EXCAVATION LOCATION

995 RI TEST PIT LOCATION

AREE LOCATION

SHORELINE

20 TOPOGRAPHIC CONTOUR (CONTOUR INTERVAL = 2 FT.)

FENCE LINE

TREE LINE

N

0 100 200

SCALE FEET

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T NO. DACA31-94-D-0064

FIGURE 2-41

WOODBRIDGE RESEARCH FACILITY

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17-97

TASK NO: 66220

ICF DWG NO:

A36A-SMP

PRIOR AND 1995 RI SAMPLING LOCATIONS FOR AREES 3 AND 6A

3

Table 2-1
Summary of RI Results for OU1 Background

Media Sampled[a]	Number of Samples Collected[b]	Compounds/Analytes Detected above LOC[c]	Summary of Fate & Transport
Surface Soil	6	None	Infiltration/percolation through soil to groundwater Stormwater runoff to surface water/sediments
Subsurface Soil (0- to 2-ft bgs)	3	None	
Subsurface Soil (2-ft bgs to water table)	4	None	
Groundwater	Round 1 - 4 Round 2 - 5	TPH as gas, TPH as Diesel	Discharge to surface water
Sediment	6	None	Leaching to surface water
Surface Water	6	None	Uptake into aquatic plants and animals

a Surface soil, subsurface soil, test pit, and groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PCTs. Surface soil and groundwater samples were also analyzed for PAHs.

b Duplicates are included in this number.

c LOC - Level of Concern. Refers to either the WRF site background maximum concentrations for inorganics detected in all media or USEPA Region III residential risk-based concentrations for organics detected in all media.

Table 2-1 (Continued)
Inorganic Compounds Detected in Background Surface Soil Samples

Sample ID	Aluminum (µg/g)	Arsenic (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)
RIBKSS1	14,600	3.85	<40	0.694	<100	26.7	6.46
RIBKSS1D	14,100	<7.5	<40	0.576	<100	24.2	6.32
RIBKSS2	6,550	<7.5	<40	0.364	486	9.72	12.7
RIBKSS3	8,600	<7.5	67	0.712	918	18.4	9.77
RIBKSS4	6,810	<7.5	<40	<0.2	764	14.5	6.83
RIBKSS5	10,900	<7.5	73.4	0.785	1,020	22.8	12

Sample ID	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)
RIBKSS1	7.77	23,900	17.2	1,290	119
RIBKSS1D	7.11	22,200	15	1,260	104
RIBKSS2	4.83	10,200	<7.5	881	412
RIBKSS3	12.6	21,900	18	1,340	513
RIBKSS4	5.72	12,700	15.5	1,250	266
RIBKSS5	8.7	18,200	22.4	1,700	677

Sample ID	Nickel (µg/g)	Potassium (µg/g)	Selenium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
RIBKSS1	7.42	567	<10	384	47	33.1
RIBKSS1D	7.59	527	<10	391	43.4	31.4
RIBKSS2	3.87	413	<10	380	20.6	14.8
RIBKSS3	8.17	546	14.2	467	47.1	33.5
RIBKSS4	5.21	358	<10	483	30.8	24.7
RIBKSS5	8.98	597	<10	487	43	40.4

Table 2-1 (Continued)
Organic Compounds Detected in Background Surface Soil Samples

Sample ID	Aldrin (µg/g)	Anthracene (µg/g)	Benzo(a) anthracene (µg/g)	Benzo(a)pyrene (µg/g)	Benzo(b)fluoranthene (µg/g)	Benzo(g,h,i) perylene (µg/g)
RIBKSS1	<0.003	<0.007	<0.001	<0.0007	0.002	<0.007
RIBKSS1D	<0.003	<0.007	<0.001	<0.0007	<0.001	<0.007
RIBKSS2	0.003	<0.007	0.003	0.002	0.005	<0.007
RIBKSS3	<0.003	0.027	0.005	0.006	0.01	0.011
RIBKSS4	<0.003	0.028	0.004	0.006	0.009	0.011
RIBKSS5	<0.003	0.015	0.005	0.008	0.009	0.011

Sample ID	Benzo(k)fluoranthene (µg/g)	Fluoranthene (µg/g)	Indeno(1,2,3-cd) pyrene (µg/g)	Methylene chloride (µg/g)	Phenanthrene (µg/g)	Pyrene (µg/g)
RIBKSS1	0.001	0.006	0.003	<0.01	0.341	<0.007
RIBKSS1D	0.001	0.005	0.003	<0.01	0.347	<0.007
RIBKSS2	0.002	0.006	0.008	<0.01	0.042	0.009
RIBKSS3	0.005	0.018	0.009	<0.01	<0.033	0.017
RIBKSS4	0.004	0.01	0.01	<0.01	<0.033	0.019
RIBKSS5	0.005	0.012	0.008	0.02	<0.033	0.023

Table 2-1 (Continued)
Inorganics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in Background Locations

Sample ID	Aluminum (µg/g)	Arsenic (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)
MW-52	4,740	<7.50	<40.0	0.3	149	9.42	2.47	7.41
MW-53	22,000	3.24	92.4	0.814	1,150	31.3	16.6	11.5
MW-54	14,300	<7.50	72.3	0.79	822	26.8	14.5	8.75

Sample ID	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Selenium (µg/g)
MW-52	7,630	<7.50	676	27.5	2.83	148	<10.0
MW-53	28,100	16.7	2,610	875	11.9	936	<10.0
MW-54	26,000	17.7	1,780	775	9.00	623	13.0

Sample ID	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
MW-52	439	19.9	15.2
MW-53	404	58.9	43.9
MW-54	453	49.0	39.4

Table 2-1 (Continued)
Organics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in Background Locations

Sample ID	Bis(2-ethylhexyl)phthalate (µg/g)
MW-52	<0.14
MW-53	0.18
MW-54	0.50

Table 2-1 (Continued)
Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table)
Collected in Background Locations

Sample ID	Depth bgs (ft)	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
MW-52	10	5,710	54.6	0.504	800	17.5
	17	2,000	<40.0	<0.200	562	3.66
MW-52 DUP	10	6,180	93.0	0.938	911	19.9
MW-53	10	2,660	<40.0	<0.200	113	4.24
	30	2,790	<40.0	<0.200	148	6.21
MW-54	5	18,200	67.4	1.02	454	25.0
	10	7,090	<40.0	0.346	265	11.7

Sample ID	Depth bgs (ft)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)
MW-52	10	11.1	14.7	11,300	<7.50	2,870	161
	17	7.70	3.96	6,100	<7.50	768	145
MW-52 DUP	10	6.71	19.1	8,750	11.0	3,280	75.9
MW-53	10	<2.00	1.52	4,050	<7.50	366	51.8
	30	<2.00	2.30	2,490	<7.50	405	32.8
MW-54	5	13.9	14.0	27,800	11.8	3,700	617
	10	4.56	5.54	9,170	<7.50	1,670	100

Sample ID	Depth bgs (ft)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
MW-52	10	14.9	462	927	22.8	36.9
	17	4.40	135	600	10.2	14.5
MW-52 DUP	10	20.9	480	939	28.7	55.6
MW-53	10	<2.00	184	320	6.92	5.45
	30	<2.00	148	373	6.90	<5.00
MW-54	5	12.5	624	446	60.3	38.3
	10	5.41	351	361	20.3	17.6

Table 2-1 (Continued)
Inorganics Detected In Background Groundwater Samples
Round 1 & 2

Sample ID	Aluminum (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Calcium (µg/L)	Chromium (µg/L)	Cobalt (µg/L)
Round 1							
MW-52	94.8	<1.0	107	<0.1	9,680	<10.0	<20.0
MW-53	12,500	1.1	74.9	0.8	5,450	22.3	<20.0
MW-54	117	<1.0	<25.0	0.1	2,250	<10.0	<20.0
MW-63	635	1.6	30.8	<0.1	24,300	<10.0	<20.0
Round 2							
MW-52	234	<1.0	98	<0.1	8,090	<10.0	<20.0
MW-53	293	<1.0	51.1	<0.1	5,420	<10.0	<20.0
MW-54	144	<1.0	<25.0	0.3	2,400	<10.0	<20.0
MW-63	780	6.9	30.3	<0.1	42,800	<10.0	<20.0
MW-63 Dup	514	6.5	27.2	0.2	41,600	<10.0	<20.0

Sample ID	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)
Round 1							
MW-52	<5.0	159	<1.0	6,030	60.8	18.4	1,450
MW-53	8.9	9,620	6.3	6,830	354	<15.0	6,490
MW-54	<5.0	194	<1.0	1,810	47.2	<15.0	<550
MW-63	<5.0	433	<1.0	3,580	12.0	<15.0	14,000
Round 2							
MW-52	<5.0	455	<1.0	5,940	48.4	<15.0	1,360
MW-53	<5.0	179	<1.0	7,720	18.9	<15.0	8,190
MW-54	<5.0	196	<1.0	2,020	35.2	<15.0	744
MW-63	<5.0	532	<1.0	225	10.8	<15.0	20,900
MW-63 Dup	<5.0	209	1.2	157	<5.0	<15.0	20,300

Table 2-1 (Continued)
Inorganics Detected In Background Groundwater Samples
Round 1 & 2

Sample ID	Selenium (µg/L)	Sodium (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
Round 1					
MW-52	2.1	16,600	<0.1	<10.0	46.0
MW-53	4.2	5,110	0.1	21.2	23.0
MW-54	<2.0	5,610	<0.1	<10.0	<20.0
MW-63	2.7	41,300	<0.1	12.3	<20.0
Round 2					
MW-52	<2.0	23,600	<0.1	<10.0	20.3
MW-53	<2.0	6,850	<0.1	<10.0	<20.0
MW-54	<2.0	5,720	<0.1	<10.0	<20.0
MW-63	<2.0	44,300	<0.1	31.4	<20.0
MW-63 Dup	<2.0	42,700	<0.1	28.2	<20.0

Table 2-1 (Continued)
Organics Detected In Background Groundwater Samples
Round 1 & 2

Sample ID	1-Methyl naphthalene (µg/L)	2-Methyl naphthalenene (µg/L)	Acenaphthene (µg/L)	Acenaphthylene (µg/L)	Anthracene (µg/L)	BHC,B (µg/L)
Round 1						
MW-52	<2.00	<2.00	<2.00	<2.00	0.113	<0.005
MW-53	<2.00	<2.00	<2.00	<2.00	<0.100	<0.005
MW-54	<2.00	<2.00	<2.00	<2.00	<0.100	<0.005
MW-63	119	80.5	11.0	6.34	<0.100	<0.005
Round 2						
MW-52	ND	ND	ND	ND	ND	ND
MW-53	ND	ND	ND	ND	ND	ND
MW-54	ND	ND	ND	ND	ND	ND
MW-63	101	79.3	4.17	3.01	2.00	0.017
MW-63Dup	ND	78.8	8.27	ND	ND	ND

Sample ID	BHC,G (Lindane) (µg/L)	Dieldrin (µg/L)	Dimethyl pthalate (µg/L)	Endosulfan, B (µg/L)	Endosulfan sulfate (µg/L)	Endrin (µg/L)
Round 1						
MW-52	<0.005	<0.005	<2.0	<0.005	0.146	<0.005
MW-53	<0.005	<0.005	<2.0	<0.005	<0.005	<0.005
MW-54	<0.005	<0.005	<2.0	<0.005	<0.005	<0.005
MW-63	<0.005	<0.005	<2.0	0.021	0.027	0.022
Round 2						
MW-52	ND	ND	ND	ND	0.138	ND
MW-53	ND	ND	ND	ND	ND	ND
MW-54	ND	ND	ND	ND	ND	ND
MW-63	0.098	0.026	ND	ND	0.019	ND
MW-63DUP	ND	0.018	3.90	ND	ND	ND

Table 2-1 (Continued)
Organics Detected In Background Groundwater Samples
Round 1 & 2

Sample ID	Ethylbenzene (µg/L)	Fluoranthene (µg/L)	Fluorene (µg/L)	Heptachlor (µg/L)	Naphthalene (µg/L)	Phenanthrene(µg/L)	Pyrene (µg/L)
Round 1							
MW-52	<2.0	<2.0	<2.0	<0.005	<2.0	<2.0	<2.0
MW-53	<2.0	<2.0	<2.0	<0.005	<2.0	<2.0	<2.0
MW-54	<2.0	<2.0	<2.0	<0.005	<2.0	<2.0	<2.0
MW-63	13	0.063	3.2	<0.005	30	8.69	0.158
Round 2							
MW-52	<2.0	<0.020	<0.500	<0.005	<2.00	<0.500	<0.100
MW-53	<2.0	<0.020	<0.500	<0.005	<2.00	<0.500	<0.100
MW-54	<2.0	<0.020	<0.500	<0.005	<2.00	<0.500	<0.100
MW-63	5.30	0.069	1.87	<0.005	18.0	6.43	0.162
MW-63DUP	5.20	0.069	2.01	0.011	15.2	6.35	0.137

Sample ID	Toluene (µg/L)	TPH, As Diesel (µg/L)	TPH, As Gas (µg/L)	Xylenes (µg/L)
Round 1				
MW-52	<2.0	<400	<400	<10.0
MW-53	<2.0	<400	<400	<10.0
MW-54	<2.0	<400	<400	<10.0
MW-63	5.2	900	740	54
Round 2				
MW-52	<2.0	<400	<400	<10.0
MW-53	<2.0	<400	<400	<10.0
MW-54	<2.0	<400	<400	<10.0
MW-63	2.30	1,140	558	32.0
MW-63DUP	2.10	1,130	538	31.0

Table 2-1 (Continued)
Inorganic Compounds Detected in Background Sediment Samples collected from Mason Neck Wildlife Refuge

Sample ID	Aluminum (µg/g)	Arsenic (µg/g)	Antimony (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Cadmium (µg/g)	Calcuim (µg/g)	Chromium (µg/g)	Cobalt (µg/g)
RISDBK1	14,300	<7.50	<0.30	175	1.26	<0.50	6,000	29.9	20.7
RISDBK2	13,100	<7.50	<0.30	<40.0	1.11	<0.50	4,760	26.0	16.1
RISDBK3	16,900	<7.50	<0.30	<40.0	1.38	<0.50	5,070	33.7	21.4
RISDBK3D	11,700	<7.50	<0.30	<40.0	1.06	<0.50	3,410	24.6	14.8
RISDBK4	15,200	<7.50	<0.30	<40.0	1.08	<0.50	5,990	30.1	18.0
RISDBK5	10,500	<7.50	<0.30	<40.0	0.989	<0.50	5,140	21.6	14.6

Sample ID	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Mercury (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Selenium (µg/g)
RISDBK1	40.6	34,200	42.2	3,450	1,690	<0.10	30.0	1,850	<10.0
RISDBK2	33.3	30,000	30.6	2,810	1,470	<0.10	22.4	1,730	<10.0
RISDBK3	44.4	36,500	41.8	3,740	1,220	<0.10	30.3	2,090	<10.0
RISDBK3D	34.0	23,600	<7.50	2,740	603	<0.10	21.6	1,550	<10.0
RISDBK4	41.8	32,300	<7.50	3,470	1,220	<0.10	26.9	2,120	<10.0
RISDBK5	29.8	26,100	29	2,470	1,580	<0.10	19.3	1,450	<10.0

Sample ID	Silver (µg/g)	Sodium (µg/g)	Thallium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
RISDBK1	<0.50	1,130	<20.0	51.5	139
RISDBK2	<0.50	1,240	<20.0	41.6	133
RISDBK3	<0.50	1,440	<20.0	54.1	168
RISDBK3D	<0.50	1,200	<20.0	39.6	128
RISDBK4	<0.50	1,710	<20.0	52.5	157
RISDBK5	<0.50	932	<20.0	35.5	114

Table 2-1 (Continued)
Organics Detected in Background Sediment Samples
Collected from Mason Neck Wildlife Refuge

Sample ID	1-Methyl naphthalene (µg/g)	Acenaphthene (µg/g)	Anthracene (µg/g)	Benzo(a) anthracene (µg/g)	Benzo(a)pyrene (µg/g)	Benzo(b) fluoranthene (µg/g)	Benzo(g,h,i) perylene (µg/g)
RISDBK1	<0.133	<0.133	<0.007	0.021	0.029	0.061	0.053
RISDBK2	<0.133	0.919	0.145	0.031	0.048	<0.033	<0.007
RISDBK3	0.93	<0.133	0.173	0.034	0.053	<0.133	0.09
RISDBK3 D	1.14	1.27	0.164	0.027	0.05	<0.133	0.07
RISDBK4	<0.133	<0.133	0.108	0.027	0.048	0.083	0.046
RISDBK5	0.498	<0.133	0.11	0.028	0.028	<0.033	0.070

Sample ID	Benzo(k) fluoranthene (µg/g)	Dibenz(a,h) anthracene (µg/g)	Fluoranthene (µg/g)	Fluorene (µg/g)	Indeno(1,2,3 -cd) pyrene (µg/g)	Methylene chloride (µg/g)	Naphthalene (µg/g)	Pyrene (µg/g)
RISDBK1	0.017	<0.16	0.055	<0.033	0.094	<0.01	<0.133	0.053
RISDBK2	0.032	<0.16	0.059	<0.033	0.112	<0.01	<0.133	0.085
RISDBK3	0.033	<0.16	0.096	0.297	0.137	<0.01	<0.133	0.114
RISDBK3 D	0.029	<0.016	0.092	<0.033	0.084	<0.01	0.636	0.108
RISDBK4	0.028	<0.16	0.094	0.355	0.094	<0.01	<0.133	0.116
RISDBK5	0.07	<0.16	0.086	0.225	0.064	<0.01	<0.133	0.13

Table 2-1 (Continued)
Inorganic Compounds Detected in Background Surface Water Samples collected from Mason Neck Wildlife Refuge

Sample ID	Aluminum (µg/L)	Arsenic (µg/L)	Antimony (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Cadmium (µg/L)	Calcuim (µg/L)	Chromium (µg/L)	Cobalt (µg/L)
RISDBK1	1,860	1.4	<1.0	41.8	<5.0	<1.0	18,800	<10.0	<20.0
RISDBK2	1,840	<1.0	<1.0	41.3	<5.0	<1.0	19,300	10.8	<20.0
RISDBK3	1,440	<1.0	<1.0	36.9	<5.0	<1.0	20,400	<10.0	<20.0
RISDBK3D	1,160	<1.0	<1.0	38.5	<5.0	<1.0	21,700	<10.0	<20.0
RISDBK4	1,230	<1.0	<1.0	40.4	<5.0	<1.0	22,200	<10.0	<20.0
RISDBK5	1,930	<1.0	<1.0	40.6	<5.0	<1.0	19,000	<10.0	<20.0

Sample ID	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Potassium (µg/L)	Selenium (µg/L)
RISDBK1	<5.0	2,460	1.6	6,120	236	<0.20	<15	3,350	<2.0
RISDBK2	<5.0	2,500	1.9	6,100	196	<0.20	<15	3,670	<2.0
RISDBK3	<5.0	1,810	1.3	6,350	159	<0.20	<15	3,490	<2.0
RISDBK3D	<5.0	2,000	1.3	6,880	226	<0.20	<15	2,990	<2.0
RISDBK4	<5.0	2,020	1.4	7,500	303	<0.20	<15	2,870	<2.0
RISDBK5	<5.0	2,510	1.9	5,970	176	<0.20	<15	3,300	<2.0

Sample ID	Silver (µg/L)	Sodium (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
RISDBK1	<5.0	13,000	<0.1	<10.0	<20.0
RISDBK2	<5.0	12,900	<0.1	<10.0	<20.0
RISDBK3	<5.0	13,100	<0.1	<10.0	<20.0
RISDBK3D	<5.0	14,300	<0.1	<10.0	<20.0
RISDBK4	<5.0	16,500	<0.1	<10.0	<20.0
RISDBK5	<5.0	12,500	<0.1	<10.0	<20.0

Table 2-2

Summary of RI Results for AREE 1 - Former Dump No. 1

Media Sampled[a]	Number of Samples Collected	Compounds/Analytes Detected above LOC[b]	Summary of Fate & Transport
Surface Soil	8	Al, Be, Ca, Cr, Cu, Co, Fe, Pb, Hg, K, Na, Zn benzo(a)anthrancene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(a,h)anthrancene, indeno(1,2,3-cd)pyrene, PCB-1260	Infiltration/percolation through soil to groundwater Stormwater runoff to surface water/sediments
Subsurface Soil (0- to 2-ft bgs)	6	Ba, Be, Ca, Cr, Co, Hg, Pb, Mg, Ni, K, Na, V, Zn PCB-1260	
Subsurface Soil (2-ft bgs to water table)	10	Be, Ca, Co, Pb, V PCB-1260	
Test Pits	5	Ba, Ca, Fe, Pb, K, V	
Groundwater	Round 1 - 11 Round 2 - 5	Al, Ba, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, Se, Tl, V, Zn	Discharge to surface water
Sediment	8	Ag, Co, Cr, Fe, Na, V, Zn, PCB-1260	Leaching to surface water
Surface Water	8	Al, Ba, Cr, Cu, Fe, Pb, Mn, K, V, Zn	Uptake into aquatic plants and animals
Surface Water Runoff	5	None	Overland flow

[a] Surface soil, subsurface soil, test pit, and groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PCTs. Surface soil and groundwater samples were also analyzed for PAHs.

[b] LOC - Level of Concern: Refers to either the WRF site background maximum concentrations for inorganics detected in all media or USEPA Region III residential risk-based concentrations for organics detected in all media.

Table 2-2 (Continued)

Inorganics Detected in Surface Soil Samples Collected in AREE 1

Sample ID	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)
Site Background*	14,350	92.4	0.814	1,150	31.3	16.6
RISS1	14,200	ND	0.735	1,050	24.2	8.06
RISS1DUP	11,700	ND	0.896	1,130	22.8	7.35
RISS2	11,400	ND	0.651	1,050	24.3	6.16
RISS3	13,300	53	0.639	3,580	24.5	4.70
RISS4	13,100	59.6	0.755	2,260	25	6.30
RISS54	14,700	ND	0.669	679	25.8	6.86
RISS55	11,400	62.7	0.544	1,640	96.7	5.81
RISS56	9,640	ND	0.506	1,470	19.4	20.4

Sample ID	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Mercury (µg/g)
Site Background*	12.6	28,100	22.4	2,610	875	ND
RISS1	18.1	25,400	24.3	2,370	180	ND
RISS1DUP	20.7	27,100	35.7	2,030	173	ND
RISS2	12.3	16,500	12	1,990	53.8	ND
RISS3	9.59	37,000	ND	1,090	50.6	ND
RISS4	14.7	22,800	31.9	1,590	169	0.121
RISS54	8.69	24,900	13.1	1,810	129	ND
RISS55	10.6	17,300	25.1	1,550	137	ND
RISS56	10.2	17,500	28.3	1,330	238	ND

Table 2-2 (Continued)

Inorganics Detected in Surface Soil Samples Collected in AREE 1

Sample ID	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	11.9	936	467	58.9	43.9
RISS1	11.2	990	991	37.4	177
RISS1DUP	10.6	828	550	35.2	231
RISS2	9.34	749	467	42.8	34.3
RISS3	5.88	554	530	47.6	23.3
RISS4	9.60	711	492	43.3	135
RISS54	8.47	553	311	48.3	29.9
RISS55	10.3	615	298	35.5	195
RISS56	6.88	703	271	34.3	301

ND Not Detected.

[a] Site background concentrations are from surface soil samples MW-52 through MW-54 and RISSBK1 through RISSBK5.

Table 2-2 (Continued)

Organics Detected in Surface Soil Samples Collected in AREE 1

Sample ID	1-Methyl naphthalene (µg/g)	2-Methyl naphthalene (µg/g)	Acenaphthene (µg/g)	Anthracene (µg/g)	Benzo(a) anthracene (µg/g)
RBC[a]	230[c]	230[c]	470	2,300	0.88
RISS1	ND	ND	ND	0.022	ND
RISS1DUP	ND	ND	ND	0.081	ND
RISS2	ND	ND	ND	0.009	0.004
RISS3	ND	ND	ND	ND	ND
RISS4	ND	0.189	ND	0.160	ND
RISS54	ND	ND	ND	ND	0.002
RISS55	0.383	2.98	6.29	4.12	0.999
RISS56	0.842	6.05	10.8	11.7	2.0

Sample ID	Benzo(a)pyrene (µg/g)	Benzo(b) fluoranthene (µg/g)	Benzo(g,h,i) perylene (µg/g)	Benzo(k) fluoranthene (µg/g)	Bis(2-ethylhexyl)-phthalate (µg/g)	Chlordane (µg/g)
RBC[a]	0.088	0.88	230[c]	8.8	46	0.49
RISS1	0.002	0.002	ND	ND	1.70	ND
RISS1DUP	0.004	0.003	ND	0.002	0.730	ND
RISS2	0.006	0.006	ND	0.003	0.340	ND
RISS3	0.002	0.003	ND	0.001	0.460	ND
RISS4	0.090	ND	0.045	ND	1.40	ND
RISS54	0.004	0.004	ND	0.002	ND	ND
RISS55	1.03	1.09	1.13	0.536	ND	0.025
RISS56	0.37	2.19	2.77	1.20	ND	ND

Table 2-2 (Continued)

Organics Detected in Surface Soil Samples Collected in AREE 1

Sample ID	Chrysene (µg/g)	DDD (µg/g)	DDE (µg/g)	DDT (µg/g)	Dibenzo(a,h) anthracene (µg/g)	Fluoranthene (µg/g)
RBC[a]	88	2.7	1.9	1.9	0.088	310
RISS1	ND	0.011	ND	ND	ND	0.004
RISS1DUP	0.010	ND	ND	0.004	ND	0.011
RISS2	ND	ND	ND	ND	ND	0.007
RISS3	ND	ND	ND	ND	ND	0.003
RISS4	0.048	0.005	0.006	ND	0.022	0.201
RISS54	ND	ND	ND	ND	ND	0.007
RISS55	1.07	0.024	0.008	0.056	0.287	2.52
RISS56	2.62	0.006	0.052	0.035	0.698	0.34

Sample ID	Fluorene (µg/g)	Indeno(1,2,3-cd)pyrene (µg/g)	Napthalene (µg/g)	PCB-1260 (µg/g)	Phenanthrene (µg/g)	Pyrene (µg/g)
RBC[a]	310	0.88	310	0.083[b]	230[c]	230
RISS1	ND	ND	ND	0.149	ND	ND
RISS1DUP	ND	ND	ND	0.037	ND	0.034
RISS2	ND	ND	ND	ND	ND	0.009
RISS3	ND	ND	ND	ND	ND	ND
RISS4	ND	0.038	ND	0.713	0.223	0.197
RISS54	ND	ND	0.332	ND	ND	ND
RISS55	0.487	0.707	1.80	0.279	2.36	3.33
RISS56	0.755	1.70	4.37	0.054	6.29	12.3

ND Not detected.

[a] The maximum detected concentrations of organic and inorganic compounds were compared to USEPA Region III residential RBCs, in accordance with Region III guidance (USEPA, 1996a). The RBCs are health-protective chemical concentrations that are back-calculated using toxicity criteria, a $1x10^{-6}$ target risk level or a 0.1 hazard index, and conservative exposure parameters.

[b] Value is for carcinogenic PCBs.

[c] The RBC for pyrene was used as a surrogate for non-carcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.

Table 2-2 (Continued)

Inorganics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREE 1

Sample ID	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)
Site Background[a]	16,200	73.4	1.02	454	25.0	13.9	16.9
MW-76	1,890	ND	ND	463	15.3	4.93	4.79
MW-77	7,430	50.8	0.68	900	27.2	12.1	14.1
MW-77DUP	10,200	85.7	0.70	1,090	33.0	14.4	15.7
MW-78	4,620	ND	0.40	1,240	20.3	6.92	8.40
MW-79	11,200	ND	1.20	373	24.4	6.46	11.5
MW-80	7,880	49.9	0.50	2,530	16.8	6.96	12.3

Sample ID	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Mercury (µg/g)	Nickel (µg/g)	Potassium (µg/g)
Site Background[a]	27,600	11.8	3,700	617	ND	17.9	624
MW-76	10,200	10.4	377	190	0.209	4.33	217
MW-77	17,200	13.0	3,430	117	ND	16.4	682
MW-77DUP	16,000	10.2	3,950	119	ND	18.7	899
MW-78	14,100	24.5	1,010	322	ND	7.39	460
MW-79	26,800	12.9	2,830	63.8	ND	8.80	394
MW-80	17,700	32.4	1,400	216	ND	8.65	603

Sample ID	Selenium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	--	933	25.8	46.3
MW-76	ND	409	25.5	17.4
MW-77	17.4	579	35.7	37.5
MW-77DUP	ND	638	43.6	41.4
MW-78	13.4	395	38.0	45.4
MW-79	ND	982	54.4	32.6
MW-80	15.4	480	32.1	61.3

ND Not detected.

[a] Background concentrations are from soil samples MW-52 through MW-54 and RISSBK-1 through RISSBK-5.

Table 2-2 (Continued)

Organics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREE 1

Sample ID	Benzo(b) fluoranthene (µg/g)	Chrysene (µg/g)	DDD (µg/g)	DDE (µg/g)	Dieldrin (µg/g)	Endosulfan sulfate (µg/g)
RBC[a]	0.88	88	2.7	1.9	0.04	47[b]
MW-76	ND	ND	ND	ND	ND	ND
MW-77	ND	ND	ND	ND	ND	ND
MW-77DUP	ND	ND	ND	ND	ND	0.03
MW-78	0.20	0.17	ND	ND	ND	ND
MW-79	ND	ND	ND	ND	ND	ND
MW-80	ND	ND	0.01	0.01	0.02	ND

Sample ID	Fluoranthene (µg/g)	PCB-1260 (µg/g)	Pyrene (µg/g)
RBC[a]	310	0.083[c]	230
MW-76	ND	ND	ND
MW-77	ND	ND	ND
MW-77DUP	ND	ND	ND
MW-78	0.19	0.11	0.20
MW-79	ND	ND	ND
MW-80	0.91	10.8	0.85

ND Not detected.

[a] RBC values are from USEPA Region III Residential Soil RBCs. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

[b] The RBC for endosulfan was used.

[c] Value is for carcinogenic PCBs.

Table 2-2 (Continued)

Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREE 1

Sample ID	Depth bgs (ft)	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
Site Background*		18,200	73.8	ND	454	25
MW-76	5	3,140	ND	0.390	726	18.4
	7	4,480	ND	0.499	653	17.1
MW-77	5	3,190	ND	ND	190	8.96
	7	3,680	ND	0.27	228	10.7
MW-78	5	1,780	ND	0.34	145	5.41
	10	1,930	ND	ND	193	4.32
MW-79	5	7,240	ND	0.39	295	13.8
	10	2,630	ND	ND	140	5.35
MW-80	5	6,150	50.6	0.47	702	15.7
	10	2,180	ND	ND	138	4.70

Sample ID	Depth bgs (ft)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)
Site Background*		13.9	16.9	27,800	11.8	3,700	617
MW-76	5	14.4	8.50	13,200	11.3	784	138
	7	9.23	8.00	11,400	ND	1,230	108
MW-77	5	ND	2.28	3,200	ND	751	29.3
	7	2.89	4.62	12,600	ND	685	93.3
MW-78	5	ND	2.58	11,800	ND	308	77.1
	10	ND	2.17	2,350	ND	352	40.1
MW-79	5	3.86	5.73	4,410	ND	1,470	43.5
	10	ND	2.44	2,650	ND	438	17.4
MW-80	5	10.3	10.7	10,400	ND	1,380	115
	10	ND	2.65	4,200	ND	340	43.0

Table 2-2 (Continued)

Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREE 1

Sample ID	Depth bgs (ft)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]		17.9	624	933	25.8	46.3
MW-76	5	6.15	320	466	37.2	20.1
	7	8.03	575	547	27.7	22.1
MW-77	5	4.28	341	302	7.06	8.78
	7	3.90	340	436	10.6	12.0
MW-78	5	ND	ND	262	6.49	8.08
	10	ND	149	249	6.49	ND
MW-79	5	5.57	330	417	21.5	18.8
	10	ND	191	247	8.27	ND
MW-80	5	7.59	568	422	30.1	23.5
	10	ND	ND	250	6.37	ND

ND Not detected.

[a] Background concentrations are from samples MW-52 through MW-54, each at two depths.

Table 2-2 (Continued)

Organic Compounds Detected In Subsurface Soil Samples (2 ft bgs to Water Table) Collected In AREE 1

Sample ID	Depth bgs (ft)	Acetone (µg/g)	Bis(2-ethythexyl) phthalate (µg/g)	Endosulfan Sulfate (µg/g)	Fluoranthene (µg/g)	Methoxychlor (µg/g)
RBC[a]		780	46	47[b]	310	39
MW-76	5	ND	ND	ND	0.33	ND
	7	0.02	ND	ND	ND	ND
MW-77	5	ND	0.17	0.01	ND	ND
	7	0.01	ND	ND	ND	ND
MW-78	10	0.03	ND	ND	ND	ND
MW-79	10	0.01	0.29	ND	ND	ND
MW-80	5	0.02	ND	ND	ND	ND
	10	ND	6.50	ND	ND	0.01

Sample ID	Depth bgs (ft)	PCB-1260 (µg/g)	Pyrene (µg/g)
RBC[a]		0.083[c]	230
MW-76	5	ND	0.28
	7	ND	ND
MW-77	5	ND	ND
	7	ND	ND
MW-78	10	ND	ND
MW-79	10	ND	ND
MW-80	5	1.62	ND
	10	ND	ND

ND Not detected.

[a] USEPA Region III residential risk-based concentration (RBC) values. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

[b] The RBC for endosulfan was used.

[c] Value is for carcinogenic PCBs.

Table 2-2 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREE 1

Sample ID	Depth bgs (ft)	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
Site Background[a] (0 ft bgs)		14,350	92.4	0.814	1,150	31.3
Site Background[b] (2 ft bgs)		18,200	73.8	1.02	454	25.0
TP-1A	0	11,900	ND	ND	967	18.3
TP-1ADUP	0	10,900	ND	0.312	1,120	17.9
TP-1B	2	11,400	ND	0.725	697	20.3
TP-2A	2	13,600	ND	0.320	571	20.8
TP-2B	2	12,700	75.2	0.539	476	17.7

Sample ID	Depth bgs (ft)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)
Site Background[a] (0 ft bgs)		16.6	12.6	28,100	22.4	2,610
Site Background[b] (2 ft bgs)		13.9	16.9	27,800	11.8	3,700
TP-1A	0	4.17	8.61	21,500	10.7	1,040
TP-1ADUP	0	4.02	9.30	23,600	12.0	1,060
TP-1B	2	8.47	13.9	29,200	12.5	1,850
TP-2A	2	7.28	8.19	17,200	25.0	1,500
TP-2B	2	6.98	11.7	17,100	20.3	765

Table 2-2 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREE 1

Sample ID	Depth bgs (ft)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a] (0 ft bgs)		875	11.9	936	487	58.9	43.9
Site Background[b] (2 ft bgs)		617	17.9	624	933	25.8	46.3
TP-1A	0	36.6	5.66	457	361	32.8	30.0
TP-1ADUP	0	36.4	5.65	363	419	41.3	25.1
TP-1B	2	110	10.1	629	538	33.2	37.9
TP-2A	2	163	8.02	916	492	36.0	35.8
TP-2B	2	262	6.59	573	380	33.9	37.0

ND Not detected.

[a] Background concentrations are from soil samples MW-52 through MW-54 and RISSBK1 through RISSBK5.

[b] Background concentrations are from soil samples MW-52 through MW-54, each at two depths.

Table 2-2 (Continued)

Organics Detected in Test Pit Samples Collected in AREE 1

Sample ID	Depth bgs (ft)	Bis(2-ethylhexyl)-phthalate (µg/g)	DDD (µg/g)	DDE (µg/g)	Methoxychlor (µg/g)
RBC[a]		46	2.7	1.9	39
TP-1A	0	0.160	ND	ND	ND
TP-1AD	0	ND	ND	ND	ND
TP-1B	2	ND	ND	ND	ND
TP-2A	2	ND	0.009	0.008	ND
TP-2B	2	ND	0.005	0.017	ND

ND Not detected.

[a] USEPA Region III residential risk-based concentration (RBC) values. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

Table 2-2 (Continued)

Inorganics Detected In Groundwater Samples Collected In AREE 1

Sample ID	Aluminum (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Calcium (µg/L)	Chromium (µg/L)	Cobalt (µg/L)
Site Background[a]	12,500	6.70	107	0.600	42,200	22.3	ND
MW-7	85,000	4.1	324	0.5	21,700	1,120	73
MW-8	209	ND	ND	0.1	1,190	ND	ND
MW-9	56.9	ND	123	ND	49,200	ND	ND
MW-10	1,090	ND	73.9	ND	17,000	31.6	ND
MW-11	380	1.9	111	ND	22,300	ND	ND
MW-12	1,510	ND	43	ND	17,900	ND	ND
MW-76	157	ND	43.5	ND	24,300	ND	ND
MW-76 Round 2	307	ND	29.1	ND	16,700	ND	ND
MW-77	170	ND	27.9	0.1	7,820	ND	ND
MW-77 Round 2	2,780	ND	42.0	0.1	9,530	ND	ND
MW-78	593	ND	48.4	ND	13,600	ND	27.4
MW-78 Round 2	5,750	ND	63.9	ND	15,100	ND	ND
MW-79	209	2.7	34.5	ND	7,980	ND	30.7
MW-79 Round 2	1,000	2.8	29.4	ND	6,970	ND	22.4
MW-80	68	ND	ND	ND	2,920	ND	ND
MW-80 Round 2	1,430	ND	25.3	ND	3,960	ND	ND

Table 2-2 (Continued)

Inorganics Detected In Groundwater Samples Collected In AREE 1

Sample ID	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)
Site Background[a]	8.9	9,620	6.3	7,720	354	18.4	20,600
MW-7	124	109,000	54.6	35,300	1,610	706	8,160
MW-8	ND	216	7.3	1,410	26	ND	568
MW-9	ND	73,700	ND	21,400	5,160	ND	2,330
MW-10	5.5	38,600	48	9,300	1,900	20.5	2,070
MW-11	ND	30,300	7.2	11,600	2,850	ND	1,120
MW-12	ND	3,020	2	4,830	252	ND	3,600
MW-76	ND	13,500	ND	8,710	1,050	ND	1,500
MW-76 Round 2	ND	11,400	ND	5,540	994	ND	1,880
MW-77	ND	340	ND	4,440	304	ND	1,270
MW-77 Round 2	5.9	6,050	1.6	8,120	328	ND	1,740
MW-78	ND	690	ND	11,100	970	ND	805
MW-78 Round 2	6.1	7,840	2.4	12,400	1350	ND	1,290
MW-79	ND	15,200	ND	9,170	609	ND	779
MW-79 Round 2	ND	17,600	ND	7,920	479	ND	1,430
MW-80	ND	343	ND	2,440	165	ND	678
MW-80 Round 2	ND	3,510	ND	3,250	285	ND	1,210

Table 2-2 (Continued)

Inorganics Detected In Groundwater Samples Collected In AREE 1

Sample ID	Selenium (µg/L)	Sodium (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
Site Background[a]	4.2	43,500	0.1	29.8	46
MW-7	5.1	26,600	1.7	259	267
MW-8	ND	14,700	ND	ND	135
MW-9	ND	31,200	ND	ND	49.4
MW-10	ND	31,000	ND	ND	228
MW-11	ND	24,300	ND	ND	107
MW-12	ND	8,950	ND	ND	ND
MW-76	ND	25,500	ND	ND	ND
MW-76 Round 2	ND	11,700	ND	ND	ND
MW-77	2.1	22,100	ND	ND	ND
MW-77 Round 2	ND	20,800	ND	ND	ND
MW-78	4.2	22,400	ND	ND	ND
MW-78 Round 2	ND	24,600	ND	16.9	20.0
MW-79	3.5	20,700	ND	ND	ND
MW-79 Round 2	ND	17,800	ND	ND	ND
MW-80	3	12,400	ND	ND	ND
MW-80 Round 2	3.0	14,400	ND	ND	ND

ND Not detected.

[a] Site background concentrations are from samples MW-52 through MW-54, and MW-63, which were sampled in two rounds.

[b] Round 2 sampling was conducted in March, 1996.

Table 2-2 (Continued)

Organics Detected In Groundwater Samples Collected In AREE 1

Sample ID RBC[a]	2-Methyl naphthalene (µg/L)	Acenaphthene (µg/L)	Acenaphthylene (µg/L)	Acetone (µg/L)	Anthracene (µg/L)	Alpha, BHC (µg/L)
	110[b]	220	110[b]	370	1,100	0.011
MW-7	ND	ND	17.3	ND	ND	ND
MW-8	ND	ND	ND	ND	ND	ND
MW-9	ND	ND	ND	ND	ND	ND
MW-10	ND	ND	ND	ND	ND	ND
MW-11	ND	ND	ND	ND	ND	ND
MW-12	ND	ND	ND	23	ND	ND
MW-76	ND	ND	ND	ND	ND	ND
MW-76 Round 2	ND	ND	ND	ND	ND	0.008
MW-77	6.2	6.34	ND	ND	ND	ND
MW-77 Round 2	ND	ND	ND	ND	ND	ND
MW-78	ND	ND	ND	ND	ND	0.006
MW-78 Round 2	ND	ND	ND	11	ND	ND
MW-79	ND	ND	ND	ND	0.595	0.006
MW-79 Round 2	ND	ND	ND	ND	ND	0.008
MW-80	ND	ND	ND	ND	ND	ND
MW-80 Round 2	ND	ND	ND	ND	ND	0.008

Table 2-2 (Continued)

Organics Detected In Groundwater Samples Collected In AREE 1

Sample ID RBC[a]	BHC,G(Lindane) (µg/L)	Bis(2-ethylhexyl) phthalate (µg/L)	Chrysene (µg/L)	Delta BHC (µg/L)	Endosulfan sulfate (µg/L)	Fluoranthene (µg/L)
	0.052	4.8	9.2	NA	22[c]	150
MW-7	ND	ND	ND	ND	ND	0.032
MW-8	ND	ND	ND	ND	0.044	ND
MW-8 Round 2	ND	NS	NS	ND	NS	NS
MW-9	ND	2.6	ND	ND	ND	ND
MW-9 Round 2	ND	NS	NS	ND	NS	NS
MW-10	ND	4.2	ND	ND	ND	ND
MW-11	ND	5.2	ND	ND	ND	ND
MW-11 Round 2	ND	NS	NS	ND	NS	NS
MW-12	ND	ND	ND	ND	ND	ND
MW-76	ND	ND	ND	ND	ND	ND
MW-76 Round 2	0.007	ND	ND	0.007	ND	ND
MW-77	ND	6.9	0.188	ND	ND	0.037
MW-77 Round 2	ND	5.3	ND	ND	ND	ND
MW-78	ND	ND	ND	ND	ND	0.024
MW-78 Round 2	ND	ND	ND	ND	ND	ND
MW-79	ND	2.5	ND	ND	ND	0.025
MW-79 Round 2	ND	ND	ND	ND	ND	ND
MW-80	ND	2.2	ND	ND	ND	ND
MW-80 Round 2	ND	ND	ND	ND	0.018	ND

ND Not detected.
NA Not available.
-- No value available.
[a] The groundwater and surface water RBC values are from USEPA Region III Tap Water RBCs (USEPA 1996$_a$). RBCs for non-carcinogenic chemicals are based on a hazard quotient of 1.0, following USEPA Region III guidance.
[b] The RBC for pyrene was used as a surrogate for non-carcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.
[c] The RBC for endosulfan was used.

Table 2-2 (Continued)

Inorganics Detected In Sediment Samples Collected In AREE 1

Sample ID	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)
Site Background[3]	15,200	175	1.26	6,000	30.1	20.7	41.8
RISD14	1,360	ND	ND	246	9.4	2.73	3.11
RISD15	1,900	ND	ND	436	10.3	4.28	4.1
RISD16	3,340	ND	0.459	1,160	10.9	6.21	9.81
RISD17	2,490	ND	0.316	585	10.7	5.98	5.21
RISD18	1,870	ND	0.397	1,360	9.7	7.19	6.21
RISD19	964	ND	ND	214	5.2	7.28	4.65
RISD20	10,300	ND	ND	5,420	23	12	36.9
RISD21	6,700	ND	0.967	856	34.9	29.4	28.1

Sample ID	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)
Site Background[4]	34,200	42.2	3,740	1,690	30.0	2,120
RISD14	8,160	ND	256	125	2.78	181
RISD15	8,980	ND	563	525	4.68	243
RISD16	11,100	14.8	799	383	6.41	492
RISD17	10,200	11	835	388	6.59	372
RISD18	12,700	10.6	515	529	5.27	270
RISD19	6,530	ND	227	142	2.53	ND
RISD20	22,500	ND	2,910	895	22.2	1,140
RISD21	48,500	ND	1,750	585	20.4	565

Table 2-2 (Continued)

Inorganics Detected In Sediment Samples Collected In AREE 1

Sample ID	Silver (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	ND	1,710	52.5	157
RISD14	ND	365	21.4	20.1
RISD15	ND	364	22.3	29.5
RISD16	ND	519	19.3	42
RISD17	3.45	385	20.6	27.5
RISD18	ND	440	24.3	34.4
RISD19	ND	411	13.5	15.5
RISD20	ND	2,290	56.7	158
RISD21	ND	965	112	71.7

ND Not detected.

[a] Site background concentrations are from samples RISDBK1 through RISDBK5.

Table 2-2 (Continued)

Organics Detected In Sediment Samples Collected In AREE 1

Sample ID	2-Methyl-naphthalene (µg/g)	Acenaphthene (µg/g)	Acetone (µg/g)	Anthracene (µg/g)	Benzo(a) anthracene (µg/g)	Benzo(a)pyrene (µg/g)
RBC[a]	230[b]	470	780	2,300	0.88	0.088
RISD14	ND	ND	ND	ND	ND	0.001
RISD15	ND	ND	ND	ND	0.002	0.003
RISD16	ND	ND	ND	0.051	0.031	0.041
RISD17	ND	ND	ND	ND	0.002	ND
RISD18	1.93	7.15	0.03	0.041	0.075	0.027
RISD19	ND	ND	ND	ND	0.002	0.003
RISD20	ND	ND	ND	0.552	0.142	0.195
RISD21	ND	ND	ND	0.084	0.053	0.085

Sample ID	Benzo(b) fluoranthene (µg/g)	Benzo(g,h,i) perylene (µg/g)	Benzo(k) fluoranthene (µg/g)	Chrysene (µg/g)	DDD (µg/g)	DDE (µg/g)
RBC[a]	0.88	230[b]	8.8	88	2.7	1.9
RISD14	0.003	ND	0.0009	ND	ND	ND
RISD15	0.006	ND	0.002	ND	ND	ND
RISD16	0.055	0.059	0.024	ND	ND	ND
RISD17	0.004	ND	0.002	ND	ND	ND
RISD18	0.094	0.119	0.046	0.035	ND	ND
RISD19	0.004	ND	0.002	ND	0.017	0.009
RISD20	0.141	0.102	0.082	ND	ND	ND
RISD21	0.106	0.067	0.044	ND	ND	ND

Table 2-2 (Continued)

Organics Detected In Sediment Samples Collected In AREE 1

Sample ID / RBC[a]	DDT (µg/g)	Dibenzo(a,h) anthracene (µg/g)	Fluoranthene (µg/g)	Indeno(1,2,3-cd)pyrene (µg/g)	PCB-1260 (µg/g)	Phenanthrene (µg/g)	Pyrene (µg/g)
	1.9	0.088	310	0.88	0.083[c]	230[b]	230
RISD14	ND	ND	0.002	ND	ND	ND	ND
RISD15	ND	ND	0.004	ND	ND	ND	0.01
RISD16	ND	0.015	0.061	0.027	ND	ND	0.062
RISD17	ND	ND	0.005	ND	ND	ND	ND
RISD18	ND	0.012	0.131	0.056	ND	0.045	0.059
RISD19	0.018	ND	0.004	ND	ND	ND	0.009
RISD20	ND	ND	0.259	0.094	0.084	ND	0.419
RISD21	ND	ND	0.14	0.046	ND	ND	0.28

ND Not detected.

[a] Sediment RBC values are from USEPA Region III Residential Soil RBCs. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

[b] The RBC for pyrene was used as a surrogate for non-carcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.

[c] Value is for carcinogenic PCBs.

Table 2-2 (Continued)

Inorganics Detected in Surface Water Samples Collected in AREE 1

SampleID	Aluminum (µg/L)	Barium (µg/L)	Calcium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)
Site Background[a]	1,930	41.8	22,200	10.8	ND	2,510
RISW14	1,040	31.8	15,500	ND	ND	1,460
RISW15	953	31.7	15,500	ND	ND	1,400
RISW16	1,100	30.9	15,100	11.1	ND	1,420
RISW17	1,040	31.3	15,400	ND	ND	1,380
RISW18	927	31.5	15,500	ND	ND	1,310
RISW19	5,070	69.9	20,200	ND	17.6	6,900
RISW20	1,620	43	18,700	ND	ND	2,480
RISW21	3,170	55.2	18,900	ND	6.9	4,510

Sample ID	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Potassium (µg/L)	Sodium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
Site Background[a]	1.9	7,500	303	3,670	16,500	ND	ND
RISW14	1.5	5,050	238	3,400	11,800	ND	29.9
RISW15	1.5	5,050	148	3,670	11,300	ND	24.1
RISW16	1.6	4,930	159	3,720	11,100	ND	22.2
RISW17	1.4	5,050	204	3,460	11,500	ND	20.9
RISW18	1.5	5,020	136	3,780	11,400	ND	20.6
RISW19	8.4	6,970	373	5,070	14,700	13.1	40.1
RISW20	3.5	6,120	103	4,110	14,400	ND	25.8
RISW21	5.3	6,340	210	4,360	13,500	ND	29.2

ND Not detected.

[a] Site background concentrations are from samples RISWBK1 through RISWBK5.

Table 2-2 (Continued)

Inorganics Detected In Surface Water Runoff Samples Collected In AREE 1

Sample ID	Aluminum (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Calcium (µg/L)	Chromium (µg/L)
SWR01	6,480	2.2	49.8	ND	58,300	10.0
SWR01DUP	8,880	1.3	47.8	ND	33,300	11.4
SWR02	34,600	4.4	122	0.2	27,700	43.8
SWR03	43,300	5.6	139	0.3	21,800	53.0
SWR04	35,700	3.4	171	0.3	15,300	60.9

Sample ID	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Mercury (µg/L)	Nickel (µg/L)
SWR01	ND	9,980	5.5	10,600	555	ND	ND
SWR01DUP	5.5	12,600	8.7	6,600	207	ND	ND
SWR02	28.0	45,200	70.2	8,400	344	0.23	25.8
SWR03	28.4	48,500	47.2	9,460	603	0.23	22.6
SWR04	33.3	57,800	42.5	8,860	498	ND	29.0

Sample ID	Potassium (µg/L)	Sodium (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
SWR01	2,660	7,740	ND	16.4	34.0
SWR01DUP	2,300	5,430	0.2	25	45.6
SWR02	6,880	5,680	0.3	87.4	164
SWR03	8,500	5,930	0.4	92.8	177
SWR04	7,950	3,260	0.3	106	197

ND Not detected.

Table 2-2 (Continued)

Organics Detected In Surface Water Runoff Samples Collected in AREE 1

Sample ID	Anthracene (µg/L)	Benzo(a)pyrene (µg/L)	Benzoic Acid (µg/L)	Fluoranthene (µg/L)	PCB-1260 (µg/L)	Pyrene (µg/L)
SWR01	ND	ND	5.2	ND	ND	ND
SWR02	1.35	0.014	ND	0.053	0.486	0.129
SWR03	2.73	0.016	ND	0.050	4.40	0.237
SWR04	0.923	ND	ND	ND	0.224	0.151

ND Not detected.

Table 2-2 (Continued)

Compounds Detected in Site Wide Fish Tissue Samples in AREE 1

Sample ID	Location	Alpha Chlordane (µg/g)	DDD (µg/g)	DDE (µg/g)	Gamma Chlordane (µg/g)
RBC		0.0024	0.013	0.0093	0.0024
S.FISH-1W	Marumsco	ND	ND	15.9	ND
S.FISH-2W	Marumsco	ND	ND	14.5	ND
S.FISH-3W	Marumsco	ND	ND	14	ND
S.FISH-4W	Marumsco	ND	ND	30.2	ND
S.FISH-5W	Marumsco	ND	ND	ND	ND
WPERCH-1W	Marumsco	14.7	ND	34.9	ND
WPERCH-2W	Marumsco	13.2	30.9	30.9	ND
WPERCH-3W	Marumsco	12.3	ND	28.6	ND
WPERCH-4W	Marumsco	16.3	ND	38.3	ND
WPERCH-5W	Marumsco	12	ND	29.1	ND

Sample ID	Location	Heptachlor (µg/g)	Mercury (µg/g)	PCB-1260 (µg/g)
RBC[a]		0.007	0.41	0.00041
S.FISH-1W	Marumsco	ND	ND	126
S.FISH-2W	Marumsco	1.42	ND	105
S.FISH-3W	Marumsco	ND	ND	97.6
S.FISH-4W	Marumsco	ND	ND	110
S.FISH-5W	Marumsco	ND	ND	115
WPERCH-1W	Marumsco	ND	0.05	267
WPERCH-2W	Marumsco	ND	0.026	227
WPERCH-3W	Marumsco	ND	0.025	234
WPERCH-4W	Marumsco	ND	0.039	277
WPERCH-5W	Marumsco	ND	0.029	221

ND Not Detected.

[a] The maximum detected concentrations of organic and inorganic compounds were compared to USEPA Region III residential RBCs, in accordance with Region III guidance (USEPA, 1996a). The RBCs are health-protective chemical concentrations that are back-calculated using toxicity criteria, a $1x10^{-6}$ target risk level or a 0.1 hazard index, and conservative exposure parameters.

Table 2-3

Summary of RI Results for AREEs 2 and 5 - Former Dump Nos. 2 and 5

Media Sampled[a]	Number of Samples Collected	Compounds/Analytes Detected above LOC[b]	Summary of Fate & Transport
Surface Soil	5	Al, Ba, Be, Cu, Pb, Mn, K, Na	Infiltration/percolation through soil to groundwater
Subsurface Soil (0- to 2-feet bgs)	7	Al, As, Ba, Be, Ca, Cr, Co, Pb, Mn, Hg, K, Se, V	
Subsurface Soil (2-ft bgs to Water Table)	19	Sb, Ca, Mn, K, Ag, V PCB-1248, PCB-1254	
Test Pits	4	Al, Ba, Be, Ca, Cr, Co, Cu, Fe, Pb, Mn, K, Na, Zn	
Groundwater[c]	Round 1 - 15 Round 2 - 9	Cr, Fe, Pb, Mg, Mn, Ni, Se, Tl, Zn Aldrin, gamma-BHC, heptachlor epoxide	Discharge to surface water
Sediment	3	Na, V	Stormwater runoff to surface water/sediment
Surface Water	3	Al, Ba, Cu, Fe, Pb, K, V	Stormwater runoff to surface water/sediment
Surface Water Runoff	3	Anthracene, DDE, DDT, Fluoranthene, Pyrene	Stormwater runoff to surface water/sediment

[a] Surface soil and groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, PCTs, and TPH. Subsurface soil and test pit samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PCTs, and TPH.

[b] LOC - Level of Concern. Refers to either the WRF site background maximum concentrations for inorganics or Region III residential risk-based concentrations (RBCs) for organics.

[c] PCB 1016 was detected in MW81 during Round 2 sampling.

Table 2-3 (Continued)

Inorganics Detected in Surface Soil Samples Collected in AREEs 2 and 5

Sample ID	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg g)	Calcium (µg/g)	Chromium (µg g)	Cobalt (µg/g)
Site Background[a]	14,350	92.4	0.814	1,150	31.3	16.6
RISS5	13,100	55.6	0.874	312	20.6	6.96
RISS6	6,480	ND	0.451	346	7.58	ND
RISS7	15,200	80.2	1.02	517	17.8	11.4
RISS8	7,990	67.2	0.609	631	11.5	5.33
RISS9	9,810	117	1.33	1,080	13.4	16.3

Sample ID	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Nickel (µg/g)
Site Background[a]	12.6	28,100	22.4	2,610	875	11.9
RISS5	4.41	13,700	17.2	1,320	207	8.33
RISS6	4.73	7,790	21.3	523	45.6	4.18
RISS7	13.3	19,800	22.1	1,260	116	9.22
RISS8	7.79	11,000	24.8	658	195	6.53
RISS9	9.52	10,900	13.0	1,140	1,450	10.4

Sample ID	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	936	487	58.9	43.9
RISS5	608	465	35.2	29.8
RISS6	495	457	22.3	18.8
RISS7	1,130	551	45.3	43.1
RISS8	647	425	32.7	31.0
RISS9	751	497	21.0	37.7

[a] Site background concentrations are based on WRF maximum background concentrations in surface soil samples MW-52 through MW-54 and RISSBK1 through RISSBK5 .

ND Not detected.

Table 2-3 (Continued)

Organics Detected in Surface Soil Samples Collected in AREEs 2 and 5

Sample ID	Acenaphthene (µg/g)	Anthracene (µg/g)	Benzo(a)anthracene (µg/g)	Benzo(a)pyrene (µg/g)	Benzo(b) fluoranthene (µg/g)	Benzo(g,h,i)perylene (µg/g)
RBC[a]	470	2,300	0.88	0.088	0.88	230[b]
RISS5	ND	ND	ND	0.001	0.002	ND
RISS6	ND	0.040	0.004	0.006	0.011	0.011
RISS7	0.185	0.010	0.005	0.006	0.009	0.012
RISS8	ND	0.037	0.003	0.005	0.009	0.009
RISS9	ND	0.044	0.007	0.004	0.024	0.014

Sample ID	Benzo(k)fluoranthene (µg/g)	Bis(2-ethylhexyl)-phthalate (µg/g)	Chrysene (µg/g)	DDT (µg/g)	Fluoranthene (µg/g)	Indeno(1,2,3-cd)pyrene (µg/g)
RBC[a]	8.8	46	88	1.9	310	0.88
RISS5	0.001	0.870	ND	ND	0.004	ND
RISS6	0.005	ND	0.013	ND	0.022	0.009
RISS7	0.005	ND	ND	ND	0.018	0.008
RISS8	0.004	ND	ND	ND	0.012	0.007
RISS9	0.009	ND	0.022	0.009	0.025	0.009

Sample ID	Naphthalene (µg/g)	Phenanthrene (µg/g)	Pyrene (µg/g)
RBC[a]	310	230[b]	230
RISS5	ND	0.060	ND
RISS6	1.27	0.474	ND
RISS7	4.97	0.187	ND
RISS8	ND	1.39	ND
RISS9	ND	ND	0.051

ND Not detected.

[a] The maximum detected concentrations of organic and inorganic compounds were compared to USEPA Region III residential RBCs, inaccordance with Region III guidance (USEPA, 1996a). The RBCs are health-protective chemical concentrations tht are back-clculated using toxicity criteria, a $1x10^{-6}$ target risk level or a 0.1 hazard index, conservative exposure parameters.

[b] The RBC for pyrene was used as a surrogate for non-carcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.

Table 2-3 (Continued)

Inorganics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREEs 2 and 5

Sample ID	Aluminum (µg/g)	Arsenic (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
Site Background[a]	16,200	ND	73.4	1.02	454	25.0
MW-68	13,400	ND	71.6	0.99	285	23.3
MW-70	21,100	ND	62.1	0.80	182	29.5
MW-71	9,430	ND	ND	0.64	522	30.6
MW-71DUP	9,940	ND	62.4	1.26	575	15.1
MW-74	10,500	ND	43.9	0.46	227	14.1
MW-81	8,980	ND	77.4	0.56	4,170	17.8
RISB6	9,660	ND	ND	0.69	209	12.7

Sample ID	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Mercury (µg/g)
Site Background[a]	13.9	16.9	27,800	11.8	3,700	617	—
MW-68	20.0	7.46	26,700	14.6	1,300	858	ND
MW-70	10.2	11.4	25,300	11.1	2,100	148	ND
MW-71	8.77	14.0	16,400	ND	1,830	247	ND
MW-71DUP	37.5	8.08	17,900	11.5	1,310	684	ND
MW-74	4.24	6.74	11,400	23.6	775	48.2	ND
MW-81	12.8	8.35	13,500	22.4	891	1,100	ND
RISB6	4.25	9.72	14,600	24.3	693	57.7	ND

Table 2-3 (Continued)

Inorganics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREEs 2 and 5

Sample ID	Nickel (µg/g)	Potassium (µg/g)	Selenium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	17.9	624	----	933	25.8	46.3
MW-68	6.52	412	15.3	429	50.3	26.0
MW-70	11.8	665	ND	365	54.8	41.9
MW-71	11.6	503	ND	585	37.6	34.5
MW-71DUP	6.37	589	ND	494	31.5	23.0
MW-74	5.40	569	ND	441	25.0	25.4
MW-81	8.62	478	ND	320	28.8	32.3
RISB6	4.95	519	ND	489	29.6	32.6

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for subsurface soil samples.

Table 2-3 (Continued)

Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREEs 2 and 5

Sample ID / Site Background[a]	Depth bgs (ft)	Aluminum (µg/g)	Antimony (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
		18,200	ND	73.8	1.02	454	25.0
MW-68	10	6,610	ND	ND	0.40	266	10.5
	20	1,850	ND	ND	0.40	392	4.50
MW-70	5	11,100	ND	ND	0.44	ND	18.8
	10	4,020	ND	ND	ND	ND	6.19
MW-71	5	14,700	0.40	ND	0.84	265	18.6
	10	4,580	ND	68.9	0.72	1,260	8.22
MW-72	5	10,100	ND	ND	0.30	154	16.6
	10	5,650	ND	ND	ND	637	7.56
	15	815	ND	ND	ND	128	1.68
MW-73	5	9,360	ND	ND	0.43	479	15.9
	10	4,830	ND	54.8	0.80	871	7.46
	15	6,880	ND	ND	0.38	634	13.3
MW-74	5	7,780	ND	ND	0.38	ND	15.4
	15	2,610	ND	ND	0.36	370	4.53
MW-74DUP	15	4,760	ND	ND	0.37	531	5.14
MW-81	5	12,100	ND	47.7	0.44	7,520	20.1
	10	11,400	ND	64.4	0.81	2,700	19.2
RISB6	5	7,640	ND	54.9	0.47	298	13.9
	15	7,480	ND	73	0.53	934	6.55

Table 2-3 (Continued)

Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREEs 2 and 5

Sample ID / Site Background[a]	Depth bgs (ft)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)
		13.9	16.9	27,800	11.8	3,700	617
MW-68	10	3.39	6.26	10,900	ND	1,410	62.8
	20	ND	5.41	17,900	ND	281	53.3
MW-70	5	4.84	8.08	12,300	ND	2,090	56.0
	10	4.91	2.67	4,480	ND	519	131
MW-71	5	9.71	11.40	19,100	ND	1,730	412
	10	ND	13.20	3,240	ND	884	10.9
MW-72	5	2.58	8.96	7,630	ND	1,660	49.7
	10	ND	6.05	5,110	ND	712	9.40
	15	ND	1.36	3,330	ND	121	18.7
MW-73	5	3.29	7.92	10,100	10.2	1,200	69.9
	10	3.68	8.75	8,550	ND	823	8.54
	15	ND	7.01	17,800	ND	854	57.0
MW-74	5	2.44	9.21	4,370	9.02	943	23.0
	15	ND	3.87	5,040	ND	415	12.8
MW-74DUP	15	3.01	4.33	3,440	ND	665	25.6
MW-81	5	6.08	10	14,000	ND	2,690	151
	10	11	9.15	17,100	17	1,180	622
RISB6	5	4.37	9.38	6,560	10.6	821	19.5
	15	6.43	12.7	6,770	ND	1,260	98.2

Table 2-3 (Continued)

Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREEs 2 and 5

Sample ID / Site Background[a]	Depth bgs (ft)	Nickel (µg/g)	Potassium (µg/g)	Silver (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
		17.9	624	ND	933	25.8	46.3
MW-68	10	4.57	278	ND	345	26.1	16.4
	20	ND	188	ND	346	7.30	ND
MW-70	5	6.17	359	2.08	383	36.8	21.3
	10	ND	163	ND	249	10.5	6.71
MW-71	5	8.52	576	ND	484	37.5	26.7
	10	4.34	336	ND	407	18.5	13.0
MW-72	5	8.12	343	ND	357	27.9	27.2
	10	3.09	182	ND	350	11.6	8.70
	15	ND	ND	ND	244	5.88	ND
MW-73	5	5.50	381	ND	413	34.0	27.1
	10	5.72	216	ND	456	16.9	26.4
	15	4.10	460	ND	541	24.2	23.7
MW-74	5	4.20	264	ND	344	17.8	14.6
	15	2.80	164	ND	432	10.8	8.70
MW-74DUP	15	3.79	428	ND	472	13.0	17
MW-81	5	8.15	460	ND	431	35.8	24.6
	10	8.25	778	ND	332	32.6	37.7
RISB6	5	4.39	430	ND	557	26.9	16.4
	15	5.64	567	ND	535	14.2	24.1

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for subsurface soil samples.

Table 2-3 (Continued)

Organics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREEs 2 and 5

Sample ID	Bis(2-ethylhexyl)-phthalate (µg/g)	DDT (µg/g)	Di-n-butylphthalate (µg/g)	Endosulfan Sulfate (µg/g)	Methoxychlor (µg/g)
RBC[a]	46	1.9	780	47[c]	39
MW-68	ND	ND	ND	ND	ND
MW-70	0.63	ND	4.10	ND	ND
MW-71	0.24	0.01	ND	ND	ND
MW-71DUP	0.38	ND	ND	ND	ND
MW-74	ND	ND	ND	ND	ND
MW-81	ND	ND	ND	ND	ND
RISB6	0.21	ND	ND	ND	ND

Sample ID	PCB-1248 (µg/g)	PCB-1254 (µg/g)	TPH, as Diesel (µg/g)	TPH, as Gas (µg/g)
RBC[a]	0.083[b]	0.16	---	---
MW-68	ND	ND	ND	ND
MW-70	ND	ND	ND	ND
MW-71	ND	ND	ND	ND
MW-71DUP	ND	ND	ND	ND
MW-74	ND	ND	27.9	9.88
MW-81	0.22	1.00	ND	ND
RISB6	ND	ND	ND	ND

ND Not detected

[a] The soil RBC values are from the USEPA Region III Residential RBCs (USEPA, 1996a). RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

[b] Value is for carcinogenic PCBs.

[c] RBC for endosulfan was used.

Table 2-3 (Continued)

Organics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREEs 2 and 5

Sample ID	Depth bgs (ft)	Acetone (µg/g)	Benzoic Acid (µg/g)	Bis(2-ethyl-hexyl) phthalate (µg/g)	Di-n-butyl Phthalate (µg/g)	Endosulfan Sulfate (µg/g)	Methylene Chloride (µg/g)	PCB-1248 (µg/g)	PCB-1254 (µg/g)
RBC[a]		780	31,000	46	780	47[b]	85	0.083[c]	0.16
MW-68	10	ND	ND	0.40	ND		ND	ND	ND
	20	0.01	ND	ND	ND	ND	ND	ND	ND
MW-70	5	ND	ND	0.54	3.90	ND	ND	ND	ND
	10	0.01	ND	0.49	3.60	ND	ND	ND	ND
MW-71	5	ND	ND	0.19	ND	ND	ND	ND	ND
	10	ND	ND	ND	ND	ND	ND	ND	ND
MW-72	5	ND	ND	0.81	3.70	ND	ND	ND	ND
	10	ND	ND	1.10	4.30	ND	ND	ND	ND
	15	0.02	ND	1.00	3.50	ND	0.01	ND	ND
MW-73	5	ND	ND	0.21	ND	ND	ND	ND	ND
	10	ND	ND	0.22	ND	ND	ND	ND	ND
	15	ND	ND	0.74	ND	ND	ND	ND	ND
MW-74	5	ND	ND	ND	ND	ND	ND	ND	ND
	15	ND	ND	ND	ND	ND	ND	ND	ND
MW-74	15	ND	0.68	ND	ND	ND	ND	ND	ND
MW-81	5	0.02	ND	ND	ND	ND	ND	ND	ND
	10	ND	ND	ND	ND	ND	ND	0.36	0.16
RISB6	5	ND	ND	0.23	ND	ND	ND	ND	ND
	15	ND	ND	0.23	ND	ND	ND	ND	ND

ND Not detected.

[a] The maximum detected concentrations of organic and inorganic compounds were compared to USEPA Region III residential RBCs, in accordance with Region III guidance (USEPA, 1996a). The RBCs are health-protective chemical concentrations that are back-calculated using toxicity criteria, a $1x10^{-6}$ target risk level or a 0.1 hazard index, and conservative exposure parameters.

[b] The RBC for endosulfan was used.

[c] Value is for carcinogenic PCBs.

-- No value available.

Table 2-3 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREEs 2 and 5

Sample ID / Site Background[a]	Depth bgs (ft)	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
		18,200	73.6	1.02	454	25.0
TP-3A	9.4	15,000	ND	0.963	200	14.2
TP-3B	7	20,700	53.3	0.609	436	26.1
TP-4A	6	15,800	375	2.44	8,820	24.4
TP-4B	4	9,480	66.6	1.08	535	22.8

Sample ID / Site Background[a]	Depth bgs (ft)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)
		13.9	16.9	27,800	11.8	3,700
TP-3A	9.4	6.82	6.36	14,300	ND	1,150
TP-3B	7	6.79	10.4	16,700	12.5	2,340
TP-4A	6	23.2	47.0	40,400	113	1,960
TP-4B	4	7.40	13.0	18,000	18.9	1,250

Sample ID	Depth bgs (ft)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]		617	17.9	624	933	25.8	46.3
TP-3A	9.4	134	7.59	583	413	27.7	30.3
TP-3B	7	143	9.04	846	465	46.1	42.5
TP-4A	6	3,270	16.8	1,230	1,190	44.3	416
TP-4B	4	211	9.41	892	453	49.4	66.2

ND Not detected.

[a] Site background concentrations are based on WRF maximum background concentrations for samples MW-52 through MW-54, each at two depths.

Table 2-3 (Continued)

Organics Detected in Test Pit Samples Collected in AREES 2 and 5

Sample ID	Depth bgs (ft)	Methylene Chloride (µg/g)
RBC[a]		85
TP-3A	9.4	ND
TP-3B	7	0.010
TP-4A	6	0.03
TP-4B	4	0.01

ND Not detected.

[a] USEPA Region III residential risk-based concentration (RBC) values.

Table 2-3 (Continued)

Inorganics Detected in Groundwater Samples Collected in AREEs 2 and 5

Sample ID	Aluminum (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Calcium (µg/L)	Chromium (µg/L)
Site Background[a]	12,500	6.70	107	0.8	42,200	22.3
MW-1	130	ND	ND	ND	790	ND
MW-2	63.2	ND	38.4	ND	10,600	ND
MW-3	ND	ND	30.1	ND	16,900	ND
MW-4	5,950	ND	52.9	0.1	2,470	23.5
MW-5	150	1.7	58.5	0.1	8,050	ND
MW-68	101	ND	ND	0.2	1,120	ND
MW-68 Round 2	132	ND	ND	ND	888	ND
MW-70	156	ND	32.8	ND	2,530	ND
MW-70 Round 2	263	ND	ND	ND	1,620	ND
MW-71	ND	ND	31.3	ND	2,530	ND
MW-71 Round 2	161	ND	31.9	ND	2,460	ND
MW-71DUP	ND	ND	30.1	ND	2,460	ND
MW-72	51.6	ND	33.1	ND	2,640	ND
MW-72 Round 2	174	ND	25.0	ND	1,680	ND
MW-73	72.8	ND	31.1	ND	2,850	ND
MW-73 Round 2	232	ND	29.9	ND	3,480	ND
MW-74	ND	ND	52.4	ND	5,180	ND
MW-74 Round 2	188	ND	ND	ND	942	ND
MW-81	416	ND	51.3	ND	20,700	ND
MW-81 Round 2	284	1.7	58.3	ND	26,600	ND
MW-82	242	ND	86.3	ND	12,300	ND
MW-82 Round 2	165	ND	80.3	ND	11,900	ND
MW-83	494	ND	ND	ND	2,690	ND
MW-83 Round 2	1,910	ND	ND	ND	1,590	ND

Table 2-3 (Continued)

Inorganics Detected in Groundwater Samples Collected in AREEs 2 and 5

Sample ID	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)
Site Background[a]	8.9	9,620	6.3	7,720	354	18.4
MW-1	ND	127	15.9	706	ND	ND
MW-2	ND	45.9	ND	5,700	388	ND
MW-3	ND	829	ND	5,880	203	ND
MW-4	8.3	4,290	25.7	2,470	104	28.1
MW-5	ND	14,600	15.5	4,640	74.5	ND
MW-68	ND	75.8	ND	837	32.1	ND
MW-68 Round 2	ND	98.3	3.3	677	14.4	ND
MW-70	ND	157	ND	2,890	153	ND
MW-70 Round 2	ND	188	1.2	2,230	95.6	ND
MW-71	ND	ND	ND	2,160	46.3	ND
MW-71 Round 2	ND	126	2.9	2,390	45.5	ND
MW-71DUP	ND	ND	ND	2,140	44.5	ND
MW-72	ND	144	6.6	1,790	70.1	ND
MW-72 Round 2	ND	136	1.9	1,580	34.6	ND
MW-73	ND	1,310	ND	1,380	80.1	ND
MW-73 Round 2	ND	558	1.6	1,570	64.2	ND
MW-74	ND	3,290	ND	2,650	115	ND
MW-74 Round 2	ND	309	1.4	559	40.4	ND
MW-81	ND	2,720	ND	3,960	353	ND
MW-81 Round 2	ND	2,990	ND	3,730	324	18.8
MW-82	ND	12,500	ND	6,440	547	ND
MW-82 Round 2	ND	9,520	ND	5,890	491	ND
MW-83	ND	3,750	ND	845	225	ND
MW-83 Round 2	5.7	4,470	1.4	801	275	ND

Table 2-3 (Continued)

Inorganics Detected in Groundwater Samples Collected in AREEs 2 and 5

Sample ID	Potassium (µg/L)	Selenium (µg/L)	Sodium (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
Site Background[a]	20,600	4.2	43,500	0.1	29.8	46
MW-1	ND	ND	8,530	ND	ND	51
MW-2	1,100	ND	3,390	ND	ND	ND
MW-3	1,310	ND	4,640	ND	ND	ND
MW-4	1,260	ND	5,610	0.1	10.7	85.4
MW-5	1,890	ND	26,400	ND	ND	ND
MW-68	ND	ND	8,710	ND	ND	ND
MW-68 Round 2	607	ND	9,120	ND	ND	26.3
MW-70	ND	2.5	17,600	ND	ND	23.9
MW-70 Round 2	588	ND	9,680	ND	ND	40.0
MW-71	714	ND	5,350	ND	ND	ND
MW-71 Round 2	971	ND	4,730	ND	ND	ND
MW-71DUP	648	ND	5,170	ND	ND	ND
MW-72	ND	ND	7,380	ND	ND	24.4
MW-72 Round 2	614	ND	5,710	ND	ND	33.6
MW-73	1,040	ND	5,550	ND	ND	21.7
MW-73 Round 2	1,530	ND	5,440	ND	ND	ND
MW-74	868	3.1	25,600	ND	ND	25.9
MW-74 Round 2	966	ND	18,200	ND	ND	ND
MW-81	3,740	2.5	5,910	ND	ND	ND
MW-81 Round 2	7,520	2.6	6,580	ND	ND	ND
MW-82	3,230	ND	34,300	ND	ND	ND
MW-82 Round 2	2,890	2.5	27,700	ND	ND	22.8
MW-83	1,290	ND	3,360	ND	ND	ND
MW-83 Round 2	1,430	ND	3,230	ND	ND	ND

ND Not detected.
[a] Site background concentrations are based on WRF maximum background concentrations for groundwater.
[b] Round 2 sampling was conducted in March, 1996.

Table 2-3 (Continued)

Organics Detected in Groundwater Samples Collected in AREEs 2 and 5

Sample ID	1-Methyl naphthalene (µg/L)	4-Methyl Phenol (µg/L)	Acenaphthylene (µg/L)	Aldrin (µg/L)	Anthracene (µg/L)	Benzoic Acid (µg/L)	Alpha BHC (µg/L)
RBC*	110	18	110	0.004	1,100	15,000	–
MW-1	ND	ND	ND	ND	ND	ND	ND
MW-2	ND	ND	ND	ND	ND	ND	ND
MW-3	ND	ND	ND	ND	ND	ND	ND
MW-4	ND	ND	ND	ND	ND	ND	ND
MW-5	ND	ND	ND	ND	ND	ND	ND
MW-68	ND	ND	ND	ND	ND	ND	ND
MW-68 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-70	ND	ND	ND	ND	0.177	ND	ND
MW-70 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-71	ND	ND	ND	ND	ND	ND	ND
MW-71 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-71DUP	ND	ND	ND	ND	ND	ND	0.006
MW-72	ND	ND	ND	ND	ND	ND	ND
MW-72 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-73	ND	ND	ND	ND	0.203	ND	ND
MW-73 Round 2	ND	ND	ND	ND	ND	ND	0.008
MW-74	ND	ND	ND	ND	ND	ND	ND
MW-74 Round 2	ND	ND	ND	0.010	ND	ND	0.008
MW-81	ND	3.6	ND	ND	2.91	7.3	ND
MW-81 Round 2	ND	11	ND	ND	ND	25	0.008
MW-82	3.38	ND	6.49	0.009	1.32	ND	ND
MW-82 Round 2	ND	ND	ND	ND	ND	ND	0.033
MW-83	ND	ND	ND	ND	ND	ND	ND
MW-83 Round 2	ND	ND	ND	ND	ND	ND	0.008

Note: PCB 1016 was detected in sample from MW81 during Round 2 sampling at a concentration of 2.93 µg/L.

Table 2-3 (Continued)

Organics Detected in Groundwater Samples Collected in AREEs 2 and 5

Sample ID	Gamma-BHC (Lindane) (µg/L)	Bis(2-ethyl hexyl) Phthalate (µg/L)	DDT (µg/L)	Dimethyl Phthalate (µg/L)	Endosulfan Sulfate (µg/L)	Endosulfan II (µg/L)	Endrin (µg/L)
RBC*	0.052	4.8	0.2	37,000	22	--	1.1
MW-1	ND	ND	ND	ND	ND	ND	ND
MW-2	ND	ND	ND	ND	ND	ND	ND
MW-3	ND	ND	ND	ND	ND	ND	ND
MW-4	ND	45	ND	ND	ND	ND	ND
MW-5	ND	6	ND	ND	ND	ND	ND
MW-68	ND	5.2	ND	ND	ND	ND	ND
MW-68 Round 2	0.007	3.5	ND	ND	ND	ND	ND
MW-70	ND	2.3	ND	ND	ND	ND	ND
MW-70 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-71	ND	46	ND	ND	ND	ND	ND
MW-71 Round 2	ND	4.9	ND	ND	ND	ND	ND
MW-71DUP	ND	19	ND	ND	ND	ND	ND
MW-72	ND	2.6	ND	ND	ND	ND	ND
MW-72 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-73	ND	2	ND	ND	0.016	ND	ND
MW-73 Round 2	ND	ND	ND	ND	0.016	ND	ND
MW-74	ND	6.6	ND	ND	ND	ND	ND
MW-74 Round 2	ND	ND	ND	ND	ND	ND	0.012
MW-81	ND	29	ND	ND	ND	ND	ND
MW-81 Round 2	ND	2.5	ND	ND	ND	ND	ND
MW-82	0.214	13	0.051	5.3	0.033	0.031	0.022
MW-82 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-83	ND	13	ND	ND	ND	ND	ND
MW-83 Round 2	ND	2.1	ND	ND	ND	ND	ND

Table 2-3 (Continued)

Organics Detected in Groundwater Samples Collected in AREEs 2 and 5

Sample ID	Fluoranthene (µg/L)	Gamma Chlordane (µg/L)	Heptachlor Epoxide (µg/L)	Methoxychlor (µg/L)	Phenanthrene (µg/L)	Phenol (µg/L)	Pyrene (µg/L)
RBC[a]	150	0.052	0.0012	18	110[b]	2,200	110
MW-1	ND	ND	ND	ND	ND	ND	ND
MW-2	ND	ND	ND	ND	ND	ND	ND
MW-3	ND	ND	ND	ND	ND	ND	ND
MW-4	ND	ND	ND	ND	ND	ND	ND
MW-5	ND	ND	ND	ND	ND	ND	ND
MW-68	ND	ND	ND	ND	ND	ND	ND
MW-68 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-70	ND	ND	ND	ND	ND	ND	ND
MW-70 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-71	ND	ND	ND	ND	ND	ND	ND
MW-71 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-71DUP	ND	ND	ND	ND	ND	ND	ND
MW-72	ND	ND	ND	ND	ND	ND	ND
MW-72 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-73	0.023	ND	ND	ND	ND	ND	ND
MW-73 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-74	ND	ND	ND	ND	ND	ND	ND
MW-74 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-81	0.041	ND	ND	ND	2.77	5.9	ND
MW-81 Round 2	ND	ND	ND	ND	ND	14	ND
MW-82	0.052	0.012	0.035	ND	4.03	ND	0.551
MW-82 Round 2	ND	ND	ND	ND	ND	ND	ND
MW-83	ND	ND	ND	0.012	ND	ND	ND
MW-83 Round 2	ND	ND	ND	ND	ND	ND	ND

ND Not detected.
[a] Groundwater RBC values are from USEPA Region III Tap Water RBCs. RBCs for noncarcinogenic chemicals are based on hazard quotient of 0.1, following USEPA Region III guidance.
[b] The RBC for pyrene was used as a surrogate for non-carcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.
– No value available.

Table 2-3 (Continued)

Inorganics Detected in Sediment Samples Collected from AREEs 2 and 5

Sample ID / Site Background[a]	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)
	16,900	175	1.38	6,000	33.7	21.4	44.4	36,500
RISD11	13,700	ND	ND	3,060	21.4	10.2	20.7	24,500
RISD12	13,200	ND	1.38	4,440	21.2	13.1	29.2	20,400
RISD13	14,700	ND	1.26	4,380	28.8	20.1	35.6	26,200

Sample ID / Site Background[a]	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
	42.2	3,740	1,690	30.3	2,120	1,710	54.1	168
RISD11	ND	2,140	284	15.4	1,060	2,650	47.6	85.5
RISD12	ND	2,460	287	19.1	969	2,450	60.9	100
RISD13	35.3	3,200	874	22.5	1,610	1,530	64.4	139

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for sediment samples.

Table 2-3 (Continued)

Organics Detected in Sediment Samples Collected from AREEs 2 and 5

Sample ID	1-Methylnaph-thalene (µg/g)	2-Methylnaph-thalene (µg/g)	Acenaphthene (µg/g)	Acenaph-thlyene (µg/g)	Acetone (µg/g)	Alpha-chlordane (µg/g)	Anthra-cene (µg/g)	Benzo(a) anthracene (µg/g)	Benzo(a) pyrene (µg/g)	Benzo(b) fluoranthene (µg/g)
RBC[a]	230[b]	230[b]	470	230[b]	780	0.49	2,300	0.88	0.088	0.88
RISD11	0.479	ND	0.867	ND	ND	ND	0.331	0.016	ND	ND
RISD12	2.41	ND	1.59	ND	ND	ND	0.979	0.026	0.198	0.132
RISD13	ND	ND	ND	ND	0.05	ND	0.102	0.024	0.036	0.07

Sample ID	Benzo(g,h,i) perylene (µg/g)	Benzo(k)fluor anthene (µg/g)	Benzoic Acid (µg/g)	Bis(2-ethyl hexyl)phthalate (µg/g)	Chrysene (µg/g)	Chlordane (µg/g)	DDD (µg/g)	DDE (µg/g)	Dibenzo(a,h)a nthracene (µg/g)	Diethyl phthalate (µg/g)
RBC[a]	230[b]	8.8	31,000	46	88	0.49	2.7	1.9	0.088	6,300
RISD11	0.162	ND	ND	ND	ND	ND	ND	ND	ND	ND
RISD12	ND	0.07	ND	ND	ND	ND	ND	ND	ND	ND
RISD13	ND	0.021	ND	ND	ND	ND	ND	ND	ND	ND

Sample ID	Fluoranthene (µg/g)	Fluorene (µg/g)	Gamma-chlordane (µg/g)	Indeno(1,2,3-cd)p yrene (µg/g)	Naphthalene (µg/g)	PCB-1260 (µg/g)	Phenanthrene (µg/g)	Pyrene (µg/g)	TPH, as Diesel (µg/g)
RBC[a]	310	310	0.049	0.88	310	0.083[c]	230[b]	230	--
RISD11	0.045	ND	ND	ND	1.11	ND	ND	0.103	35.6
RISD12	0.095	ND	ND	0.66	1.88	ND	ND	0.081	57.8
RISD13	0.07	0.151	ND	0.069	ND	ND	ND	0.159	ND

ND Not detected.

[a] Sediment RBC values are from USEPA Region III Residential Soil RBCs. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

[b] The RBC for pyrene was used as a surrogate for non-carcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.

[c] Value is for carcinogenic PCBs.

-- No value available.

Table 2-3 (Continued)

Inorganics Detected in Surface Water Samples Collected from AREEs 2 and 5

Sample ID	Aluminum (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Calcium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)
Site Background[a]	1,930	1.4	41.8	ND	22,200	10.8	ND	2,510	1.9
RISW11	1,800	ND	ND	ND	3,470	ND	ND	2,110	1.2
RISW12	2,100	ND	ND	ND	3,920	ND	ND	2,770	1.6
RISW13	3,460	ND	54.3	ND	183	ND	6.1	4,110	5.2

Sample ID	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)	Selenium (µg/L)	Sodium (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
Site Background[a]	7,500	303	ND	3,670	ND	16,500	ND	ND	ND
RISW11	1,840	56.1	ND	2,650	ND	2,480	ND	ND	ND
RISW12	2,070	91.2	ND	2,910	ND	3,320	ND	ND	ND
RISW13	6,310	183	ND	4,490	ND	13,800	ND	10.8	ND

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for surface water samples.

Table 2-3 (Continued)

Inorganics Detected In Surface Water Runoff Samples Collected In AREEs 2 and 5

Sample ID	Aluminum (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Calcium (µg/L)	Chromium (µg/L)
SWR010	2,570	1.2	86.3	0.1	7,020	ND
SWR011	30,200	2.9	178	0.6	6,880	40.9
SWR012	1,080	ND	72.1	ND	6,220	ND

Sample ID	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)
SWR010	ND	15,800	5.3	4,610	863	ND	1,250
SWR011	33.0	31,100	45.9	4,640	571	16.1	6,240
SWR012	ND	20,790	1.3	4,450	1,390	ND	1,920

Sample ID	Sodium (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
SWR010	9,720	ND	12.2	27.2
SWR011	1,460	0.4	82.5	723
SWR012	5,640	ND	ND	86.0

ND Not detected.

Table 2-3 (Continued)

Organics Detected In Surface Water Runoff Samples Collected In AREEs 2 and 5

Sample ID	Anthracene (µg/L)	DDE (µg/L)	DDT (µg/L)	Endosulfan Sulfate (µg/L)	Fluoranthene (µg/L)	Pyrene (µg/L)
SWR010	ND	ND	ND	0.105	0.023	ND
SWR011	0.161	0.012	0.018	ND	0.022	0.137
SWR012	ND	ND	ND	0.495	ND	ND

ND Not detected.

Table 2-4

Summary of RI Results for AREE 3 and 6A - Potential Dump Nos. 3 and 6A

Media Sampled[a]	Number of Samples Collected	Compounds/Analytes Detected above LOC[b]	Summary of Fate & Transport
Surface Soil	12	Al, As, Be, Cr, Cu, Na, Ni, K, Pb, Se	Infiltration/percolation through soil
Subsurface Soil (0-2 feet bgs)	1	As, Cr, Pb, k, PCB-1248, PCB-1254, V	Infiltration/percolation through soil
Subsurface Soil (2 ft. to water table)	2	None	Infiltration/percolation through soil
Test Pits	12	Al, Ba, Be, Ca, Cd, Cr, Co, Cu, Fe, Pb, Mg, Ni, K, Sb, V, Zn	Former potential dumping area's
Groundwater - Round 1 Groundwater - Round 2	1 1	Fe, Mg Fe, Mg	Discharge to surface water
Sediment	1	None	Stormwater runoff to surface water/sediments
Surface Water	1	None	Stormwater runoff to surface water/sediments
Surface Water Runoff	2	None	Stormwater runoff to surface water/sediments

[a] Surface soil, subsurface soil, test pit, and groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, and TAL metals. If PCBs were detected, the laboratory was instructed to analyze for PCTs. Surface soil and groundwater samples were also analyzed for PAHs.

[b] LOC - Level of Concern. Refers to either the WRF site background maximum concentrations for inorganics or USEPA Region III residential risk-based concentrations (RBCs) for organics.

Table 2-4 (Continued)

Inorganics Detected in Surface Soil Samples Collected in AREE 3 and 6A

Sample ID	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)
Site Background[a]	14,350	92.4	0.814	1,150	31.3	16.6
RISS10	15,500	ND	0.804	280	26.4	7.25
RISS11	6,630	ND	0.721	260	17.8	10.4
RISS11DUP	6,720	ND	0.520	288	17.4	12.8
RISS12	10,100	51.8	0.576	235	21.4	7.52
RISS17	12,700	ND	0.695	215	24.9	7.65
RISS18	13,600	ND	0.518	286	18.4	4.49
RISS19	9,970	ND	0.444	461	14.9	3.96
RISS20	12,500	ND	0.458	252	17.7	3.70
RISS21	12,200	ND	0.777	477	23.7	6.35
RISS21DUP	14,000	51.1	0.881	530	26.9	6.96
RISS22	16,300	ND	0.825	152	28.0	6.00
RISS23	13,800	ND	0.682	450	23.5	5.94

Sample ID	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Nickel (µg/g)
Site Background[a]	12.6	28,100	22.4	2,610	875	11.9
RISS10	12.7	20,000	9.54	2,250	100	11.4
RISS11	7.79	14,100	ND	1,320	67.2	9.36
RISS11DUP	7.69	11,700	ND	1,400	79.3	9.12
RISS12	9.31	13,600	ND	1,570	53.8	8.84
RISS17	5.45	22,100	19.7	999	227	6.36
RISS18	6.63	15,200	12.7	988	49.6	6.93
RISS19	8.60	12,700	17.9	909	49.5	6.67
RISS20	5.63	15,400	11.8	965	39.9	5.65
RISS21	16.4	18,800	13.9	2,130	55.8	10.3
RISS21DUP	17.9	21,200	14.7	2,300	67.7	12.0
RISS22	16.8	26,000	13.5	2,330	69.3	11.3
RISS23	12.5	19,000	12.5	1,640	65.5	9.21

Table 2-4 (Continued)

Inorganics Detected in Surface Soil Samples Collected in AREE 3 and 6A

Sample ID	Potassium (µg/g)	Selenium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	936	14.2	487	58.9	43.9
RISS10	1,020	ND	496	45.3	36.9
RISS11	533	ND	426	22.0	19.5
RISS11DUP	504	ND	426	21.9	21.1
RISS12	651	ND	487	31.7	24.1
RISS17	628	ND	446	43	28.6
RISS18	922	ND	482	31.4	29.1
RISS19	930	ND	421	29	27.9
RISS20	707	ND	455	33	25.9
RISS21	844	17.7	534	40.7	42.4
RISS21DUP	950	20	535	47.1	46.7
RISS22	1,080	24.5	544	53.2	40.6
RISS23	958	ND	500	38.3	37.2

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for surface soil samples MW-52 through MW-54 and RISSBK1 through RISSBK5.

Table 2-4 (Continued)

Organics Detected in Surface Soil Samples Collected in AREE 3 and 6A

Sample ID	Acenaphthene (µg/g)	Anthracene (µg/g)	Benzo(a)anthracene (µg/g)	Benzo(a)pyrene (µg/g)	Benzo(b)-fluoranthene (µg/g)
RBC[a]	470	2,300	0.88	0.088	0.88
RISS10	ND	ND	ND	ND	ND
RISS11	ND	0.012	ND	ND	ND
RISS11DUP	ND	0.017	ND	ND	ND
RISS12	ND	0.035	ND	ND	ND
RISS17	ND	0.039	0.003	0.004	0.006
RISS18	ND	0.032	0.002	0.003	0.008
RISS19	3.32	0.015	0.004	0.005	0.015
RISS20	ND	0.032	0.002	0.002	0.006
RISS21	ND	0.012	0.002	0.001	0.006
RISS21DUP	ND	ND	0.002	0.001	0.005
RISS22	ND	ND	ND	ND	ND
RISS23	ND	ND	ND	ND	0.004

Sample ID	Benzo(g,h,i)perylene (µg/g)	Benzo(k) fluoranthene (µg/g)	Bis(2-ethylhexyl)-phthalate (µg/g)	Fluoranthene (µg/g)	Indeno(1,2,3-cd)-pyrene (µg/g)	Methylene chloride (µg/g)
RBC[a]	230[b]	8.8	46	310	0.88	85
RISS10	ND	ND	ND	ND	ND	0.020
RISS11	ND	ND	8.20	ND	ND	0.010
RISS11DUP	ND	ND	0.970	ND	ND	0.010
RISS12	ND	ND	ND	ND	ND	ND
RISS17	ND	0.003	ND	0.015	ND	0.020
RISS18	ND	0.004	ND	0.012	0.005	0.020
RISS19	0.015	0.006	ND	0.011	0.012	ND
RISS20	ND	0.003	ND	0.024	ND	ND
RISS21	ND	0.003	ND	0.004	0.005	ND
RISS21DUP	ND	0.002	ND	0.004	ND	ND
RISS22	ND	ND	ND	ND	ND	ND
RISS23	ND	0.002	ND	0.005	ND	ND

Table 2-4 (Continued)

Organics Detected in Surface Soil Samples Collected in AREE 3 and 6A

Sample ID	Naphthalene (µg/g)	Phenanthrene (µg/g)	Pyrene (µg/g)
RBC[a]	310	230[b]	230
RISS10	ND	ND	ND
RISS11	ND	ND	ND
RISS11DUP	ND	ND	ND
RISS12	ND	ND	ND
RISS17	ND	ND	0.011
RISS18	ND	ND	ND
RISS19	1.82	0.191	ND
RISS20	ND	ND	0.009
RISS21	ND	ND	ND
RISS21DUP	ND	ND	ND
RISS22	ND	ND	ND
RISS23	ND	ND	ND

ND Not detected.

[a] The maximum detected concentrations of organic and inorganic compounds were compared to USEPA Region III residential RBCs, in accordance with Region III guidance (USEPA, 1996a). The RBCs are health-protective chemical concentrations that are back-calculated using toxicity criteria, a $1x10^{-6}$ target risk level or a 0.1 hazard index, and conservative exposure parameters.

[b] The RBC for pyrene was used as a surrogate for noncarcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.

Table 2-4 (Continued)

Inorganics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREEs 3 and 6A

Sample ID	Aluminum (µg/g)	Arsenic (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
Site Background[a]	18,200	ND	73.4	1.02	454	25.0
MW-69	16,000	2.85	51.9	0.71	282	25.3

Sample ID	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Mercury (µg/g)
Site Background[a]	13.9	16.9	27,800	11.6	3,700	617	—
MW-69	8.20	11.6	26,200	13.8	1,630	86.9	ND

Sample ID	Nickel (µg/g)	Potassium (µg/g)	Selenium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	17.9	624	—	933	25.8	46.3
MW-69	9.88	764	15.5	453	44.2	36.7

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for subsurface soil samples.

Table 2-4 (Continued)

Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREEs 3 and 6A

Sample ID	Depth bgs (ft)	Aluminum (µg/g)	Antimony (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
Site Background[a]		18,200	ND	73.8	1.02	454	25.0
MW-69	25	1,480	ND	ND	ND	ND	4.11
	27	659	ND	ND	ND	ND	2.13

Sample ID	Depth bgs (ft)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)
Site Background[a]		13.9	16.9	27,800	11.8	3,700	617
MW-69	25	ND	2.30	1,620	ND	442	15.4
	27	ND	1.06	836	ND	182	7.56

Sample ID	Depth bgs (ft)	Nickel (µg/g)	Potassium (µg/g)	Silver (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]		17.9	624	ND	933	25.8	46.3
MW-69	25	ND	248	ND	305	4.93	6.55
	27	ND	156	ND	317	ND	ND

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for subsurface soil samples.

Table 2-4 (Continued)

Organics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREEs 3 and 6A

Sample ID	Bis(2-ethylhexyl)-phthalate (µg/g)	DDT (µg/g)	Di-n-butylphthalate (µg/g)	Endosulfan Sulfate (µg/g)	Methoxychlor (µg/g)
RBC[a]	46	1.9	—	47	39
MW-69	ND	ND	ND	0.02	ND

Sample ID	PCB-1248 (µg/g)	PCB-1254 (µg/g)	TPH, as Diesel (µg/g)	TPH, as Gas (µg/g)
RBC[a]	0.083[b]	0.16[b]	100	100
MW-69	ND	ND	ND	ND

ND Not detected

[a] The soil RBC values are from the USEPA Region III Residential RBCs (USEPA, 1996a). RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

[b] Value is for carcinogenic PCBs.

Table 2-4 (Continued)

Organics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREEs 3 and 6A

Sample ID	Depth bgs (ft)	Acetone (µg/g)	Benzoic Acid (µg/g)	Bis(2-ethyl-hexyl) phthalate (µg/g)	Di-n-butyl Phthalate (µg/g)	Endosulfan Sulfate (µg/g)	Methylene Chloride (µg/g)	PCB-1248 (µg/g)	PCB-1254 (µg/g)
RBC[a]		780	31,000	46	---	47[b]	85	0.083[c]	0.16
MW-69	25	0.01	ND	ND	ND	ND	ND	ND	ND
	27	0.02	ND	ND	ND	0.03	ND	ND	ND

ND Not detected.

[a] USEPA Region III residential risk-based concentration (RBC) values.

[b] The RBC for endosulfan was used.

[c] Value is for carcinogenic PCBs.

-- No value available.

Table 2-4 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREE 3 and 6A

Sample ID	Depth bgs (ft)	Aluminum (µg/g)	Antimony (µg/g)	Arsenic (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Cadmium (µg/g)
Site Background[a] (0-2ft bgs)		14,350	ND	3.8	92.4	0.814	ND
Site Background[a] (2ft-water table)		16,200	ND	ND	73.8	1.02	ND
TP-13A	6.5	6,410	ND	ND	ND	0.612	ND
TP-13B	5.0	5,610	ND	ND	ND	0.614	ND
TP-14A	4.0	10,600	ND	ND	48.8	1.16	ND
TP-14ADUP	4.0	7,890	ND	ND	ND	0.895	ND
TP-14B	7.0	5,590	ND	ND	ND	0.721	ND
TP-15A	1.0	12,200	ND	ND	ND	0.562	ND
TP-15B	4.0	12,900	0.522	NA	64.8	0.444	1.02
TP-16A	3.0	15,500	ND	ND	ND	0.312	ND
TP-16ADUP	3.0	15,900	ND	NA	52.2	0.549	ND
TP-16B	3.33	9,550	ND	ND	52.4	0.848	ND
TP-17A	6.0	12,300	ND	ND	506	0.725	ND
TP-17B	0.0	18,300	ND	ND	ND	0.754	ND

Table 2-4 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREE 3 and 6A

Sample ID	Depth bgs (ft)	Calcium µg/g	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)
Site Background[a] (0-2 ft bgs)		1,150	31.3	16.6	12.6	28,100	22.4
Site Background[a] (2ft-water table)		454	25.0	13.9	16.9	27,800	11.8
TP-13A	6.5	489	19.0	20.3	6.68	7,320	ND
TP-13B	5.0	359	15.7	21.5	7.03	7,810	ND
TP-14A	4.0	179	17.6	6.89	7.61	21,000	12.1
TP-14ADUP	4.0	129	13.7	6.87	10.6	12,200	13.9
TP-14B	7.0	142	12.1	3.70	5.19	6,930	ND
TP-15A	1.0	941	34.5	11.1	50.3	67,300	67.0
TP-15B	4.0	21,500	26.0	4.78	15.8	20,400	24.0
TP-16A	3.0	913	25.0	4.94	22.1	24,400	17.0
TP-16ADUP	3.0	743	25.2	3.81	13.0	16,700	19.5
TP-16B	3.33	1,150	19.7	7.32	36.9	18,600	49.8
TP-17A	6.0	836	27.2	24.1	26.6	18,300	9.52
TP-17B	0.0	242	24.1	5.68	11.0	30,400	11.6

Table 2-4 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREE 3 and 6A

Sample ID	Depth bgs (ft)	Magnesium (µg/g)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a] (0-2ft bgs)		2,610	875	11.9	936	487	58.9	43.9
Site Background[a] (2ft-water table)		3,700	617	17.9	624	933	25.8	46.3
TP-13A	6.5	2,110	184	16.4	647	626	28.9	41.4
TP-13B	5.0	1,620	201	10.5	535	459	19.2	28.0
TP-14A	4.0	1,110	59.6	7.29	456	447	33.4	34.4
TP-14ADUP	4.0	1,080	50.2	6.09	335	512	25.3	26.3
TP-14B	7.0	661	29.0	3.61	289	404	20.2	21.0
TP-15A	1.0	1,410	158	35.7	635	449	43.1	242
TP-15B	4.0	1,180	303	9.88	830	644	34.4	610
TP-16A	3.0	1,780	67.5	9.81	1,170	444	40.4	350
TP-16ADUP	3.0	1,660	50.6	9.06	1,290	391	41.3	159
TP-16B	3.33	1,510	56.3	7.74	626	456	42.9	189
TP-17A	6.0	3,880	138	17.3	727	610	44.0	41.4
TP-17B	0.0	1,150	48.7	7.72	905	458	38.5	32.2

ND Not detected.

NA Not available.

[a] Site background concentrations are based on WRF site background maximum concentrations for surface soils (0-2 ft. bgs) and subsurface soils (2ft.-water table).

Table 2-4 (Continued)

Organics Detected in Test Pit Samples Collected in AREE 3 and 6A

Sample ID	Benzo(a)anthracene (µg/g)	Benzo(a)pyrene (µg/g)	Benzo(b)fluoranthene (µg/g)	Benzo(k)fluoranthene (µg/g)
RBC[a]	0.88	0.088	0.88	8.8
TP-13A	ND	ND	ND	ND
TP-13B	ND	ND	ND	ND
TP-14A	ND	ND	ND	ND
TP-14AD	ND	ND	ND	ND
TP-14B	ND	ND	ND	ND
TP-15A	ND	ND	ND	ND
TP-15B	ND	ND	ND	ND
TP-16A	ND	ND	ND	ND
TP-16AD	ND	ND	ND	ND
TP-16B	0.690	0.440	0.640	0.740
TP-17A	ND	ND	ND	ND
TP-17B	ND	ND	ND	ND

Table 2-4 (Continued)

Organics Detected in Test Pit Samples Collected in AREE 3 and 6A

Sample ID	Chrysene (µg/g)	Fluoranthene (µg/g)	Indeno(1,2,3-cd)-pyrene (µg/g)	Pyrene (µg/g)
RBC[a]	88	310	0.88	230
TP-13A	ND	ND	ND	ND
TP-13B	ND	ND	ND	ND
TP-14A	ND	ND	ND	ND
TP-14AD	ND	ND	ND	ND
TP-14B	ND	ND	ND	ND
TP-15A	ND	ND	ND	ND
TP-15B	ND	ND	ND	ND
TP-16A	ND	ND	ND	ND
TP-16AD	ND	ND	ND	ND
TP-16B	1.20	0.380	0.210	0.480
TP-17A	ND	ND	ND	ND
TP-17B	ND	ND	ND	ND

ND Not detected.

[a] USEPA Region III residential risk-based concentration (RBC) values (USEPA 1996). RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

Table 2-4 (Continued)

Inorganics Detected in Groundwater Samples Collected in AREEs 3 and 6A

Sample ID	Aluminum (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Calcium (µg/L)	Chromium (µg/L)
Site Background[a]	12,500	6.70	107	0.8	42,200	22.3
MW-69	77.2	1.4	83.1	ND	11,200	ND
MW-69 Round 2	98.6	2.2	70.6	ND	11,400	ND

Sample ID	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)
Site Background[a]	8.9	9,620	6.3	7,720	354	18.4
MW-69	ND	25,800	ND	8,210	641	ND
MW-69 Round 2	ND	20,300	ND	7,160	575	ND

Sample ID	Potassium (µg/L)	Selenium (µg/L)	Sodium (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
Site Background[a]	20,600	4.2	43,500	0.1	29.8	46
MW-69	2,190	4.7	38,800	ND	ND	ND
MW-69 Round 2	2,040	3.0	33,400	ND	ND	ND

ND Not detected.

NS Not sampled.

[a] Site background concentrations are based on WRF maximum background concentrations for groundwater.

[b] Round 2 sampling was conducted in March, 1996.

Table 2-4 (Continued)

Organics Detected in Groundwater Samples Collected in AREEs 3 and 6A

Sample ID	1-Methyl naphthalene (µg/L)	4-Methyl Phenol (µg/L)	Acenaphthylene (µg/L)	Aldrin (µg/L)	Anthracene (µg/L)	Benzoic Acid (µg/L)	Alpha BHC (µg/L)
RBC[a]	110	18	110	0.004	1,100	15,000	
MW-69	ND	ND	ND	ND	0.25	ND	ND
MW-69 Round 2	NS	NS	NS	NS	NS	NS	NS

Sample ID	Gamma-BHC (Lindane) (µg/L)	Bis(2-ethyl hexyl) Phthalate (µg/L)	DDT (µg/L)	Dimethyl Phthalate (µg/L)	Endosulfan Sulfate (µg/L)	Endosulfan II (µg/L)	Endrin (µg/L)
RBC[a]	0.052	4.8	0.2	37,000	22		1.1
MW-69	ND	2.4	ND	ND	ND	ND	ND
MW-69 Round 2	NS	NS	NS	NS	NS	NS	NS

Sample ID	Fluoranthene (µg/L)	Gamma Chlordane (µg/L)	Heptachlor Epoxide (µg/L)	Methoxychlor (µg/L)	Phenanthrene (µg/L)	Phenol (µg/L)	Pyrene (µg/L)
RBC[a]	150	0.052	0.0012	18	110	2,200	110
MW-69	ND	ND	ND	ND	ND	ND	ND
MW-69 Round 2	NS	NS	NS	NS	NS	NS	NS

ND Not detected;

NS Not sampled.

[a] Groundwater RBC values are from USEPA Region III Tap Water RBCs. RBCs for noncarcinogenic chemicals are based on hazard quotient of 0.1, following USEPA Region III guidance.

Table 2-4 (Continued)

Inorganics Detected In Sediment Samples Collected In AREE 3 and 6A

Sample ID	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)
Site Background[a]	15,200	175	1.26	6,000	30.1	20.7	41.6
RISD10	13,200	85.2	0.747	989	25	8.97	19.6

Sample ID	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)
Site Background[a]	34,200	42.2	3,740	1,690	30.0	2,120
RISD10	13,800	16.4	2,600	92.8	14.7	1,130

Sample ID	Silver (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	ND	1,710	52.5	157
RISD10	ND	657	37.1	72.5

ND Not detected.

[a] Site background concentrations are maximum concentrations from samples RISDBK-1 through RISDBK-5.

Table 2-4 (Continued)

Organics Detected In Sediment Samples Collected In AREE 3 and 6A

Sample ID / RBC[a]	2-Methyl-naphthalene (µg/g)	Acenaphthene (µg/g)	Acetone (µg/g)	Anthracene (µg/g)	Benzo(a) anthracene (µg/g)	Benzo(a)pyrene (µg/g)
	230[b]	470	780	2,300	0.88	0.088
RISD10	ND	ND	ND	0.031	ND	0.002

Sample ID / RBC[a]	Benzo(b) fluoranthene (µg/g)	Benzo(g,h,i) perylene (µg/g)	Benzo(k) fluoranthene (µg/g)	Chrysene (µg/g)	DDD (µg/g)	DDE (µg/g)
	0.88	230[b]	8.8	88	2.7	1.9
RISD10	0.004	ND	0.002	ND	ND	ND

Sample ID / RBC[a]	DDT (µg/g)	Dibenzo(a,h) anthracene (µg/g)	Fluoranthene (µg/g)	Indeno(1,2,3-cd)pyrene (µg/g)	PCB-1260 (µg/g)	Phenanthrene (µg/g)	Pyrene (µg/g)
	1.9	0.088	310	0.88	0.083[c]	230[b]	230
RISD10	ND	ND	0.006	ND	ND	ND	ND

ND Not detected.

[a] Sediment RBC values are from USEPA Region III Residential Soil RBCs. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

[b] The RBC for pyrene was used as a surrogate for non-carcinoganic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.

[c] Value is for carcinogenic for PCBs.

Table 2-4 (Continued)

Inorganics Detected in Surface Water Samples Collected in AREE 3 and 6A

SampleID	Aluminum (µg/L)	Barium (µg/L)	Calcium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)
Site Background[a]	1,930	41.8	22,200	10.8	ND	2,510
RISW10	547	ND	2,020	ND	ND	705

Sample ID	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Potassium (µg/L)	Sodium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
Site Background[a]	1.9	7,500	303	3,670	16,500	ND	ND
RISW10	ND	1,250	28.3	2,010	1,380	ND	ND

ND Not detected.

[a] Site background concentrations are from samples RISWBK-1 through RISWBK-5.

Table 2-4 (Continued)

Inorganics Detected In Surface Water Runoff Samples Collected In AREE 3 and 6A

Sample ID	Aluminum (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Calcium (µg/L)	Chromium (µg/L)
SWR05	19,200	1.5	147	1.0	6,130	32.1
SWR09	12,800	ND	55.3	0.1	4,160	20.1

Sample ID	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)
SWR05	65.9	21,700	21.9	5,260	251	29.8	4,400
SWR09	12.0	15,100	8.5	3,740	125	ND	2,940

Sample ID	Sodium (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
SWR05	5,930	0.3	55.3	456
SWR09	5,680	0.2	36.0	51.3

ND Not detected.

Table 2-4 (Continued)

Organics Detected In Surface Water Runoff Samples Collected In AREE 3 and 6A

Sample ID	Anthracene (µg/L)	Fluoranthene (µg/L)	Pyrene (µg/L)
SWR05	2.52	0.033	0.224
SWR09	ND	ND	ND

ND Not detected.

Table 2-5

Summary of RI Results for AREE 4 - Former Dump No. 4

Media Sampled[a]	Number of Samples Collected	Compounds/Analytes Detected above LOC[b]	Summary of Fate & Transport
Surface Soil	4	Pb, K, Na	Infiltration/percolation through soil to groundwater Stormwater runoff to surface water/sediments
Subsurface Soil (0- to 2-ft bgs)	5	Cu, Na benzo(a)pyrene	
Subsurface Soil (2-ft bgs to water table)	8	Ba, Ca, Cr, Co, Cu, Mg, Ni, K, V, Zn	
Test Pits	16	Al, Ba, Be, Cu, Cr, Co, Cu, Fe, Pb, Mg, Ni, K, Na, V, Zn	
Groundwater	Round 1 - 5 Round 2 - 4	Co, Fe, Mn, Zn	Discharge to surface water
Surface Water Runoff	2	None	Storm water runoff

[a] Surface soil, subsurface soil, test pit, and groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PCTs, and TPH. Surface soil and groundwater samples were also analyzed for PAHs.

[b] LOC - Level of Concern. Refers to either the WRF site background maximum concentrations for inorganics or USEPA Region III residential risk-based concentrations (RBCs) for organics.

Table 2-5 (Continued)

Inorganics Detected in Surface Soil Samples Collected in AREE 4

Sample ID	Aluminum (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)
Site Background[a]	14,350	0.814	1,150	31.3	16.6
RISS13	8,240	0.454	167	12.8	3.81
RISS14	8,960	0.524	172	15.6	5.02
RISS15	8,640	0.407	210	17.0	3.64
RISS16	8,900	0.434	219	15.0	3.61

Sample ID	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)
Site Background[a]	12.6	28,100	22.4	2,610	875
RISS13	4.04	10,500	22.5	669	99.2
RISS14	6.56	12,900	22.7	950	84.4
RISS15	4.11	14,700	15.9	684	134
RISS16	6.63	14,300	22.3	721	64.7

Sample ID	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	11.9	936	487	58.9	43.9
RISS13	4.94	547	475	23.1	20.1
RISS14	6.12	692	505	32.2	24.5
RISS15	4.74	542	462	30.8	20.8
RISS16	5.82	604	490	30.3	23.6

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for surface soil samples collected from MW-52 through MW-54 and RISSBK1 through RISSBK5.

Table 2-5 (Continued)

Organics Detected in Surface Soil Samples Collected in AREE 4

Sample ID	Acenaphthene (µg/g)	Acetone (µg/g)	Anthracene (µg/g)	Benzo(a)anthracene (µg/g)	Benzo(a)pyrene (µg/g)
RBC[a]	470	780	2,300	0.88	0.088
RISS13	ND	ND	0.058	0.003	0.004
RISS14	ND	ND	0.034	0.006	0.009
RISS15	0.931	ND	0.014	0.003	0.005
RISS16	ND	0.020	0.055	0.004	0.006

Sample ID	Benzo(b)fluoranthene (µg/g)	Benzo(g,h,i)perylene (µg/g)	Benzo(k)fluoranthene (µg/g)	Chrysene (µg/g)	Fluoranthene (µg/g)
RBC[a]	0.88	230[b]	8.8	88	310
RISS13	0.008	ND	0.004	0.025	0.058
RISS14	0.012	0.015	0.005	ND	0.017
RISS15	0.006	0.008	0.003	ND	0.009
RISS16	0.008	0.012	0.004	ND	0.015

Sample ID	Indeno(1,2,3-cd)-pyrene (µg/g)	Methylene chloride (µg/g)	Naphthalene (µg/g)	Phenanthrene (µg/g)	Pyrene (µg/g)
RBC[a]	0.88	85	310	230[b]	230
RISS13	ND	ND	0.314	0.054	0.032
RISS14	0.007	ND	ND	ND	0.019
RISS15	ND	ND	ND	ND	0.013
RISS16	0.004	0.010	ND	ND	0.013

ND Not detected.

[a] The soil and sediment RBC values are from USEPA Region III Residential Soil RBCs (USEPA 1996a). RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

[b] The RBC for pyrene was used as a surrogate for noncarcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.

Table 2-5 (Continued)

Inorganics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREE 4

Sample ID	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)
Site Background[a]	18,200	92.4	0.814	1,150	31.3	16.6
MW-64	12,500	ND	0.66	168	19.2	5.78
MW-65	9,820	ND	0.70	724	20.2	6.30
MW-65DUP	7,440	63.1	0.46	955	13.1	8.22
MW-66	11,500	50.7	0.43	142	19.3	5.86
MW-67	11,600	ND	0.61	148	19.2	4.78

Sample ID	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Nickel (µg/g)
Site Background[a]	12.6	28,100	22.4	2,610	875	11.9
MW-64	10.3	19,900	11.3	1,630	65.5	8.80
MW-65	13.9	23,200	14.7	1,670	96.9	9.16
MW-65DUP	7.16	9,780	ND	1,190	97.6	8.29
MW-66	6.80	14,500	10.3	1,320	139	6.53
MW-67	8.68	18,800	16.7	1,180	65.0	6.61

Sample ID	Potassium (µg/g)	Selenium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	936	14.2	487	58.9	43.9
MW-64	579	13.0	357	38.3	34.2
MW-65	705	ND	424	39.1	39.3
MW-65DUP	445	ND	503	24.3	21.9
MW-66	570	ND	470	32.7	31.7
MW-67	629	ND	406	38.4	29.4

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for surface soil samples collected from MW-52 through MW-54.

Table 2-5 (Continued)

Organics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREE 4

Sample ID RBC[a]	Benzo(a)pyrene (µg/g)	Bis(2-ethylhexyl)phthalate (µg/g)	Di-n-butyl phthalate (µg/g)
	0.088	46	780
MW-64	ND	ND	ND
MW-65	0.22	1.20	4.90
MW-65DUP	ND	2.40	4.20
MW-66	ND	ND	ND
MW-67	ND	ND	ND

ND Not detected.

[a] Soil RBC values are from Region III Residential Soil RBCs (USEPA 1996a). RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

Table 2-5 (Continued)

Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREE 4

Sample ID	Depth bgs (ft)	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
Site Background[a]		18,200	73.8	1.02	454	25.0
MW-64	15	11,800	86.5	0.93	1,200	31.9
	20	4,970	ND	ND	205	10.8
MW-65	10	6,990	55.4	0.71	409	12.6
	15	1,880	ND	0.27	280	5.74
MW-66	5	7,430	ND	0.35	129	12.1
	10	2,870	ND	ND	196	3.87
MW-67	5	7,510	ND	0.40	145	12.6
	10	4,580	ND	0.37	168	7.73

Sample ID	Depth bgs (ft)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)
Site Background[a]		13.9	16.9	27,800	11.8	3,700
MW-64	15	24.2	24.2	1,890	10.1	4,570
	20	4.42	4.47	3,130	ND	842
MW-65	10	4.58	12.2	7,840	ND	1,050
	15	ND	2.91	1,460	ND	448
MW-66	5	8.90	5.65	6,100	ND	955
	10	2.98	1.65	1,750	ND	322
MW-67	5	8.23	5.59	8,190	ND	1,030
	10	2.22	3.90	10,200	ND	383

Table 2-5 (Continued)

Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREE 4

Sample ID	Depth bgs (ft)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]		617	17.9	624	933	25.8	46.3
MW-64	15	141	21.3	994	720	55.5	46.5
	20	344	5.24	292	406	11.7	11.5
MW-65	10	24.4	4.84	252	424	20.8	14.0
	15	9.49	ND	138	358	6.73	ND
MW-66	5	396	7.17	335	386	22.6	13.8
	10	37.0	ND	143	414	4.72	7.76
MW-67	5	578	5.61	433	357	18.3	16.9
	10	156	2.41	170	378	14.7	10.3

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for subsurface soil samples MW-52 through MW-54, collected at two depths.

Table 2-5 (Continued)

Organics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREE 4

Sample ID RBC[a]	Depth bgs (ft)	Acetone (µg/g)	Bis(2-ethylhexyl)phthalate (µg/g)	Di-n-butyl phthalate (µg/g)
		780	46	780
MW-64	10	ND	ND	ND
	15	ND	ND	ND
MW-65	10	0.01	1.00	4.50
	15	ND	0.84	4.60
MW-66	10	ND	ND	ND
	15	ND	ND	ND
MW-67	10	ND	ND	ND
	15	ND	ND	ND

ND Not detected.

[a] The soil RBC values are from Region III Residential Soil RBCs (USEPA 1996a). RBCs for noncarcinogenic chemicals are based on hazard quotient of 0.1, following USEPA Region III guidance.

Table 2-5 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREE 4

Sample ID	Depth bgs (ft)	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
Site Background[a] (0-2ft)		14,350	92.4	0.814	1,150	31.3
Site Background[a] (2ft-water table)		18,200	73.8	1.02	454	25.0
TP-5A	5.75	8,840	ND	0.750	466	16.3
TP-5B	0.0	10,400	ND	0.507	290	21.2
TP-6A	5.6	16,800	53.3	1.25	237	31.1
TP-7A	0.0	13,900	ND	0.916	528	21.6
TP-7B	6.66	15,000	64.6	0.631	261	26.7
TP-8A	8.0	2,680	ND	ND	153	5.42
TP-8B	6.5	18,600	222	1.44	1,130	40.8
TP-9A	7.0	4,480	ND	ND	190	12.8
TP-9ADUP	7.0	5,470	ND	0.377	225	12.7
TP-9B	8.0	17,100	116	0.902	615	40.1
TP-10A	8.0	11,300	ND	0.750	265	18.1
TP-10B	0.0	15,100	ND	0.859	241	25.6
TP-11A	7.0	8,790	ND	0.237	505	26.8
TP-11B	0.0	14,700	103	1.30	421	29.1
TP-12A	0.0	15,900	ND	0.871	200	26.2
TP-12B	7.0	13,300	ND	1.37	572	31.6

Table 2-5 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREE 4

Sample ID	Depth bgs (ft)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)
Site Background* (0-2ft)		16.6	12.6	28,100	22.4	2,610
Site Background* (2ft-water table)		13.9	16.9	27,800	11.8	3,700
TP-5A	5.75	5.26	5.90	13,700	17.3	773
TP-5B	0.0	5.85	5.48	15,900	18.8	811
TP-6A	5.6	10.6	12.3	19,000	11.1	3,140
TP-7A	0.0	5.53	8.49	21,200	19.6	1,140
TP-7B	6.66	7.01	15.4	14,300	14.3	2,430
TP-8A	8.0	2.92	3.35	2,880	ND	459
TP-8B	6.5	15.3	27.8	17,600	12.4	5,250
TP-9A	7.0	6.47	5.53	5,350	ND	1,550
TP-9ADUP	7.0	6.19	5.34	6,210	ND	1,520
TP-9B	8.0	22.9	27.4	24,900	12.6	5,870
TP-10A	8.0	4.14	10.5	31,900	9.13	870
TP-10B	0.0	5.04	14.4	36,700	14.8	1,150
TP-11A	7.0	5.83	8.36	12,900	ND	3,330
TP-11B	0.0	29.0	100	31,500	13.4	3,770
TP-12A	0.0	6.76	11.4	31,200	15.4	1,470
TP-12B	7.0	8.19	22.0	11,900	14.8	3,230

Table 2-5 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREE 4

Sample ID	Depth bgs (ft)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a] (0-2ft)		875	11.9	936	487	58.9	43.9
Site Background[a] (2 ft-water table)		617	17.9	624	933	25.8	46.3
TP-5A	5.75	141	4.68	521	364	29.6	31.4
TP-5B	0.0	115	5.70	524	461	34.8	30.4
TP-6A	5.6	85.1	13.6	1,010	520	47.5	36.7
TP-7A	0.0	81.3	7.42	717	506	39.3	35.1
TP-7B	6.66	53.4	11.1	966	709	38.0	40.5
TP-8A	8.0	48	2.93	224	482	10.2	13.8
TP-8B	6.5	121	31.3	1,340	996	66.7	61.4
TP-9A	7.0	49.4	4.98	254	627	20	21.9
TP-9ADUP	7.0	50.7	6.65	279	669	20.9	22.4
TP-9B	8.0	124	29.8	1,030	1,540	64.9	73.0
TP-10A	8.0	46.6	5.47	586	442	30.7	27.0
TP-10B	0.0	38.8	6.16	751	278	49.1	29.6
TP-11A	7.0	89.8	12.3	952	523	28.3	37.2
TP-11B	0.0	182	19.2	733	700	49.5	49.2
TP-12A	0.0	134	8.69	765	436	50.4	34.8
TP-12B	7.0	60.6	14.8	815	772	62.3	57.6

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for surface (0-2ft. bgs) and subsurface soil (2 ft. bgs to water table).

Table 2-5 (Continued)

Organics Detected in Test Pit Samples Collected in AREE 4

Sample ID	Acetone (µg/g)	Bis(2-ethylhexyl)-phthalate (µg/g)	DDE (µg/g)	DDT (µg/g)	Diethyl Phthalate (µg/g)	Methoxychlor (µg/g)	Methylene Chloride (µg/g)
RBC[a]	780	46	1.9	1.9	6,300	39	85
TP-5A	ND	0.300	ND	ND	ND	ND	ND
TP-5B	ND	ND	0.006	0.004	ND	0.004	ND
TP-6A	ND	ND	ND	ND	ND	ND	ND
TP-6B	ND	ND	ND	ND	ND	ND	ND
TP-7A	ND	1.200	ND	ND	ND	ND	ND
TP-7B	0.010	ND	ND	ND	ND	ND	ND
TP-8A	0.020	ND	ND	ND	ND	ND	ND
TP-8B	ND	ND	ND	ND	ND	ND	ND
TP-9A	0.010	ND	ND	ND	ND	ND	ND
TP-9AD	0.010	ND	ND	ND	ND	ND	ND
TP-9B	0.020	ND	ND	ND	ND	ND	ND
TP-10A	ND	ND	ND	ND	ND	ND	ND
TP-10B	ND	ND	ND	ND	ND	ND	ND
TP-11A	ND	ND	ND	ND	ND	ND	0.010
TP-11B	ND	ND	ND	ND	ND	ND	0.020
TP-12A	ND	ND	ND	ND	ND	ND	0.020
TP-12B	ND	ND	ND	ND	ND	ND	0.020

ND Not detected.

[a] The soil RBC values are from USEPA Region III Residential Soil RBCs (USEPA 1996a). RBC values for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

Table 2-5 (Continued)

Inorganics Detected in Groundwater Samples Collected in AREE 4

Sample ID	Aluminum (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Calcium (µg/L)	Chromium (µg/L)
Site Background[a]	12,500	6.70	107	42,200	22.3
MW-64	1,400	ND	50.5	7,110	ND
MW-64 Round 2[b]	89.8	ND	37.0	4,930	ND
MW-65	57.6	ND	88.8	9,090	ND
MW-65 Round 2	40.2	ND	82.0	8,470	ND
MW-65DUP	83.9	ND	87.6	8,900	ND
MW-66	242	ND	38.6	5,760	10.7
MW-66 Round 2	336	ND	38.6	5,030	ND
MW-67	689	3.1	76.4	3,300	ND
MW-67 Round 2	95.0	3.6	63.3	3,050	ND

Sample ID	Cobalt (µg/L)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)
Site Background[a]	ND	9,620	6.3	7,720	354
MW-64	ND	1,910	2.00	4,240	490
MW-64 Round 2	ND	143	ND	3,570	117
MW-65	ND	261	ND	9,660	115
MW-65 Round 2	ND	330	ND	8,870	63.5
MW-65DUP	ND	304	ND	9,460	112
MW-66	ND	290	ND	4,680	276
MW-66 Round 2	ND	528	ND	4,800	391
MW-67	32.3	10,500	ND	4,230	4,670
MW-67 Round 2	24.3	8,070	ND	3,920	3,730

Table 2-5 (Continued)

Inorganics Detected in Groundwater Samples Collected in AREE 4

Sample ID Site Background[a]	Nickel (µg/L) 18.4	Potassium (µg/L) 20,600	Selenium (µg/L) 4.2	Sodium (µg/L) 43,500	Zinc (µg/L) 46.0
MW-64	16.6	2,690	2.9	16,400	31.1
MW-64 Round 2	ND	1,070	ND	15,700	105
MW-65	ND	1,320	5.6	38,800	28.2
MW-65 Round 2	ND	1,210	3.1	37,400	ND
MW-65DUP	ND	1,220	5.7	38,100	35.5
MW-66	ND	780	3.4	29,600	38.6
MW-66 Round 2	ND	1,020	2.1	26,400	ND
MW-67	ND	1,290	ND	21,400	27.3
MW-67 Round 2	ND	1,450	ND	20,400	26.1

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for groundwater samples.

[b] Round 2 sampling was conducted in March, 1996.

Table 2-5 (Continued)

Organics Detected in Groundwater Samples Collected from AREE 4

Sample ID	Bis(2-ethylhexyl) phthalate
RBC[a]	4.8
MW-64	ND
MW-65	ND
MW-65DUP	2.2
MW-66	ND
MW-67	ND

ND Not detected.

[a] Groundwater RBC values are from USEPA Region III Tap Water RBCs. RBCs for noncarcinogenic chemicals are based on hazard quotient of 0.1, following USEPA Region III guidance.

Table 2-5 (Continued)

Inorganics Detected In Surface Water Runoff Samples Collected In AREE 4

Sample ID	Aluminum (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Calcium (µg/L)	Chromium (µg/L)	Cobalt (µg/L)
SWR06	9,780	78.2	0.2	4,480	14.0	ND
SWR07	7,010	138	0.5	6,160	11.5	21.6

Sample ID	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)
SWR06	7.1	10,900	15.9	2,760	187	ND	3,280
SWR07	9.8	12,300	25.4	5,520	321	19.3	2,620

Sample ID	Selenium (µg/L)	Sodium (µg/L)	Thallium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
SWR06	ND	2,540	0.1	30.0	42.5
SWR07	2.3	13,600	0.1	27.4	112

ND Not detected.

Table 2-5 (Continued)

Organics Detected In Surface Water Runoff Samples Collected In AREE 4

Sample ID	Anthracene (µg/L)	DDD,pp' (µg/L)	DDT,pp' (µg/L)	Fluoranthene (µg/L)	Pyrene (µg/L)
SWR06	0.485	ND	ND	0.029	ND
SWR07	3.80	0.010	0.009	0.044	0.214

ND Not detected.

Table 2-6

Summary of RI Results for AREE 6B - Potential Dump No. 6B

Media Sampled[a]	Number of Samples Collected	Compounds/Analytes Detected above LOC[b]	Summary of Fate & Transport
Surface Soil	1	K	Infiltration/percolation through soil to groundwater Stormwater runoff to surface water/sediment
Subsurface Soil (0- to 2-ft bgs)	2	None	
Subsurface Soil (2-ft bgs to Water Table)	5	Ca, Co, V	
Test Pits	6	Al, Ba, Ca, Cr, Cu, Fe, Pb, Mg, Ni, K, Na, V	
Groundwater - Round 1 Groundwater - Round 1	3 3	heptachlor epoxide None	Discharge to surface water

[a] Surface soil, subsurface soil, and groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and TPH. If PCBs were detected, the laboratory was instructed to analyze for PCTs. Surface soil samples were also analyzed for PAHs.

[b] LOC - Level of Concern. Refers to either the WRF site background maximum concentrations for inorganics and USEPA Region III residential risk-based concentrations (RBCs) for organics.

Table 2-6 (Continued)

Inorganics Detected in Surface Soil Sample Collected in AREE 6B

Sample ID	Aluminum (µg/g)	Arsenic (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
Site Background[a]	14,350	3.8	92.4	0.814	1,150	31.3
RISS24	15,400	0.643	55.9	0.857	211	27.7

Sample ID	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)
Site Background[a]	16.6	12.6	28,100	22.4	2,610	875
RISS24	7.99	15.5	37,300	15.1	1350	40.2

Sample ID	Nickel (µg/g)	Potassium (µg/g)	Selenium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	11.9	936	14.2	487	58.9	43.9
RISS24	7.98	692	17.8	448	52.3	32.0

ND Not detected.

[a] Site background concentrations are based on WRF maximum site background concentrations for surface soil samples from MW-52 through MW-54 and RISSBK1 through RISSBK5.

Table 2-6 (Continued)

Inorganics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREE 6B

Sample ID	Aluminum (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)
Site Background[a]	14,350	0.814	1,150	31.3	16.6	12.6	28,100	22.4
MW-60	9,580	0.388	755	16.6	ND	9.17	24,700	13.4
MW-75	5,760	0.755	716	14.9	6.04	9.98	14,800	16.9

Sample ID	Magnesium (µg/g)	Manganese (µg/g)	Mercury (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	2,610	875	ND	11.9	936	487	58.9	43.9
MW-60	674	22	ND	3.1	313	440	41.8	15.6
MW-75	1,440	106	ND	6.36	482	463	30.2	24.2

ND Not detected.

[a] Site background concentrations are based on WRF maximum site background concentrations for surface soils collected from MW-52 through MW-54 and RISSBK1 through RISSBK5.

Table 2-6 (Continued)

Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREE 6B

Sample ID	Depth bgs (ft)	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)
Site Background[a]		18,200	73.8	1.02	454	25.0	13.9	16.9	27,800
MW-60	20	5,840	54.5	0.429	1,150	21.9	7.06	14.2	23,600
	35	1,660	ND	0.618	403	3.85	61.0	6.85	15,200
MW-75	5	4,300	ND	0.427	700	11.8	5.06	4.58	14,900
	15	2,030	ND	ND	144	4.77	ND	2.43	1,750
MW-75DUP	5	3,560	ND	0.599	678	10.6	3.16	4.20	10,300

Sample ID	Depth bgs (ft)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]		11.8	3,700	617	17.9	624	933	25.8	46.3
MW-60	20	ND	3,090	112	11	546	639	38.4	28.8
	35	ND	600	1,020	6.5	289	424	13.5	15.7
MW-75	5	9.68	706	87.4	3.53	271	525	22.4	11.9
	15	ND	431	12.6	ND	183	454	7.16	6.41
MW-75DUP	5	ND	634	82.4	3.32	243	547	20.9	10.7

ND Not detected.

[a] Site background concentrations are based on WRF maximum site background concentrations for subsurface soils collected from MW-52 through MW-54, at 2 depths.

Table 2-6 (Continued)

Organics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREE 6B

Sample ID	Depth bgs (ft)	Acetone (µg/g)	Benzo(a)pyrene (µg/g)	Bis(2-ethylhexyl) phthalate (µg/g)	DDT (µg/g)
RBC[a]		780	0.088	46	1.9
MW-60	20	ND	ND	ND	ND
	35	ND	ND	ND	ND
MW-75	5	0.08	ND	ND	ND
	15	0.02	0.24	0.23	ND
MW-75DUP	5	ND	ND	ND	0.01

ND Not detected.

[a] Soil RBC values are from USEPA Region III Residential Soil RBCs. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

Table 2-6 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREE 6B

Sample ID	Depth bgs (ft)	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)
Site Background[a] (0 ft bgs)		14,350	92.4	0.814	1,150	31.3
Site Background[a] (2 ft bgs)		18,200	73.8	1.02	454	25.0
TP-18A	6.6	5,450	ND	ND	179	7.03
TP-18B	0.0	10,800	ND	0.369	210	19.4
TP-19A	8.3	6,810	ND	ND	198	9.48
TP-19B	0.0	11,000	54.4	0.430	1,280	20.8
TP-20A	5.0	12,900	74.0	0.510	1,100	28.9
TP-20B	0.0	16,200	ND	0.731	500	27.3

Sample ID	Depth bgs (ft)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)
Site Background[a] (0 ft bgs)		16.6	12.6	14,350	22.4	2,610
Site Background[a] (2 ft bgs)		13.9	16.9	28,100	11.8	3,700
TP-18A	6.6	ND	2.60	2,040	ND	484
TP-18B	0	5.19	9.98	19,300	19.2	1,380
TP-19A	8.3	2.71	4.23	4,700	ND	789
TP-19B	0	7.75	9.35	20,500	17.6	1,750
TP-20A	5	13.3	15.0	18,000	10.9	4,240
TP-20B	0	6.58	14.3	24,300	15.5	2,550

Table 2-6 (Continued)

Inorganics Detected in Test Pit Samples Collected in AREE 6B

Sample ID	Depth bgs (ft)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a] (0 ft bgs)		875	11.9	936	487	58.9	43.9
Site Background[a] (2 ft bgs)		617	17.9	624	933	25.8	46.3
TP-18A	6.6	14.7	3.29	326	331	8.26	8.62
TP-18B	0	93.9	6.40	809	384	37.9	29.2
TP-19A	8.3	22.3	3.45	384	458	16.0	14.3
TP-19B	0	140	9.00	716	450	38.8	35.6
TP-20A	5	205	19.0	1,190	929	40.4	38.5
TP-20B	0	83.7	10.6	1,090	650	48.8	34.3

ND Not detected.

[a] Site background concentrations are based on WRF site background maximum concentrations for surface (0-2 ft. bgs) and subsurface (2 ft. bgs - water table) soils.

Table 2-6 (Continued)

Organics Detected in Test Pit Samples Collected in AREE 6B

Sample ID	Depth bgs (ft)	Acetone (µg/g)	Bis(2-ethylhexyl)-phthalate (µg/g)	DDT (µg/g)	Methoxychlor (µg/g)
RBC[a]		780	46	1.9	39
TP-18A	6.6	0.020	3.50	ND	ND
TP-18B	0	ND	ND	ND	0.004
TP-19A	8.3	0.020	0.220	ND	ND
TP-19B	0	ND	0.220	ND	ND
TP-20A	5	ND	3.20	ND	ND
TP-20B	0	ND	ND	0.006	ND

ND Not detected.

[a] USEPA Region III residential risk-based concentration (RBC) values. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

Table 2-6 (Continued)

Inorganics Detected in Groundwater Samples Collected in AREE 6B

Sample ID	Aluminum (µg/L)	Barium (µg/L)	Calcium (µg/L)	Iron (µg/L)	Magnesium (µg/L)
Site Background[a]	12,500	107	42,200	9,620	7,720
MW-60	2,620	27.5	5,290	3,470	4,960
MW-60 Round 2	918	ND	4,170	3,340	3,660
MW-75	47.3	ND	4,450	1,440	2,940
MW-75 Round 2	133	ND	3,250	2,770	2,910
MW-75DUP	55.5	ND	4,390	1,420	2,900
MW-75DUP Round 2	NS	NS	NS	NS	NS

Sample ID	Manganese (µg/L)	Potassium (µg/L)	Sodium (µg/L)	Zinc (µg/L)
Site Background[a]	354	20,600	43,500	46.0
MW-60	281	1,560	13,200	ND
MW-60 Round 2	215	733	8,860	ND
MW-75	139	997	10,400	22.9
MW-75 Round 2	117	1,200	9,440	ND
MW-75DUP	138	1,060	10,200	ND
MW-75DUP Round 2	NS	NS	NS	NS

ND Not detected.

NS Not sampled

[a] Site background concentrations are based on WRF maximum site background concentrations in groundwater.

Table 2-6 (Continued)

Organics Detected in Groundwater Samples Collected in AREE 6B

Sample ID	2-Methyl Naphthalene (µg/L)	Acetone (µg/L)	Bis(2-ethylhexyl)phthalate (µg/L)	DDE (µg/L)	DDT (µg/L)
RBC[a]	110[b]	370	4.8	0.20	0.20
MW-60	2.48	16	3.6	0.024	0.019
MW-60 Round 2	ND	ND	ND	ND	ND
MW-75	ND	ND	2.3	ND	ND
MW-75 Round 2	ND	ND	32	ND	ND
MW-75DUP	ND	ND	3.2	ND	ND
MW-75DUP Round 2	NS	NS	NS	NS	NS

Sample ID	Endosulfan Sulfate (µg/L)	Endosulfan II (µg/L)	Fluoranthene (µg/L)	Gamma-Chlordane (µg/L)	Heptachlor Epoxide (µg/L)
RBC[a]	22[c]	22[c]	150	0.052	0.0012
MW-60	0.027	0.021	0.034	0.008	0.088
MW-60 Round 2	ND	ND	ND	ND	ND
MW-75	ND	ND	ND	ND	ND
MW-75 Round 2	ND	ND	ND	ND	ND
MW-75DUP	ND	ND	ND	ND	ND
MW-75DUP Round 2	NS	NS	NS	NS	NS

ND Not detected.

NS Not sampled

[a] Groundwater and surface water RBC values are from USEPA Region III Tap Water RBCs. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region guidance.

[b] The RBC for pyrene was used as a surrogate for noncarcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.

[c] The RBC for endosulfan was used.

Table 2-7

Summary of Preliminary RI Results for AREE 7 - Former Pistol Range

Media Sampled[a]	Number of Samples Collected	Compounds/Analytes Detected above LOC[b]	Summary of Fate & Transport
Surface Soil	1	Al, Be, Cu, Fe, Se	Infiltration/percolation through soil to groundwater Stormwater runoff to surface water/sediment
Subsurface Soil (0- to 2-feet bgs)	1	None	
Subsurface Soil (2-feet bgs to Water Table)	2	None	
Groundwater	Round 1 - 1 Round 2 - 1	None	Discharge to surface water

a Surface soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and TPH. If PCBs were detected, the laboratory was instructed to analyze for PCTs. Subsurface soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PCTs, and TPH. Groundwater samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, PCTs, and TPH.

b LOC - Level of Concern. Refers to either the WRF site background maximum concentrations for inorganics or USEPA Region III residential risk-based concentrations (RBCs) for organics.

Table 2-7 (Continued)

Inorganics Detected in Surface Soil Samples Collected in AREE 7

Sample ID	Aluminum (µg/g)	Beryllium (µg/g	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)
Site Background[a]	14,350	0.814	1,150	31.3	16.6
RISS25	13,500	0.739	191	22.1	5.47

Sample ID	Copper (µg/g)	Iron (µg/g)	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)
Site Background[a]	12.6	28,100	22.4	2,610	875
RISS25	11.1	22,900	14.7	1,570	87.2

Sample ID	Nickel (µg/g)	Potassium (µg/g)	Selenium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	11.9	936	14.2	487	58.9	43.9
RISS25	8.92	1,110	14.1	481	39.5	33.6

ND Not detected.

[a] Site background concentrations are based on WRF maximum site background concentrations for surface soil samples collected from MW-52 through MW-54 and RISSBK1 through RISSBK5.

Table 2-7 (Continued)

Organics Detected in Surface Soil Samples Collected in AREE 7

Sample ID	Benzo(a)pyrene (µg/g)	Benzo(b)fluoranthene (µg/g)	Benzo(k)fluoranthene (µg/g)	Fluoranthene (µg/g)
RBC[a]	0.088	0.88	8.8	310
RISS25	0.002	0.002	0.001	0.003

[a] USEPA Region III residential risk-based concentration (RBC) values. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.

Table 2-7 (Continued)

Inorganics Detected in Subsurface Soil Samples (0 to 2 ft bgs) Collected in AREE 7

Sample ID	Aluminum (µg/g)	Barium (µg/g)	Beryllium (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)	Iron (µg/g)
Site Background[a]	14,350	92.4	0.814	1,150	31.3	16.6	12.6	28,100
MW-59	11,900	52.5	0.65	437.00	20.80	7.43	12.1	18,200

Sample ID	Lead (µg/g)	Magnesium (µg/g)	Manganese (µg/g)	Nickel (µg/g)	Potassium (µg/g)	Sodium (µg/g)	Vanadium (µg/g)	Zinc (µg/g)
Site Background[a]	22.4	2,610	875	11.9	936	487	58.9	43.9
MW-59	12.0	1,730	98.9	9.05	599	374	36.8	32.5

ND Not detected.

[a] Site background concentrations are based on WRF maximum site background concentrations for surface soils collected from MW-52 through MW-54 and RISSBK1 through RISSBK5.

Table 2-7 (Continued)

Inorganics Detected in Subsurface Soil Samples (2 ft bgs to Water Table) Collected in AREE 7

Sample ID	Depth bgs (ft)	Aluminum (µg/g)	Calcium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)
Site Background[a]		18,200	454	25.0	13.9	16.9
MW-59	25	1,030	ND	3.62	ND	2.50
	29	2,700	290	8.97	2.66	5.22

Sample ID	Depth bgs (ft)	Iron	Magnesium	Manganese	Nickel	Potassium
Site Background[a]		27,800	3,700	617	17.9	624
MW-59	25	1,160	200	9.59	ND	125
	29	3,530	790	25.5	4.21	217

Sample ID	Depth bgs (ft)	Sodium	Vanadium	Zinc
Site Background[a]		933	25.8	46.3
MW-59	25	256	4.82	ND
	29	370	9.12	11.2

ND Not detected.

[a] Site background concentrations are based on WRF maximum site background concentrations for subsurface soils collected from samples from MW-52 through MW-54.

Table 2-7 (Continued)

Inorganics Detected in Groundwater Samples Collected in AREE 7

Sample ID	Aluminum (µg/L)	Barium (µg/L)	Calcium (µg/L)	Iron (µg/L)
Site Background[a]	12,500	107	42,200	9,620
MW-59	483	25.4	3,370	346
MW-59 Round 2	185	30.7	4,190	180

Sample ID	Magnesium (µg/L)	Manganese (µg/L)	Potassium (µg/L)	Sodium (µg/L)
Site Background[a]	7,720	354	20,600	43,500
MW-59	2,410	54.1	947	8,070
MW-59 Round 2	2,480	65.7	1,010	8,300

[a] Site background concentrations are based on WRF maximum site background concentrations in groundwater.

3.0 HUMAN HEALTH RISK ASSESSMENT

3.1 PURPOSE AND APPROACH

This section of the FFS presents the HHRA, which evaluates the probability and magnitude of adverse effects on human health associated with actual or potential exposure to site-related chemicals at OU1 of the WRF. As discussed in Section 2.0 and shown in Figure 2-19, OU1 consists of AREEs 1 through 5, 6A, 6B, and 7, which are the former dump areas and former pistol range, all located on about 24 acres in the southwest portion of WRF. OU1 is bounded on the south by the Occoquan Bay, on the west by lake drive, and on the east by Deephole Point Road. Brief descriptions of the individual AREEs at OU1 are discussed below, however, Section 2.0 should be referred to for a more complete description of each AREE.

AREE 1 is a 0.4 acre former dump site located on the southern portion of the facility. The landfill was used as a dumping site for construction debris including scap metal, concrete, and miscellaneous debris. Some capacitors may have been buried there prior to closure of the landfill. AREEs 2 and 5 are sites of former landfills where transformers, capacitors, and metal debris were buried. These disposal areas are located adjacent to each other, and the proximity of these AREEs to each other is such that they were considered to be one study area. AREE 3 is approximately 100 feet by 25 feet and is located south and west of the ephemerial pond on the east side of Lake Drive. The burial of debris, such as wood, lead-coated wire, paper, and plastic at AREE 3 reportedly began in 1966 and continued until the area was covered with soil in 1973 (Weston, 1992). AREE 4 is a former dump site where debris, such as wire, wood, concrete, pipe insulation, and empty oil drums, were dumped from the late 1950s until 1973 when the dump was covered with dirt (Weston, 1992). AREE 6A is a former dump area located west of Deephole Point Road and south of Lake Drive. Contents of previous disposal at AREE 6A are unknown. AREE 6B is also a former dump located west of Deephole Point Road, east of Marumsco Creek, and immediately south of AREE 7. Disposed materials at AREE 6B have included metal debris. Finally, AREE 7 is a former pistol range located at the intersection of Deephole Point Road and Shady Lane. The range was used for small arms firing on a semi-annual basis during the 1970s.

This focused risk assessment is based on groundwater, surface and subsurface soil, sediment, and surface water data collected from OU1 during the RI conducted in 1995/1996, and sediment and test pit data collected by Earth Tech in 1993. This risk assessment is consistent with, Section 300.430(d)(4) of the NCP (40 CFR 300), which directs that a Baseline Risk Assessment be conducted "to characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to groundwater or surface water, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain." This section of the NCP was applied to the WRF OU1 risk assessment, in which human health effects associated with site-related chemicals in specific media (groundwater, surface soil, subsurface soil, sediment, and surface water) were evaluated. This risk assessment has been prepared to be consistent with guidance and standards developed by the U.S. Environmental Protection Agency (USEPA, 1986a,b, 1989a,b, 1991a, 1992a,b,c, 1996a). In addition, the methodologies for conducting the risk assessment have been discussed with USEPA Region III and the VADEQ in correspondence and a meeting.

The remainder of this risk assessment is organized as follows:

- Identification of COPCs (Section 3.2). The chemicals detected in groundwater, surface soil, subsurface soil, sediment, and surface water are identified and discussed. The analytical data are summarized by presenting the frequency of detection and the range of detected concentrations in site and background samples. COPCs are selected for quantitative evaluation in the human health risk evaluation based on an evaluation of the data, a comparison of maximum site concentrations to USEPA Region III RBCs, and a comparison of site and background concentrations for inorganic chemicals.
- Human Exposure Assessment (Section 3.3). The potential pathways through which individuals may be exposed to COPCs in groundwater, surface soil, subsurface soil, sediment, and surface water are discussed and exposure pathways are selected for evaluation. The chemical concentrations at the points of potential exposure are presented for each pathway

selected for quantitative evaluation. Assumptions are made for the magnitude, frequency, and duration of exposure for each pathway and potential exposures (intakes) are then quantified.

- Toxicity Assessment (Section 3.4). The potential toxicity of chemicals to humans and the chemical-specific health effects criteria to be used in the quantitative assessment are presented.
- Risk Characterization (Section 3.5). Quantitative risk estimates are developed for each exposure pathway selected for evaluation by combining the toxicity criteria with estimated intakes of potentially exposed individuals.
- Uncertainties (Section 3.6). Major sources of uncertainty in the HHRA are discussed.
- Summary and Conclusions (Section 3.7). The HHRA is summarized and the conclusions are presented.

3.2 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

This section of the risk assessment discusses the methodology used to summarize the data (Section 3.2.1) and the methodology used to select COPCs for detailed evaluation in the HHRA (Section 3.2.2). The summarization of data and the selection of COPCs are then presented for each medium in Sections 3.2.3 through 3.2.7. Finally, a summary of the COPCs selected in all media is provided in Section 3.2.8.

3.2.1 Methodology for Data Summary

The first step in the risk assessment process was to summarize the analytical data collected during the RI.[1] The following steps, which are in accordance with USEPA (1989a) guidance, were used to summarize the analytical data for this risk assessment:

- Analytical data were summarized by environmental medium (i.e., groundwater, surface soil, subsurface soil, sediment, and surface water). The data summary for each environmental medium is described later in this section.
- Analytical data were compared to blank (laboratory, field, and trip) concentration data. If the detected concentration in a site-related sample was less than 10 times (for common laboratory contaminants) or five times (for all other compounds) the concentration in the corresponding blank sample, the sample was qualified with a B, indicating that the analyte was found in the method blank (laboratory) or quality control (QC) blank (field and trip) as well as the sample. In accordance with USEPA Region III, B-qualified data were rejected and were not used to determine the arithmetic mean of detected concentrations.
- Data from duplicate samples (samples collected from the same sample location at the same time) were averaged together and treated as one result. If a chemical was detected in only one of two duplicate samples, the detected value was averaged with one-half the quantitation limit of the nondetect sample, and the result was counted as one detect sample.
- Mean chemical concentrations for a given medium were calculated by averaging the detected concentrations with one-half the detection limit of the nondetect sample. One-half the detection limit is typically used in RAs (USEPA, 1989a) when averaging non-detect concentrations because the actual value can be between zero and a value just below the detection limit. This procedure also was used when the non-detect sample quantitation limit was two or more times higher than the maximum detected concentration in that medium. The uncertainties associated with using one-half the detection limit for non-detects will be discussed in the uncertainty section of the report (Section 3.6).

[1]It should be noted that additional validation to the data is planned, and will be conducted by an independent contractor at a later date. The results of the Data validation will be incorporated into the Final FFS.

- Frequency of detection was calculated as the number of samples in which the chemical was detected over the total number of samples analyzed for the particular chemical. The frequency of detection was determined after the averaging of duplicate sample results.

3.2.2 Selection of Chemicals of Potential Concern

Once the sampling data from OU1 were grouped and summarized, COPCs were selected. The purpose of selecting COPCs is to identify those chemicals that are present as a result of past activities at the site and most likely to be of concern to human health. Therefore, a screening process was used in the HHRA to eliminate: (1) chemicals present at concentrations below levels of concern (as represented by an RBC screening); (2) chemicals present at or below naturally occurring background levels; or (3) essential human nutrients that were present at concentrations below levels of concern. The following methodology was used to conduct these screenings.

- The maximum detected concentrations of organic and inorganic compounds were compared to USEPA Region III residential RBCs, in accordance with Region III guidance (USEPA, 1996a). The RBCs are health-protective chemical concentrations that are back-calculated using toxicity criteria, a $1x10^{-6}$ target risk level or a 0.1 hazard index, and conservative exposure parameters. A hazard index of 0.1, instead of 1.0, was used to ensure that compounds that could combine to result in a hazard index greater than 1.0 were not eliminated from evaluation. If the maximum detected on-site chemical concentration was less than the relevant RBC, the probability of contracting cancer would be less than 1 in 1 million and adverse non-carcinogenic effects would not be expected to occur. As a result, these chemicals were eliminated from further evaluation.

  Residential soil RBCs were used to screen chemicals detected in soil, since residential exposures were evaluated in the risk assessment (see Section 3.3). Because no RBCs exist for sediment exposures, residential soil RBCs also were used for comparison to sediment concentrations. Tap water RBCs were used to screen chemicals in groundwater, and because RBCs are not available for surface water, tap water RBCs also were conservatively used for comparison to surface water chemical concentrations, even though the surface water from OU1 is not used for drinking water purposes.

  RBCs are not available for four essential human nutrients (i.e., calcium, magnesium, sodium, and potassium). These chemicals were eliminated as COPCs if they were present at concentrations that would not be likely to cause adverse effects (i.e., below allowable daily intake [ADI] levels). RBCs are not available for lead, since no toxicity criteria exist for this chemical. Therefore, other available lead screening criteria were used instead of RBCs for the purposes of screening lead in the risk assessment. For soil and sediment, the residential soil screening level of 400 mg/kg (USEPA, 1994a) was used, while for groundwater and surface water, the lead action level of 15 µg/L was used (USEPA, 1990a). RBCs for all chemicals detected at OU1 are presented in Table 3-1 for groundwater and surface water and Table 3-2 for soil and sediment.

- In accordance with USEPA (1989a), inorganic chemicals present at naturally occurring background levels may be eliminated from the quantitative risk assessment. Therefore, this additional screening was conducted for inorganic compounds that were elevated above RBC levels. In order to determine if detected levels of inorganic compounds present at concentrations exceeding RBCs were representative of naturally occurring background levels, on-site data were statistically compared to site-specific background data for each medium where at least five site and five background samples were available. In cases where fewer than five site and five background samples were available, a statistical comparison was not conducted, and the inorganic chemical was selected as a COPC.

  The site and background data were first tested using the Shapiro-Wilks test to determine the distribution type of the data sets. For normally or log-normally distributed data, a two-tailed variance ratio test (the F test) was performed to determine if the variances of the on-site and background data sets were similar. If the variances for the two data sets were found to be similar, then the one-tailed pooled variance t-test was considered appropriate to test for

similarity between on-site and background levels. If on-site and background variances were found to differ significantly, or if the data were determined to be neither normally nor log-normally distributed, then a nonparametric test (the one-tailed Mann-Whitney test) was used to test for similarity between on-site and background levels. All statistical tests were performed using a significance level of 95% (alpha = 0.05) and are described in detail by Zar (1984). Statistical tests for log-normally distributed data were performed using natural log-transformed monitoring data. Those inorganic compounds that were considered to be statistically within background levels were eliminated as COPCs.

In accordance with USEPA Region III policy, inorganic compounds that were present at concentrations within background levels, but greater than their RBCs, were evaluated separately from risks associated with COPCs that both exceeded background and RBCs. Risks for these chemicals are presented in the Uncertainty Section.

- Some analytes collected during the sampling events were not presented nor evaluated in the risk assessment, including TPH (for which no toxicity criteria are available) and some water and sediment quality parameters (e.g., moisture and TOC for sediment and subsurface soil samples).

The following sections summarize the groundwater, surface soil, subsurface soil, sediment, and surface water data collected from OU1 and used in the risk assessment. The data summaries provide the frequency of detection, the mean sample size, the arithmetic mean, the range of chemical-specific detection limits, the range of detected concentrations, the relevant RBCs, and the range of background concentrations for all detected chemicals. Chemicals that were selected as COPCs and retained for quantitative evaluation based on the comparison to RBCs and, in some cases, a comparison of site concentrations to background concentrations, were marked with an asterisk (*) in the data summary table.

3.2.3 Groundwater

Two rounds of unfiltered groundwater data were collected from 22 newly installed wells at OU1 to determine whether contamination associated with the study area had been detected in groundwater (i.e., MW-59 and MW-60, MW-64 through MW-83). In addition, one round of unfiltered groundwater samples were collected from 11 existing wells at OU1 (i.e., MW-1 through MW-5, and MW-7 through MW-12). Groundwater data collected from the Direct Push samples collected by Earth Tech during the 1993 SI were not included in the risk assessment because these are not considered monitoring wells. The results of the sampling from the previous round (for which only limited analytes were analyzed for) indicated that acetone was detected at a concentration of 13 µg/L, far below its tap water RBC (see Table 3-1 for tap water RBCs). All wells were screened in the surficial aquifer, thus all were grouped together in the risk assessment. Groundwater samples used in the risk assessment were analyzed for target compound list (TCL) VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs (in some cases, PCTs were only analyzed for when PCBs were detected).

As discussed in Section 2.3.1 and shown in Figure 2-20, four background wells were installed at WRF, from which two rounds of groundwater samples were collected: MW-52, on the northwest side of WRF; MW-53 and MW-63, on the northern boundary of WRF, and MW-54, on the south side of Bayview Road. These samples were collected from areas that were believed to be unaffected by past activities at WRF. The range of concentrations for chemicals detected in background groundwater samples is presented in the data summary table (Table 2-1) to show how the site concentrations compare to the background levels. The background inorganics data were statistically compared to site concentrations to determine whether any of the inorganics detected in groundwater at OU1 were within background levels. Background samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, PCTs, PAHs, and TAL metals.[2]

[2] It should be noted that organic compounds were detected in two of the background groundwater wells. However, as discussed earlier in Section 3.2.2, the comparison to background was conducted only for inorganics, and no organics were screened out due to the presence of organics in background samples.

The data summary for chemicals detected in groundwater from OU1 is presented in Table 3-3. As shown in Table 3-3, 31 organics, primarily PAHs and pesticides, were detected in groundwater from OU1. A comparison of maximum detected concentrations to tap water RBCs indicated that organics were present at concentrations exceeding respective tap water RBCs. The organic compounds that were selected as COPCs in groundwater were aldrin, gamma-BHC (lindane), dieldrin, bis(2-ethylhexyl)phthalate, heptachlor, heptachlor epoxide, and PCB-1016. In addition, delta-BHC does not have an RBC (since it lacks toxicity criteria), thus it was also selected as a COPC in groundwater. All of the organic COPCs were detected infrequently in OU1 groundwater (all but bis[2-ethylhexyl]phthalate were detected in 5% or fewer of the samples). Pesticides that were selected as COPCs were detected in AREEs 2/5, 6A, and 6B, while PCB-1016 was detected only in AREE 2.

Nineteen inorganic chemicals were detected in groundwater at OU1. A comparison of maximum detected inorganic concentrations to tap water RBCs (or acceptable daily intake levels for essential human nutrients and the action level for lead) indicated that the inorganics that exceeded respective tap water RBC concentrations (or other relevant screening criteria) were aluminum, arsenic, barium, chromium, iron, lead, manganese, nickel, thallium, and vanadium. All inorganics above RBCs were fairly widespread throughout OU1, with the exception of chromium, nickel, thallium, and vanadium. The next step of the selection process for inorganics was to conduct a statistical comparison of groundwater concentrations to site-specific background concentrations for those inorganic chemicals that exceeded tap water RBCs. The statistical comparison indicated that iron and manganese were detected above background levels, therefore these two inorganic chemicals were selected as COPCs in groundwater. As requested by USEPA Region III, inorganic chemicals that exceeded RBCs but were within background levels were evaluated separately from site-related chemicals. Accordingly, exposures and risks associated with aluminum, arsenic, barium, chromium, lead, nickel, thallium, and vanadium, which were greater than respective screening levels, but within background levels, were evaluated separately from site-related chemicals.

Although all groundwater samples were grouped together for this assessment, a qualitative analysis of elevated concentrations (i.e., those that exceeded their respective RBCs, or other relevant screening criteria, by a factor of ten or more) is presented on an AREE-specific basis in Section 3.5.1.1 for information purposes.

3.2.4 Surface Soil

A total of 57 surface soil samples were collected from the OU1 study area to determine whether there was surface soil contamination associated with past activities at OU1. Twenty-seven of the samples were 0-6" surface soil samples (i.e., RISS-1 through RISS-24, RISS-54 through RISS-56), 19 were 0-2' surface soil samples from borings (i.e., RISB-6, MW-59, MW-60, MW-64 through MW-71, MW-74 through MW-81), and 11 were surficial test pit samples collected during the RI from 0-2' (i.e., TP-1, TP-5, TP-7, TP-10 through TP-12, Tp-15, TP-17 through TP-20). All surficial soil samples from 0-6" and from 0-2' were grouped together in the risk assessment. All samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PCTs (in some cases, PCTs were only analyzed for when PCBs were detected). In addition, PAHs were analyzed for in all 0-6" surface soil samples.

As discussed in Section 2.3.1 and presented on Figure 2-20, five background surface soil samples (RIBKSS-1, 2, 3, 4, and 5, all collected between 0-6") were collected from locations along the northern and eastern boundary of WRF. In addition, three background 0-2' surface soil samples were collected from borings drilled on the northwest side of WRF (MW-52), on the northern boundary of WRF (MW-53), and on the south side of Bayview Road (MW-54). All background surface soil samples were collected from areas that were believed to be unaffected by past activities at WRF. The range of concentrations for chemicals detected in background surface soil samples is presented in the data summary table to show how the site concentrations compare to the background levels. The background inorganics data were statistically compared to site concentrations to see which inorganic chemicals detected in OU1 were within background levels. All background samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PCTs; in addition, surface soil samples collected from 0-6" also were analyzed for PAHs.

The data summary for chemicals detected in surface soil at OU1 is presented in Table 3-4. As shown in Table 3-4, 32 organics were detected in surface soil samples, consisting primarily of pesticides,

PAHs, and PCBs. A comparison of maximum detected concentrations to residential soil RBCs indicated that benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-c,d)pyrene, PCB-1248, PCB-1254, and PCB-1260 were detected above respective screening concentrations and were thus selected as COPCs in surface soil. PAHs were detected in roughly one-third of the samples, while PCBs were detected infrequently. PCB-1248 and PCB-1254 were each only detected in one of 57 samples (both in AREE 2), while PCB-1260 was detected in 7/57 samples (all in AREE 1).

Nineteen inorganic chemicals were detected in surface soil from OU1. A comparison of maximum detected inorganic concentrations to residential soil RBCs (or acceptable daily intake levels for essential human nutrients and the residential soil screening level for lead) indicated that aluminum, arsenic, beryllium, chromium, iron, and manganese were above respective screening levels. All inorganics above RBCs, except arsenic, were widespread, being detected in almost all samples.

The next step of the selection process was to conduct a statistical comparison of surface soil concentrations to site-specific background concentrations for those inorganic chemicals that exceeded residential soil RBCs. The statistical comparison indicated that only aluminum was present at concentrations above background levels, and thus was selected as a COPC. As requested by USEPA Region III, any inorganic chemicals that exceeded RBCs but were within background levels were evaluated separately from site-related chemicals. Accordingly, exposures and risks associated with arsenic, beryllium, chromium, iron, and manganese were evaluated separately from site-related chemicals.

Although all surface soil samples were grouped together for this assessment, a qualitative analysis of elevated concentrations (i.e., those that exceeded their respective RBCs, or other relevant screening criteria, by a factor of ten or more) is presented on an AREE specific basis in Section 3.5.1.2 for information purposes.

It should be noted that two additional surface soil samples from test pits were collected by Earth Tech from a backhoe. Because these samples could not be associated with a specific sampling depth and/or location, they were not quantitatively evaluated in the risk assessment. Chemicals detected in soil samples from the test pit samples are presented in Table 3-5. As shown in Table 3-5, only two PCB congeners were detected, each in one of the two samples. Detected concentrations, which were from AREE 1, were several times greater than residential soil RBC levels.

3.2.5 Subsurface Soil

A total of 72 subsurface soil samples were collected from the OU1 study area to determine whether there was subsurface soil contamination associated with past dumping activities at OU1. Subsurface soil samples consisted of all soil samples that were collected at depths below 2 feet from either soil borings (44 subsurface soil samples [i.e., subsurface soil samples from two depths of MW-59, MW-60, MW-64 through MW-71, MW-74 through MW-81, RISB-6,; subsurface soil samples from three depths of MW-72 and MW-73]) or test pits (28 subsurface soil samples [i.e., subsurface soil smaples from one depth of TP-1, Tp-5 through TP-7, TP-10 through TP-12, TP-15, TP-17 through TP-20; subsurface soil samples from two depths of TP-2 through TP-4, TP-8, TP-9, TP-13, TP-14, TP-16]). Samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PCTs (in some cases, PCTs were analyzed for only where PCBs had been detected).

As discussed in Section 2.0 and presented in Figure 2-20, six background subsurface soil samples were collected from borings drilled on the northwest side of WRF (MW-52), on the northern boundary of WRF (MW-53), and on the south side of Bayview Road (MW-54). All background subsurface soil samples were collected from areas that were believed to be unaffected by past activities at WRF. The range of concentrations for chemicals detected in background subsurface soil samples is presented in the data summary table to show how the site concentrations compare to the background levels. The background inorganics data were statistically compared to site concentrations to see which inorganic chemicals detected in OU1 were within background levels. All background samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, and PCTs.

The data summary for chemicals detected in subsurface soil at OU1 is presented in Table 3-6. As shown in Table 3-6, 22 organics, primarily PCBs, pesticides, and PAHs, were detected in subsurface

soil samples. A comparison of maximum detected concentrations to residential soil RBCs indicated that the organics that were present above RBC levels were benzo(a)pyrene, PCB-1248, PCB-1254, and PCB-1260. All these organics were retained as COPCs in the risk assessment. PCBs were each detected in 1/72 samples, and similar to surface soil, PCB-1248 and PCB-1254 were both detected in AREE 2, while PCB-1260 was detected in AREE 1.

Twenty inorganic chemicals were detected in subsurface soil from OU1. A comparison of maximum detected inorganic concentrations to residential soil RBCs (or acceptable daily intake levels for essential human nutrients and the residential soil screening level for lead) indicated that aluminum, arsenic, beryllium, chromium, iron, manganese, and vanadium were present above respective screening criteria. All inorganics above RBC levels, except arsenic, were fairly widespread, having been detected in most samples. The next step of the selection process was to conduct a statistical comparison of subsurface soil concentrations to site-specific background concentrations for those inorganic chemicals that exceeded residential soil RBCs. Arsenic was not detected in background samples, and thus was selected as a COPC. In addition, there were fewer than five background samples for aluminum and vanadium, so statistical comparisons could not be conducted for these chemicals, and they were retained as COPCs. In summary, aluminum, arsenic, and vanadium were selected as COPCs in the risk assessment.

As noted above, any inorganic chemicals that exceeded RBCs but were within background levels were evaluated separately from site-related chemicals. Accordingly, exposures and risks associated with beryllium, chromium, iron, and manganese were evaluated separately from site-related chemicals.

A qualitative analysis of elevated concentrations (i.e., those that exceeded their respective RBCs, or other relevant screening criteria, by a factor of ten or more) was performed for subsurface soil samples for information purposes. It was determined that all chemical concentrations were less than five times their respective screening criteria, therefore no further analysis was performed. Industrial soil RBCs were used to screen subsurface soil data since exposure to subsurface soil would likely occur for excavation workers only.

3.2.6 Sediment

A total of 12 sediment samples (i.e., RISD-10 through RISD-21) were collected from the OU1 study area to determine whether runoff from the OU had resulted in sediment contamination. Samples RISD-10 through RISD-12 were collected in marshy areas, while the remaining sediment samples were collected in more open water areas. All samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs.

In addition, sediment data collected at AREE 2 by Earth Tech were reviewed to determine whether these data should be incorporated into the risk assessment. A review of the sediment data indicated that only two PCB hits were detected in sediment from the Earth Tech data; accordingly, these two sample results were incorporated into the data summarization for OU1 sediment.

Based on exposure considerations discussed later in Section 3.3, the sediment data were grouped according to whether the samples had been collected in open water areas or in marshy areas. Sediment samples RISD-10 through RISD-12, as well as the two Earth Tech samples were grouped together as samples collected in the Marsh Area, while the remaining sediment samples (i.e., RISD-13 through RISD-21) were grouped together as Open Water sediment samples.

As discussed in Section 2.3.1 and shown in Fugure 2-21, five background sediment samples (RISDBK1 through RISDBK5) were collected from Mason Neck Wildlife Refuge, which is located away from potential source areas and unaffected by past activities at WRF. The range of concentrations for chemicals detected in background sediment samples is presented in the data summary table for both sediment groupings to show how the site concentrations compare to the background levels. The background inorganics data were statistically compared to site concentrations for the larger Open Water Area grouping, which included five samples. The statistical comparison could not be conducted for the Marsh Area grouping where only three samples were available (as noted above, the Earth Tech samples only had PCB results, and no inorganics results, thus the two Earth Tech samples were not used to statistically compare site and background inorganics concentrations). Background sediment samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, PAHs, and PCTs.

The data summary for chemicals in both sediment groupings is presented in Table 3-7. As shown in Table 3-7, 13 organics, consisting of PCBs and PAHs, were detected in sediment samples collected in the Marsh Area, while 19 organics, consisting of PCBs, PAHs, and pesticides, were detected in the Open Water Area grouping. A comparison of maximum detected concentrations to residential soil RBCs indicated that only benzo(a)pyrene and PCB-1260 in both the Marsh and Open Water Areas were present at concentrations above respective RBCs. These two organics were therefore selected as COPCs in both groupings.

Sixteen inorganic chemicals were detected in sediment from both the Marsh and Open Water Area groupings. A comparison of maximum detected inorganic concentrations to residential soil RBCs (or other respective screening concentrations) indicated that the same five inorganics (aluminum, beryllium, iron, manganese, and vanadium) were detected above screening concentrations in both groupings. The five inorganics above RBC levels were widespread in both groupings, having been detected in most sediment samples for which they were analyzed for.

The next step of the selection process was to conduct a comparison of sediment concentrations to site-specific background concentrations for those inorganic chemicals that exceeded residential soil RBCs. A statistical comparison was conducted only for samples in the Open Water Area grouping (with the exception of aluminum, for which too few samples were available to statistically compare site and background samples); too few samples were available in the Marsh Area Grouping with which to conduct a statistical comparison of site and background data. Therefore, all inorganics that were above RBC levels in the Marsh Area grouping were selected as COPCs. The statistical comparison of samples from the Open Water Area grouping indicated that all inorganics present above RBC levels were within background concentrations. As noted above, however, fewer than five aluminum samples were available with which to conduct statistical comparisons, thus aluminum in the Open Water grouping was selected as a COPC.

As noted above, inorganic chemicals that exceeded RBCs but were within background levels were evaluated separately from site-related chemicals. Accordingly, exposures and risks associated with beryllium, iron, manganese, and vanadium in the Open Water Area grouping were evaluated separately from site-related chemicals.

Although sediment samples were grouped into Marsh and Open Water Areas for this assessment, a qualitative analysis of elevated concentrations (i.e., those that exceeded their respective RBCs, or other relevant screening criteria, by a factor of ten or more) is presented on an AREE specific basis in Section 3.5.1.4.

3.2.7 Surface Water

Surface water samples from OU1 were collected at the same locations as the sediment samples, and were grouped in the same manner: RISW10 through RISW12 were grouped together (Marsh Area grouping), and RISW13 through RISW21 were grouped together (Open Water Area grouping). Only unfiltered (i.e., total) inorganics surface water concentrations were collected from site and background locations. Surface water samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL inorganics, PAHs, and PCTs. It should be noted that Earth Tech data were not available for surface water in the two locations where sediment data were collected.

As discussed in Section 2.3.1 and presented in Figure 2-21, five background surface water samples (RISWBK1 through RISWBK5) were collected from the same locations as the background sediment samples, away from potential source areas and unaffected by activities at WRF. The range of concentrations for chemicals detected in background surface water is presented in the data summary table for both surface water groupings to show how the site concentrations compare to the background levels. Background inorganics data were statistically compared to site concentrations to determine which inorganics could be considered within background levels. Background samples were analyzed for TCL, VOCs, SVOCs, pesticides/PCBs, PAHs, and TAL metals.

As shown in Table 3-8, no organics were detected in surface water from either of the surface water groupings at OU1. From the Marsh Area grouping, eight inorganics were detected, of which iron and manganese were above respective tap water RBCs. As noted earlier for sediment, too few samples

were available in the Marsh Area grouping with which to statistically compare site and background data. Therefore, both inorganics from the Marsh Area were selected as COPCs.

Also shown in Table 3-8, 13 inorganics were detected in surface water from the Open Water Area grouping. A comparison of detected concentrations to tap water RBCs indicated that aluminum, iron, and manganese were detected above respective RBCs. Because an adequate number of site and background samples were available, a statistical comparison of site and background inorganics concentrations was conducted. The statistical comparison of site concentrations to background levels indicated that the concentration(s) of all three inorganics were within background levels, thus exposures to these inorganics were evaluated separately from site-related chemicals.

A qualitative analysis of elevated concentrations (i.e., those that exceeded their respective RBCs, or other relevant screening criteria, by a factor of ten or more) was performed for surface water samples in OU1. It was determined that all chemical concentrations were less than ten times their respective screening criteria, therefore no further analysis was performed.

3.2.8 Summary of Chemicals of Potential Concern

Table 3-9 summarizes the COPCs in all media sampled at OU1. As shown in this table, PCBs were the only COPCs that were in both soil and groundwater, while pesticides were selected as COPCs only in groundwater. PAHs were selected as COPCs in soils and sediment. With respect to inorganic COPCs, there were no COPCs that were consistently selected in all media.

3.3 EXPOSURE ASSESSMENT

In this section, the potential pathways through which individuals may be exposed to COPCs in groundwater, surface soil, subsurface soil, sediment, and surface water from OU1 are identified and exposures are quantified. A definition of an exposure pathway (Section 3.3.1) is followed by a discussion of potential exposure pathways through which populations could be exposed to COPCs at OU1 (Section 3.3.2). The potential exposure pathways through which humans could currently be exposed to contamination resulting from past activities at OU1 are discussed below for each exposure medium. In order to place this discussion into perspective, a description of OU1 is first presented, which provides some background for the exposure pathway analysis.

In general, the area surrounding WRF is residential. Northwest of WRF are former Army housing units, which are currently used as civilian residential housing. Directly to the north, there is a proposed civilian residential development and a golf course. The Occoquan and Belmont Bays are located south and west, respectively, and are popular for recreation.

As discussed in Section 3.1, OU1 is bounded on the south by the Occoquan Bay, on the west by Lake Drive, and on the east by Deephole Point Road. Currently, there are few receptors to potential contamination at OU1. The principal current potential receptors at OU1 include individuals performing WRF maintenance activities and visitors involved with birding activities along the bay area. The main activities at WRF, where the most receptors would be located, are in the main compound area, towards the center of WRF.

According to USEPA (1995a), a risk assessment evaluating potential future exposures should reflect the most reasonably anticipated future land-uses. WRF will be transferred to the USFWS in the near future, and it is assumed that the land-use at the site would not likely change significantly, with the most likely receptors being USFWS workers, visitors, and individuals involved in environmental education. Nevertheless, in accordance with USEPA Region III and the VADEQ and to provide a baseline understanding of worst-case risks, it was assumed that residential receptors could potentially reside at OU1.

In order to streamline the risk assessment process, and in accordance with the state and federal regulators, only the most conservative possible receptor at OU1 (i.e., a future resident for exposures to surface soil, sediment, surface water, and groundwater, and a future excavation worker for exposures to subsurface soil) was evaluated for the purposes the assessment. Evaluating a resident and an excavation worker provides a highly conservative evaluation, because all other potential receptors would have lower exposures, and therefore, lower risks. The exposure scenarios evaluated in the risk

assessment assume that no remedial action occurs (i.e., the no action alternative). For each pathway selected for quantitative evaluation, the COPC concentrations at the points of exposure are estimated, followed by the methodology for calculating potential chemical intakes (Section 3.3.3).

3.3.1 Potential Exposure Pathways

An exposure pathway describes the course a chemical takes from the source to the exposed individual. It is defined by four elements:

- a source and mechanism of chemical release to the environment;
- an environmental transport medium (e.g., soil) for the released chemical;
- a point of potential contact with the contaminated medium (referred to as the exposure point); and
- an exposure route (e.g., ingestion) at the contact point.

An exposure pathway is considered complete only if all four elements are present, and only complete exposure pathways will be quantitatively evaluated. In the following sections, information presented previously about COPCs at OU1 is combined with information on population locations, activity patterns, and land use to identify potential human exposure pathways at OU1.

3.3.2 Pathways Selected for Evaluation

Potential exposure pathways through which future receptors could be exposed to COPCs at OU1 are discussed below and are presented in Table 3-10. Table 3-10 presents the exposure media, exposure points, potential receptors, and exposure routes; indicates whether the pathway is retained for evaluation; and provides the basis for selecting or excluding the pathway. As stated previously, exposures to only future residential receptors and future excavation workers were evaluated, in order to provide a baseline understanding of worst-case exposures.

3.3.2.1 Groundwater

Future on-site child and adult residents were assumed to be exposed to COPCs in groundwater. Potentially complete pathways for both child and adult on-site residents include ingestion of drinking water and dermal absorption of COPCs in groundwater while bathing. In addition, inhalation of VOCs while showering was considered for evaluation. However, because no volatile organic compounds were selected as COPCs in groundwater, inhalation exposures while showering were not evaluated. It should be noted that the use of groundwater at OU1 is considered to be highly unlikely, due to high iron levels, necessitating treatment prior to consumption.

3.3.2.2 Surface Soil

Future child and adult residents were assumed to contact and be exposed to COPCs in surface soil. Children could contact COPCs in surface soil while playing, while adults could contact COPCs in surface soil while gardening or performing other activities. Potentially complete exposure pathways for child and adult residents would be incidental ingestion of soil and dermal absorption of chemicals in soil. Therefore, both pathways were evaluated for hypothetical future child and adult residents.

3.3.2.3 Subsurface Soil

It is unlikely that future residents would have significant opportunity to contact soil more than 2 feet below the surface. It is more likely that children and adults would primarily come into contact with the top 2 feet of soil, rather than soil at greater depths. Therefore, exposures to subsurface soil would not be likely to occur for residents and were not evaluated. However, if the site were to become residential, or if other development at OU1 were to occur, it is possible that all or portions of OU1 could be excavated and that excavation workers could come into intimate contact with subsurface soil. Accordingly, incidental ingestion, dermal absorption, and inhalation of chemicals in subsurface soil were quantitatively evaluated in the risk assessment for hypothetical future excavation workers.

3.3.2.4 Sediment

If WRF were to become residential in the future, child residents could play along the shoreline and be exposed to COPCs in sediment at OU1. Therefore, it was assumed that child residents could come into contact with sediment on a regular basis while wading or playing and be exposed to COPCs in sediment via incidental ingestion and dermal absorption. Although adult residents also could be exposed to COPCs in sediment, frequent exposures are considered much more unlikely, since adults would not be as likely to spend as much time wading/recreating along the shoreline. In addition, it should be noted that it is more conservative to evaluate child residents for this pathway, as opposed to adult residents, due to the higher ingestion rate per body weight for the child resident.

As noted earlier in the summary of COPCs selected for evaluation in sediment, the sediment samples were grouped according to whether they were collected in the Marsh Area of OU1 or in the Open Water Area of OU1. Although it is possible that children could come into contact with sediment in the Marsh Area and incidentally ingest and dermally absorb chemicals in sediment, it is not likely that they would have significant exposures to chemicals in sediment from the Open Water Areas, since samples were collected below several feet of water. Therefore, exposures only to sediment from the Marsh Area were evaluated in the risk assessment.

3.3.2.5 Surface Water

Future residents could be exposed to COPCs in surface water while wading or swimming. It would be more likely for adults to be swimming in the bay than small children. Conversely, it would be more likely for children to wade and play in the Marsh Area than adults. Accordingly, it was assumed that adults could be exposed to COPCs in surface water via incidental ingestion and dermal absorption while swimming in the Open Water Area, while children could be exposed to COPCs in surface water from the Marsh Area while wading (it should be noted that no COPCs were selected for the Open Water Area grouping; however, because several inorganics were detected within background levels, but above RBCs, this pathway was nevertheless evaluated for those chemicals).

3.3.2.6 Summary of Pathways Selected for Evaluation

The exposure pathways quantitatively evaluated are the following:

- Ingestion of COPCs in groundwater by on-site child and adult residents;
- Dermal absorption of COPCs in groundwater by on-site child and adult residents while bathing;
- Incidental ingestion of COPCs in soil by on-site child and adult residents;
- Dermal absorption of COPCs in soil by on-site child and adult residents;
- Incidental ingestion of COPCs in subsurface soil by excavation workers;
- Dermal absorption of COPCs in subsurface soil by excavation workers;
- Inhalation of COPCs in airborne particulate matter from subsurface soil by excavation workers;
- Incidental ingestion of COPCs in sediment from the Marsh Area grouping by on-site child residents;
- Dermal absorption of COPCs in sediment from the Marsh Area grouping by on-site child residents;
- Incidental ingestion of COPCs in surface water from the Open Water Area by on-site adult residents while swimming;
- Dermal absorption of COPCs in surface water from the Open Water Area by on-site adult residents while swimming; and
- Dermal absorption of COPCs in surface water from the Marsh Area by on-site child residents while wading.

3.3.3 Quantification of Exposure

To quantitatively assess potential exposures to COPCs at OU1, estimates of environmental concentrations at the exposure points were combined with information describing the extent, frequency, and duration of exposure for each potential receptor. This section presents how exposure point concentrations were calculated, followed by an overview of the approaches used to quantify exposures for each selected exposure pathway. The approaches used in this section to quantify exposures are consistent with USEPA (1989a, 1992a) guidance.

3.3.3.1 Exposure Point Concentrations

In order to estimate potential exposures and risks associated with site-related chemicals, chemical concentrations at the points of exposure were first determined. According to USEPA (1992a,c), the most appropriate measurement of central tendency for environmental chemical concentrations is the arithmetic mean. To account for uncertainty associated with this value, USEPA guidance requires the use of the 95% upper confidence limit (UCL) on the arithmetic mean concentration for the estimation of the reasonable maximum exposure (RME) risk. The term RME is defined as the maximum exposure that is reasonably expected to occur at a site (USEPA, 1989a). The methodology for calculating the UCL for logtransformed data, which is discussed by Gilbert (1987) and Land (1975), and is presented in USEPA guidance documents (1992a,c), is as follows:

$$UCL_{1-\alpha} = \exp\left(y + 0.5 s_y^2 + \frac{s_y * H_{1-\alpha}}{\sqrt{n-1}}\right)$$

where:

UCL = upper confidence limit;
α = probability of error (0.05);
y = mean of the transformed data;
s_y = standard deviation of the transformed data;
$(s_y)^2$ = variance of the data;
H = H-statistic (i.e., from Gilbert 1987); and
n = number of samples in population.

When the 95% UCL exceeds the maximum measured value, USEPA (1989a) directs that the maximum measured value be used as the exposure point concentration.

As discussed earlier in Section 3.2.1, the 95% UCL on the arithmetic mean was calculated for each chemical by including nondetects at one-half of their sample-specific detection limits. The RME concentrations of each COPC were assumed to represent the concentrations to which receptors could be exposed at OU1. All RME exposure concentrations are presented in Table 3-11.

3.3.3.2 Exposure Estimates

For the ingestion and dermal absorption exposure pathways, quantification of exposure involves the estimation of an average daily dose, expressed in units of mg chemical/kg body weight per day (mg/kg-day). Dose can be defined as an exposure rate to a chemical determined over an exposure period per unit body weight, and is calculated similarly for both ingestion and dermal absorption pathways. There are, however, significant differences in the meaning and terms used to describe dose for the ingestion and dermal pathways. For the ingestion exposure pathways, the doses calculated in this assessment are referred to as "potential doses." The potential dose is the amount of chemical ingested and available for uptake in the body, and is analogous to the administered dose in a dose-response toxicity experiment. For the dermal absorption pathways, the estimated dose is referred to as an "internal dose," and reflects the amount of chemical that has been absorbed into the body and is available for interaction with biologically important tissues.

Average daily doses are estimated differently for chemicals exhibiting noncarcinogenic and carcinogenic effects, since different toxicity criteria are available for carcinogenic effects and

noncarcinogenic effects of chemicals (see Section 3.4, Toxicity Assessment). Average daily doses for noncarcinogens are averaged over the duration of exposure and, following USEPA (1992a) guidance, are given the acronym ADD for average daily dose. Average daily doses for carcinogens are averaged over a lifetime, and are given the acronym LADD for lifetime average daily dose. LADDs and ADDs for ingestion exposures, or potential doses, are indicated by (L)ADD_{pot}, while LADDs and ADDs for dermal exposures, or internal doses, are indicated by (L)ADD_{int}.

The ADDs and LADDs are estimated using exposure point concentrations of chemicals together with exposure parameters that specifically describe the exposure pathway. ADDs and LADDs for each pathway were derived by combining the selected exposure point concentration (based on the maximum or the 95% UCL on the mean concentration) of each chemical with reasonable maximum values describing the extent, frequency, and duration of exposure (USEPA, 1989a,1992a).

The following sections present equations by which (L)ADDs were calculated for those pathways quantitatively evaluated in the risk assessment. The assumptions associated with calculating these exposures and the equations used to estimate $ADDs_{pot}$ and $LADDs_{pot}$ for ingestion exposures and $ADDs_{int}$ and $LADDs_{int}$ for dermal absorption exposures are provided below. It was conservatively assumed that the chemical concentrations in groundwater, surface soil, subsurface soil, sediment, and surface water would remain constant over the exposure period.

Ingestion of Groundwater by On-Site Child and Adult Residents. Exposures for ingestion of groundwater by on-site child and adult residents were calculated using the equation and exposure parameters presented in Table 3-12 and discussed below.

The RME exposure point concentrations to which on-site residents could be exposed were presented earlier in Table 3-11. Drinking water ingestion rates used for residents were based on USEPA guidance. The adult ingestion rate of 2 L/day was a standard USEPA (1989a, 1991a) default value, while the child 1 L/day ingestion rate was based on one-half the adult ingestion rate. Child and adult residents were conservatively assumed to consume groundwater for 350 days/year, which is an USEPA (1989a, 1991a) standard default value for seven days/week, 50 weeks/year. The duration of exposure for the 1-6 year old child resident was assumed to be six years, based on the child's age duration being evaluated, while the duration of exposure for the adult resident was assumed to be 30 years, which is the USEPA (1989b) upper-bound value for residential tenure at one residence.

The body weight value of 70 kg for an adult resident was the standard USEPA (1989a, 1991a) recommended default parameter, while the body weight value of 15 kg for the 1-to-6 year old child was obtained from USEPA (1991a). The USEPA (1989a, 1991a) standard default of 70 years for a lifetime was used as the averaging time to calculate carcinogenic exposures, while the duration of exposure (i.e., 30 years for the adult and six years for the child) was used as the averaging time to calculate noncarcinogenic exposures.

The resulting LADDs for carcinogenic effects and ADDs for the noncarcinogenic effects for groundwater ingestion by future on-site child and adult residents are presented later in Table 3-28 in the Risk Characterization Section.

Dermal Absorption of Chemicals in Groundwater by On-Site Child and Adult Residents. Dermal absorption of chemicals while bathing were calculated for COPCs selected in groundwater by using the equation and exposure parameters presented in Table 3-13.

The groundwater concentrations to which on-site residents could be exposed while bathing were the same as used for the drinking water exposure pathway. Unfiltered inorganic concentrations were used to evaluate the dermal pathway, in accordance with USEPA Region III protocol, even though it is more likely that chemicals in the dissolved phase, rather than the total particulate phase would be absorbed through the skin. When estimating potential child and adult dermal exposures while bathing, it was assumed that the entire body was available for contact with water. The surface areas that were used in the evaluation were calculated based on data provided in USEPA (1985), and were 7,000 cm^2 for a 1-6 year old and 18,000 cm^2 for an adult. It was also assumed that the resident takes bathes once per day (i.e., 1 event per day). In addition, exposure

parameters including exposure frequency, exposure duration, body weight, and averaging time were identical to those used when evaluating the groundwater ingestion pathway.

The dose absorbed per unit area per event is a function of chemical concentration in water, the permeability coefficient for that chemical from water through the skin, and exposure time. The dose absorbed (DA) value is calculated differently, depending on whether a steady-state or nonsteady-state approach is used. Following USEPA (1992b) guidance, a steady-state approach should be used to evaluate dermal absorption of inorganics from an aqueous matrix, while a nonsteady-state approach has been recommended to evaluate dermal absorption of organics in an aqueous matrix.

When calculating the absorbed dose for inorganics assuming steady-state conditions, it is assumed that the concentration gradient across all skin layers is constant and the rate that a chemical enters the skin equals the rate that it exits. Under these assumptions, DA can be estimated using the following steady-state equation from USEPA (1992b):

$$DA = C_{gw} * CF_1 * CF_2 * PC * ET$$

where:

DA_{event} = dose absorbed per unit area per event (mg/cm2-event);
Cgw = chemical concentration in groundwater (µg/L);
CF1 = conversion factor (1 L/103 cm3);
CF2 = conversion factor (1 mg/103 µg);
PC = chemical-specific dermal permeability coefficient (cm/hr); and
ET = exposure time (hours/event).

The RME groundwater concentrations that were used for the ingestion pathway also were used to evaluate the dermal pathway. As noted above, total (unfiltered) concentrations were used to evaluate dermal exposures.

The permeability coefficient is defined as a flux value, normalized for concentrations, that represents the rate at which a chemical penetrates the skin (in units of cm/hr). The default permeability coefficient for inorganics was used for all evaluated inorganics (i.e, 10^{-3} cm/hr [USEPA, 1992b]). Permeability coefficients for all COPCs in groundwater are presented in Table 3-14. The assumed exposure time for contact with water was assumed to be 15 minutes (0.25 hour).

As noted above, USEPA (1992b) has recommended the nonsteady-state approach to estimate the dermally absorbed dose of organics from water and has recommended that it be used over the more traditional steady-state approach described above for inorganics. This approach accounts for the total amount of chemicals crossing the exposed (outside) skin surface rather than the amount that has traversed the skin and entered the blood during the exposure period (i.e., under a steady-state condition). Therefore, the nonsteady-state approach more accurately reflects normal exposure conditions and accounts for the dose that may enter the circulatory system after the exposure event due the storage of chemicals in skin lipids (USEPA, 1992b). The nonsteady-state approach has been developed for organics for which octanol-water partitioning data are available, thus was applied to the organic COPCs identified in this assessment.

The equations applied to derive DA using the nonsteady-state dermal dose model for organics were dependent on the length of assumed exposure time (ET) in relation to the time required after initial contact of a chemical with the skin for steady-state to be achieved (termed t^*). The value of t^* is dependent on chemical-specific properties, and the appropriate equation to derive t^* for a chemical is dependent on a dimensionless constant reflecting the partitioning properties of that chemical (USEPA, 1992b). This constant, termed B, can be derived from the octanol-water partition coefficient ($K_{o/w}$) as follows:

$$B = \frac{K_{o/w}}{10^4}$$

Once B has been derived, t^* can be calculated using the appropriate equation.

If $B \leq 0.1$, then:

$$t^* = 2.4 * \tau$$

where:

τ = lag time (hr)

If $0.1 < B < 1.17$, then:

$$t^* = (8.4 + 6 * \log B) * \tau$$

If $B \geq 1.17$, then:

$$t^* = 6 * (b - \sqrt{b^2 - c^2}) * \tau$$

where:

$$b = \frac{2}{\pi} * (1 + B)^2 - c$$

$$c = \frac{1 + 3 * B}{3}$$

The lag time (τ) is defined for the stratum corneum, the outermost layer of the skin, which is thought to provide the major resistance to the absorption into the circulatory system of chemicals deposited on the skin (USEPA, 1992b). τ can be derived from the following equation:

$$\tau = \frac{l_{sc}^2}{6 * D_{sc}}$$

where:

l_{sc} = thickness of stratum corneum (10^{-3} cm); and
D_{sc} = diffusivity of a chemical within the stratum corneum (cm2/hr).

The diffusivity of a chemical within the stratum corneum (D_{sc}) can be estimated from the thickness of the stratum corneum (l_{sc}) and the molecular weight (MW) of the chemical using the following equation:

$$\text{Log}\frac{D_{sc}}{l_{sc}} = -2.72 - 0.0061 * MW$$

Once the time until steady-state (t^*) has been derived, it can be compared to the assumed exposure time (ET) in order to select the appropriate equation to derive the dermal dose (DA). If the exposure time was less than the time until steady-state (i.e., if ET < t^*), the following equation was used:

$$DA_{event} = 2 * C_{gw} * CF_1 * CF_2 * PC * \sqrt{\frac{6 * \tau * ET}{\pi}}$$

where:

DA_{event} = dose absorbed per unit area per event (mg/cm^2-event);
C_{gw} = chemical concentration in water (µg/L);
CF_1 = conversion factor (1 L/10^3 cm^3);
CF_2 = conversion factor (1 mg/10^3 µg);
PC = chemical-specific dermal permeability coefficient (cm/hr); and
ET = exposure time (hours/event).

If the exposure time was greater than the time until steady-state (i.e., if ET > t^*), then the following equation was used:

$$DA_{event} = C_{gw} * CF_1 * CF_2 * PC * [\frac{ET}{1+B} + 2 * \tau * \frac{1+3*B}{1+B}]$$

Experimental or measured permeability coefficients (PC) provided in USEPA (1992b) were used for the organic COPCs. In the absence of measured values for organics, permeability coefficients were estimated by USEPA (1992b) using the following equation:

$$\log(PC) = -2.72 + (0.71 * \log K_{ow}) - (0.0061 * MW)$$

All inputs to equations presented above, including permeability coefficients, log K_{ow}s, and molecular weights that were needed to calculate the DA_{event} for all COPCs in groundwater are presented in Table 3-14.

The resulting $LADDs_{int}$ for the carcinogenic effects and the $ADDs_{int}$ for noncarcinogenic effects of a child's and adult's dermal absorption of chemicals while bathing are summarized in Table 3-29 of the Risk Characterization Section.

Incidental Ingestion of Surface Soil by Child and Adult Residents. Exposures for incidental ingestion of chemicals in soil for hypothetical future child and adult residents were calculated using the equation and exposure parameters presented in Table 3-15 and discussed below.

The surface soil exposure point concentrations that were used to evaluate ingestion exposures are shown in Table 3-11. The standard default value for a soil ingestion rate (100 mg/day) recommended by USEPA (1989a, 1991a) for individuals over the age of six was used for calculating potential incidental ingestion exposures for adults, while the soil ingestion rate of 200 mg/day (USEPA, 1989a, 1991a) for children under six was used to evaluate ingestion exposures for children. The exposure frequency for both child and adult residents was assumed to be 350

days/year, a standard default USEPA (1989a, 1991a) value, assuming exposures seven days/week for 50 weeks/year. The exposure duration for adults was assumed to be 30 years, which is the upper-bound value for residential tenure at one residence (USEPA, 1989b). The exposure duration for children was assumed to be six years, based on the age period evaluated.

One of the several factors affecting the dose calculation for soil ingestion is a chemical's bioavailability. Ingested chemicals present in a soil matrix may not be as readily absorbed through the gastrointestinal tract (due to their affinity to the soil particles) as chemicals ingested in the matrices administered in experimental studies (from which toxicity criteria are derived). The differences in absorption expected between the ingestion of chemicals adsorbed onto soil in comparison with typical toxicological study conditions, can be accounted for by incorporating a bioavailability factor into the exposure equation. However, for this assessment, the bioavailability factors for all the COPCs were conservatively assumed to be 1.0 (assuming that the absorption efficiency was equivalent for the toxicological study matrix and the soil matrix).

An average body weight value of 70 kg for adults was obtained from USEPA (1989a, 1991a), while the average body weight of 15 kg for children was obtained from USEPA (1991a). The USEPA (1989a, 1991a) standard default of 70 years for a lifetime was used as the averaging time for carcinogenic exposures, while the duration of exposure (i.e., 30 years for adults and six years for children) was used as the averaging time for calculating the noncarcinogenic exposures.

The calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects due to the incidental ingestion of surface soil by hypothetical future residents are summarized in Table 3-31, and later in the Risk Characterization Section.

Dermal Absorption of Chemicals in Surface Soil by Child and Adult Residents. Internal doses ($ADDs_{int}$ and $LADDs_{int}$) due to dermal absorption of chemicals in surface soil were estimated using the equation and exposure parameters discussed below and presented in Table 3-16.

The chemical concentrations in soil, as well as the parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used above when estimating incidental ingestion of surface soil by hypothetical future child and adult residents.

Parameters that are specific to the dermal exposure scenarios include the area of exposed skin, the amount of soil adhering to the skin, and amount of chemical absorbed through the skin from soil. For the residential scenario, it was assumed that the hands, ½ arms (i.e., forearms), ½ legs (i.e., lower legs), and feet would be exposed and available for contact with soil. Using data from USEPA (1985), and averaging across gender and age, it was estimated that the exposed skin surface area for child and adult residents would be 2,200 cm^2 and 6,400 cm^2. The soil-to-skin adherence factor was assumed to be 1.0 mg/cm^2-day, the reasonable upper-bound default value estimated by USEPA (1992b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal doses. For a chemical to be absorbed through the skin from soil, it must be released from the soil matrix, pass through the layers of the skin and enter into the systemic circulation. This series of events is dependent on a number of factors including the characteristics of the chemical, the concentration in the applied dose, the site of exposure, inter-individual variability, and characteristics of soil (e.g., particle size and organic carbon content). Data regarding the amount of specific chemicals that may be absorbed through the skin under conditions normally encountered in the environment (and assumed to occur for this assessment) are lacking. While a number of approaches have been developed to estimate absorption of compounds from the soil matrix, the resulting dose estimates are highly uncertain (USEPA 1992b). Despite this uncertainty, dermal absorption factors from USEPA (1995b) were used in this assessment, and include 3.2% for arsenic, 1% for other inorganics, 6% for PCBs, and 10% for other semivolatiles.

The resulting LADDs for carcinogenic effects and ADDs for the noncarcinogenic effects due to dermal absorption of COPCs in soil are summarized in Table 3-32 and in the Risk Characterization Section.

Incidental Ingestion of Subsurface Soil by Excavation Workers. Exposures for incidental ingestion of chemicals in subsurface soil by hypothetical future excavation workers were calculated using the equation and exposure parameters presented in Table 3-17 and discussed below.

Exposure point concentrations used in the exposure assessment were presented earlier in Table 3-11. The excavation worker's soil ingestion rate was assumed to be 480 mg/day, which is an USEPA (1991a) value for short-term outdoor industrial/commercial activities, and accounts for more intimate contact with loose soils. The exposure frequency for excavation workers was assumed to be 250 days/year; this value was obtained from USEPA (1989a, 1991a) and assumes that excavation workers are at OU1 for 5 days per week 50 weeks per year. The exposure duration for excavation workers was conservatively assumed to be 1 year, which assumes that all excavation work in the evaluated areas would be complete within this time period. As noted earlier, the bioavailability factors for all the COPCs were conservatively assumed to be 1.0.

An average adult body weight value of 70 kg for excavation workers was obtained from USEPA (1989a, 1991a). The USEPA (1989a, 1991a) standard default of 70 years for a lifetime was used as the averaging time for carcinogenic exposures, while the averaging time for noncarcinogenic exposures was the duration of exposure (i.e., one year).

The calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects due to the incidental ingestion of subsurface soil by excavation workers are summarized in Table 3-33 in the Risk Characterization Section.

Dermal Absorption of Chemicals in Subsurface Soil by Excavation Workers. Internal doses due to dermal absorption of chemicals in subsurface soil by hypothetical future excavation workers were estimated using the equation and exposure parameters discussed below and presented in Table 3-18.

The chemical concentrations in subsurface soil to which excavation workers could be exposed, as well as the parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used above when estimating incidental ingestion of COPCs in subsurface soil by hypothetical future excavation workers.

As noted earlier, parameters that are specific to the dermal exposure scenarios include the area of exposed skin, the amount of soil adhering to the skin, and amount of chemical absorbed through the skin from soil. For the excavation worker exposure scenario, it was assumed that the worker's hands and arms could be exposed and available for contact with soil, based on the likelihood that workers at the site would wear long pants, and may wear short sleeves. Using data from USEPA (1985) and averaging across gender, an exposed skin surface area of 3,500 cm^2 was estimated. The soil-to-skin adherence factor was assumed to be 1.0 mg/cm^2-event, the reasonable upper-bound default value estimated by USEPA (1992b). Dermal absorption factors were obtained from USEPA (1995b) and are presented in Table 3-18 (3.2% for arsenic, 1% for other inorganics, 6% for PCBs, and 10% for other semivolatiles).

The resulting LADDs for carcinogenic effects and ADDs for the noncarcinogenic effects due to dermal absorption of COPCs in subsurface soil are summarized in Table 3-34 in the Risk Characterization Section.

Inhalation of Particulate Matter from Subsurface Soil by Excavation Workers. COPCs sorbed to particulate matter in subsurface soils could be released into the air during excavation activities. Inhalation exposure concentrations (IECs) associated with airborne particulate matter from subsurface soil to which excavation workers could be exposed were determined using equations provided in USEPA (1996b), the equation presented in Table 3-19, and the excavation worker exposure parameters. A default particulate emission factor (PEF) was used to calculate inhalation exposure concentrations, which are presented later in Table 3-35 of the Risk Characterization Section.

Additional exposure parameters were used to calculate the IECs, including exposure frequency, exposure duration, and averaging time, and were the same as those used to evaluate excavation

worker incidental ingestion and dermal absorption exposures to chemicals in subsurface soils. In addition, the exposure time was assumed to be 8 hours/day, based on a typical work day.

The RME IECs calculated using the modeled ambient air concentrations, in addition to LADDs for carcinogenic effects are presented in Table 3-35, later in the Risk Characterization Section (ADDs were not calculated, since none of the COPCs had noncarcinogenic inhalation toxicity criteria).

Incidental Ingestion of Sediment by Child Residents. Exposures for incidental ingestion of chemicals in sediment in the Marsh Area for hypothetical future 1-to-6 year old child residents were calculated using the equation and exposure parameters presented in Table 3-20 and discussed below.

The sediment exposure point concentrations that were used to evaluate ingestion exposures for sediment are shown in Table 3-11. The standard default value for a soil ingestion rate of 200 mg/day (USEPA, 1989a, 1991a) for children under six was used to evaluate incidental ingestion exposures of sediment for children. The exposure frequency for child residents playing/wading in OU1 sediment was assumed to be 100 days/year, based on exposures two days/week for 50 weeks/year. The exposure duration for children was assumed to be six years, based on the age period evaluated. As noted earlier, the bioavailability factors for all the COPCs were conservatively assumed to be 1.0.

An average body weight value of 15 kg for children was obtained from USEPA (1991a). The USEPA (1989a, 1991a) standard default of 70 years for a lifetime was used as the averaging time for carcinogenic exposures, while the duration of exposure (i.e., six years) was used as the averaging time for calculating the noncarcinogenic exposures.

The calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects due to the incidental ingestion of sediment by hypothetical future child residents are summarized in Table 3-36 of the Risk Characterization Section.

Dermal Absorption of Chemicals in Sediment by Child Residents. Exposures due to dermal absorption of chemicals in Marsh Area sediment were estimated for hypothetical future child residents using the equation and exposure parameters discussed below and presented in Table 3-21.

The chemical concentrations in sediment, as well as the parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used above when estimating incidental ingestion of sediment by hypothetical future child residents at OU1.

As noted earlier, parameters that are specific to the dermal exposure scenarios include the area of exposed skin, the amount of sediment adhering to the skin, and amount of chemical absorbed through the skin from sediment. For the child resident exposure scenario, it was assumed that the child's hands, ½ arms (i.e., forearms), ½ legs (i.e., lower legs), and feet could be exposed and available for contact with sediment. Based on data provided in USEPA (1985), the resulting body surface area was 2,200 cm^2. Because no sediment-to-skin adherence factor exists, the soil-to-skin adherence factor of 1.0 mg/cm^2-event, which is the reasonable upper-bound default value estimated by USEPA (1992b), was used. The amount of chemical in sediment absorbed through the skin must be estimated in order to calculate dermal doses. The dermal absorption factors for COPCs are presented in Table 3-21 (1% for inorganics, 6% for PCBs, and 10% for other semivolatiles), and were obtained from USEPA (1995b).

The resulting LADDs for carcinogenic effects and ADDs for noncarcinogenic effects due to dermal absorption of COPCs in sediment at OU1 are summarized in Table 3-37 in the Risk Characterization Section for hypothetical future child residents.

Incidental Ingestion of Surface Water by Adult Residents While Swimming. Exposures for incidental ingestion of surface water by adult residents while swimming were calculated using the equation and exposure parameters presented in Table 3-22 and discussed below.

The RME exposure point concentrations to which adult residents could be exposed were presented earlier in Table 3-11. The incidental ingestion rate of 0.05 L/hour obtained from USEPA (1989a)

was used for individuals swimming in the Open Water Area in the vicinity of OU1. Adult residents were conservatively assumed to swim in the water 2 hours/day, 48 days/year, which assumes that they swim in the bay for three days/week during the summer months from June through August. The duration of exposure for the adult resident was assumed to be 30 years, based on the USEPA (1989b) upper-bound value for residential tenure at one residence.

The body weight value of 70 kg for the adult was obtained from USEPA (1991a). The USEPA (1989a, 1991a) standard default of 70 years for a lifetime was used as the averaging time to calculate carcinogenic exposures, while the duration of exposure (i.e., 30 years for the adult) was used as the averaging time to calculate noncarcinogenic exposures.

The resulting ADDs for the noncarcinogenic effects (only ADDs were calculated, since none of the COPCs has carcinogenic toxicity criteria) for incidental ingestion of surface water by future adult residents are presented in Table 3-47 in the Uncertainty Section. None of the chemicals evaluated in the Open Water grouping were COPCs, since all were above RBCs, but within background levels.

Dermal Absorption of Chemicals in Surface Water by Adult Residents While Swimming. Dermal absorption of chemicals while swimming in Open Water in the vicinity of OU1 for hypothetical future adult residents were calculated by using the equation and exposure parameters presented in Table 3-23 and discussed below.

The surface water RME exposure point concentrations to which adult residents could be exposed are presented on Table 3-11 and are the same concentrations as used to evaluate incidental ingestion of surface water while swimming. In addition, exposure parameters including exposure frequency, exposure duration, body weight, and averaging time were identical to those used to evaluate incidental ingestion exposures while swimming. When estimating potential adult dermal exposures while swimming, it was assumed that the entire body surface area (excluding the head) of 14,000 cm^2 for the adult was exposed and available for absorption of chemicals from water.

As described earlier in the discussion of dermal absorption of COPCs in groundwater, the dose absorbed per unit area per event is a function of chemical concentration in water, the permeability coefficient for that chemical from water through the skin, and exposure time. Inorganics were assumed to have default permeability coefficients of 10^{-3} cm/hr (USEPA, 1992b), and the exposure time was assumed to be 2 hours/event.

The resulting ADDs for noncarcinogenic effects (only ADDs were calculated, since none of the COPCs has carcinogenic toxicity criteria) of an adult's dermal absorption of chemicals in Open Water Area surface water while swimming are summarized in Table 3-48 of the Uncertainty Section. None of the chemicals evaluated in the Open Water grouping were COPCs, since all were above RBCs, but within background levels.

Dermal Absorption of Chemicals in Surface Water by Child Residents While Wading. Dermal absorption of chemicals while wading in Marsh Area surface water in the vicinity of OU1 for hypothetical future child residents were calculated by using the equation and exposure parameters presented in Table 3-24 and discussed below.

The surface water RME exposure point concentrations to which child residents could be exposed while wading in the Marsh Area are presented on Table 3-11. When estimating potential child dermal exposures while wading, it was assumed that the hands, ½ arms, ½ legs, and feet (2,200 cm^2) were exposed and available for absorption of chemicals from water (USEPA, 1985). In addition, it was assumed that the child wades in the Marsh Area 48 days/year, based on exposures three days/week from June through August. Children were assumed to wade and play in the Marsh Area one time per day (i.e., one event/day). An exposure duration of six years was used for a child, based on the child's age duration being evaluated.

A body weight of 15 kg for a 1-6 year old was obtained from USEPA (1991a). The USEPA (1989a, 1991a) standard default of 70 years for a lifetime was used as the averaging time to calculate carcinogenic exposures, while the duration of exposure (i.e., six years) was used as the averaging time to calculate noncarcinogenic exposures.

As described earlier, the dose absorbed per unit area per event is a function of chemical concentration in water, the permeability coefficient for that chemical from water through the skin, and exposure time. Inorganics were assumed to have default permeability coefficients of 10^{-3} cm/hr (USEPA, 1992b), and the exposure time was assumed to be 2 hours/event.

The RME exposure point concentrations and resulting ADDs for noncarcinogenic effects of a child's dermal absorption of chemicals in Marsh Area surface water are summarized in Table 3-38 (only ADDs were calculated, since none of the COPCs has carcinogenic toxicity criteria).

3.4 TOXICITY ASSESSMENT

The general methodology for the classification of health effects and the development of health effects criteria is described in Section 3.4.1. This provides the analytical framework for the characterization of human health risks. In Section 3.4.2, the health effects criteria used to derive estimates of risk are presented. These values are combined with dose information for each pathway quantitatively evaluated to predict potential risks associated with exposures to COPCs.

The methodology used for classifying health effects from exposure to chemicals is recommended by USEPA guidance (1986a,b, 1989a, 1995c, 1996c). Chronic toxicity criteria were obtained from USEPA's Integrated Risk Information System (IRIS) (USEPA, 1996c) and Health Effects Assessment Summary Tables (HEAST) (USEPA, 1995c). These sources list the most recent toxicity values recommended by USEPA for use in HHRAs.

3.4.1 Health Effects Classification and Criteria Development

Separate health criteria are developed for chemicals depending on whether exposure to them may be associated with principally carcinogenic (cancer-causing) or noncarcinogenic effects. This distinction relates to the currently held scientific opinion that the mechanism of action for each category is different. For assessing risks associated with potential carcinogens, USEPA has adopted the scientific policy position that a small number of molecular events can evoke changes in a single cell, or a small number of cells, that can lead to tumor formation. This is described as a no-threshold initiator mechanism, because it is assumed that there is essentially no level of exposure (i.e., a threshold) to a carcinogen that will not result in some finite possibility of causing cancer. Another assumption stemming from USEPA's science policy is that the dose-response curve is linear at low doses. In reality, this curve can take many shapes depending on the exact biological mechanisms of action of a chemical. The dose-response curve will especially vary if the chemical is behaving as a cancer promotor rather than as an initiator, with the net effect that the most accurate shape may be indicative of a threshold for response.

In the case of chemicals exhibiting noncarcinogenic effects, however, it is believed that organisms have repair and detoxification capabilities that must be exceeded by some critical concentration (threshold) before the adverse effect is manifested. For example, an organ can have a large number of cells performing the same or similar functions that must be significantly depleted before the effect on the organ is realized. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without an appreciable risk of adverse effects.

3.4.1.1 Health Effects Criteria for Potential Carcinogens

For carcinogens, USEPA's Carcinogen Risk Assessment Verification Endeavor (CRAVE) evaluates the excess lifetime cancer risks associated with various levels of exposure by developing cancer slope factors and unit risks. Cancer slope factors are expressed in terms of reciprocal dose, as units of $(\text{mg chemical/kg body weight-day})^{-1}$. They describe the upper-bound increase in an individual's risk of developing cancer over a 70-year lifetime per unit of exposure. Unit risks are expressed either as a reciprocal air concentration in units of $(\mu g/m3)^{-1}$, or as a reciprocal drinking water concentration, in units of $(\mu g/L)^{-1}$. Similarly, they are defined as the probability of an individual developing cancer over a 70-year lifetime as a result of exposure to one unit of concentration in air or water. Because regulatory efforts are geared to be protective of public health, including even the most sensitive members of the population, the cancer slope factors are derived using conservative assumptions.

Cancer slope factors and unit risks are derived from the results of human epidemiological studies or chronic animal bioassays. The animal studies usually must be conducted using relatively high doses to detect possible adverse effects. Because humans are expected to be exposed to doses lower than those used in the animal studies, the potential cancer risks at lower doses are estimated by using mathematical models. The data from animal studies are typically fitted to the linearized multistage model to obtain a dose-response relationship. In general, after the data are fit to the dose-response model, the 95 percent upper confidence limit of the slope of the resulting dose-response relationship at low doses is calculated. This upper-bound limit is subjected to various adjustments, and an interspecies scaling factor is applied to derive the slope factor or unit risk for humans. Thus, the actual risks associated with a given intake of a potential carcinogen quantitatively evaluated based on animal data are generally regarded as not likely to exceed the risks estimated using these slope factors and unit risks, and they may be as low as zero (USEPA, 1986a). Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves. These models provide rough, but plausible, estimates of the upper limits on lifetime risk. Slope factors and unit risks based on human epidemiological data are derived using conservative assumptions and, as such, they too are unlikely to underestimate risks for a given level of exposure.

USEPA assigns weight-of-evidence classifications to potential carcinogens. Under this system, chemicals are classified as either Group A, Group B1, Group B2, Group C, Group D, or Group E. These categories represent an assessment of the amount and quality of the data that support the finding that specific chemicals and elements can cause cancer in humans. Group A includes those substances for which high-quality studies have demonstrated a relationship between the exposure to the substance in question and the development of cancer in human populations. Groups B1, B2 and C represent chemicals with limited (B1) or insufficient (B2) human evidence of carcinogenicity; and sufficient (B1, B2) or insufficient (C) animal data. Group D substances are those for which there is insufficient or no evidence of carcinogenicity in humans or animals, while Group E substances are those for which no evidence of carcinogenicity is available in adequate human or animal studies.

3.4.1.2 Health Effects Criteria for Noncarcinogens

Health criteria for chemicals exhibiting noncarcinogenic effects are generally developed using verified risk reference doses (RfDs) or reference concentrations (RfCs). These are developed by USEPA's RfD/RfC Work Group and listed in IRIS (USEPA, 1996b), or can be obtained from HEAST (USEPA, 1995a) and supplements. The RfD is expressed in units of dose (mg chemical/kg body weight-day), while the RfC is expressed in concentration units (mg chemical/m^3 air or μg chemical/m^3 air). RfDs and RfCs are usually derived either from human studies involving work-place exposures or from animal studies. The RfD and RfC are estimates (with uncertainty spanning perhaps an order of magnitude) of the daily exposure to the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD/RfC is used as a reference point for gauging the potential effects of exposures. Usually, exposures (as chemical intakes or doses) that are less than the RfD/ RfC are not likely to be associated with adverse health effects. As the frequency and/or magnitude of the exposures exceeding the RfD/RfC increase, the probability of adverse effects in a human population increases.

RfDs/RfCs are developed for both chronic and subchronic exposures. Chronic RfDs/RfCs are presented in IRIS or HEAST and are intended for use in evaluating exposures of durations greater than seven years. Subchronic RfDs/RfCs are developed by USEPA's National Center for Environmental Assessment (NCEA) and are used to characterize the potential for the occurrence of noncarcinogenic effects associated with short-term exposures (two weeks to seven years as defined by USEPA [1989a]). The subchronic RfDs/RfCs are developed similarly to chronic RfDs/RfCs, and are typically equal to chronic RfDs or are 1 order of magnitude greater (less stringent). The subchronic RfDs are presented in HEAST, but they are not peer reviewed.

The RfDs/RfCs are derived using uncertainty factors that reflect scientific judgment regarding the various types of data used to estimate the RfD. RfDs are typically estimated from no-observable-adverse-effect-levels (NOAELs) or lowest-observable-adverse-effect-levels (LOAELs) in human or animal studies. Uncertainty factors, generally 10-fold factors, are intended to account for:

- the variation in sensitivity among members of the human population;
- the uncertainty in extrapolating animal data to the case of humans;
- the uncertainty in extrapolating from data obtained in a study that is less-than-lifetime exposure;
- the uncertainty in using LOAEL data, when necessary, rather than NOAEL data; and
- the inability of any single study to adequately address all possible adverse outcomes in humans.

To derive RfDs/RfCs, NOAELs or LOAELs are divided by one or more uncertainty factors, as appropriate. When taken together, these uncertainty factors may confer an extra margin of safety of up to a factor of 10,000 below a LOAEL. In some cases, modifying factors are also applied to RfDs to take into account other uncertainties in the toxicity database and reflect the professional judgment of those reviewing the database. The net result is that RfDs/RfCs are generally considered to provide a conservative estimate of the likelihood of adverse noncarcinogenic effects.

3.4.2 Health Effects Criteria for Individual Chemicals of Potential Concern

Table 3-25 presents the oral human health effects criteria used to quantitatively evaluate potential health effects of human exposures to COPCs at OU1. Consistent with USEPA (1989a), subchronic toxicity criteria should be used to evaluate substantially less-than-lifetime exposures. As a result, chronic toxicity criteria were used to evaluate exposure pathways for all receptors except excavation workers. Because excavation workers would be expected to work at OU1 for no more than one year, subchronic toxicity criteria were used for this receptor. The only compounds for which subchronic toxicity criteria differed from chronic toxicity criteria presented in Table 3-25 were PCB-1254, whose subchronic RfD is $5x10^{-5}$ mg/kg-day, and Chromium VI, whose subchronic RfD is $2x10^{-2}$ mg/kg-day. Table 3-26 presents the inhalation human health effects criteria used to quantitatively evaluate potential health effects of via inhalation exposures to COPCs at OU1 (only COPCs in subsurface soil are presented in Table 3-26, since the inhalation pathway was evaluated only for chemicals in subsurface soil).

USEPA-approved oral health effects criteria were not available for delta-BHC, which was identified as a COPC in groundwater. Oral toxicity criteria exist for other BHC congeners (e.g., alpha-, beta- and gamma-BHC), although none has the same Class D weight-of-classification as delta-BHC (i.e., the other BHC congeners are Class B2 or C carcinogens). Therefore, no other BHC congener was used as a surrogate to evaluate potential ingestion risks. The uncertainties associated with not evaluating delta-BHC are discussed in the Uncertainty Section.

Toxicity criteria have not been developed by USEPA specifically for the dermal route of exposure; instead, oral health effects criteria are adjusted to assess this pathway. In order to have a meaningful comparison between the dermal dose estimates, which represent internal (or absorbed) doses, and toxicity criteria, which typically represent potential (or administered) doses, toxicity criteria should be modified to represent absorbed doses. (In cases where the toxicity criteria are based on internal doses, this modification is not required.) The method for modifying toxicity criteria involves determination of an absolute oral absorption factor for each chemical and use of this value to increase the chemical's cancer slope factor or decrease the chemical's RfD. Cancer slope factors and RfDs adjusted in this manner are then more appropriate to assess absorbed dose-response, rather than administered dose-response. The absolute oral absorption factors that are applied should reflect the specific conditions under which the toxicological study was conducted (e.g., method of administration such as gavage, water or diet, and vehicle of administration such as solvent or solution). Table 3-27 presents the absolute oral absorption factors used to adjust the oral toxicity criteria for the chemicals of concern when evaluating dermal absorption of chemicals from sediment and surface water, as well as the actual adjusted toxicity criteria. For most chemicals, absolute oral absorption factors were obtained from the Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile documents. For those chemicals for which sufficient information is lacking, a default absolute oral absorption factor of one (1.0) was used (i.e., oral toxicity criteria were not changed).

3.5 RISK CHARACTERIZATION

This section of the risk assessment evaluates the potential human health effects associated with exposures to chemicals in groundwater, surface soil, subsurface soil, sediment, and surface water at OU1. To quantitatively assess risks associated with exposures to chemicals at the site, the health effects criteria (slope factors/RfDs) presented in the toxicity assessment (Section 3.4) were combined with the average daily doses ([L]ADDs) derived in the exposure assessment (Section 3.3).

For oral exposures to potential carcinogens, excess lifetime cancer risks were obtained by multiplying the estimated LADDs for each chemical by its upper-bound cancer slope factor. The total upper-bound excess lifetime cancer risk for each pathway was obtained by summing the chemical-specific risk estimates. This approach is consistent with USEPA's guidelines for evaluating the toxic effects of chemical mixtures (USEPA, 1989a). Using this approach, a risk level of $1x10^{-6}$, for example, represents an upper-bound probability of one in one million that an individual could contract cancer due to exposure to the potential carcinogens under the specified exposure conditions at a site.

The approach of calculating carcinogenic risks by multiplying the LADD by the slope factor assumes that the increased risk of cancer resulting from exposure to a constituent is linearly proportional to the amount of chemical intake averaged over a lifetime. According to USEPA (1989a) risk assessment guidance, this approach is only appropriate when the estimated carcinogenic risks calculated are less than 10^{-2} (i.e., one excess cancer case per 100 people exposed). If the estimated risks are above 10^{-2}, the assumption of linearity is not valid. In such cases, the carcinogenic risks should be calculated using the following equation, per USEPA risk assessment guidance (USEPA, 1989a).

$$\text{Risk} = 1 - e^{(-\text{LADD} * \text{CSF})}$$

For those chemicals resulting in risks greater than $1x10^{-2}$, the potential carcinogenic risks were estimated by summing the chemical-specific risks to yield exposure pathways risks. Implicit in this approach is the assumption that potential carcinogenic risks from multiple chemical exposures are additive such that the total pathway-specific risk is equal to the sum of the individual chemical-specific risks. Similarly, the excess lifetime cancer risks for each carcinogenic compound were also summed for each exposure pathway. The resulting total chemical-specific risks represent the upper-bound potential risk of developing cancer from that chemical upon exposure to that medium (i.e., the risk may be lower, but is unlikely to be greater).

The upper-bound lifetime excess cancer risks derived in this report can be compared to USEPA's risk range for health protectiveness at Superfund sites of $1x10^{-6}$ to $1x10^{-4}$ (USEPA, 1990b). In addition, USEPA's Office of Solid Waste and Emergency Response (USEPA, 1991b) has issued a directive clarifying the role of the risk assessment in the Superfund process. The directive states that where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for current or future land-use for all media combined is less than $1x10^{-4}$, and the non-carcinogenic hazard quotient is less than one, action generally is not warranted unless there could be adverse environmental effects, or unless a regulatory requirement applies mandating action (see Section 5.0, ARARs).

Potential adverse effects associated with oral and dermal exposures to noncarcinogens are presented as the ratio of the ADD to the reference dose (ADD:RfD). Values of these ratios, called hazard quotients, that are greater than one are indicative of a potential for adverse health effects. The additive effect for each noncarcinogen is assumed, and the sum of the hazard quotients for all the individual COPCs in a given pathway is termed the hazard index. The hazard index is useful as a reference point for gauging the potential effects of environmental exposures to complex mixtures. Hazard indices that are less than 1.0 should be viewed as indicating, with a high level of assurance, but not complete certainty, that adverse effects would not be associated with the exposures being evaluated. Hazard indices exceeding 1.0 indicate the potential for the occurrence of adverse effects. A decision should not be categorically drawn that hazard indices less than one are acceptable (or risk-free) or that hazard indices greater than one are unacceptable (or will result in adverse effects). This is a consequence of the great uncertainty inherent in estimates of the ADD:RfD ratio, in addition to the fact

that there are uncertainties associated with assuming the individual hazard quotients in the hazard index calculation are additive.

In cases where the calculated hazard index exceeds one, the COPCs are subdivided into categories based on target organ or critical effect (e.g., liver, kidney, etc.), in accordance with USEPA guidance (USEPA, 1989a). Hazard indices are then recalculated for these categories to identify the potential for noncarcinogenic effects to occur with respect to any given endpoint. Organ-specific hazard indices exceeding 1.0 indicate the potential for the occurrence of adverse effects. They do not, however, provide a numerical estimate of either the probability or severity of the adverse effect.

The following sections present the predicted risks and hazard indices associated with each exposure pathway evaluated in the HHRA. Section 3.5.1 presents the estimated risks for each of the individual pathways evaluated in the assessment, while Section 3.5.2 presents the cumulative risk estimates for all exposure pathways evaluated in the risk assessment. Chemical specific risks are shown in each of the individual pathway spreadsheets (Tables 3-28 through 3-38), while a summary of pathway risks is presented in Table 3-39.

3.5.1 Pathway-Specific Risks

3.5.1.1 Groundwater

Excess lifetime cancer risks associated with on-site child and adult groundwater exposures were $1x10^{-6}$ and $3x10^{-6}$ for ingestion of drinking water, and were $2x10^{-6}$ and $5x10^{-6}$ for dermal absorption of chemicals in groundwater while bathing (see Tables 3-28 and 3-29). Hazard indices associated with ingestion and dermal exposures to chemicals in groundwater were above one for both child and adult receptors for both pathways. For ingestion of groundwater, the hazard indices were 10 and 5 for child and adult residents, both due to iron (which is not associated with a specific target organ/critical effect) and manganese (which affects the CNS). For dermal absorption of chemicals in groundwater, the hazard indices were 5 and 3, both due to exposures to PCB-1016 (associated with a decrease in birth weight).

Since exposures to the most conservative receptor for groundwater resulted in a hazard index greater than 1, risks and hazard indices for hypothetical future workers also were evaluated for groundwater exposures (only ingestion risks were calculated, since dermal exposures to workers would likely be minimal [i.e., primarily via washing hands]). Using default exposure parameters from USEPA (1991a) (i.e., ingestion of 1 L/day, 250 days/year, 25 years, for a 70 kg worker), a drinking water risk of $9x10^{-7}$ and a hazard index of 2 (due to exposures to iron).

As noted earlier, a qualitative analysis of elevated concentrations was performed on the groundwater data on an AREE by AREE basis. This was done in order to determine whether risks above the target risk range could occur at any of the individual AREEs. The discussion below focuses only on those chemicals that significantly exceeded screening criteria (i.e., concentrations greater than 10 times respective screening criteria): It should be noted that there were many hits detected at concentrations less than ten times respective screening levels, although these chemicals are not discussed below. It was determined that organic chemical concentrations that exceeded respective tap water RBCs by a factor of 10 or more were found predominantly in the northern part of OU1. Single exceedances, on the order of 20 times respective tap water RBCs, of bis(2-ethylhexyl)phthalate, PCB-1016 (MW-81), and heptachlor epoxide (MW-60 and MW-82) occurred around AREE 4 (MW-67 for bis(2-ethylhexyl)phthalate), and within AREE 2, and AREE 6B. In addition, an exceedance of heptachlor epoxide occurred to the east of AREE 6B and was approximately 70 times its tap water RBC.

Inorganic concentrations that exceeded respective screening criteria were found predominantly in the southern part of OU1. Aluminum, chromium, and vanadium exceedances were located in AREE 1 at levels 20 (vanadium and aluminum) to 65 times (chromium) their tap water RBCs. Iron and manganese exceedances generally occurred near AREE 1. Magnitudes of exceedance ranged from 11 to 99 times for iron and 12 to approximately 60 times for manganese. Arsenic exceedances primarily occurred in the northern part of OU1. Half of those samples exceeding arsenic's tap water RBC in the northern areas were located in AREE 2. The magnitude of exceedance ranged from 25 to 91 times.

3.5.1.2 Surface Soil

Excess lifetime cancer risks associated with future child and adult residential exposures to chemicals in surface soil were 8x10-6 and 4x10-6 for incidental ingestion, and were 9x10-6 and 3x10-5 for dermal absorption (see Tables 3-31 and 3-32). Hazard indices associated with ingestion and dermal exposures to chemicals in surface soil were less than one for both ingestion and dermal pathways.

As noted in the previous section, the discussion regarding screening criteria exceedances focuses only on those chemicals that significantly exceeded respective screening levels. After reviewing the surface soil data on an AREE by AREE basis, it was determined that organic chemicals that exceeded their respective residential soil RBCs were located in the southern sections of OU1 just west of AREE 1. Benzo(a)pyrene was detected in two samples where concentrations were greater than its RBC. Exceedances were 12 and 27 times the residential soil RBC, respectively. PCB-1260 was detected in sample MW-80 with an exceedance of 130 times its residential soil RBC.

Although there were numerous exceedances of iron in surface soil, there did not appear to be any distinct patterns of elevated iron concentrations. Samples where concentrations exceeded iron's residential soil RBC were spread relatively evenly throughout OU1. Exceedances were on the order of 10 to 30 times greater than iron's screening criterion. Arsenic was found to exceed its residential soil RBC by a factor of 11 in one sample located just north of AREE 2.

3.5.1.3 Subsurface Soil

Excess lifetime cancer risks associated with an excavation worker's ingestion, dermal, and inhalation exposures to chemicals in subsurface soil were $5x10^{-7}$, $1x10^{-7}$, and $4x10^{-11}$, respectively (see Tables 3-33, 3-34, and 3-35). Hazard indices associated with ingestion and dermal exposures to chemicals in subsurface soil were less than one for the ingestion and dermal pathways (noncarcinogenic hazard indices were not evaluated for the inhalation pathway since no COPCs in subsurface soil have inhalation RfCs).

3.5.1.4 Sediment

Excess lifetime cancer risks associated with child resident ingestion and dermal exposures to chemicals in sediment from the Marsh Area grouping were $3x10^{-6}$ and $4x10^{-5}$, respectively (see Tables 3-36 and 3-37). Hazard indices associated with ingestion and dermal exposures to chemicals in Marsh Area sediment were less than one for child residents through both pathways.

As noted in the exposure section, there would not be contact exposures to chemicals in Open Water grouping sediment, since this sediment would not be accessible for contact exposures.

As noted earlier, the discussion regarding screening criteria exceedances focuses only on those chemicals that significantly exceeded respective screening levels. After reviewing the sediment data on an AREE by AREE basis, it was determined that only iron exceeded its RBC. All three samples where exceedances occurred are located in the central portion of OU1. Sample RISD11 had an exceedance of approximately 11 times its RBC and is located in the marshy area between AREEs 4 and 5. Samples RISD13 and RISD21 had exceedances of 12 and 22, respectively. RISD13 is located near the middle of Marumsco Creek just south of AREE 4, where RISD21 is closer to the shore just north of the western edge of AREE 6B.

3.5.1.5 Surface Water

No COPCs in Marsh Area surface water had carcinogenic toxicity criteria so risks were not calculated for exposures to COPCs in this area. The hazard index for dermal absorption of chemicals in Marsh Area surface water by child residents was less than 1 (see Table 3-38), indicating that noncarcinogenic adverse effects would not be likely to occur.

In the Open Water Area, all chemicals that exceeded RBCs were within background levels, thus no COPCs were selected (instead, risks for these chemicals were presented in the Uncertainty Section).

3.5.2 Cumulative Risks

Individuals may be exposed at one time by a combination of pathways, and therefore, the combined pathway risks for plausible multiple pathway exposures were calculated. Cumulative risk estimates were calculated for child and adult residents, and for excavation workers, who were assumed to be exposed under future land-use conditions.

3.5.2.1 Child and Adult Residents

The summary of cumulative risks and hazard indices for child and adult residents are presented in Table 3-39. As shown in this table, the cumulative risks for children and adults were $6x10^{-5}$ and $4x10^{-5}$, both were in the mid- to high-range of the $1x10^{-6}$ to $1x10^{-4}$ risk range for health protectiveness at Superfund sites. The cumulative hazard index for both child and adult residents was above one (16 for children and eight for adults), due to exposures to COPCs in groundwater. Adverse effects to both child and adult residents could be associated with the CNS (due to ingestion of manganese in groundwater) and decreased birth weight (due to dermal absorption of PCB-1016 in groundwater). Although the hazard index for iron was exceeded for ingestion by child and adult residents, iron is not associated with a specific target organ/critical effect.

3.5.2.2 Excavation Workers

A summary of cumulative risks for hypothetical future excavation workers is also presented in Table 3-39. As shown in this table, the cumulative risk for excavation workers was $2x10^{-6}$, which is at the low end of the $1x10^{-6}$ to $1x10^{-4}$ risk range for health protectiveness at Superfund sites. The cumulative hazard index was equal to 2, due to ingestion of iron (which is not associated with a specific target organ/critical effect).

3.6 UNCERTAINTY ANALYSIS

There is a large degree of uncertainty associated with the estimates of human health risks in any risk assessment. Consequently, the estimates calculated for OU1 should not be construed as absolute estimates of risk but rather as conditional estimates based on a number of assumptions regarding exposure and toxicity. In general, the primary sources of uncertainty are associated with environmental sampling and analysis; selection of chemicals for evaluation; exposure assessment; and toxicological data.

A thorough understanding of the uncertainties associated with the risk estimates is critical to understanding the true nature of the estimated risks and to placing the estimated risks in proper perspective. Some of the more important sources of uncertainty associated with the estimations of risk at OU1 are summarized below.

3.6.1 Environmental Sampling and Analysis

Uncertainty in environmental chemical analysis can stem from several sources including errors inherent in the sampling or analytical methods. Analytical precision or accuracy errors can be the source of a great deal of uncertainty. There is uncertainty associated with chemicals reported in samples at concentrations below the reported detection limit, but still included in data analysis, and with those chemicals qualified with the letter J, indicating that the concentrations are estimated. The effects of using data with these uncertainties may over- or under-estimate risks.

3.6.2 Selection of Chemicals for Evaluation

A comparison of maximum detected chemical concentrations to USEPA Region III RBCs was conducted for each medium. Chemicals whose maximum concentrations were below their respective RBCs were not carried through the assessment. It is unlikely that this risk-based screening would have excluded chemicals that would be of concern, based on the conservative exposure assumptions and conservatively derived toxicity criteria that are the basis of the RBCs. Although following this methodology does not provide a quantitative risk estimate for all chemicals, it focuses the assessment on the chemicals accounting for the greatest risks (i.e., chemicals whose maximum concentrations exceeded their respective RBCs), and the overall cumulative risk estimates would not be expected to be significantly (if at all) greater.

There is uncertainty associated with eliminating inorganic chemicals from evaluation based on comparisons of site and background data. Although at least five site and five background samples were used to conduct statistical analyses, there nevertheless exists some uncertainty associated with the inorganic chemical selection process if the background samples do not adequately characterize true background concentrations. Therefore, in accordance with USEPA Region III policy, an evaluation was conducted for chemicals that were determined to be within background concentrations, but that exceeded their respective RBCs. Risk estimates were calculated for all chemicals that were classified as "b" (within background levels but above respective RBCs) in Tables 3-3 through and 3-8 for groundwater, surface soil, subsurface soil, and surface water. As shown in Tables 3-40 through 3-48, risks for all chemicals and pathways were typically similar in order of magnitude as risks associated with exposures to COPCs. Consequently, eliminating chemicals as COPCs that were within background concentrations, but greater than RBCs, did not significantly alter the conclusions concerning risks associated with exposures to site-related inorganic concentrations.

3.6.3 Exposure Assessment

There are several sources of uncertainty in the exposure assessment, including the determination of the exposure point concentrations, the selection of input parameters used to estimate chemical intakes ([L]ADDs), and other assumptions used in the exposure models. The uncertainties associated with these various sources are discussed below.

When calculating exposure point concentrations from sampling data, ½ of the reported detection limit was used for non-detected concentrations in the calculation of the 95% UCL. Any approach dealing with non-detected chemical concentrations is associated with some uncertainty. This is because chemicals that were not detected at the specified detection limit may be absent from the medium or may be present at any concentration below the detection limit. The uncertainty in the exposure point concentration will increase as the number of non-detects in a data set increases.

The 95% UCL was used preferably as the exposure point concentration for each medium. If the 95% UCL exceeded the maximum detected value, the maximum was conservatively used as a default for the exposure point concentration. Using a value that is based on one sampling location (i.e., the maximum) is associated with some uncertainty, and adds a great deal of conservatism to the assessment. Maximum detected concentrations were typically used as the exposure point concentrations for Marsh Area surface water and for Marsh Area and Open Water Area sediment, likely resulting in an overestimate of risk for pathways associated with these media.

Uncertainty is associated with how data are grouped for evaluation. Risk estimates can be calculated differently as a result of samples being grouped in different ways. The quantitative risk evaluation grouped samples on a site-wide basis since exposure scenarios would more likely encompass broader areas of OU1 rather than individual AREEs. Since some exposure point concentrations were lower than they would have been if groupings had been made on an AREE by AREE basis, qualitative analyses of elevated concentrations were performed for each medium and are presented in Sections 3.5.1.1 through 3.5.1.4.

With respect to determining exposure point concentrations, it was assumed that the concentrations of chemicals in the media evaluated would remain constant over time. Depending on the properties of the chemicals and the media in which they were detected, this assumption could overestimate risks to a low or high degree, since it is possible that chemicals could degrade or be transported to other media.

An underlying assumption of the risk assessment is that individuals in the site would engage in certain activities that would result in exposures via each selected pathway. However, even if an individual engaged in an activity, it is not necessarily true that an exposure would be experienced.

The parameter values used to describe the extent, frequency, and duration of exposure are associated with some uncertainty. Actual risks for certain individuals within an exposed population may vary from those predicted depending upon their actual intake rates (e.g., soil ingestion rates), nutritional status, or body weights. The exposure assumptions were selected to produce an upper-bound estimate of exposure in accordance with USEPA guidelines regarding evaluation of potential exposures at Superfund sites (e.g., soil exposures were assumed to occur for 350 days/year for 30 years for adult

residents). In addition, many USEPA (1989a) default exposure parameters are highly conservative and are based on risk management interpretations of limited data. An example is soil ingestion rates, which were used to evaluate soil ingestion exposures. Although current USEPA guidance recommends default soil ingestion rates of 100 mg/day for those over six years of age, other studies, such as Calabrese et al. (1990), have shown that the USEPA default soil ingestion rate of 100 mg/day is likely to greatly overestimate exposures and risks. In addition, all chemicals in soil and sediment were assumed to be 100% bioavailable; this assumes that all ingested chemicals present in a soil or sediment matrix are absorbed through the gastrointestinal tract, which is unlikely due to their affinity to the soil or sediment particles. Therefore, based on the conservative exposure assumptions used in the risk assessment, exposures and estimated potential risks are likely to be overestimated for the exposure pathways.

Evaluation of the dermal exposure pathway is affected by uncertainties in exposure parameters specific to dermal contact. For example, there is uncertainty associated with the exposed skin surface areas used, since the choice of exposed body parts could slightly over- or under-estimate risks. More significant uncertainties are associated with the selection and use of dermal absorption fractions. Very limited information is available on dermal absorption of chemicals from contacted soil and sediment under realistic environmental conditions. In fact, there are no actual human epidemiological data to support the hypothesis that absorption of soil- or sediment-bound compounds under realistic exposure conditions is a complete route of exposure. Therefore, evaluation of dermal absorption of COPCs from soil or sediment may result in an overestimation of risks.

3.6.4 Toxicological Data

In most RAs, one of the largest sources of uncertainty is health criteria values. The health criteria used to evaluate long-term exposures, such as reference doses or cancer slope factors, are based on concepts and assumptions that bias an evaluation in the direction of over-estimation of health risk. As USEPA notes in its Guidelines for Carcinogenic Risk Assessment (USEPA, 1986a):

> *There are major uncertainties in extrapolating both from animals to humans and from high to low doses. There are important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility. Human populations are variable with respect to genetic constitution, diet, occupational and home environment, activity patterns, and other cultural factors.*

These uncertainties are compensated for by using upper-bound 95% UCLs or maximum likelihood estimates for cancer slope factors for carcinogens, and safety factors for reference doses for noncarcinogens. The assumptions provide a rough but plausible estimate of the upper limit of risk.

For dermal exposure pathways, the absence of dermal toxicity criteria necessitated the use of oral toxicity data. To calculate risk estimates for the dermal pathway, therefore, absorbed dermal doses were combined with oral toxicity values. As described in Section 3.4, oral toxicity values, which are typically expressed in terms of potential (or administered) doses, should be adjusted when assessing dermal doses, which are expressed as internal (or absorbed) doses. In this assessment, absolute oral absorption factors that reflect the toxicity study conditions were used to modify the oral toxicity criteria. For those chemicals for which sufficient information is lacking, a default oral absorption factor of 100% (1.0) was used. The risk estimates for the dermal pathways may be underestimated where a default oral absorption factor of 100% was used, and may be over- or underestimated for chemicals for which chemical-specific oral absorption factors were used, depending on how closely these values reflect the difference between the oral and dermal routes.

Delta-BHC could not be quantitatively evaluated because no toxicity criteria exist for this compound. Although oral toxicity criteria exist for other BHC congeners (e.g., alpha-, beta- and gamma-BHC), although none has the same Class D weight-of-classification as delta-BHC (i.e., the other BHC congeners are Class B2 and C carcinogens). Therefore, no other BHC congener was used as a surrogate to evaluate potential ingestion risks. Although not quantifying risks for delta-BHC could underestimate groundwater ingestion and dermal risks, risks would not likely be significantly underestimated, because delta-BHC was detected in only 1/43 samples at a very low concentration (0.007 µg/L) and chemicals that drove risks for the groundwater pathways were detected at much greater concentrations.

In addition, lead was present in groundwater at a concentration above the action level of 15 µg/L, but within background levels. Lead does not have toxicity criteria, thus exposures to this compound could not be evaluated; however, lead was detected in 21/55 samples, with five of the samples having concentrations exceeding the action level (up to a maximum concentration of 54 µg/L). Nevertheless, because there are no plans to use groundwater at OU1, adverse effects associated with exposures to lead would not occur.

3.7 SUMMARY AND CONCLUSIONS

3.7.1 Selection of Chemicals for Evaluation

This risk assessment was performed to evaluate the potential human health effects associated with chemical contamination at OU1. The first task of the HHRA was to summarize chemicals found in groundwater, surface soil, subsurface soil, sediment, and surface water at OU1. The data for sediment and surface water were then separated into groupings, according to areas of exposure.

After the data were summarized, maximum concentrations of detected chemicals were compared to USEPA Region III RBCs. If the chemical concentrations exceeded the RBCs, they were retained as COPCs. The next step in the screening process was to statistically compare on-site and background chemical concentrations for inorganic chemicals that were not screened out in the RBC screening. If inorganic chemical concentrations were within background levels, they were not considered to be COPCs. Risks for these inorganic chemicals present at concentrations greater than RBCs but within background levels also were evaluated, although separately from site-related COPCs. Chemicals that were not eliminated as a result of both the RBC and background screening procedures were considered to be COPCs, and were retained for detailed evaluation in the risk assessment.

3.7.2 Exposure Assessment

In order to streamline this assessment, potential exposure pathways for hypothetical future residents at WRF were evaluated, even though such exposures would not likely occur, since the site will be transferred to the USFWS in the future. The following exposure pathways were evaluated in the risk assessment:

- Ingestion of COPCs in groundwater by on-site child and adult residents;
- Dermal absorption of COPCs in groundwater by on-site child and adult residents while bathing;
- Incidental ingestion of COPCs in soil by on-site child and adult residents;
- Dermal absorption of COPCs in soil by on-site child and adult residents;
- Incidental ingestion of COPCs in subsurface soil by excavation workers;
- Dermal absorption of COPCs in subsurface soil by excavation workers;
- Inhalation of airborne particulate matter from subsurface soil by excavation workers;
- Incidental ingestion of COPCs in sediment from the Marsh Area grouping by on-site child residents;
- Dermal absorption of COPCs in sediment from the Marsh Area grouping by on-site child residents;
- Incidental ingestion of COPCs in surface water from the Open Water Area by on-site adult residents while swimming;
- Dermal absorption of COPCs in surface water from the Open Water Area by on-site adult residents while swimming; and
- Dermal absorption of COPCs in surface water from the Marsh Area by on-site child residents while wading.

An RME case was evaluated in this risk assessment, in order to place a conservative upper-bound on the potential risks, meaning that the risk estimates were unlikely to be underestimated but may very well have been overestimated. ADDs for noncarcinogenic effects and LADDs for carcinogenic effects were estimated using exposure point concentrations and assumptions to characterize human exposure to COPC from the site via oral and dermal pathways. IECs were determined to characterize human exposures to COPC from the site via the inhalation pathway. ADDs/LADDs or IECs were then compared to relevant toxicity criteria to calculate risks associated with the evaluated exposures. The resulting risk estimates were the upper-bound excess lifetime cancer risks for carcinogenic chemicals and hazard indices for noncarcinogenic chemicals. Using the risk or hazard index values, risks and potential adverse effects from exposure to site-related chemicals were assessed. Cancer risk estimates were compared to USEPA's target risk range for health protectiveness at Superfund sites of $1x10^{-6}$ to $1x10^{-4}$, as recommended by USEPA (1990b). The potential for adverse noncarcinogenic effects was assessed by comparing the noncarcinogenic hazard indices to a value of one; a hazard index less than one indicates that adverse noncarcinogenic health effects would not be expected to occur. The following sections summarize the results of the quantitative risk assessment.

3.7.3 Toxicity Assessment

For each COPC, quantitative oral toxicity criteria were compiled to evaluate ingestion and dermal pathways, while quantitative inhalation toxicity criteria were compiled to evaluate the inhalation pathway. The toxicity criteria were obtained primarily from USEPA's IRIS and HEAST. USEPA-approved oral health effects criteria were not available for delta-BHC and lead, which were identified as COPCs in groundwater (uncertainties associated with not evaluating these compounds are discussed in the Uncertainty Section).

3.7.4 Risk Characterization

3.7.4.1 Groundwater

Excess lifetime cancer risks associated with child and adult groundwater exposures were $1x10^{-6}$ and $3x10^{-6}$ for ingestion, and were $2x10^{-6}$ and $5x10^{-6}$ for dermal absorption of chemicals in groundwater while bathing. Hazard indices associated with ingestion and dermal exposures to chemicals in groundwater were above one for both child and adult receptors for both pathways. For ingestion of groundwater, the hazard indices were 10 and 5 for child and adult residents, both due to iron (which is not associated with a specific target organ/critical effect) and manganese (which affects the CNS). For dermal absorption of chemicals in groundwater, the hazard indices were 5 and 3, both due to exposures to PCB-1016 (associated with a decrease in birth weight).

Since exposures to the most conservative receptor for groundwater resulted in a hazard index greater than 1, risks and hazard indices for hypothetical future workers also were evaluated for groundwater exposures (only ingestion risks were calculated, since dermal exposures to workers would likely be minimal [i.e., primarily via washing hands]). Using default exposure parameters from USEPA (1991a) (i.e., ingestion of 1 L/day, 250 days/year, 25 years, for a 70 kg worker), a drinking water risk of $9x10^{-7}$ and a hazard index of 2 (due to iron).

3.7.4.2 Surface Soil

Excess lifetime cancer risks associated with child and adult residential exposures to chemicals in surface soil were $8x10^{-6}$ and $4x10^{-6}$ for incidental ingestion, and were $9x10^{-6}$ and $3x10^{-5}$ for dermal absorption. Hazard indices associated with ingestion and dermal exposures to chemicals in surface soil were less than one for both ingestion and dermal pathways.

3.7.4.3 Subsurface Soil

Excess lifetime cancer risks associated with an excavation worker's ingestion, dermal, and inhalation exposures to chemicals in subsurface soil were $5x10^{-7}$, $1x10^{-7}$, and $4x10^{-11}$, respectively. Hazard indices associated with ingestion and dermal exposures to chemicals in subsurface soil were less than one for the ingestion and dermal pathways (noncarcinogenic hazard indices were not evaluated for the inhalation pathway since no COPCs in subsurface soil have inhalation RfCs).

3.7.4.4 Sediment

Excess lifetime cancer risks associated with child resident ingestion and dermal exposures to chemicals in sediment from the Marsh Area grouping were $3x10^{-6}$ and $4x10^{-5}$, respectively. Hazard indices associated with ingestion and dermal exposures to chemicals in Marsh Area sediment were less than one for child residents through both pathways. As noted earlier, there would not be contact exposures to chemicals in Open Water grouping sediment, since this sediment would not be accessible for contact exposures.

3.7.4.5 Surface Water

No COPCs in Marsh Area surface water had carcinogenic toxicity criteria so risks were not calculated for exposures to COPCs in this area. The hazard index for dermal absorption of chemicals in Marsh Area surface water by child residents was less than 1, indicating that noncarcinogenic adverse effects would not be likely to occur. In the Open Water Area, all chemicals that exceeded RBCs were within background levels, thus no COPCs were selected for this area.

3.7.4.6 Cumulative Risks

Individuals may be exposed at one time by a combination of pathways, and therefore, the combined pathway risks for plausible multiple pathway exposures were calculated. Cumulative risk estimates were calculated for child and adult residents, and for excavation workers, who were assumed to be exposed under future land-use conditions.

Child and Adult Residents. Cumulative risks for child and adult residents were $6x10^{-5}$ and $4x10^{-5}$, respectively, both in the mid- to high-range of the $1x10^{-6}$ to $1x10^{-4}$ risk range for health protectiveness at Superfund sites. The cumulative hazard index for both child and adult residents was above one (16 for children and eight for adults), due to exposures to COPCs in groundwater. Adverse effects to both child and adult residents could be associated with the CNS (due to ingestion of manganese) and decreased birth weight (due to dermal absorption of PCB-1016). Although the hazard index for iron was exceeded due to ingestion exposures, iron is not associated with a specific target organ/critical effect.

Excavation Workers. The cumulative risk for excavation workers was $2x10^{-6}$, which is at the low end of the $1x10^{-6}$ to $1x10^{-4}$ risk range for health protectiveness at Superfund sites. The cumulative hazard index was equal to 2, due to ingestion of iron in groundwater.

3.7.4.7 Overall Risks at OU1

The most significant risks associated with exposures to evaluated media at OU1 are associated with ingestion and dermal absorption of chemicals in groundwater by hypothetical future residents. Even though elevated hazard indices were calculated for exposures to chemicals in groundwater, it should be noted that this pathway is considered to be highly unlikely for several reasons. First, residents would not likely reside at WRF, since the facility will be transferred to the USFWS. Second, drinking water is provided by the local water supplier, and third, the high iron levels would preclude individuals from installing drinking water wells at OU1. Risks and hazard indices associated with groundwater ingestion for the next most conservative receptor (i.e., a worker) also were calculated, and the risk was lower than the $1x10^{-6}$ to $1x10^{-4}$ risk range, although the hazard index was equal to 2 (due to iron).

Risks associated with exposures to COPC in all other media were within or below the $1x10^{-6}$ to $1x10^{-4}$ risk range for all receptors, while all noncancer hazard indices were lower than one, indicating the noncarcinogenic adverse effects would not be likely to occur.

Risks also were calculated for inorganics that were present at concentrations above respective RBCs but within background levels. Risks and hazard indices for all chemicals and pathways were typically in the same order of magnitude as risks and hazard indices for COPCs, indicating that the elimination of chemicals as COPCs that were within background concentrations, but greater than RBCs did not significantly alter the conclusions concerning risks associated with exposures to site-related inorganic concentrations.

TABLE 3-1
USEPA REGION III RISK-BASED CONCENTRATIONS (RBCs) FOR CHEMICALS DETECTED IN GROUNDWATER AND SURFACE WATER AT WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in ug/L)

Chemical	RBC Value (a)
Organics:	
Acenaphthene	220
Acenaphthylene	110(b)
Acetone	370
Aldrin	0.004
Anthracene	1,100
Benzoic acid	15,000
delta-BHC	NA
gamma-BHC (Lindane)	0.052
gamma-Chlordane	0.052
Chrysene	9.2
4,4'-DDD	0.28
4,4'-DDE	0.2
4,4'-DDT	0.2
Dieldrin	0.0042
Dimethylphthalate	37,000
beta Endosulfan	22(c)
Endosulfan sulfate	22(c)
Endrin	1.1
bis(2-Ethylhexyl)phthalate	4.8
Fluoranthene	150
Heptachlor	0.0023
Heptachlor epoxide	0.0012
Isophorone	71
Methoxychlor	18
1-Methylnaphthalene	110(b)
2-Methylnaphthalene	110(b)
4-Methylphenol	18
PCB-1016	0.26
Phenanthrene	110(b)
Phenol	2,200
Pyrene	110
Inorganics:	
Aluminum	3,700
Arsenic	0.045
Barium	260
Cadmium	1.8
Calcium	400,000(d)
Chromium	18(e)
Cobalt	220
Copper	150
Iron	1,100
Lead	15(f)
Magnesium	80,500(d)

TABLE 3-1 (Continued)
USEPA REGION III RISK-BASED CONCENTRATIONS (RBCs) FOR CHEMICALS DETECTED IN GROUNDWATER AND SURFACE WATER AT WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in ug/L)

Chemical	RBC Value (a)
Manganese	84
Nickel	73
Potassium	100,000(d)
Selenium	18
Sodium	100,000(d)
Thallium	0.29(g)
Vanadium	26
Zinc	1,100

(a) The groundwater and surface water RBC values are from USEPA Region III Tap Water RBCs (USEPA 1996a). RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance. RBC values are presented only for chemicals detected in groundwater or surface water.
(b) The RBC for pyrene was used as a surrogate for noncarcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.
(c) The RBC for endosulfan was used.
(d) Value is an allowable daily intake (ADI) level for essential human nutrients.
(e) The RBC for chromium VI was used.
(f) Because no RBC exists for lead, the action level (USEPA 1990b) was used.
(g) The most conservative value for thallium salts was used.
NA = Not available.

TABLE 3-2
USEPA REGION III RESIDENTIAL SOIL RISK-BASED CONCENTRATIONS (RBCs)
FOR CHEMICALS DETECTED IN SOIL AND SEDIMENT AT
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	RBC Value (a)
Organics:	
Acenaphthene	470
Acetone	780
Anthracene	2,300
Benzo(a)anthracene	0.88
Benzo(a)pyrene	0.088
Benzo(b)fluoranthene	0.88
Benzo(g,h,i)perylene	230(b)
Benzo(k)fluoranthene	8.8
Benzoic acid	31,000
Chlordane	0.49
Chrysene	88
4,4'-DDD	2.7
4,4'-DDE	1.9
4,4'-DDT	1.9
Dibenz(a,h)anthracene	0.088
Dieldrin	0.04
Diethylphthalate	6,300
Endosulfan sulfate	47(c)
bis(2-Ethylhexyl)phthalate	46
Fluoranthene	310
Fluorene	310
Indeno(1,2,3-c,d)pyrene	0.88
Methoxychlor	39
Methylene chloride	85
1-Methylnaphthalene	230(b)
2-Methylnaphthalene	230(b)
Naphthalene	310
PCB-1242	0.083(d)
PCB-1248	0.083(d)
PCB-1254	0.16
PCB-1260	0.083(d)
Phenanthrene	230(b)
Pyrene	230
Inorganics:	
Aluminum	7,800
Antimony	3.1
Arsenic	0.43
Barium	550
Beryllium	0.15
Cadmium	3.9
Calcium	4,000,000(e)

TABLE 3-2 (Continued)
USEPA REGION III RESIDENTIAL SOIL RISK-BASED CONCENTRATIONS (RBCs)
FOR CHEMICALS DETECTED IN SOIL AND SEDIMENT AT
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	RBC Value (a)
Chromium	39(f)
Cobalt	470
Copper	310
Iron	2,300
Lead	400(g)
Magnesium	800,000(e)
Manganese	180
Mercury	2.3
Nickel	160
Potassium	1,000,000(e)
Selenium	39
Silver	39
Sodium	1,000,000(e)
Vanadium	55
Zinc	2,300

(a) The soil and sediment RBC values are from USEPA Region III Residential Soil RBCs (USEPA 1996a). RBC values are presented for chemicals detected in soil and/or sediment. RBCs for noncarcinogenic chemicals are based on a hazard quotient of 0.1, following USEPA Region III guidance.
(b) The RBC for pyrene was used as a surrogate for noncarcinogenic polycyclic aromatic hydrocarbons (PAHs) lacking RBCs.
(c) The RBC for Endosulfan was used.
(d) Value is for carcinogenic PCBs.
(e) Value is an allowable daily intake (ADI) level for essential human nutrients.
(f) The RBC for Chromium VI was used.
(g) Because no RBC exists for lead, the residential soil screening level (USEPA 1994) was used.

TABLE 3-3
SUMMARY OF CHEMICALS DETECTED IN GROUNDWATER
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in ug/L)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Tap Water RBC (d)	Maximum Detect > RBC?	Range of Background Concentrations (e)	Site > Background? (f)
Organics:									
Acenaphthene	2 / 55	55	1.13	2.0	2.93 - 6.34	220	No	6.22 - 11.0	---
Acenaphthylene	3 / 55	55	1.46	2.0	4.53 - 17.3	110	No	2.01 - 6.34	---
Acetone	1 / 52	52	5.35	10.0	23.0	370	No	ND	---
* Aldrin	2 / 55	55	0.00275	0.0050	0.0090 - 0.0100	0.004	**Yes**	ND	---
Anthracene	9 / 55	55	0.178	0.100	0.177 - 2.91	1,100	No	0.113 - 2.38	---
* delta-BHC	1 / 43	43	0.00260	0.0050	0.0070	**NRA**	**NRA**	ND	---
* gamma-BHC (Lindane)	2 / 43	43	0.00752	0.0050	0.0070 - 0.214	0.052	**Yes**	0.0503	---
Benzoic acid	2 / 55	55	1.55	2.0	7.30 - 25.0	15,000	No	ND	---
gamma-Chlordane	2 / 55	55	0.00277	0.0050	0.0080 - 0.0120	0.052	No	ND	---
Chrysene	3 / 55	55	0.0543	0.100	0.0930 - 0.188	9.2	No	ND	---
4,4'-DDD	2 / 55	55	0.00268	0.0050	0.0060 - 0.0090	0.28	No	ND	---
4,4'-DDE	1 / 55	55	0.00387	0.0070	0.0240	0.2	No	ND	---
4,4'-DDT	3 / 55	55	0.00475	0.0070	0.0090 - 0.0510	0.2	No	ND	---
* Dieldrin	1 / 55	55	0.00276	0.0050	0.0170	0.0042	**Yes**	0.0220	---
Dimethylphthalate	1 / 55	55	1.08	2.0	5.30	37,000	No	2.45	---
beta Endosulfan	2 / 55	55	0.00335	0.0050	0.0210 - 0.0310	22	No	0.0210	---
Endosulfan sulfate	7 / 53	53	0.00508	0.0050	0.0078 - 0.0440	22	No	0.0108 - 0.146	---
Endrin	2 / 55	55	0.00303	0.0050	0.0120 - 0.0220	1.1	No	0.0220	---
* bis(2-Ethylhexyl)phthalate	2 / 23	23	8.52	2.0	45.0 - 130	4.8	**Yes**	ND	---
Fluoranthene	11 / 55	55	0.0152	0.0200	0.0210 - 0.0640	150	No	0.0630 - 0.0690	---
* Heptachlor	1 / 55	55	0.00265	0.0050	0.0110	0.0023	**Yes**	0.0068	---
* Heptachlor epoxide	3 / 55	55	0.00469	0.0050	0.0048 - 0.0880	0.0012	**Yes**	ND	---
Isophorone	1 / 55	55	1.03	2.0	2.80	71	No	ND	---
Methoxychlor	1 / 55	55	0.00464	0.0090	0.0120	18	No	ND	---
1-Methylnaphthalene	2 / 55	55	1.10	2.0	3.38 - 4.24	110	No	51.0 - 119	---
2-Methylnaphthalene	3 / 55	55	1.17	2.0	2.48 - 6.20	110	No	56.8 - 80.5	---
4-Methylphenol	2 / 55	55	1.23	2.0	3.60 - 11.0	18	No	ND	---
* PCB-1016	1 / 55	55	0.117	0.130	2.93	0.26	**Yes**	ND	---
Phenanthrene	5 / 55	55	0.553	0.500	2.27 - 5.08	110	No	6.39 - 8.69	---
Phenol	2 / 55	55	1.33	2.0	5.90 - 14.0	2,200	No	ND	---
Pyrene	2 / 55	55	0.0626	0.100	0.244 - 0.551	110	No	0.150 - 0.158	---

TABLE 3-3 (Continued)
SUMMARY OF CHEMICALS DETECTED IN GROUNDWATER
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in ug/L)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Tap Water RBC (d)	Maximum Detect > RBC?	Range of Background Concentrations (e)	Site > Background? (f)
Inorganics:									
b Aluminum	49 / 52	52	2,290	40.0	40.2 - 85,000	3,700	**Yes**	94.8 - 12,500	No
b Arsenic	11 / 55	55	0.873	1.0	0.800 - 4.10	0.045	**Yes**	1.10 - 6.70	No
b Barium	43 / 55	55	47.2	25.0	18.9 - 324	260	**Yes**	28.8 - 107	No
Cadmium	8 / 55	55	0.0664	0.100	0.100 - 0.500	1.8	No	0.100 - 0.800	---
Calcium	55 / 55	55	8,630	NU	790 - 49,200	400,000	No	2,250 - 42,200	---
b Chromium	4 / 55	55	26.2	10.0	10.7 - 1,120	18	**Yes**	22.3	No
Cobalt	6 / 55	55	12.7	20.0	22.4 - 73.0	220	No	ND	---
Copper	7 / 55	55	5.53	5.0	5.50 - 124	150	No	8.90	---
* Iron	51 / 52	52	9,090	45.0	45.9 - 109,000	1,100	**Yes**	159 - 9,620	No
b Lead	21 / 55	55	4.05	1.0	1.20 - 54.6	15	**Yes**	0.850 - 6.30	No
Magnesium	55 / 55	55	5,400	NU	559 - 35,300	80,500	No	191 - 7,720	---
* Manganese	54 / 55	55	619	5.0	14.4 - 5,160	84	**Yes**	6.65 - 354	**Yes**
b Nickel	5 / 55	55	21.2	15.0	16.6 - 706	73	**Yes**	18.4	No
Potassium	51 / 55	55	1,580	550	568 - 8,160	100,000	No	744 - 20,600	---
Selenium	18 / 55	55	1.73	2.0	1.75 - 5.65	18	No	2.10 - 4.20	---
Sodium	48 / 48	48	18,200	NU	3,230 - 38,800	100,000	No	5,110 - 43,500	---
b Thallium	2 / 55	55	0.0809	0.100	0.100 - 1.70	0.29	**Yes**	0.100	No
b Vanadium	3 / 55	55	9.94	10.0	10.7 - 259	26	**Yes**	12.3 - 29.8	No
Zinc	23 / 55	55	31.8	20.0	16.4 - 267	1,100	No	20.3 - 46.0	---

(a) The number of samples in which the chemical was detected divided by the total number of samples analyzed, excluding samples rejected as a result of data validation.
(b) The number of samples used in calculating the mean. Non-detect samples with high detection limits were included when calculating the mean, following USEPA Region III guidance.
(c) Calculated by averaging the detected concentration(s) with one-half the detection limit of non-detected sample(s).
(d) See Table 3-1 for a list of all tap water RBCs. Calcium, magnesium, potassium, and sodium are essential nutrients that do not have RBCs. Maximum concentrations of these chemicals were compared to allowable daily intake (ADI) levels. For lead, the action level of 15 µg/L (USEPA 1990b) was used.
(e) Background concentrations are from samples MW-52 through MW-54, and MW-63, which were sampled in two rounds.
(f) Statistical comparisons to background data were performed only for inorganics that exceed respective RBCs or ADIs.
b = Chemical was detected at concentrations above its tap water RBC or ADI but within background levels and was evaluated separately from site-related chemicals.
ND = Not detected.
NRA = No RBC available. Delta-BHC was selected as COPC because it lacks an RBC and could not be screened.
NU = Not used. The chemical was detected in all samples, thus detection limits were not used to calculate mean concentrations.
* = Selected as a COPC.

TABLE 3-4
SUMMARY OF CHEMICALS DETECTED IN SURFACE SOIL
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Residential Soil RBC (d)	Maximum Detect > RBC?	Range of Background Concentrations (e)	Site > Background? (f)
Organics:									
Acenaphthene	5 / 57	57	0.445	0.133 - 0.700	0.185 - 10.8	470	No	ND	---
Acetone	1 / 57	57	0.00526	0.0100	0.0200	780	No	ND	---
Anthracene	20 / 57	57	0.332	0.0070 - 0.700	0.0078 - 11.7	2,300	No	0.0150 - 0.0280	---
* Benzo(a)anthracene	17 / 57	57	0.0965	0.001 - 0.700	0.0020 - 2.0	0.88	**Yes**	0.0030 - 0.0050	---
* Benzo(a)pyrene	22 / 57	57	0.106	0.0007 - 0.700	0.001 - 2.40	0.088	**Yes**	0.0020 - 0.0080	---
* Benzo(b)fluoranthene	22 / 57	57	0.105	0.001 - 0.700	0.0020 - 2.19	0.88	**Yes**	0.00125 - 0.0100	---
Benzo(g,h,i)perylene	11 / 57	57	0.120	0.0070 - 0.800	0.0080 - 2.77	230	No	0.0110	---
Benzo(k)fluoranthene	21 / 57	57	0.0740	0.0007 - 0.700	0.001 - 1.20	8.8	No	0.001 - 0.0050	---
Benzoic acid	1 / 57	57	0.0832	0.140 - 0.700	0.190	31,000	No	ND	---
Chlordane	1 / 57	57	0.0103	0.0200	0.0250	0.49	No	ND	---
Chrysene	8 / 57	57	0.111	0.0070 - 0.700	0.0068 - 2.62	88	No	ND	---
4,4'-DDD	5 / 57	57	0.00234	0.0030	0.0050 - 0.0240	2.7	No	ND	---
4,4'-DDE	5 / 57	57	0.00284	0.0030	0.0060 - 0.0520	1.9	No	ND	---
4,4'-DDT	8 / 57	57	0.00345	0.0030	0.0028 - 0.0560	1.9	No	ND	---
* Dibenzo(a,h)anthracene	3 / 57	57	0.0660	0.0030 - 0.800	0.0220 - 0.698	0.088	**Yes**	ND	---
Dieldrin	1 / 57	57	0.00182	0.0030	0.0200	0.04	No	ND	---
Diethylphthalate	1 / 38	38	0.0847	0.140 - 0.700	0.280	6,300	No	ND	---
Endosulfan sulfate	2 / 57	57	0.00202	0.0030	0.0138 - 0.0190	47	No	ND	---
bis(2-Ethylhexyl)phthalate	10 / 54	54	0.267	0.140 - 0.700	0.115 - 4.59	46	No	ND	---
Fluoranthene	24 / 57	57	0.195	0.001 - 0.140	0.0030 - 5.05	310	No	0.0055 - 0.0180	---
Fluorene	2 / 57	57	0.0708	0.0330 - 0.700	0.487 - 0.755	310	No	ND	---
* Indeno(1,2,3-c,d)pyrene	12 / 57	57	0.0862	0.0030 - 0.700	0.0033 - 1.70	0.88	**Yes**	0.0080 - 0.0100	---
Methoxychlor	3 / 57	57	0.00161	0.0030	0.0028 - 0.0040	39	No	ND	---
Methylene chloride	7 / 57	57	0.00649	0.0100	0.0100 - 0.0200	85	No	0.0200	---
1-Methylnaphthalene	2 / 27	27	0.107	0.133	0.383 - 0.842	230	No	ND	---
2-Methylnaphthalene	3 / 57	57	0.231	0.133 - 0.700	0.189 - 6.05	230	No	ND	---
Naphthalene	7 / 57	57	0.326	0.133 - 0.700	0.314 - 4.97	310	No	ND	---
* PCB-1248	1 / 57	57	0.0103	0.0130	0.223	0.083	**Yes**	ND	---
* PCB-1254	1 / 57	57	0.0239	0.0130	1.0	0.16	**Yes**	ND	---
* PCB-1260	7 / 57	57	0.218	0.0130	0.0310 - 10.8	0.083	**Yes**	ND	---
Phenanthrene	9 / 57	57	0.244	0.0330 - 0.700	0.0540 - 6.29	230	No	0.0420 - 0.354	---
Pyrene	14 / 57	57	0.334	0.0070 - 0.140	0.0090 - 12.3	230	No	0.0090 - 0.0230	---

TABLE 3-4 (Continued)
SUMMARY OF CHEMICALS DETECTED IN SURFACE SOIL
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Residential Soil RBC (d)	Maximum Detect > RBC?	Range of Background Concentrations (e)	Site > Background? (f)
Inorganics:									
* Aluminum	53 / 53	53	11,900	NU	4,620 - 21,100	7,800	**Yes**	4,740 - 14,350	**Yes**
b Arsenic	3 / 57	57	3.69	7.50	0.643 - 4.31	0.43	**Yes**	3.24 - 3.80	No
Barium	19 / 53	53	35.0	40.0	35.5 - 117	550	No	67.0 - 92.4	---
b Beryllium	52 / 53	53	0.665	0.200	0.206 - 1.33	0.15	**Yes**	0.300 - 0.814	No
Calcium	43 / 43	43	610	NU	142 - 3,580	4,000,000	No	486 - 1,150	---
b Chromium	57 / 57	57	22.2	NU	7.58 - 96.7	39	**Yes**	9.42 - 31.3	No
Cobalt	55 / 57	57	7.72	2.0	3.61 - 29.0	470	No	2.47 - 16.6	---
Copper	55 / 55	55	12.4	NU	4.04 - 100	310	No	4.83 - 12.6	---
b Iron	57 / 57	57	20,400	NU	7,790 - 67,300	2,300	**Yes**	7,630 - 28,100	No
Lead	52 / 55	55	17.2	7.50	7.62 - 67.0	400	No	15.5 - 22.4	---
Magnesium	53 / 53	53	1,480	NU	523 - 3,770	800,000	No	881 - 2,610	---
b Manganese	49 / 49	49	179	NU	22.0 - 1,450	180	**Yes**	112 - 875	No
Mercury	3 / 57	57	0.0549	0.100	0.102 - 0.209	2.3	No	ND	---
Nickel	56 / 56	56	8.64	NU	3.10 - 35.7	160	No	2.83 - 11.9	---
Potassium	42 / 42	42	703	NU	313 - 1,130	1,000,000	No	358 - 936	---
Selenium	9 / 57	57	6.66	10.0	10.2 - 24.5	39	No	14.2	---
Sodium	41 / 41	41	493	NU	271 - 982	1,000,000	No	380 - 487	---
Vanadium	55 / 55	55	37.9	NU	21.0 - 54.8	55	No	19.9 - 58.9	---
Zinc	55 / 55	55	49.1	NU	18.8 - 301	2,300	No	14.8 - 43.9	---

(a) The number of samples in which the chemical was detected divided by the total number of samples analyzed, excluding samples rejected as a result of data validation.
(b) The number of samples used in calculating the mean. Non-detect samples with high detection limits were included when calculating the mean, following USEPA Region III guidance.
(c) Calculated by averaging the detected concentration(s) with one-half the detection limit of non-detected sample(s).
(d) See Table 3-2 for a list of all USEPA Region III residential soil RBCs. Calcium, magnesium, potassium, and sodium are essential nutrients that do not have RBCs. Maximum concentrations of these chemicals were compared to allowable daily intake (ADI) levels. For lead, the residential soil screening level of 400 mg/kg (USEPA 1994) was used.
(e) Background concentrations are from samples MW-52 through MW-54 and RISSBK-1 through RISSBK-5.
(f) Statistical comparisons to background were performed only for inorganics that exceed respective RBCs or ADIs.
b = Chemical was detected at concentrations above its industrial soil RBC or ADI but within background levels and was evaluated separately from site-related chemicals.
ND = Not detected.
NU = Not used. The chemical was detected in all samples, thus detection limits were not used to calculate mean concentrations.
* = Selected as a COPC.

TABLE 3-5
SUMMARY OF CHEMICALS DETECTED IN SOIL FROM TEST PITS BY EARTHTECH
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Residential Soil RBC (d)	Maximum Detect > RBC?
Organics:							
PCB-1242	1 / 2	2	0.101	0.04	0.183	0.083	**Yes**
PCB-1260	1 / 2	2	0.235	0.04	0.45	0.083	**Yes**

(a) The number of samples in which the chemical was detected divided by the total number of samples analyzed, excluding samples rejected as a result of data validation.

(b) The number of samples used in calculating the mean. Non-detect samples with high detection limits were included when calculating the mean, following USEPA Region III guidance.

(c) Calculated by averaging the detected concentration(s) with one-half the detection limit of non-detected sample(s).

(d) See Attachment A for a list of all USEPA Region III residential soil RBCs.

TABLE 3-6
SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOIL
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Residential Soil RBC (d)	Maximum Detect > RBC?	Range of Background Concentrations (e)	Site > Background? (f)
Organics:									
Acetone	12 / 62	62	0.00810	0.0100	0.0100 - 0.0500	780	No	ND	---
Benzo(a)anthracene	1 / 72	72	0.106	0.140 - 2.80	0.690	0.88	No	ND	---
* Benzo(a)pyrene	2 / 72	72	0.105	0.140 - 2.80	0.240 - 0.440	0.088	**Yes**	ND	---
Benzo(b)fluoranthene	1 / 72	72	0.105	0.140 - 2.80	0.640	0.88	No	ND	---
Benzo(k)fluoranthene	1 / 72	72	0.107	0.140 - 2.80	0.740	8.8	No	ND	---
Benzoic acid	1 / 72	72	0.101	0.140 - 2.80	0.375	31,000	No	ND	---
Chrysene	1 / 72	72	0.113	0.140 - 2.80	1.20	88	No	ND	---
4,4'-DDD	3 / 72	72	0.00177	0.0030	0.0050 - 0.0100	2.7	No	ND	---
4,4'-DDE	4 / 72	72	0.00221	0.0030	0.0080 - 0.0210	1.9	No	ND	---
4,4'-DDT	2 / 72	72	0.00191	0.0030	0.0068 - 0.0260	1.9	No	ND	---
Dieldrin	1 / 72	72	0.00158	0.0030	0.0070	0.04	No	ND	---
Diethylphthalate	2 / 28	28	0.110	0.140 - 1.40	0.170 - 0.450	6,300	No	ND	---
Endosulfan sulfate	2 / 72	72	0.00194	0.0030	0.0100 - 0.0250	47	No	ND	---
bis(2-Ethylhexyl)phthalate	14 / 58	58	0.375	0.140 - 2.80	0.160 - 6.50	46	No	0.370 - 0.450	---
Fluoranthene	2 / 72	72	0.105	0.140 - 2.80	0.330 - 0.380	310	No	ND	---
Indeno(1,2,3-c,d)pyrene	1 / 72	72	0.0992	0.140 - 2.80	0.210	0.88	No	ND	---
Methoxychlor	4 / 72	72	0.00181	0.0030	0.0040 - 0.0100	39	No	ND	---
Methylene chloride	6 / 72	72	0.00583	0.0100	0.0100 - 0.0300	85	No	ND	---
* PCB-1248	1 / 72	72	0.0114	0.0130	0.362	0.083	**Yes**	ND	---
* PCB-1254	1 / 72	72	0.00867	0.0130	0.163	0.16	**Yes**	ND	---
* PCB-1260	1 / 72	72	0.0290	0.0130 - 0.0260	1.62	0.083	**Yes**	ND	---
Pyrene	2 / 72	72	0.106	0.140 - 2.80	0.280 - 0.480	230	No	ND	---
Inorganics:									
* Aluminum	53 / 53	53	8,950	NU	1,660 - 20,700	7,800	**Yes**	5,945 - 18,200	---
Antimony	2 / 72	72	0.159	0.300	0.395 - 0.522	3.1	No	ND	---
* Arsenic	2 / 72	72	3.94	7.50	2.98 - 18.4	0.43	**Yes**	ND	**Yes**
Barium	21 / 69	69	45.9	40.0	34.4 - 506	550	No	67.4 - 73.8	---
b Beryllium	47 / 64	64	0.504	0.200	0.237 - 2.44	0.15	**Yes**	0.346 - 1.02	No
Cadmium	1 / 72	72	0.261	0.500	1.02	3.9	No	ND	---

TABLE 3-6 (Continued)
SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOIL
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Residential Soil RBC (d)	Maximum Detect > RBC?	Range of Background Concentrations (e)	Site > Background? (f)
Calcium	41 / 47	47	1,070	100	129 - 21,500	4,000,000	No	113 - 454	---
b Chromium	67 / 67	67	15.6	NU	1.68 - 40.8	39	**Yes**	3.66 - 25.0	No
Cobalt	56 / 72	72	7.16	2.0	2.00 - 61.0	470	No	4.56 - 13.9	---
Copper	58 / 58	58	11.1	NU	1.65 - 47.0	310	No	1.52 - 16.9	---
b Iron	55 / 55	55	13,800	NU	1,750 - 40,400	2,300	**Yes**	2,490 - 27,800	No
Lead	25 / 72	72	9.22	7.50	9.02 - 113	400	No	7.38 - 11.8	---
Magnesium	55 / 55	55	1,680	NU	322 - 5,870	800,000	No	366 - 3,700	---
b Manganese	47 / 47	47	210	NU	10.9 - 3,270	180	**Yes**	32.8 - 617	No
Nickel	58 / 71	71	7.15	2.0	2.41 - 31.3	160	No	4.40 - 17.9	---
Potassium	45 / 48	48	553	100	143 - 1,340	1,000,000	No	148 - 624	---
Silver	1 / 72	72	0.275	0.500	2.08	39	No	ND	---
Sodium	36 / 36	36	582	NU	345 - 1,540	1,000,000	No	320 - 933	---
* Vanadium	53 / 54	54	29.3	2.50	4.72 - 66.7	55	**Yes**	6.90 - 25.8	---
Zinc	42 / 50	50	53.1	5.0	6.41 - 610	2,300	No	5.45 - 46.3	---

(a) The number of samples in which the chemical was detected divided by the total number of samples analyzed, excluding samples rejected as a result of data validation.
(b) The number of samples used in calculating the mean. Non-detect samples with high detection limits were included when calculating the mean, following USEPA Region III guidance.
(c) Calculated by averaging the detected concentration(s) with one-half the detection limit of non-detected sample(s).
(d) See Table 3-2 for a list of all USEPA Region III residential soil RBCs. Calcium, magnesium, potassium, and sodium are essential nutrients that do not have RBCs. Maximum concentrations of these chemicals were compared to allowable daily intake (ADI) levels. For lead, the residential soil screening level of 400 mg/kg (USEPA 1994) was used.
(e) Background concentrations are from samples MW-52 through MW-54, each at two depths.
(f) Statistical comparisons to background were performed only for inorganics that exceed respective RBCs or ADIs, and that had at least five site and five background samples. Aluminum and vanadium had fewer than five background samples and were thus selected as COPCs.
b = Chemical was detected at concentrations above its residential soil RBC or ADI, but within background levels and was evaluated separately from site related chemicals.
ND = Not detected.
NU = Not used. The chemical was detected in all samples, thus detection limits were not used to calculate mean concentrations.
* = Selected as a COPC.

TABLE 3-7
SUMMARY OF CHEMICALS DETECTED IN SEDIMENT
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Residential Soil RBC (d)	Maximum Detect > RBC?	Range of Background Concentrations (e)	Site > Background? (f)
Marsh Area									
Organics:									
Acenaphthene	2 / 3	3	0.841	0.133	0.867 - 1.59	470	No	0.668 - 0.919	---
Anthracene	3 / 3	3	0.447	NU	0.0310 - 0.979	2,300	No	0.108 - 0.169	---
Benzo(a)anthracene	2 / 3	3	0.0142	0.001	0.0160 - 0.0260	0.88	No	0.0210 - 0.0310	---
* Benzo(a)pyrene	2 / 3	3	0.0697	0.0180	0.0020 - 0.198	0.088	**Yes**	0.0290 - 0.0515	---
Benzo(b)fluoranthene	2 / 3	3	0.0508	0.0330	0.0040 - 0.132	0.88	No	0.0610 - 0.0830	---
Benzo(g,h,i)perylene	1 / 3	3	0.0663	0.0070 - 0.0670	0.162	230	No	0.0460 - 0.0800	---
Benzo(k)fluoranthene	2 / 3	3	0.0270	0.0180	0.0020 - 0.0700	8.8	No	0.0170 - 0.0320	---
Fluoranthene	3 / 3	3	0.0487	NU	0.0060 - 0.0950	310	No	0.0550 - 0.0940	---
Indeno(1,2,3-c,d)pyrene	1 / 3	3	0.234	0.0030 - 0.0830	0.660	0.88	No	0.0640 - 0.112	---
1-Methylnaphthalene	2 / 3	3	0.985	0.133	0.479 - 2.41	230	No	0.498 - 1.04	---
Naphthalene	2 / 3	3	1.02	0.133	1.11 - 1.88	310	No	0.351	---
* PCB-1260	2 / 5	5	0.0439	0.0130	0.0700 - 0.130	0.083	**Yes**	ND	---
Pyrene	2 / 3	3	0.0625	0.0070	0.0810 - 0.103	230	No	0.0530 - 0.130	---
Inorganics:									
* Aluminum	3 / 3	3	13,400	NU	13,200 - 13,700	7,800	**Yes**	10,500 - 15,200	---
Barium	1 / 3	3	41.7	40.0	85.2	550	No	175	---
* Beryllium	2 / 3	3	0.742	0.200	0.747 - 1.38	0.15	**Yes**	0.989 - 1.26	---
Calcium	2 / 2	2	3,750	NU	3,060 - 4,440	4,000,000	No	4,240 - 6,000	---
Chromium	3 / 3	3	22.5	NU	21.2 - 25.0	39	No	21.6 - 30.1	---
Cobalt	3 / 3	3	10.8	NU	8.97 - 13.1	470	No	14.6 - 20.7	---
Copper	3 / 3	3	23.2	NU	19.6 - 29.2	310	No	29.8 - 41.8	---
* Iron	3 / 3	3	19,600	NU	13,800 - 24,500	2,300	**Yes**	26,100 - 34,200	---
Lead	1 / 3	3	7.97	7.50	16.4	400	No	22.8 - 42.2	---
Magnesium	3 / 3	3	2,400	NU	2,140 - 2,600	800,000	No	2,470 - 3,470	---
* Manganese	2 / 2	2	286	NU	284 - 287	180	**Yes**	912 - 1,690	---
Nickel	3 / 3	3	16.4	NU	14.7 - 19.1	160	No	19.3 - 30.0	---
Potassium	3 / 3	3	1,050	NU	969 - 1,130	1,000,000	No	1,450 - 2,120	---
Sodium	3 / 3	3	1,920	NU	657 - 2,650	1,000,000	No	932 - 1,710	---
* Vanadium	3 / 3	3	48.5	NU	37.1 - 60.9	55	**Yes**	35.5 - 52.5	---
Zinc	3 / 3	3	86.0	NU	72.5 - 100	2,300	No	114 - 157	---

TABLE 3-7 (Continued)
SUMMARY OF CHEMICALS DETECTED IN SEDIMENT
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Residential Soil RBC (d)	Maximum Detect > RBC?	Range of Background Concentrations (e)	Site > Background? (f)
Open Water Area									
Organics:									
Acenaphthene	1 / 9	9	0.854	0.133	7.15	470	No	0.668 - 0.919	---
Anthracene	5 / 9	9	0.0938	0.0070	0.0410 - 0.552	2,300	No	0.108 - 0.169	---
Benzo(a)anthracene	8 / 9	9	0.0368	0.001	0.0020 - 0.142	0.88	No	0.0210 - 0.0310	---
* Benzo(a)pyrene	8 / 9	9	0.0435	0.0007	0.001 - 0.195	0.088	**Yes**	0.0290 - 0.0515	---
Benzo(b)fluoranthene	9 / 9	9	0.0537	NU	0.0030 - 0.141	0.88	No	0.0610 - 0.0830	---
Benzo(g,h,i)perylene	4 / 9	9	0.0405	0.0070	0.0590 - 0.119	230	No	0.0460 - 0.0800	---
Benzo(k)fluoranthene	9 / 9	9	0.0249	NU	9E-04 - 0.0820	8.8	No	0.0170 - 0.0320	---
Chrysene	1 / 9	9	0.00700	0.0070	0.0350	88	No	ND	---
4,4'-DDD	1 / 9	9	0.00322	0.0030	0.0170	2.7	No	ND	---
4,4'-DDE	1 / 9	9	0.00233	0.0030	0.0090	1.9	No	ND	---
4,4'-DDT	1 / 9	9	0.00333	0.0030	0.0180	1.9	No	ND	---
Dibenz(a,h)anthracene	2 / 9	9	0.00417	0.0030	0.0120 - 0.0150	0.088	No	0.0130 - 0.0220	---
Fluoranthene	6 / 6	6	0.111	NU	0.0040 - 0.259	310	No	0.0550 - 0.0940	---
Fluorene	1 / 9	9	0.0314	0.0330	0.151	310	No	0.157 - 0.355	---
Indeno(1,2,3-c,d)pyrene	5 / 9	9	0.0331	0.0030	0.0270 - 0.0940	0.88	No	0.0640 - 0.112	---
2-Methylnaphthalene	1 / 9	9	0.274	0.133	1.93	230	No	ND	---
* PCB-1260	1 / 9	9	0.0151	0.0130	0.0840	0.083	**Yes**	ND	---
Phenanthrene	1 / 9	9	0.0197	0.0330	0.0450	230	No	ND	---
Pyrene	7 / 9	9	0.112	0.0070	0.0090 - 0.419	230	No	0.0530 - 0.130	---
Inorganics:									
* Aluminum	4 / 4	4	8,760	NU	3,340 - 14,700	7,800	**Yes**	10,500 - 15,200	---
b Beryllium	5 / 9	9	0.422	0.200	0.316 - 1.26	0.15	**Yes**	0.989 - 1.26	No
Calcium	3 / 3	3	3,720	NU	1,360 - 5,420	4,000,000	No	4,240 - 6,000	---
Chromium	9 / 9	9	15.9	NU	5.20 - 34.9	39	No	21.6 - 30.1	---
Cobalt	9 / 9	9	10.6	NU	2.73 - 29.4	470	No	14.6 - 20.7	---
Copper	8 / 8	8	16.3	NU	4.10 - 36.9	310	No	29.8 - 41.8	---
b Iron	9 / 9	9	17,200	NU	6,530 - 48,500	2,300	**Yes**	26,100 - 34,200	No
Lead	4 / 9	9	10.1	7.50	10.6 - 35.3	400	No	22.8 - 42.2	---
Magnesium	5 / 5	5	1,900	NU	799 - 3,200	800,000	No	2,470 - 3,470	---
b Manganese	9 / 9	9	494	NU	125 - 895	180	**Yes**	912 - 1,690	No
Nickel	9 / 9	9	10.4	NU	2.53 - 22.5	160	No	19.3 - 30.0	---
Potassium	2 / 3	3	933	100	1,140 - 1,610	1,000,000	No	1,450 - 2,120	---

TABLE 3-7 (Continued)
SUMMARY OF CHEMICALS DETECTED IN SEDIMENT
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Residential Soil RBC (d)	Maximum Detect > RBC?	Range of Background Concentrations (e)	Site > Background? (f)
Silver	1 / 9	9	0.606	0.500	3.45	39	No	ND	---
Sodium	4 / 4	4	1,330	NU	519 - 2,290	1,000,000	No	932 - 1,710	---
b Vanadium	9 / 9	9	39.4	NU	13.5 - 112	55	**Yes**	35.5 - 52.5	No
Zinc	7 / 7	7	71.7	NU	27.5 - 158	2,300	No	114 - 157	---

(a) The number of samples in which the chemical was detected divided by the total number of samples analyzed, excluding samples rejected as a result of data validation.
(b) The number of samples used in calculating the mean. Non-detect samples with high detection limits were included when calculating the mean, following USEPA Region III guidance.
(c) Calculated by averaging the detected concentration(s) with one-half the detection limit of non-detects.
(d) See Table 3-2 for a list of all USEPA Region III residential soil RBCs. Calcium, magnesium, potassium, and sodium are essential nutrients that do not have RBCs. Maximum concentrations of these chemicals were compared to allowable daily intake (ADI) levels. For lead, the residential soil screening level of 400 mg/kg (USEPA 1994) was used.
(e) Background concentrations are from samples RISDBK-1 through RISDBK-5.
(f) All inorganics above RBC levels in the Marsh Area grouping were selected as COPCs; no background comparison was performed due to the low sample size. Statistical comparisons were performed on chemicals in the Open Water Area for inorganics that exceed respective RBCs or ADIs, and that had at least five site and five background samples. In the Open Water Area grouping, aluminum had fewer than five background samples and was thus selected as a COPC.
b = Chemical was detected at concentration above its residential soil RBC or ADI, but within background levels and was evaluated separately from site-related chemicals.
NA = Not analyzed.
ND = Not detected.
NU = Not used. The chemical was detected in all samples, thus detection limits were not used to calculate mean concentrations.
* = Selected as a COPC.

TABLE 3-8
SUMMARY OF CHEMICALS DETECTED IN SURFACE WATER
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in ug/L)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Arithmetic Mean (c)	Range of Detection Limits	Range of Detected Concentrations	Tap Water RBC (d)	Maximum Detect > RBC?	Range of Background Concentrations (e)	Site > Background? (f)
Marsh Area									
Inorganics:									
Aluminum	3 / 3	3	1,480	NU	547 - 2,100	3,700	No	1,230 - 1,930	---
Calcium	3 / 3	3	3,140	NU	2,020 - 3,920	400,000	No	18,800 - 22,200	---
* Iron	3 / 3	3	1,860	NU	705 - 2,770	1,100	**Yes**	1,905 - 2,510	---
Lead	2 / 3	3	1.10	1.0	1.20 - 1.60	15	No	1.30 - 1.90	---
Magnesium	3 / 3	3	1,720	NU	1,250 - 2,070	80,500	No	5,970 - 7,500	---
* Manganese	3 / 3	3	58.5	NU	28.3 - 91.2	84	**Yes**	176 - 303	---
Potassium	3 / 3	3	2,520	NU	2,010 - 2,910	100,000	No	2,870 - 3,670	---
Sodium	3 / 3	3	2,390	NU	1,380 - 3,320	100,000	No	12,500 - 16,500	---
Open Water Area									
Inorganics:									
b Aluminum	9 / 9	9	2,040	NU	927 - 5,070	3,700	**Yes**	1,230 - 1,930	No
Barium	9 / 9	9	42.2	NU	30.9 - 69.9	260	No	37.7 - 41.8	---
Calcium	9 / 9	9	17,000	NU	15,100 - 20,200	400,000	No	18,800 - 22,200	---
Chromium	1 / 9	9	5.68	10.0	11.1	18	No	10.8	---
Copper	3 / 9	9	5.07	5.0	6.10 - 17.6	150	No	ND	---
b Iron	9 / 9	9	2,770	NU	1,310 - 6,900	1,100	**Yes**	1,905 - 2,510	No
Lead	9 / 9	9	3.32	NU	1.40 - 8.40	15	No	1.30 - 1.90	---
Magnesium	9 / 9	9	5,650	NU	4,930 - 6,970	80,500	No	5,970 - 7,500	---
b Manganese	9 / 9	9	195	NU	103 - 373	84	**Yes**	176 - 303	No
Potassium	9 / 9	9	4,010	NU	3,400 - 5,070	100,000	No	2,870 - 3,670	---
Sodium	9 / 9	9	12,600	NU	11,100 - 14,700	100,000	No	12,500 - 16,500	---
Vanadium	2 / 9	9	6.54	10.0	10.8 - 13.1	26	No	ND	---
Zinc	8 / 9	9	24.8	20.0	20.6 - 40.1	1,100	No	ND	---

(a) The number of samples in which the chemical was detected divided by the total number of samples analyzed, excluding samples rejected as a result of data validation.
(b) The number of samples used in calculating the mean. Non-detect samples with high detection limits were included when calculating the mean, following USEPA Region III guidance.
(c) Calculated by averaging the detected concentration(s) with one-half the detection limit of non-detected sample(s).
(d) See Table 3-1 for a list of all tap water RBCs. Calcium, magnesium, potassium, and sodium are essential nutrients that do not have RBCs. Maximum concentrations of these chemicals were compared to allowable daily intake (ADI) levels. For lead, the action level of 15 µg/L (USEPA 1990b) was used.
(e) Background concentrations are from samples RISWBK-1 through RISWBK-5.
(f) No comparison of site to background concentrations was performed on chemicals detected in the Marsh Area because of low sample size; statistical comparisons were performed only on chemicals in the Open Water Area. Comparisons to background for the Open Water Area were performed only for inorganics that exceed respective RBCs or ADIs.
b = Chemical was detected at concentrations above its tap water RBC or ADI but within background levels and was evaluated separately from site-related chemicals.
NU = Not used. The chemical was detected in all samples, thus detection limits were not used to calculate mean concentrations.
* = Selected as a COPC.

TABLE 3-9

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN AT OU1

CHEMICAL	GROUNDWATER	SURFACE SOIL	SUBSURFACE SOIL	SEDIMENT		SURFACE WATER	
				Marsh Area	Open Water Area	Marsh Area	Open Water Area
Organic Chemicals							
Aldrin	X						
Benzo(a)anthracene		X					
Benzo(a)pyrene		X	X	X	X		
Benzo(b)fluoranthene		X					
delta-BHC	X						
gamma-BHC (lindane)	X						
Dibenzo(a,h)anthracene		X					
Dieldrin	X						
bis(2-Ethylhexyl)phthalate	X						
Heptachlor	X						
Heptachlor epoxide	X						
Indeno(1,2,3-c,d)pyrene		X					
PCB 1016	X						
PCB 1248		X	X				
PCB 1254		X	X				
PCB 1260		X	X	X	X		
Inorganic Chemicals							
Aluminum	b	X	X	X	X		b
Arsenic	b	b	X				
Barium	b						
Beryllium		b	b	X	b		
Chromium	b	b	b				
Iron	X	b	b	X	b	X	b
Lead	b						
Manganese	X	b	b	X	b	X	b
Nickel	b						
Thallium	b						
Vanadium	b		X	X	b		

X = Selected as a COPC.

b = Inorganic chemical within background levels, but above residential soil RBCs (for soil and sediment) or tap water RBCs (for groundwater and surface water).

TABLE 3-10

POTENTIAL HUMAN EXPOSURE PATHWAYS UNDER HYPOTHETICAL FUTURE LAND-USE CONDITIONS AT OU1

Exposure Medium	Potential Receptor	Exposure Route	Retained for Analysis?	Rationale for Selection or Exclusion
Groundwater	Child and adult residents	• Ingestion • Dermal contact • Inhalation	Yes (for ingestion and dermal contact)	COPCs were selected in groundwater, and both child and adult residents could be exposed to COPCs via ingestion of drinking water and dermal absorption while bathing. VOCs were not selected as COPCs in groundwater, therefore, inhalation of VOCs while showering was not evaluated.
Surface soil	Child and adult residents	• Ingestion • Dermal contact • Inhalation	Yes (for ingestion and dermal contact)	COPCs were selected in surface soil and both child and adult residents could be exposed to COPCs via incidental ingestion and dermal absorption. Due to the low concentrations in surface soil, it is unlikely that significant inhalation exposures due to generation of particulate matter from soils would occur.
Subsurface soil	Child and adult residents	• Ingestion • Dermal contact • Inhalation	No	It is unlikely that future residents would be exposed to COPCs in soil below 2 feet.
	Excavation workers	• Ingestion • Dermal contact • Inhalation	Yes	COPCs were selected in subsurface soil and excavation workers could be exposed to COPCs via incidental ingestion, dermal absorption, and inhalation of particulate matter from soils.
Marsh Area Sediment	Child and adult residents	• Incidental ingestion • Dermal contact	Yes (child residents only)	Children playing or wading along the shoreline could be exposed to COPCs in Marsh Area sediment via incidental ingestion and dermal absorption. It is unlikely that adult residents would have greater exposures than child residents, thus sediment exposures for adults were not evaluated.
Open Water Sediment	Child and adult residents	• Incidental ingestion • Dermal contact	No	Exposures to sediment in the Open Water Area grouping would not be significant, since Open Water Area sediment was under at least 2 feet of water.

TABLE 3-10 (continued)

POTENTIAL HUMAN EXPOSURE PATHWAYS UNDER HYPOTHETICAL FUTURE LAND-USE CONDITIONS AT OU1

Exposure Medium	Potential Receptor	Exposure Route	Retained for Analysis?	Rationale for Selection or Exclusion
Marsh Area Surface water	Child and adult residents	• Incidental ingestion • Dermal contact	Yes (child residents only)	Children wading along the shoreline in the Marsh Area could be exposed to COPCs in surface water via dermal absorption; surface water would be too shallow in this area for incidental ingestion exposures to occur. As for exposures to sediment, it is unlikely that adult residents would have greater exposures than child residents, thus surface water exposures for adults were not evaluated for the Marsh Area.
Open Area Surface Water	Child and adult residents	• Incidental ingestion • Dermal contact	No	No COPCs were selected in Open Water Area surface water (however, adult residents could be exposed to chemicals above RBCs but within background levels via incidental ingestion and dermal absorption while swimming, thus risks associated with these exposures are presented in the Uncertainty Section).

TABLE 3-11
EXPOSURE POINT CONCENTRATIONS FOR CHEMICALS OF POTENTIAL CONCERN
AT WOODBRIDGE RESEARCH FACILITY - OU1

Chemical	Arithmetic Mean	Maximum Detected Concentration	95% UCL	Exposure Point Concentration
GROUNDWATER (ug/L)				
Organics:				
Aldrin	0.00275	0.0100	0.00288	0.00288
delta-BHC	0.00260	0.0070	0.00270	0.00270
gamma-BHC (Lindane)	0.00752	0.214	0.00449	0.00449
Dieldrin	0.00276	0.0170	0.00285	0.00285
bis(2-Ethylhexyl)phthalate	8.52	130	7.18	7.18
Heptachlor	0.00265	0.0110	0.00275	0.00275
Heptachlor epoxide	0.00469	0.0880	0.00396	0.00396
PCB-1016	0.117	2.93	0.0906	0.0906
Inorganics:				
b Aluminum	2,290	85,000	1,930	1,930
b Arsenic	0.873	4.10	0.959	0.959
b Barium	47.2	324	57.0	57.0
b Chromium	26.2	1,120	10.2	10.2
Iron	9,090	109,000	39,700	39,700
b Lead	4.05	54.6	4.11	4.11
Manganese	619	5,160	1,220	1,220
b Nickel	21.2	706	13.0	13.0
b Thallium	0.0809	1.70	0.0686	0.0686
b Vanadium	9.94	259	7.56	7.56
SURFACE SOIL (mg/kg)				
Organics:				
Benzo(a)anthracene	0.0965	2.0	0.508	0.508
Benzo(a)pyrene	0.106	2.40	0.493	0.493
Benzo(b)fluoranthene	0.105	2.19	0.312	0.312
Dibenzo(a,h)anthracene	0.0660	0.698	0.383	0.383
Indeno(1,2,3-c,d)pyrene	0.0862	1.70	0.273	0.273
PCB-1248	0.0103	0.223	0.00867	0.00867
PCB-1254	0.0239	1.0	0.0106	0.0106
PCB-1260	0.218	10.8	0.0415	0.0415
Inorganics:				
Aluminum	11,900	21,100	12,900	12,900
b Arsenic	3.69	4.31	3.94	3.94
b Beryllium	0.665	1.33	0.753	0.753
b Chromium	22.2	96.7	23.8	23.8
b Iron	20,400	67,300	22,300	22,300
b Manganese	179	1,450	213	213
SUBSURFACE SOIL (mg/kg)				
Organics:				
Benzo(a)pyrene	0.105	0.440	0.0999	0.0999
PCB-1248	0.0114	0.362	0.00853	0.00853
PCB-1254	0.00867	0.163	0.00792	0.00792
PCB-1260	0.0290	1.62	0.0102	0.0102

TABLE 3-11 (Continued)
EXPOSURE POINT CONCENTRATIONS FOR CHEMICALS OF POTENTIAL CONCERN
AT WOODBRIDGE RESEARCH FACILITY - OU1

Chemical	Arithmetic Mean	Maximum Detected Concentration	95% UCL	Exposure Point Concentration
Inorganics:				
Aluminum	8,950	20,700	10,800	10,800
Arsenic	3.94	18.4	4.04	4.04
b Beryllium	0.504	2.44	0.676	0.676
b Chromium	15.6	40.8	19.0	19.0
b Iron	13,800	40,400	17,500	17,500
b Manganese	210	3,270	277	277
Vanadium	29.3	66.7	38.4	38.4
SEDIMENT (mg/kg)				
Marsh Area				
Organics:				
Benzo(a)pyrene	0.0697	0.198	1.02E+21	0.198 *
PCB-1260	0.0439	0.130	11.7	0.130 *
Inorganics:				
Aluminum	13,400	13,700	13,900	13,700 *
Beryllium	0.742	1.38	6.17E+07	1.38 *
Iron	19,600	24,500	46,600	24,500 *
Manganese	286	287	NC	287 *
Vanadium	48.5	60.9	87.4	60.9 *
Open Water Area				
Organics:				
Benzo(a)pyrene	0.0435	0.195	13.2	0.195 *
PCB-1260	0.0151	0.0840	0.0309	0.0309
Inorganics:				
Aluminum	8,760	14,700	44,000	14,700 *
b Beryllium	0.422	1.26	1.46	1.26 *
b Iron	17,200	48,500	31,500	31,500
b Manganese	494	895	1010	895 *
b Vanadium	39.4	112	75.6	75.6
SURFACE WATER (ug/L)				
Marsh Area				
Inorganics:				
Iron	1,860	2,770	223,000	2,770 *
Manganese	58.5	91.2	1,600	91.2 *
Open Water Area				
Inorganics:				
b Aluminum	2,040	5,070	3,780	3,780
b Iron	2,770	6,900	4,850	4,850
b Manganese	195	373	259	259

b = Chemical was detected at concentrations above its RBC or ADI, but within background concentrations and was evaluated separately from site-related chemicals.
NC = Not calculated because of low sample size.
* = Indicates RME concentration is the maximum detected concentration.

TABLE 3-12

EXPOSURE PARAMETERS FOR INGESTION OF CHEMICALS IN GROUNDWATER BY RESIDENTS AT OU1
[FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{pot} = \frac{C_{gw} * IR * EF * ED * CF}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case		
		Child	Adult	Source
Potential (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{pot}$	--	--	--
Chemical Concentration in Groundwater (μg/L)	C_{gw}	--	--	--
Ingestion Rate (L/day)	IR	1	2	EPA 1991a
Exposure Frequency (days/year)	EF	350	350	EPA 1991a
Exposure Duration (years)	ED	6	30	EPA 1991a
Conversion Factor	CF	$mg/10^3$ μg	$mg/10^3$ μg	--
Body Weight (kg)	BW	15	70	EPA 1991a
Averaging time (years)	AT			
Carcinogens		70	70	EPA 1991a
Noncarcinogens		6	30	EPA 1991a
Conversion Factor (days/year)	Days	365	365	--

TABLE 3-13

EXPOSURE PARAMETERS FOR DERMAL ABSORPTION OF CHEMICALS IN GROUNDWATER WHILE BATHING
BY RESIDENTS AT OU1
[FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{int} = \frac{DA * SA * EV * EF * ED}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case		Source
		Child	Adult	
Internal (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{int}$	--	--	--
Dose Absorbed Per Unit Area Per Event (mg/cm^2-event) (a)	DA	Calculated Value	Calculated Value	--
Skin Surface Area Available for Contact (cm^2) (b)	SA	7,000	18,000	EPA 1985
Event Frequency (events/day)	EV	1	1	Assumed
Exposure Frequency (days/year)	EF	350	350	EPA 1991a
Exposure Duration (years)	ED	6	30	EPA 1991a
Body Weight (kg)	BW	15	70	EPA 1991a
Averaging time (years)	AT			
Carcinogens		70	70	EPA 1991a
Noncarcinogens		6	30	EPA 1991a
Conversion Factor (days/year)	Days	365	365	--

(a) See text for equations on the derivation of the DA value.
(b) The values for surface area assumed that the entire body is available for exposure.

TABLE 3-14
PARAMETERS FOR CALCULATING DA_{event}

Chemical	Kp (cm/hr)	Tau (hr)	t* (hr)	log Kow (---)	MW (g/mol)	B (---)	Dsc (cm^2/hr)
Organics:							
Aldrin	1.60E-03	1.47E+01	3.62E+01	3.01	365	1.02E-01	1.13E-08
gamma-BHC (lindane)	1.40E-02	5.21E+00	3.50E+01	3.72	291	5.25E-01	3.20E-08
Dieldrin	1.60E-02	1.84E+01	9.38E+01	4.56	380.95	3.63E+00	9.04E-09
bis(2-Ethylhexyl)phthalate	3.30E-02	2.12E+01	1.02E+02	5.11	391	1.29E+01	7.85E-09
Heptachlor	1.10E-02	1.66E+01	9.43E+01	4.27	373.5	1.86E+00	1.00E-08
Heptachlor epoxide	6.7E-04	2.06E+01	4.95E+01	2.7	389	5.01E-02	8.07E-09
PCB-1016	7.6E-01	3.27E+00	1.55E+01	5.88	257.9	7.59E+01	5.09E-08
Inorganics:							
Aluminum	1.00E-03	NU	NU	NU	NU	NU	NU
Arsenic	1.00E-03	NU	NU	NU	NU	NU	NU
Barium	1.00E-03	NU	NU	NU	NU	NU	NU
Chromium	1.00E-03	NU	NU	NU	NU	NU	NU
Iron	1.00E-03	NU	NU	NU	NU	NU	NU
Manganese	1.00E-03	NU	NU	NU	NU	NU	NU
Nickel	1.00E-03	NU	NU	NU	NU	NU	NU
Thallium	1.00E-03	NU	NU	NU	NU	NU	NU
Vanadium	1.00E-03	NU	NU	NU	NU	NU	NU

NU = Not used. These parameters were not used to calculate DA_{event} for inorganic chemicals.

TABLE 3-15

EXPOSURE PARAMETERS FOR INCIDENTAL INGESTION OF CHEMICALS IN SURFACE SOIL BY RESIDENTS AT OU1
[FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{pot} = \frac{C_s * IR * EF * ED * Bio * CF}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case		
		Child	Adult	Source
Potential (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{pot}$	--	--	--
Chemical Concentration in Surface Soil (mg/kg)	C_s	--	--	--
Ingestion Rate (mg/day)	IR	200	100	EPA 1991a
Exposure Frequency (days/year)	EF	350	350	EPA 1991a
Exposure Duration (years)	ED	6	30	EPA 1991a
Bioavailability Factor (unitless)	Bio	1.0	1.0	Assumed
Conversion Factor	CF	$kg/10^6$ mg	$kg/10^6$ mg	--
Body Weight (kg)	BW	15	70	EPA 1991a
Averaging time (years)	AT			
Carcinogens		70	70	EPA 1991a
Noncarcinogens		6	30	EPA 1991a
Conversion Factor (days/year)	Days	365	365	--

TABLE 3-16

EXPOSURE PARAMETERS FOR DERMAL ABSORPTION OF CHEMICALS IN SURFACE SOIL BY RESIDENTS AT OU1
[FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{int} = \frac{C_s * SA * AF * Ab * EF * ED * CF}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case		
		Child	Adult	Source
Internal (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{int}$	--	--	--
Chemical Concentration in Surface Soil (mg/kg)	C_s	--	--	--
Skin Surface Area Available for Contact (cm^2) (a)	SA	2,200	6,400	EPA 1985
Soil-to-Skin Adherence Factor (mg/cm^2-day)	AF	1.0	1.0	EPA 1992b
Dermal Absorption Factor (percent)	Ab			
Inorganics		1	1	EPA 1995b
PCBs		6	6	
Semivolatiles		10	10	
Exposure Frequency (days/year)	EF	350	350	EPA 1991a
Exposure Duration (years)	ED	6	30	EPA 1991a
Conversion Factor	CF	$kg/10^6$ mg	$kg/10^6$ mg	--
Body Weight (kg)	BW	15	70	EPA 1991a
Averaging time (years)	AT			
Carcinogens		70	70	EPA 1991a
Noncarcinogens		6	30	EPA 1991a
Conversion Factor (days/year)	Days	365	365	--

(a) The values for surface area assumed that ½ arms, ½ legs, feet, and hands are available for exposures.

TABLE 3-17

EXPOSURE PARAMETERS FOR INCIDENTAL INGESTION OF CHEMICALS IN SUBSURFACE SOIL BY EXCAVATION WORKERS AT OU1
[FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{pot} = \frac{C_s * IR * EF * ED * Bio * CF}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case	Source
Potential (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{pot}$	--	--
Chemical Concentration in Surface Soil (mg/kg)	C_s	--	--
Ingestion Rate (mg/day)	IR	480	EPA 1991a
Exposure Frequency (days/year)	EF	250	EPA 1991a
Exposure Duration (years)	ED	1	EPA 1991a
Bioavailability Factor (unitless)	Bio	1.0	Assumed
Conversion Factor	CF	$kg/10^6$ mg	--
Body Weight (kg)	BW	70	EPA 1991a
Averaging time (years)	AT		
Carcinogens		70	EPA 1991a
Noncarcinogens		1	EPA 1991a
Conversion Factor (days/year)	Days	365	---

TABLE 3-18

EXPOSURE PARAMETERS FOR DERMAL ABSORPTION OF CHEMICALS IN SUBSURFACE SOIL BY EXCAVATION WORKERS AT OU1
[FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{int} = \frac{C_s * SA * AF * Ab * EF * ED * CF}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case	Source
Internal (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{int}$	--	--
Chemical Concentration in Surface Soil (mg/kg)	C_s	--	--
Skin Surface Area Available for Contact (cm^2) (a)	SA	3,500	EPA 1985
Soil-to-Skin Adherence Factor (mg/cm^2-day)	AF	1.0	EPA 1992b
Dermal Absorption Factor (percent)	Ab		
Inorganics		1	EPA 1995b
PCBs		6	
Semivolatiles		10	
Exposure Frequency (days/year)	EF	250	EPA 1991a
Exposure Duration (years)	ED	1	EPA 1991a
Conversion Factor	CF	$kg/10^6$ mg	--
Body Weight (kg)	BW	70	EPA 1991a
Averaging time (years)	AT		
Carcinogens		70	EPA 1991a
Noncarcinogens		1	EPA 1991a
Conversion Factor (days/year)	Days	365	--

(a) The value for surface area assumed that hands and arms are available for exposures.

TABLE 3-19

EXPOSURE PARAMETERS FOR INHALATION OF AIRBORNE PARTICULATE MATTER BY EXCAVATION WORKERS AT OU1
[FUTURE LAND-USE CONDITIONS]

$$IEC = \frac{\frac{1}{PEF} * C_s * ET * EF * ED * CF_1}{AT * Days * CF_2}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case	Source
Inhalation Exposure Concentration ($\mu g/m^3$ for carcinogens, mg/m^3 for noncarcinogens)	IEC	--	--
Particulate Emission Factor (m^3/kg)	PEF	1.32×10^9	EPA 1996b
Chemical Concentration in Subsurface Soil (mg/kg)	C_s	--	--
Exposure Time (hours/day)	ET	8	Assumed
Exposure Frequency (days/year)	EF	250	EPA 1991a
Exposure Duration (years)	ED	1	Assumed
Conversion Factor	CF_1	1 (noncarcinogens) 10^3 $\mu g/mg$ (carcinogens)	--
Averaging time (years)	AT		
Carcinogens		70	EPA 1991a
Noncarcinogens		1	EPA 1991a
Conversion Factor (days/year)	Days	365	--
Conversion Factor (hours/day)	CF_2	24	--

TABLE 3-20

EXPOSURE PARAMETERS FOR INCIDENTAL INGESTION OF CHEMICALS IN SEDIMENT BY CHILD RESIDENTS AT OU1
[FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{pot} = \frac{C_{sed} * IR * EF * ED * Bio * CF}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case	Source
Potential (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{pot}$	--	--
Chemical Concentration in Sediment (mg/kg)	C_{sed}	--	--
Ingestion Rate (mg/day)	IR	200	EPA 1991a
Exposure Frequency (days/year)	EF	100	Assumed
Exposure Duration (years)	ED	6	EPA 1991a
Bioavailability Factor (unitless)	Bio	1.0	Assumed
Conversion Factor	CF	$kg/10^6$ mg	--
Body Weight (kg)	BW	15	EPA 1991a
Averaging time (years)	AT		
Carcinogens		70	EPA 1991a
Noncarcinogens		6	EPA 1991a
Conversion Factor (days/year)	Days	365	--

TABLE 3-21

EXPOSURE PARAMETERS FOR DERMAL ABSORPTION OF CHEMICALS IN SEDIMENT BY CHILD RESIDENTS AT OU1 [FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{int} = \frac{C_{sed} * SA * AF * Ab * EF * ED * CF}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case	Source
Internal (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{int}$	--	--
Chemical Concentration in Sediment (mg/kg)	C_s	--	--
Skin Surface Area Available for Contact (cm^2) (a)	SA	2,200	EPA 1985
Soil-to-Skin Adherence Factor (mg/cm^2-day)	AF	1.0	EPA 1992b
Dermal Absorption Factor (percent)	Ab		
Inorganics		1	EPA 1995b
PCBs		6	
Semivolatiles		10	
Exposure Frequency (days/year)	EF	100	Assumed
Exposure Duration (years)	ED	6	EPA 1991a
Conversion Factor	CF	$kg/10^6$ mg	--
Body Weight (kg)	BW	15	EPA 1991a
Averaging time (years)	AT		
Carcinogens		70	EPA 1991a
Noncarcinogens		6	EPA 1991a
Conversion Factor (days/year)	Days	365	--

(a) The value for surface area assumed that hands, ½ arms, ½ legs, and feet are available for exposures.

TABLE 3-22

EXPOSURE PARAMETERS FOR INCIDENTAL INGESTION OF CHEMICALS IN SURFACE WATER BY ADULT RESIDENTS AT OU1 WHILE SWIMMING
[FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{pot} = \frac{C_{sw} * IR * ET * EF * ED * CF}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case	Source
Potential (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{pot}$	--	--
Chemical Concentration in Surface Water (μg/L)	C_{sw}	--	--
Ingestion Rate (L/hour)	IR	0.05	EPA 1989a
Exposure Time (hours/day)	ET	2	Assumed
Exposure Frequency (days/year)	EF	48	Assumed
Exposure Duration (years)	ED	30	EPA 1991a
Conversion Factor	CF	$mg/10^3$ μg	--
Body Weight (kg)	BW	70	EPA 1991a
Averaging time (years)	AT		
Carcinogens		70	EPA 1991a
Noncarcinogens		30	EPA 1991a
Conversion Factor (days/year)	Days	365	--

TABLE 3-23

EXPOSURE PARAMETERS FOR DERMAL ABSORPTION OF CHEMICALS IN SURFACE WATER WHILE SWIMMING BY ADULT RESIDENTS AT OU1
[FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{int} = \frac{DA * SA * EV * EF * ED}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case	Source
Internal (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{int}$	--	--
Dose Absorbed Per Unit Area Per Event (mg/cm^2-event) (a)	DA	Calculated value	--
Skin Surface Area Available for Contact (cm^2) (b)	SA	14,000	EPA 1985
Event Frequency (events/day)	EV	1	Assumed
Exposure Frequency (days/year)	EF	48	Assumed
Exposure Duration (years)	ED	30	EPA 1991a
Body Weight (kg)	BW	70	EPA 1991a
Averaging time (years)	AT		
Carcinogens		70	EPA 1991a
Noncarcinogens		30	EPA 1991a
Conversion Factor (days/year)	Days	365	--

(a) See text for equations on the derivation of the DA value.
(b) The value for surface area assumed that the entire body, except the head, is available for exposure.

TABLE 3-24

EXPOSURE PARAMETERS FOR DERMAL ABSORPTION OF CHEMICALS IN SURFACE WATER BY CHILD RESIDENTS AT OU1 WHILE WADING
[FUTURE LAND-USE CONDITIONS]

$$(L)ADD_{int} = \frac{DA * SA * EV * EF * ED}{BW * AT * Days}$$

Parameter	Parameter Abbreviation	Reasonable Maximum Exposure (RME) Case	Source
Internal (Lifetime) Average Daily Dose (mg/kg-day)	$(L)ADD_{int}$	--	--
Dose Absorbed Per Unit Area Per Event (mg/cm^2-event) (a)	DA	Calculated value	--
Skin Surface Area Available for Contact (cm^2) (b)	SA	2,200	EPA 1985
Event Frequency (events/day)	EV	1	Assumed
Exposure Frequency (days/year)	EF	48	Assumed
Exposure Duration (years)	ED	6	EPA 1991a
Body Weight (kg)	BW	15	EPA 1991a
Averaging time (years)	AT		
Carcinogens		70	EPA 1991a
Noncarcinogens		6	EPA 1991a
Conversion Factor (days/year)	Days	365	--

(a) See text for equations on the derivation of the DA value.
(b) The value for surface area assumed that hands, ½ arms, ½ legs, and feet are available for exposures.

TABLE 3-25
CHRONIC ORAL TOXICITY CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN AT OU1

	Oral Toxicity Criteria for Carcinogens			Oral Toxicity Criteria for Noncarcinogens			
Chemical	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Class (a)	Slope Factor Source	Chronic Oral Reference Dose (RfD) (mg/kg-day)	Uncertainty Factor (b)	Target Organ/ Critical Effect (c)	RfD Source
Organics							
Aldrin	1.7E+01	B2	IRIS	3E-05	1,000	Liver	IRIS
Benzo(a)anthracene	7.3E-01 (d)	B2	IRIS	---	---	---	---
Benzo(a)pyrene	7.3E+00	B2	IRIS	---	---	---	---
Benzo(b)fluoranthene	7.3E-01 (d)	B2	IRIS	---	---	---	---
delta-BHC	---	D	IRIS	---	---	---	HEAST
gamma-BHC	1.3E+00	B2/C	HEAST	3E-04	100	Liver/Kidney	IRIS
Dibenz(a,h)anthracene	7.3E+00 (d)	B2	IRIS	---	---	---	---
Dieldrin	1.6E+01	B2	IRIS	5E-05	100	Liver	IRIS
bis(2-Ethylhexyl)phthalate	1.4E-02	B2	IRIS	2E-02	1,000	Liver	IRIS
Heptachlor	4.5E+00	B2	IRIS	5E-04	300	Liver	IRIS
Heptachlor epoxide	9.1E+00	B2	IRIS	1.3E-05	1,000	Liver	IRIS
Indeno(1,2,3-c,d)pyrene	7.3E-01 (d)	B2	IRIS	---	---	---	---
PCBs (carcinogenic)	7.7E+00	B2	IRIS	---	---	---	---
PCB-1016	---	---	---	7E-05	100	< Birth Weight	IRIS
PCB-1254	---	---	---	2E-05	300	Eyes	IRIS
Inorganics							
Aluminum	---	D	NCEA	1E+00	100	Developmental Effects	NCEA
Arsenic	1.5E+00	A	IRIS	3E-04	3	Skin	IRIS
Barium	---	---	---	7E-02	3	Incr. blood pressure	IRIS
Beryllium	4.3E+00	B2	IRIS	5E-03 (e)	100	None observed	IRIS
Chromium (VI)	---	A	IRIS	5E-03	500	CNS	IRIS
Iron	---	---	---	3E-01	---	---	NCEA
Lead	---	B2	IRIS	---	---	CNS	IRIS
Manganese	---	D	IRIS	2.4E-02	3	CNS	IRIS
Nickel	--- (f)	---	---	2E-02	300	Body Weight	IRIS
Thallium	---	D	IRIS	8E-05 (g)	3,000	None observed	IRIS
Vanadium	---	---	---	7E-03	100	None observed	HEAST

(a) USEPA weight-of-evidence classification scheme for carcinogens:
A = Human Carcinogen, sufficient evidence of carcinogenicity in humans;
B1 = Probable Human Carcinogen, limited human data are available;
B2 = Probable Human Carcinogen, sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans;
C = Possible Human Carcinogen, limited evidence from animal studies in the absence of human studies; and
D = Not classified as to human carcinogenicity, inadequate or no evidence.

(b) Uncertainty factors presented are the products of specific uncertainty factors and modifying factors. Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include:
- a 10-fold factor to account for the variation in sensitivity among the members of the human population;
- a 10-fold factor to account for the uncertainty in extrapolating animal data to the case of humans;
- a 10-fold factor to account for the uncertainty in extrapolating from less-than-chronic NOAELs to chronic NOAELs;
- a 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.

Modifying factors are applied at the discretion of the RfD reviewer to cover other uncertainties in the data and range from 1 to 10.

(c) A target organ or critical effect is the organ/effect most sensitive to the chemical exposure. RfDs are based on toxic effects in the target organ or critical effects. If an RfD is based on a study in which a target organ or critical effect was not identified, the organ/effect listed is one known to be affected by the chemical.

(d) The cancer slope factor for benzo(a)pyrene was used to evaluate carcinogenic PAHs, along with the TEF approach. The TEFs used are as follows: benzo(a)anthracene (0.1), benzo(b)fluoranthene (0.1), dibenz(a,h)anthracene (1.0), and indeno(1,2,3-c,d)pyrene (0.1).

(e) The oral RfD for chromium VI was conservatively used to assess chromium exposures, although not all chromium present at the site will be in this form. Because the RfD for chromium was derived from a toxicity study in which no effects were noted, one of the more sensitive toxicological effects, CNS effects, was designated as the target organ of concern.

(f) The slope factor for nickel is under review.

(g) The RfD for thallium sulfate was used.

--- = No information available.

CNS = Central Nervous System.

NOTE: IRIS = Integrated Risk Information System - USEPA 1996b.
HEAST = Health Effects Assessment Summary Tables - USEPA 1995a.
NCEA = National Center for Environmental Assessment

TABLE 3-26
INHALATION TOXICITY CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN AT OU1

Chemical	Carcinogenic Inhalation Toxicity Criteria			Noncarcinogenic Inhalation Toxicity Criteria			
	Unit Risk ($ug/m^3)^{-1}$	Weight-of-Evidence Class (a)	Unit Risk Source	Inhalation Reference Concentration (RfC) (mg/m^3)	Uncertainty Factor (b)	Target Organ/ Critical Effect (c)	RfC Source
Organics							
Benzo(a)pyrene	1.7E-03 (d)	B2	IRIS	---	---	---	---
PCBs (carcinogenic)	---	B2	IRIS	---	---	---	---
PCB-1254	---	---	---	---	---	---	---
Inorganics							
Aluminum	---	---	---	---	---	---	HEAST
Arsenic	4.3E-03	A	IRIS	---	---	---	---
Beryllium	2.4E-03	B2	IRIS	---	---	---	---
Chromium (VI)	1.2E-02	A	IRIS	---	---	---	---
Iron	---	---	---	---	---	---	---
Manganese	---	D	IRIS	5E-05	1,000	CNS	IRIS
Vanadium	---	---	---	---	---	---	---

(a) USEPA weight-of-evidence classification scheme for carcinogens:
A = Human Carcinogen, sufficient evidence of carcinogenicity in humans;
B1 = Probable Human Carcinogen, limited human data are available;
B2 = Probable Human Carcinogen, sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans;
C = Possible Human Carcinogen, limited evidence from animal studies in the absence of human studies; and
D = Not classified as to human carcinogenicity, inadequate or no evidence.

(b) Uncertainty factors presented are the products of specific uncertainty factors and modifying factors. Uncertainty factors used to develop reference doses generally consist of multiples of 10, with each factor representing a specific area of uncertainty in the data available. The standard uncertainty factors include:
- a 10-fold factor to account for the variation in sensitivity among the members of the human population;
- a 10-fold factor to account for the uncertainty in extrapolating animal data to the case of humans;
- a 10-fold factor to account for the uncertainty in extrapolating from less-than-chronic NOAELs to chronic NOAELs;
- a 10-fold factor to account for the uncertainty in extrapolating from LOAELs to NOAELs.

Modifying factors are applied at the discretion of the RfD reviewer to cover other uncertainties in the data and range from 1 to 10.

(c) A target organ or critical effect is the organ/effect most sensitive to the chemical exposure. RfDs are based on toxic effects in the target organ or critical effects. If an RfD is based on a study in which a target organ or critical effect was not identified, the organ/effect listed is one known to be affected by the chemical.

(d) The unit risk for benzo(a)pyrene was obtained from the EPA Region III RBC table and was converted from a dose to a concentration, assuming a 70-kg adult inhales 20 m^3/day.

--- = No information available.

CNS = Central Nervous System.

NOTE: IRIS = Integrated Risk Information System - USEPA 1996b.
HEAST = Health Effects Assessment Summary Tables - USEPA 1995a.

TABLE 3-27
ADJUSTED CHRONIC ORAL TOXICITY CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN AT OU1 (a)

			Toxicity Criteria for Carcinogens		Toxicity Criteria for Noncarcinogens	
Chemical	Absolute Oral Absorption Factor	Oral Absorption Factor Source	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Adjusted Oral Slope Factor (b) $(mg/kg\text{-}day)^{-1}$	Chronic Oral Reference Dose (mg/kg-day)	Adjusted Oral Reference Dose (c) (mg/kg-day)
Organics						
Aldrin	1	ATSDR 1991	1.7E+01	1.7E+01	3E-05	3E-05
Benzo(a)anthracene	1	Default Value	7.3E-01	7.3E-01	---	---
Benzo(a)pyrene	1	Default Value	7.3E+00	7.3E+00	---	---
Benzo(b)fluoranthene	1	Default Value	7.3E-01	7.3E-01	---	---
delta-BHC	1	Default Value	---	---	---	---
gamma-BHC	0.99	ATSDR 1992	1.3E+00	1.3E+00	3E-04	3E-04
Dibenz(a,h)anthracene	1	Default Value	7.3E+00	7.3E+00	---	---
Dieldrin	1	ATSDR 1991	1.6E+01	1.6E+01	5E-05	5E-05
bis(2-Ethylhexyl)phthalate	0.55	ATSDR 1991	1.4E-02	2.5E-02	2E-02	1E-02
Heptachlor	0.78	ATSDR 1991	4.5E+00	5.8E+00	5E-04	4E-04
Heptachlor epoxide	0.78	ATSDR 1991	9.1E+00	1.2E+01	1.3E-05	1.0E-05
Indeno(1,2,3-c,d)pyrene	1	Default Value	7.3E-01	7.3E-01	---	---
PCBs (carcinogenic)	0.93	ATSDR 1991	7.7E+00	8.3E+00	---	---
PCB-1254 (d)	0.93	ATSDR 1991	---	---	7E-05	7E-05
PCB-1016 (d)	0.93	ATSDR 1991	---	---	2E-05	2E-05
Inorganics						
Aluminum	1	Default Value	---	---	1E+00	1E+00
Arsenic	1	USEPA 1996a	1.5E+00	1.5E+00	3E-04	3E-04
Barium	0.05	ATSDR 1990	---	---	7E-02	4E-03
Beryllium	0.005	ATSDR 1992	4.3E+00	8.6E+02	5E-03	3E-05
Chromium (VI)	0.1	ASTDR 1991	---	---	5E-03	5E-04
Iron	1	Default Value	---	---	3E-01	3E-01
Manganese	0.055	ATSDR 1990	---	---	2.4E-02	1.3E-03
Nickel	0.1	ATSDR 1991	---	---	2E-02	2E-03
Thallium	1	ATSDR 1992	---	---	8E-05	8E-05
Vanadium	0.03	ATSDR 1992	---	---	7E-03	2E-04

(a) Adjusted toxicity criteria are used to evaluate potential risks associated with dermal exposures. Only COPCs that were quantitatively evaluated via dermal exposure pathways are presented.
(b) Adjusted slope factors were calculated by dividing the slope factor by the absolute oral absorption factor.
(c) Adjusted reference doses were calculated by multiplying the reference dose by the absolute oral absorption factor.
(d) The oral absorption fraction for total PCBs was used for both PCB congeners.

TABLE 3-28
EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER
BY HYPOTHETICAL FUTURE RESIDENTS AT OU1 (a)

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (ug/L)	Lifetime Average Daily Dose (mg/kg-day) Child	Lifetime Average Daily Dose (mg/kg-day) Adult	Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk Child	RME Excess Lifetime Cancer Risk Adult
Organics							
Aldrin	0.00288	1.6E-08	3.4E-08	1.7E+01	B2	3E-07	6E-07
gamma-BHC	0.00449	2.5E-08	5.3E-08	1.3E+00	B2/C	3E-08	7E-08
Dieldrin	0.00285	1.6E-08	3.3E-08	1.6E+01	B2	2E-07	5E-07
bis(2-Ethylhexyl)phthalate	7.18	3.9E-05	8.4E-05	1.4E-02	B2	6E-07	1E-06
Heptachlor	0.00275	1.5E-08	3.2E-08	4.5E+00	B2	7E-08	1E-07
Heptachlor epoxide	0.00396	2.2E-08	4.6E-08	9.1E+00	B2	2E-07	4E-07
Total:						1E-06	3E-06

Noncarcinogenic Chemical	RME Exposure Point Concentration (ug/L)	Average Daily Dose (mg/kg-day) Child	Average Daily Dose (mg/kg-day) Adult	RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio Child	RME ADD:RfD Ratio Adult
Organics							
Aldrin	0.00288	1.8E-07	7.9E-08	3E-05	Liver	6E-03	3E-03
gamma-BHC	0.00449	2.9E-07	1.2E-07	3E-04	Liver/Kidney	1E-03	4E-04
Dieldrin	0.00285	1.8E-07	7.8E-08	5E-05	Liver	4E-03	2E-03
bis(2-Ethylhexyl)phthalate	7.18	4.6E-04	2.0E-04	2E-02	Liver	2E-02	1E-02
Heptachlor	0.00275	1.8E-07	7.5E-08	5E-04	Liver	4E-04	2E-04
Heptachlor epoxide	0.00396	2.5E-07	1.1E-07	1.3E-05	Liver	2E-02	8E-03
PCB-1016	0.0906	5.8E-06	2.5E-06	7E-05	< Birth Weight	8E-02	4E-02
Inorganics							
Iron	39,700	2.5E+00	1.1E+00	3E-01	---	8E+00	4E+00
Manganese	1,220	7.8E-02	3.3E-02	2.4E-02	CNS	3E+00	1E+00
Hazard Index:						1E+01	5E+00

(a) delta-BHC is not evaluated due to a lack of toxicity criteria.

TABLE 3-29
EXPOSURES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION OF CHEMICALS IN GROUNDWATER BY HYPOTHETICAL FUTURE RESIDENTS AT OU1 (a)

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (ug/L)	Lifetime Average Daily Dose (mg/kg-day) Child	Lifetime Average Daily Dose (mg/kg-day) Adult	Adjusted Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk Child	RME Excess Lifetime Cancer Risk Adult
Organics							
Aldrin	0.00288	1.1E-09	3.0E-09	1.7E+01	B2	2E-08	5E-08
gamma-BHC	0.00449	8.7E-09	2.4E-08	1.3E+00	B2/C	1E-08	3E-08
Dieldrin	0.00285	1.2E-08	3.3E-08	1.6E+01	B2	2E-07	5E-07
bis(2-Ethylhexyl)phthalate	7.18	6.6E-05	1.8E-04	2.5E-02	B2	2E-06	5E-06
Heptachlor	0.00275	7.5E-09	2.1E-08	5.8E+00	B2	4E-08	1E-07
Heptachlor epoxide	0.00396	7.3E-10	2.0E-09	1.2E+01	B2	9E-09	2E-08
Total:						2E-06	5E-06

Noncarcinogenic Chemical	RME Exposure Point Concentration (ug/L)	Average Daily Dose (mg/kg-day) Child	Average Daily Dose (mg/kg-day) Adult	Adjusted RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio Child	RME ADD:RfD Ratio Adult
Organics							
Aldrin	0.00288	1.3E-08	6.9E-09	3E-05	Liver	4E-04	2E-04
gamma-BHC	0.00449	1.0E-07	5.6E-08	3E-04	Liver/Kidney	3E-04	2E-04
Dieldrin	0.00285	1.4E-07	7.7E-08	5E-05	Liver	3E-03	2E-03
bis(2-Ethylhexyl)phthalate	7.18	7.8E-04	4.3E-04	1E-02	Liver	7E-02	4E-02
Heptachlor	0.00275	8.8E-08	4.8E-08	4E-04	Liver	2E-04	1E-04
Heptachlor epoxide	0.00396	8.5E-09	4.7E-09	1E-05	Liver	8E-04	5E-04
PCB-1016	0.0906	8.9E-05	4.9E-05	2E-05	< Birth Weight	5E+00	3E+00
Inorganics							
Iron	39,700	5.9E-03	3.2E-03	3E-01	---	2E-02	1E-02
Manganese	1,220	1.8E-04	9.9E-05	1.3E-03	CNS	1E-01	8E-02
Hazard Index:						5E+00	3E+00

(a) delta-BHC was not evaluated due to lack of toxicity criteria.

TABLE 3-30
EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER BY HYPOTHETICAL FUTURE WORKERS AT OU1 (a)

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (ug/L)	Lifetime Average Daily Dose (mg/kg-day)	Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk
Organics					
Aldrin	0.00288	1.0E-08	1.7E+01	B2	2E-07
gamma-BHC	0.00449	1.6E-08	1.3E+00	B2/C	2E-08
Dieldrin	0.00285	1.0E-08	1.6E+01	B2	2E-07
bis(2-Ethylhexyl)phthalate	7.18	2.5E-05	1.4E-02	B2	4E-07
Heptachlor	0.00275	9.6E-09	4.5E+00	B2	4E-08
Heptachlor epoxide	0.00396	1.4E-08	9.1E+00	B2	1E-07
Total:					9E-07

Noncarcinogenic Chemical	RME Exposure Point Concentration (ug/L)	Average Daily Dose (mg/kg-day)	RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio
Organics					
Aldrin	0.00288	2.8E-08	3E-05	Liver	9E-04
gamma-BHC	0.00449	4.4E-08	3E-04	Liver/Kidney	1E-04
Dieldrin	0.00285	2.8E-08	5E-05	Liver	6E-04
bis(2-Ethylhexyl)phthalate	7.18	7.0E-05	2E-02	Liver	4E-03
Heptachlor	0.00275	2.7E-08	5E-04	Liver	5E-05
Heptachlor epoxide	0.00396	3.9E-08	1E-05	Liver	3E-03
PCB-1016	0.0906	8.9E-07	7E-05	< Birth Weight	1E-02
Inorganics					
Iron	39,700	3.9E-01	3E-01	---	1E+00
Manganese	1,220	1.2E-02	2.4E-02	CNS	5E-01
Hazard Index:					2E+00

(a) delta-BHC is not evaluated due to a lack of toxicity criteria.

TABLE 3-31
EXPOSURES AND RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF SURFACE SOIL BY HYPOTHETICAL FUTURE RESIDENTS AT OU1

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Lifetime Average Daily Dose (mg/kg-day) Child	Lifetime Average Daily Dose (mg/kg-day) Adult	Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk Child	RME Excess Lifetime Cancer Risk Adult
Organics							
Benzo(a)anthracene	0.508	5.57E-07	2.98E-07	7.3E-01	B2	4E-07	2E-07
Benzo(a)pyrene	0.493	5.40E-07	2.89E-07	7.3E+00	B2	4E-06	2E-06
Benzo(b)fluoranthene	0.312	3.42E-07	1.83E-07	7.3E-01	B2	2E-07	1E-07
Dibenz(a,h)anthracene	0.383	4.20E-07	2.25E-07	7.3E+00	B2	3E-06	2E-06
Indeno(1,2,3-c,d)pyrene	0.273	2.99E-07	1.60E-07	7.3E-01	B2	2E-07	1E-07
PCB-1248	0.00867	9.50E-09	5.09E-09	7.7E+00	B2	7E-08	4E-08
PCB-1260	0.0415	4.55E-08	2.44E-08	7.7E+00	B2	4E-07	2E-07
Total:						8E-06	4E-06

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Average Daily Dose (mg/kg-day) Child	Average Daily Dose (mg/kg-day) Adult	RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio Child	RME ADD:RfD Ratio Adult
Organics							
PCB-1254	0.0106	1.36E-07	1.45E-08	2E-05	Eyes	7E-03	7E-04
Inorganics							
Aluminum	12,900	1.65E-01	1.77E-02	1E+00	Developmental Effects	2E-01	2E-02
Hazard Index:						2E-01	2E-02

TABLE 3-32
EXPOSURES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION OF CHEMICALS IN SURFACE SOIL BY HYPOTHETICAL FUTURE RESIDENTS AT OU1

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Lifetime Average Daily Dose (mg/kg-day)		Adjusted Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk	
		Child	Adult			Child	Adult
Organics							
Benzo(a)anthracene	0.508	6.12E-07	1.91E-06	7.3E-01	B2	4E-07	1E-06
Benzo(a)pyrene	0.493	5.94E-07	1.85E-06	7.3E+00	B2	4E-06	1E-05
Benzo(b)fluoranthene	0.312	3.76E-07	1.17E-06	7.3E-01	B2	3E-07	9E-07
Dibenz(a,h)anthracene	0.383	4.62E-07	1.44E-06	7.3E+00	B2	3E-06	1E-05
Indeno(1,2,3-c,d)pyrene	0.273	3.29E-07	1.03E-06	7.3E-01	B2	2E-07	7E-07
PCB-1248	0.00867	6.27E-09	1.95E-08	8.3E+00	B2	5E-08	2E-07
PCB-1260	0.0415	3.00E-08	9.36E-08	8.3E+00	B2	2E-07	8E-07
Total:						9E-06	3E-05

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Average Daily Dose (mg/kg-day)		Adjusted RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio	
		Child	Adult			Child	Adult
Organics							
PCB-1254	0.0106	8.94E-08	5.58E-08	7E-05	Eyes	1E-03	9E-04
Inorganics							
Aluminum	12,900	1.81E-02	1.13E-02	1E+00	Developmental Effects	2E-02	1E-02
Hazard Index:						2E-02	1E-02

TABLE 3-33
EXPOSURES AND RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF SUBSURFACE SOIL BY HYPOTHETICAL FUTURE EXCAVATION WORKERS AT OU1

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Lifetime Average Daily Dose (mg/kg-day)	Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk
Organics					
Benzo(a)pyrene	0.0999	6.70E-09	7.3E+00	B2	5E-08
PCB-1248	0.00853	5.72E-10	7.7E+00	B2	4E-09
PCB-1260	0.0102	6.84E-10	7.7E+00	B2	5E-09
Inorganics					
Arsenic	4.04	2.71E-07	1.5E+00	A	4E-07
Total:					5E-07

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Average Daily Dose (mg/kg-day)	Subchronic RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio
Organics					
PCB-1254	0.00792	3.72E-08	5E-05	Eyes	7E-04
Inorganics					
Aluminum	10,800	5.07E-02	1E+00	Developmental Effects	5E-02
Arsenic	4.04	1.90E-05	3E-04	Skin	6E-02
Vanadium	38.4	1.80E-04	7E-03	None observed	3E-02
Hazard Index:					1E-01

TABLE 3-34
EXPOSURES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION OF CHEMICALS IN SUBSURFACE SOIL BY HYPOTHETICAL FUTURE EXCAVATION WORKERS AT OU1

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Lifetime Average Daily Dose (mg/kg-day)	Adjusted Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk
Organics					
Benzo(a)pyrene	0.0999	4.89E-09	7.3E+00	B2	4E-08
PCB-1248	0.00853	2.50E-10	8.3E+00	B2	2E-09
PCB-1260	0.0102	2.99E-10	8.3E+00	B2	2E-09
Inorganics					
Arsenic	4.04	6.32E-08	1.5E+00	A	9E-08
Total:					1E-07

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Average Daily Dose (mg/kg-day)	Adjusted Subchronic RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio
Organics					
PCB-1254	0.00792	1.63E-08	5E-05	Eyes	3E-04
Inorganics					
Aluminum	10,800	3.70E-03	1E+00	Developmental Effects	4E-03
Arsenic	4.04	4.43E-06	3E-04	Skin	1E-02
Vanadium	38.4	1.32E-05	2E-04	None observed	6E-02
Hazard Index:					8E-02

TABLE 3-35
EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF PARTICULATE MATTER FROM SUBSURFACE SOIL BY HYPOTHETICAL FUTURE EXCAVATION WORKERS AT OU1

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Inhalation Exposure Concentration (ug/m^3)	Unit Risk $(ug/m^3)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk
Organics					
Benzo(a)pyrene	0.0999	2.47E-10	1.7E-03	B2	4E-13
Inorganics					
Arsenic	4.04	9.98E-09	4.3E-03	A	4E-11
Total:					4E-11

TABLE 3-36
EXPOSURES AND RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF MARSH AREA SEDIMENT BY HYPOTHETICAL FUTURE CHILD RESIDENTS AT OU1

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Lifetime Average Daily Dose (mg/kg-day)	Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk
Organics					
Benzo(a)pyrene	0.198 *	6.20E-08	7.3E+00	B2	5E-07
PCB-1260	0.13 *	4.07E-08	7.7E+00	B2	3E-07
Inorganics					
Beryllium	1.38 *	4.32E-07	4.3E+00	B2	2E-06
Total:					3E-06

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Average Daily Dose (mg/kg-day)	RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio
Inorganics					
Aluminum	13,700 *	5.00E-02	1E+00	Developmental Effects	5E-02
Beryllium	1.38 *	5.04E-06	5E-03	None observed	1E-03
Iron	24,500 *	8.95E-02	3E-01	---	3E-01
Manganese	287 *	1.05E-03	2.4E-02	CNS	4E-02
Vanadium	60.9 *	2.22E-04	7E-03	None observed	3E-02
Hazard Index:					4E-01

* Maximum detected concentration.

TABLE 3-37
EXPOSURES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION OF CHEMICALS IN MARSH AREA SEDIMENT BY HYPOTHETICAL FUTURE CHILD RESIDENTS AT OU1

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Lifetime Average Daily Dose (mg/kg-day)	Adjusted Slope Factor (mg/kg-day)$^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk
Organics					
Benzo(a)pyrene	0.198 *	6.82E-08	7.3E+00	B2	5E-07
PCB-1260	0.13 *	2.69E-08	8.3E+00	B2	2E-07
Inorganics					
Beryllium	1.38 *	4.75E-08	8.6E+02	B2	4E-05
Total:					4E-05

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Average Daily Dose (mg/kg-day)	Adjusted RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio
Inorganics					
Aluminum	13,700 *	5.51E-03	1E+00	Developmental Effects	6E-03
Beryllium	1.38 *	5.55E-07	3E-05	None observed	2E-02
Iron	24,500 *	9.84E-03	3E-01	---	3E-02
Manganese	287 *	1.15E-04	1.3E-03	CNS	9E-02
Vanadium	60.9 *	2.45E-05	2E-04	None observed	1E-01
Hazard Index:					3E-01

* Maximum Detected Concentration.

TABLE 3-38
EXPOSURES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION OF CHEMICALS IN MARSH AREA SURFACE WATER BY CHILD RESIDENTS AT OU1

FUTURE LAND-USE CONDITIONS

Noncarcinogenic Chemical	RME Exposure Point Concentration (µg/L)	Average Daily Dose (mg/kg-day)	Adjusted RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio
Inorganics					
Iron	2,770 *	1.07E-04	3E-01	---	4E-04
Manganese	91.2 *	3.52E-06	1.3E-03	CNS	3E-03
Hazard Index:					3E-03

* Maximum detected concentration.

TABLE 3-39

SUMMARY AND CUMULATIVE RISKS ASSOCIATED WITH EXPOSURES AT OU1

Receptor/Pathway	Carcinogenic Risks		Noncarcinogenic Hazards	
	Cancer Risk	Predominant Chemicals (a)	Hazard Index	Predominant Chemicals (a)
Child Resident:				
Groundwater				
Ingestion	$1x10^{-6}$	None	>1 (10)	Iron Manganese
Dermal absorption	$2x10^{-6}$	bis(2-Ethylhexyl)phthalate	>1 (5)	PCB-1016
Surface Soil				
Incidental ingestion	$8x10^{-6}$	Benzo(a)pyrene Dibenzo(a,h)anthracene	<1 ($2x10^{-1}$)	None
Dermal absorption	$9x10^{-6}$	Benzo(a)pyrene Dibenzo(a,h)anthracene	<1 ($2x10^{-2}$)	None
Sediment (Marsh Area)				
Incidental ingestion	$3x10^{-6}$	Beryllium	<1 ($4x10^{-1}$)	None
Dermal absorption	$4x10^{-5}$	Beryllium	<1 ($3x10^{-1}$)	None
Surface Water (Marsh Area)				
Dermal absorption	NE	NE	<1 ($3x10^{-3}$)	None
Cumulative	***$6x10^{-5}$***		***>1 (16)***	
Adult Resident (b):				
Groundwater				
Ingestion	$3x10^{-6}$	bis(2-Ethylhexyl)phthalate	>1 (5)	Iron Manganese
Dermal absorption	$5x10^{-6}$	bis(2-Ethylhexyl)phthalate	>1 (3)	PCB-1016
Surface Soil				
Incidental ingestion	$4x10^{-6}$	Benzo(a)pyrene Dibenzo(a,h)anthracene	<1 ($2x10^{-2}$)	None
Dermal absorption	$3x10^{-5}$	Benzo(a)anthracene Benzo(a)pyrene Dibenzo(a,h)anthracene	<1 ($1x10^{-2}$)	None
Cumulative	***$4x10^{-5}$***		***>1 (8)***	
Worker:				
Groundwater				
Ingestion	$9x10^{-7}$	None	.>1 (2)	Iron
Subsurface Soil				
Ingestion	$5x10^{-7}$	None	<1 ($1x10^{-1}$)	None
Dermal absorption	$1x10^{-7}$	None	<1 ($8x10^{-2}$)	None
Inhalation	$4x10^{-11}$	None	NE	NE
Cumulative	***$2x10^{-6}$***		***>1 (2)***	

(a) Predominant carcinogenic chemicals are those accounting for greater than a $1x10^{-6}$ risk, while predominant noncarcinogenic chemicals are those accounting for greater than a 1.0 hazard quotient.

(b) It should be noted that hazard indices associated with surface water exposures are not presented for adult residents since all chemicals in the Open Water grouping were within background levels.

NE = Not Evaluated, since COPCs in this grouping lacked the respective carcinogenic or noncarcinogenic toxicity criteria.

TABLE 3-40
EXPOSURES AND RISKS ASSOCIATED WITH INGESTION OF GROUNDWATER
BY HYPOTHETICAL FUTURE RESIDENTS AT OU1
FOR CHEMICALS WITHIN BACKGROUND BUT ABOVE RBCS (a)

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (ug/L)	Lifetime Average Daily Dose (mg/kg-day) Child	Adult	Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk Child	Adult
Inorganics							
Arsenic	0.959	5.3E-06	1.1E-05	1.5E+00	A	8E-06	2E-05
Total:						8E-06	2E-05

Noncarcinogenic Chemical	RME Exposure Point Concentration (ug/L)	Average Daily Dose (mg/kg-day) Child	Adult	RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio Child	Adult
Inorganics							
Aluminum	1,930	1.2E-01	5.3E-02	1E+00	Developmental Effects	1E-01	5E-02
Arsenic	0.959	6.1E-05	2.6E-05	3E-04	Skin	2E-01	9E-02
Barium	57.0	3.6E-03	1.6E-03	7E-02	Incr. blood pressure	5E-02	2E-02
Chromium	10.2	6.5E-04	2.8E-04	5E-03	CNS	1E-01	6E-02
Nickel	13.0	8.3E-04	3.6E-04	2E-02	Body Weight	4E-02	2E-02
Thallium	0.0686	4.4E-06	1.9E-06	8E-05	None observed	5E-02	2E-02
Vanadium	7.56	4.8E-04	2.1E-04	7E-03	None observed	7E-02	3E-02
Hazard Index:						7E-01	3E-01

(a) Lead was not evaluated due to a lack of toxicity criteria.

TABLE 3-41
EXPOSURES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION OF CHEMICALS IN GROUNDWATER
BY HYPOTHETICAL FUTURE RESIDENTS AT OU1
FOR CHEMICALS WITHIN BACKGROUND BUT ABOVE RBCS (a)

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (ug/L)	Lifetime Average Daily Dose (mg/kg-day) Child	Lifetime Average Daily Dose (mg/kg-day) Adult	Adjusted Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk Child	RME Excess Lifetime Cancer Risk Adult
Inorganics							
Arsenic	0.959	1.2E-08	3.3E-08	1.5E+00	A	2E-08	5E-08
Total:						2E-08	5E-08

Noncarcinogenic Chemical	RME Exposure Point Concentration (ug/L)	Average Daily Dose (mg/kg-day) Child	Average Daily Dose (mg/kg-day) Adult	Adjusted RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio Child	RME ADD:RfD Ratio Adult
Inorganics							
Aluminum	1,930	2.9E-04	1.6E-04	1E+00	Developmental Effects	3E-04	2E-04
Arsenic	0.959	1.4E-07	7.8E-08	3E-04	Skin	5E-04	3E-04
Barium	57.0	8.4E-06	4.6E-06	4E-03	Incr. blood pressure	2E-03	1E-03
Chromium	10.2	1.5E-06	8.3E-07	5E-04	CNS	3E-03	2E-03
Nickel	13.0	1.9E-06	1.1E-06	2E-03	Body Weight	1E-03	5E-04
Thallium	0.0686	1.0E-08	5.6E-09	8E-05	None observed	1E-04	7E-05
Vanadium	7.56	1.1E-06	6.2E-07	2E-04	None observed	5E-03	3E-03
Hazard Index:						1E-02	7E-03

(a) Lead was not evaluated due to lack of toxicity criteria.

TABLE 3-42
EXPOSURES AND RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF SURFACE SOIL
BY HYPOTHETICAL FUTURE RESIDENTS AT OU1
FOR CHEMICALS WITHIN BACKGROUND BUT ABOVE RBCs

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Lifetime Average Daily Dose (mg/kg-day)		Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk	
		Child	Adult			Child	Adult
Inorganics							
Arsenic	3.94	4.32E-06	2.31E-06	1.5E+00	A	6E-06	3E-06
Beryllium	0.753	8.25E-07	4.42E-07	4.3E+00	B2	4E-06	2E-06
Total:						1E-05	5E-06

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Average Daily Dose (mg/kg-day)		RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio	
		Child	Adult			Child	Adult
Inorganics							
Arsenic	3.94	5.04E-05	5.40E-06	3E-04	Skin	2E-01	2E-02
Beryllium	0.753	9.63E-06	1.03E-06	5E-03	None observed	2E-03	2E-04
Chromium	23.8	3.04E-04	3.26E-05	5E-03	CNS	6E-02	7E-03
Iron	22,300	2.85E-01	3.05E-02	3E-01	---	1E+00	1E-01
Manganese	213	2.72E-03	2.92E-04	2.4E-02	CNS	1E-01	1E-02
Hazard Index:						1E+00	1E-01

TABLE 3-43
EXPOSURES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION OF CHEMICALS IN SURFACE SOIL
BY HYPOTHETICAL FUTURE RESIDENTS AT OU1
FOR CHEMICALS WITHIN BACKGROUND BUT ABOVE RBCs

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Lifetime Average Daily Dose (mg/kg-day) Child	Lifetime Average Daily Dose (mg/kg-day) Adult	Adjusted Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk Child	RME Excess Lifetime Cancer Risk Adult
Inorganics							
Arsenic	3.94	1.52E-06	4.74E-06	1.5E+00	A	2E-06	7E-06
Beryllium	0.753	9.08E-08	2.83E-07	8.6E+02	B2	8E-05	2E-04
Total:						8E-05	3E-04

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Average Daily Dose (mg/kg-day) Child	Average Daily Dose (mg/kg-day) Adult	Adjusted RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio Child	RME ADD:RfD Ratio Adult
Inorganics							
Arsenic	3.94	1.77E-05	1.11E-05	3E-04	Skin	6E-02	4E-02
Beryllium	0.753	1.06E-06	6.60E-07	3E-05	None observed	4E-02	3E-02
Chromium	23.8	3.35E-05	2.09E-05	5E-04	CNS	7E-02	4E-02
Iron	22,300	3.14E-02	1.96E-02	3E-01	---	1E-01	7E-02
Manganese	213	3.00E-04	1.87E-04	1.3E-03	CNS	2E-01	1E-01
Hazard Index:						5E-01	3E-01

TABLE 3-44
EXPOSURES AND RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF SUBSURFACE SOIL BY HYPOTHETICAL FUTURE EXCAVATION WORKERS AT OU1 FOR CHEMICALS WITHIN BACKGROUND BUT ABOVE RBCs

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Lifetime Average Daily Dose (mg/kg-day)	Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk
Inorganics					
Beryllium	0.676	4.54E-08	4.3E+00	B2	2E-07
Total:					2E-07

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Average Daily Dose (mg/kg-day)	Subchronic RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio
Inorganics					
Beryllium	0.676	3.17E-06	5E-03	None observed	6E-04
Chromium	19.0	8.92E-05	2E-02	CNS	4E-03
Iron	17,500	8.22E-02	3E-01	---	3E-01
Manganese	277	1.30E-03	2.4E-02	CNS	5E-02
Hazard Index:					3E-01

TABLE 3-45
EXPOSURES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION OF CHEMICALS IN SUBSURFACE SOIL BY HYPOTHETICAL FUTURE EXCAVATION WORKERS AT OU1 FOR CHEMICALS WITHIN BACKGROUND BUT ABOVE RBCs

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Lifetime Average Daily Dose (mg/kg-day)	Adjusted Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk
Inorganics					
Beryllium	0.676	3.31E-09	8.6E+02	B2	3E-06
Total:					3E-06

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Average Daily Dose (mg/kg-day)	Adjusted Subchronic RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio
Inorganics					
Beryllium	0.676	2.32E-07	3E-05	None observed	9E-03
Chromium	19.0	6.51E-06	2E-03	CNS	3E-03
Iron	17,500	5.99E-03	3E-01	---	2E-02
Manganese	277	9.49E-05	1.3E-03	CNS	7E-02
Hazard Index:					1E-01

TABLE 3-46
EXPOSURES AND RISKS ASSOCIATED WITH INHALATION OF PARTICULATE MATTER FROM SUBSURFACE SOIL BY HYPOTHETICAL FUTURE EXCAVATION WORKERS AT OU1 FOR CHEMICALS WITHIN BACKGROUND BUT ABOVE RBCs

FUTURE LAND-USE CONDITIONS

Carcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Inhalation Exposure Concentration (ug/m^3)	Unit Risk $(ug/m^3)^{-1}$	Weight-of-Evidence Classification	RME Excess Lifetime Cancer Risk
Inorganics					
Beryllium	0.676	1.67E-09	2.4E-03	B2	4E-12
Chromium	19.0	4.69E-08	1.2E-02	A	6E-10
Total:					6E-10

Noncarcinogenic Chemical	RME Exposure Point Concentration (mg/kg)	Inhalation Exposure Concentration (mg/m^3)	RfC (mg/m^3)	Target Organ/ Critical Effect	RME IEC:RfC Ratio
Inorganics					
Manganese	277	4.79E-08	5.0E-05	CNS	1E-03
Hazard Index:					1E-03

TABLE 3-47
EXPOSURES AND RISKS ASSOCIATED WITH INCIDENTAL INGESTION OF CHEMICALS IN OPEN WATER AREA SURFACE WATER BY HYPOTHETICAL FUTURE ADULT RESIDENTS SWIMMING AT OU1 FOR CHEMICALS WITHIN BACKGROUND BUT ABOVE RBCs

FUTURE LAND-USE CONDITIONS

Noncarcinogenic Chemical	RME Exposure Point Concentration (µg/L)	Average Daily Dose (mg/kg-day)	RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio
Inorganics					
Aluminum	3,780	7.10E-04	1E+00	Developmental Effects	7E-04
Iron	4,850	9.11E-04	3E-01	---	3E-03
Manganese	259	4.87E-05	2.4E-02	CNS	2E-03
Hazard Index:					6E-03

TABLE 3-48
EXPOSURES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION OF CHEMICALS IN OPEN WATER AREA SURFACE WATER BY HYPOTHETICAL FUTURE ADULT RESIDENTS SWIMMING AT OU1 FOR CHEMICALS WITHIN BACKGROUND BUT ABOVE RBCs

FUTURE LAND-USE CONDITIONS

Noncarcinogenic Chemical	RME Exposure Point Concentration (µg/L)	Average Daily Dose (mg/kg-day)	Adjusted RfD (mg/kg-day)	Target Organ/ Critical Effect	RME ADD:RfD Ratio
Inorganics					
Aluminum	3,780	1.99E-04	1E+00	Developmental Effects	2E-04
Iron	4,850	2.55E-04	3E-01	---	9E-04
Manganese	259	1.36E-05	1.3E-03	CNS	1E-02
Hazard Index:					1E-02

4.0 ECOLOGICAL RISK ASSESSMENT

The purpose of the ERA is to assess the potential for adverse effects to nonhuman receptors resulting from exposure to chemicals at OU1 of WRF. The ERA was conducted in accordance with national and regional USEPA guidance for evaluating ecological risks at hazardous waste sites (USEPA, 1989a,c, 1992a, and 1994b) and in accordance with relevant Army guidance (Wentsel et al. 1994). Consistent with this guidance, the approaches used in the ERA are similar to those used in the human health risk assessment. The physical features of the site are first described and individual organisms, populations, or communities likely to occur at WRF are identified. The COPCs are then identified along with the pathways by which ecological receptors could be exposed to chemicals. The potential toxicity of the COPCs to ecological receptors selected for evaluation is then characterized. Finally, information on exposure and toxicity are combined to derive qualitative or quantitative estimates of the potential for adverse effects to ecological resources at WRF OU1.

4.1 PROBLEM FORMULATION

The problem formulation section of the ERA evaluates available information about the site history and past land use activities, the ecological resources and COPCs associated with the site, and the pathways by which ecological receptors could be exposed to these chemicals. The section concludes with the identification of the ecological resources and the endpoints selected for evaluation in the ERA.

The problem formulation section is broken down into the following sub-sections. Section 4.1.1 provides a general overview of WRF and includes a description of the topography, past and present land use patterns, contaminants known to be associated with on-site activities, and the habitats/ecological resources known or likely to occur on site. Section 4.1.2 identifies the COPCs selected for evaluation and the data groupings selected for each medium. Section 4.1.3 identifies the ecological receptor species and potential exposure pathways selected for evaluation. Finally, Section 4.1.4 discusses the assessment endpoints identified for evaluation in the ERA, and the methods and/or data used for this evaluation.

4.1.1 Site Description

4.1.1.1 General Site Description and Discussion of Past On-Site Activities

WRF is approximately 579 acres in size and is located in Prince William County, Virginia (Figure 2-1, WRF Location Map). It is bounded by Marumsco Creek (part of Marumsco National Wildlife Refuge) to the west and by Occoquan and Belmont bays to the south and east, respectively. Although the majority of WRF is undeveloped, residential, commercial, and industrial areas are located directly north of the installation boundary. A residential community and golf course are presently under construction (beginning in summer 1995) along the northern installation boundary.

The topography of WRF is generally flat, with a gentle slope to the south and east. The topographic high, 30 feet amsl, occurs at the northern installation boundary. WRF lies within the western portion of the Coastal Plain Physiographic Province, approximately 8 miles east of the Fall Line.

OU1 is located in the southwest portion of WRF and is bounded to the east by Deephole Point Road, to the west/northwest by Lake Drive, and to the south/southwest by Marumsco Creek and the Occoquan Bay. The portions of Marumsco Creek and Occoquan Bay immediately adjacent to the upland portions of OU1 have also been included as part of the OU1 study area. The topography of the OU1 area generally slopes towards these water bodies. Several water bodies are associated with the OU1 area. A small ephemeral pond (less than one acre in size) is located immediately to the southeast of Lake Drive across from the large pond on the northwest side of this road. The ephemeral pond receives overflow from the large pond. A small drainage swale associated with a marshy area originates just to the south of the ephemeral pond. The drainage swale is likely to receive discharge from the ephemeral pond during storm events, though the ephemeral pond does not regularly discharge into the drainage swale. From just below the ephemeral pond, the drainage swale travels roughly 700 feet to the south where it discharges to Marumsco Creek, which in turn, discharges to the Occoquan Bay. A major portion of the drainage swale and the OU1 portions of Marumsco Creek and the Occoquan Bay are tidally influenced and are classified as tidal freshwater.

WRF was acquired by the U.S. Army in 1952. Prior to this the site was used primarily for agricultural purposes. WRF was used as an electronics testing facility with activities ranging from receiving and transmitting radio signals to testing the effects of electromagnetic pulses on electronic equipment. These activities required the construction and use of large antenna arrays at locations throughout the facility. Disposal of equipment and materiel also occurred at WRF. A brief description of each potential source area occurring in the OU1 Area of WRF is presented below. Section 2.2 should be referred to for a detailed description of past on-site activities at WRF.

OU1 consists of AREEs 1 through 5, 6A, 6B, and 7 located on approximately 579 acres in the southwest portion of WRF. This area is bounded on the south by the Occoquan Bay, and on the west by Marumsco Creek. A brief description of the individual AREEs at OU1 is discussed below:

- AREE 1 is a 0.4-acre former dump site located on the southwest portion of the WRF. It is unknown what materials were disposed of at AREE 1. AREE 1 is a 0.4 acre former dump site located on the southern portion of the facility. The landfill was used as a dumping site for construction debris including scap metal, concrete, and miscellaneous debris. Some capacitors may have been burined there prior to closure of the landfill.
- AREEs 2 and 5 are former landfills where transformers, capacitors, and metal debris were buried. These disposal areas are located adjacent to each other and were considered to be one study area for the RI.
- AREE 3 is approximately 100 feet by 25 feet and is located just east of the pond on the east side of Lake Drive. The burial of debris, such as wood, lead-coated wire, paper, and plastic, reportedly began in 1966 until AREE 3 was covered with soil in 1973 (Weston, 1992).
- AREE 4 is a former dump site where debris, such as wire, wood, concrete, pipe insulation, and empty oil drums, were dumped from the late 1950s until 1973 when the dump was covered with dirt (Weston, 1992).
- AREE 6A is a former dump area located west of Deephole Point Road and south of Lake Drive. The contents of AREE 6A are unknown, but metal debris has been observed protruding from the toe of the slope along the southwestern extent of this AREE.
- AREE 6B is a former dump site located west of Deephole Point Road and immediately south of AREE 7. Metal debris are known to have been disposed of at this site.
- AREE 7 is a former pistol range located at the intersection of Deephole Point Road and Shady Lane. The range was used for small arms firing on a semi-annual basis during the 1970s.

Section 2.0 should be referred to for a complete description of each AREE.

4.1.1.2 Description of Habitats and Wildlife on the Woodbridge Research Facility

Approximately 24 of the 579 acres on WRF support improvements such as buildings, roads, and parking areas. The remaining 556 acres consist of undeveloped land, much of which was used during testing. Woodland areas of WRF (excluding those considered wetlands) are located primarily along the western installation boundary and comprise the majority of habitat in OU1. Palustrine wetlands occur along the drainages and shoreline of Marumsco Creek in the OU1 area. A brief description of these habitats is given below. For a more detailed description, please refer to the Environmental Impact Statement (EIS) (COE, 1994).

Woodlands. The woodland areas comprising much of OU1 are dominated by northern red oak (*Quercus rubra*), white oak (*Quercus alba*), chestnut oak (*Quercus prinus*), Virginia pine (*Pinus virginiana*), and American Beech (*Fagus grandifolia*). Animal species expected to occur in the woodland areas include a variety of birds such as American robin (*Turdus migratorius*), hairy woodpecker (*Picoides villosus*), downy woodpecker (*Picoides pubescens*), redtail hawk (*Buteo jamaicenis*), and mammals such as whitetail deer (*Odocoileus virginianus*), and gray squirrel (*Sciurus carolinensis*).

Palustrine Wetlands and Aquatic Habitats. Wetlands border Marumsco Creek and its associated drainages. The wetlands are open adjacent to Marumsco Creek and become increasingly wooded towards the upper reaches of the drainages. The open wetlands are dominated by pond lily (*Nuphar variegatum*) and cattail species (*Typha* spp.), and to a lesser extent, by soft rush (*Juncus effusus*), marsh mallow (*Hibiscus moscheutos*), swamp rose (*Rosa palustrius*), buttonbush (*Cephalanthus occidentalis*), spatterdock (*Nuphar luteum*), and pickerel weed (*Pontederia cordata*). The most common tree species occurring in the wooded wetland areas are black gum (*Nyssa sylvatica*), sweet gum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), and persimmon (*Diospyros virginiana*). Understory species in these areas are dominated by northern arrowwood (*Viburnum recognitum*) and silky dogwood (*Cornus amomum*). A variety of terrestrial animal species are expected to utilize the wetland habitats including spotted salamander, (*Ambystoma maculatum*), green frog (*Rana clamitans melanota*), pickerel frog (*Rana palustris*), eastern box turtle (*Terrapene carolina*), eastern painted turtle (*Chrysemys picta*), northern water snake (*Nerodia sipedon*), belted kingfisher (*Ceryle alcyon*), wood duck (*Aix sponsa*), mallard duck (*Anas platyrhynchos*), American black duck (*Anas rubripes*), Canada goose (*Branta canadensis*), great blue heron (*Ardea herodias*), great egret (*Casmerodius albus*), little blue heron (*Egretta caerulea*), black-crowned night-heron (*Nycticorax nycticorax*), green heron (*Butorides striatus*), raccoon (*Procyon lotor*), whitetail deer, and beaver (*Castor canandensis*). A heron rookery exists on Mason Neck Wildlife Refuge which is across Belmont Bay from WRF. Herons from the rookery are likely to utilize WRF aquatic habitats.

The aquatic habitats associated with OU1 are likely to support a diverse array of aquatic species. Marumsco Creek and the Occoquan Bay adjacent to OU1 are likely to support fish species typical of the low salinity reaches of the Chesapeake Bay watershed. Fish species known or likely to occur in these water bodies include American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), brown bullhead (*Ictalurus nebulosus*), channel catfish (*Ictalurus punctatus*), white catfish (*Ictalurus catus*), yellow perch (*Perca flavescens*), carp (*Cyprinus carpio*), American eel (*Anguilla rostrata*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), and largemouth bass (*Micropterus salmoides*). These water bodies are also expected to be spawning areas for fish species such as white perch (*Morone americana*) and rockfish (*Morone saxatilis*), and a nursery area for species such as spot (*Leiostomus xanthurus*), croaker (*Micropogon undulatus*), hogchoker (*Trinectes maculatus*), and bay anchovy (*Anchoa mitchilli*). These water bodies are also likely to support blue crab (*Callinectes sapidus*) and a variety of amphibian and aquatic invertebrate species. The small pond and upper reaches of the drainage swale are expected to support amphibians, aquatic invertebrates, and small minnow populations.

A summary of surface water and sediment characteristics measured in the water bodies associated with OU1 are presented in Table 4-1.

Open Field Habitats. Open field habitats comprise the majority of WRF outside of OU1. These areas have been kept mowed during the life of the facility, though the frequency of mowing has decreased since the facility is no longer active. The vegetative community of the open field areas is dominated by jointgrass (*Manisuris cylindrica*), dropseed grass (*Muhlenbergia expansa*), bush clover (*Lespedeza capitata*), white-top sedge (*Dichromena clorata*), broomsedge (*Andropogon virginicus*), and yellow foxtail (*Setaria glauca*) among others. In many of the open fields, sweetgum saplings occur in abundance. Several bird species are expected to use the open field habitat for feeding, nesting, or roosting. Examples of the bird species expected to occur include bobwhite quail (*Colinus virginianus*), mourning dove (*Zenaida macroura*), eastern bluebird (*Sialia sialis*), redtail hawk, and a variety of finches and sparrows. Bald eagles (*Haliaeetus leucocephalus*) have been observed roosting and flying over WRF. Mammals expected to occur include groundhog (*Marmota monax*), whitetail deer, and red fox (*Vulpes vulpes*). Other animals observed or expected to utilize the open field habitats of WRF include, snakes, turtles, and mice.

Threatened and Endangered Species. A threatened and endangered species search for the WRF was requested through both the State of Virginia, Department of Conservation and Recreation and the USFWS Chesapeake Bay Field Office. Results of both searches indicate the presence of bald

eagle (*Haliaeetus leucocephalus*) on WRF (VDCR 1995, USFWS 1995). Bald eagle are currently listed as federally threatened. No known bald eagle nests occur directly on WRF though a communal bald eagle roost is present on Mason Neck, located to the east of the facility. Eagles are known to frequently travel between Mason Neck and the WRF. No other species of special concern were identified in either of the searches.

4.1.2 Identification of Chemicals of Potential Concern

This section of the ERA identifies COPCs for detailed evaluation. In this section, the methodology used to select the COPCs is described and the COPCs are identified. Chemicals are selected for evaluation in the ERA if they (1) are presumed to be present because of past activities at the site, and (2) pose potential risks to ecological species. Chemicals associated with sampling or laboratory artifacts were not selected as COPCs. Surface water runoff samples, which are also evaluated in the ERA, are summarized in Tables 2-2, 2-3, 2-4, and 2-55 of this FFS and are not included in the following section.

The following steps, which are in accordance with USEPA (1989a) guidance, were first used to summarize the analytical data for this risk assessment:

- The samples were divided into data groupings by environmental medium and exposure area (site). The creation of these data groupings allows for the characterization of environmental conditions relevant to exposure and helps to determine exposure concentrations for target populations. A grouping of background data is used to determine if chemicals detected at a site are present at naturally occurring levels. The sample data groupings used in the ERA, including background data groupings, are described by environmental medium in the sections below.
- Sample data were compared to blank (laboratory, field, and trip) concentration data. If the chemical concentration detected in a site-related sample was less than 10 times (for common laboratory chemicals) or five times (for all other compounds) the concentration in the corresponding blank sample, the sample was excluded from the ERA in accordance with USEPA (1989a) guidance and personal communication with Bob Davis (pers. comm., Davis, 1996). The identification and validation of sampling or laboratory artifacts were performed prior to data summarization.
- As requested by USEPA (1994b) Region III guidance, the maximum concentration of a pair of duplicate or split samples (taken from the same location on the same date) was used to represent the concentration for that location. This differs from the HHRA where the average of a pair of duplicate or split samples is used to represent the concentration at a location.
- The mean concentration of a chemical within a given medium and sample data grouping was calculated by averaging the detected concentration(s) with one-half the quantitation limit of the nondetect(s). It should be noted that when one-half the quantitation limit of a sample exceeds the maximum detected concentration within a sample grouping, the arithmetic mean could exceed the maximum detected concentration.
- Data that were rejected by the laboratory (R qualified) were not used in the ERA.
- Frequency of detection was calculated as the number of samples in which the chemical was detected over the total number of samples collected.

Once the sampling data were grouped and summarized, chemicals were selected for further evaluation.

- Essential nutrients for ecological receptors (i.e., calcium, magnesium, potassium, and sodium) were not considered as COPCs.
- Chemicals were selected as COPCs if their maximum detected concentrations in environmental media exceeded the screening level concentrations for ecological receptors provided by the USEPA Region III BTAG (USEPA, 1995d), instead of RBCs used in the HHRA. Region III Biological Technical Assistance Group (BTAG) Screening Levels are based on chemical concentrations considered to be protective of the most sensitive organism in a me-

dium. Screening Levels for some chemicals were available for both flora and fauna, in which case the lower of the two values was used in the ERA. Freshwater screening levels were used to screen chemicals in surface water. Surface water values dependent on hardness and/or pH were not modified for use in the screening process, though the influence of hardness and pH on the toxicity of certain COPCs was accounted for in the ecological effects assessment. Only chemicals with maximum concentrations below the BTAG screening level were eliminated as COPCs. Chemicals lacking Region III BTAG Screening Levels were maintained as COPCs.

All chemicals not eliminated by the above screens were identified as COPCs and evaluated in the ERA. However, some inorganic chemicals occurring at concentrations above the Region III BTAG Screening Levels may not be reflective of site-related contamination, but instead, may be reflective of widespread contamination or naturally elevated regional concentrations. Accordingly, the identification of chemicals occurring at concentrations above reference concentrations may be useful when interpreting the results of the ERA. The following procedures were used to identify chemicals occurring at concentrations above reference concentrations:

- When at least five samples were available for both the on-site and reference sample data sets, a two-tailed variance ratio test was first performed to determine if the variances of the on-site and background data were similar. If the variances for a given chemical in a given medium were found to be similar, then the one-tailed pooled variance t-test was used to test for differences between on-site and reference means. If on-site and reference variances were found to differ significantly, a nonparametric test (the one-tailed Mann-Whitney test) was used to test for similarity between on-site and reference medians. A detailed description of the statistical tests is presented in Zar (1984).

- When less than five samples were available for both the on-site and reference sample data sets, the maximum concentration of each inorganic detected at the on-site location was compared to the maximum concentration of that inorganic chemical detected in the background data grouping. If the maximum concentration of the inorganic chemical detected at the on-site location exceeded the maximum reference concentration of that inorganic chemical or if an inorganic chemical was not detected in relevant background data grouping, then that chemical was considered to occur at concentrations above those in the reference samples.

Inorganic chemicals with maximum concentrations which exceeded BTAG screening levels but were equal to or less than reference concentrations were selected as COPCs, but are designated with a "B" in subsequent data tables. This differentiation is made because a chemical at or below a reference concentration may not be associated with site-related contamination, but instead, is likely to reflect widespread contamination or naturally elevated regional concentrations.

The selection of a chemical as a COPC does not necessarily indicate that it poses a risk to ecological receptors. Rather, the selection of a chemical indicates there is a need to evaluate that chemical in the ERA to determine if exposures to the chemical could result in potential risks to ecological receptors.

Exposure point concentrations were calculated for the maximum case concentration and, where appropriate for the receptor being evaluated, the average case concentration (see Section 4.2). A summary of the chemicals identified for further evaluation in the ERA, the data groupings, and the reference sample locations are presented for each medium in the discussion below.

Chemical analytical data from surface soil (0-6 inches), surface water, and sediment (0-6 inches) samples collected from OU1 were evaluated in the OU1 ERA. The results of the chemical analyses for each of these media are summarized below.

4.1.2.1 Surface Soil

Twenty-seven surface soil locations (RISS-1 through 24, 54 through 56) were sampled at OU1 in November, 1995. The surface soil samples used in the ERA are shown in Figures 2-24 and 2-25. Surface soil samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, TPH[1], and PAHs.

Data for the on-site surface soil sample locations were compiled into a single data grouping for the initial analysis of data in the ERA due to the proximity of the surface soil samples. Samples may be regrouped in a later part of the assessment based on the trends in chemical concentration detected in surface soil and/or the pathways/receptors selected for evaluation. Because many of the surface soil samples were collected from areas of known historical dumping or other localized activities, they do not accurately represent the overall exposure to chemicals that receptor populations or communities would encounter while inhabiting the OU1 area, instead, sampling data from these locations are likely to represent high end concentrations to which ecological receptor species would be exposed.

Surface Soil Reference Samples. Data from a total of five surface soil samples (RISSBK-1 through 5 [Figure 2-20]) were used as the background data for OU1. All reference samples were collected from the top six inches of surface soil to be consistent with the samples taken from AREE-specific locations.

Results of the Surface Soil Samples. The chemicals detected in the OU1 surface soil samples are presented in Table 4-2, which includes a summary of the frequency of detection, the arithmetic mean and range of detected concentrations, and the screening value and reference comparisons. The following section identifies the COPCs in surface soil selected for evaluation in the OU1 ERA.

A total of 25 organic chemicals were detected in surface soil. This included two VOCs, 17 PAHs, four pesticide compounds, PCB-1260, and bis(2-ethylhexyl)phthalate. Methylene chloride, chlordane, DDT, 1,1-dichloro-2,2-bis(p-chlorophenyl)ethane (DDD), and 1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene (DDE) were not identified as COPCs because the maximum detected concentrations were less than the Region III Screening Level. All other organic compounds were selected as COPCs. Aluminum, beryllium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, vanadium, and zinc were detected at concentrations above Region III Screening Levels and were identified as COPCs. Of these inorganics, only mercury was detected at a concentration significantly greater than the reference samples. Calcium, magnesium, potassium, and sodium were eliminated from further analysis because they are essential nutrients.

4.1.2.2 Sediment

A total of 14 locations (RISD-10 through 21, and 02SE02 and 02SE04) were sampled as part of the OU1 investigation. One sediment sample was collected in the ephemeral pond immediately to the southeast of Lake Road, four sediment samples were collected from the drainage ditch downgradient of the pond, and nine samples were collected from Occoquan Bay adjacent to OU1. All but two of the samples were collected by ICF KE during December, 1995 as part of the investigation. Two sediment samples (02SE02 and 02SE04) from the wetland area were collected in 1993 as part of the Phase 1 Site Investigation (USAEC, 1995c). The sediment sample locations in OU1 are shown in Figures 2-30 and 2-31. Sediment samples collected by ICF KE were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, TPH[2], PCTs, and PAHs. The two samples collected in 1993 were analyzed for Pesticides/PCBs and TPH.

Sediment samples were collected in the ephemeral pond of OU1, in the wetland area downgradient of the pond, and in the open water area adjacent to OU1, which encompasses a portion of Marumsco Creek downgradient of the wetland area and a portion of the Occoquan Bay bordering OU1. Sediment samples from each of these three areas were grouped separately for analysis because they are likely to support different ecological resources and contain differing levels of contamination.

[1]TPH was analyzed in soil samples but was not evaluated in the ERA.

[2]TPH was analyzed in some sediment samples but was not evaluated in the ERA.

Sediment Reference Samples. Data from a total of five sediment samples (RISDBK-1 through 5) collected from surface water bodies on the Mason Neck Wildlife refuge in December, 1995 were used as the background data for OU1 (see Figure 2-21). All reference sediment samples were collected from the top six inches of sediment to be consistent with the samples taken from site-specific locations.

Results of the Sediment Sampling at OU1. The chemicals detected in the OU1 sediment samples are presented in Table 4-3, which includes a summary of the frequency of detection, the arithmetic mean and range of detected concentrations, and the Screening Level and reference comparisons. The following sections identify the COPCs selected for evaluation in the ERA for each sediment group.

- Pond: A total of five PAHs were detected in the single sediment sample taken from the ephemeral pond. However, none of the PAHs were identified as COPCs based on comparison to the Region III BTAG Screening Levels. No other organic chemicals were detected in the ephemeral pond sediment. The inorganic COPCs were aluminum, barium, beryllium, chromium, cobalt, iron, and vanadium. None of the inorganics selected as COPCs were detected at concentrations determined (using the procedure outlined in Section 4.1.2) to be at concentrations greater than in the corresponding reference samples. Magnesium, potassium, and sodium were eliminated from further analysis because they are essential nutrients.
- Wetland: A total of 13 organic chemicals were detected in the two sediment samples taken from the wetland area, consisting of 12 PAHs and PCB-1260. The organic chemicals identified as COPCs were acenaphthene, anthracene, indeno(1,2,3-c,d)pyrene, 1-methylnapthalene, napthalene, and PCB-1260. The inorganic chemicals identified as COPCs were aluminum, beryllium, chromium, cobalt, iron, manganese, and vanadium. However, with the exception of beryllium and vanadium, none of the inorganics selected as COPCs were detected at concentrations determined (using the procedure outlined in Section 4.1.2) to be at concentrations greater than in the corresponding reference samples. Calcium, magnesium, potassium, and sodium were eliminated from further analysis because they are essential nutrients.
- Open Water: A total of 19 organic chemicals were detected in the nine sediment samples taken from the open water area, consisting of 15 PAHs, the pesticide DDT and its metabolites DDD and DDE, and PCB-1260. The organic chemicals identified as COPCs were acenaphthene, anthracene, fluorene, 2-methylnapthalene, DDT, DDD, DDE, and PCB-1260. The inorganic chemicals identified as COPCs were aluminum, beryllium, chromium, cobalt, copper, iron, manganese, nickel, silver, vanadium, and zinc. However, with the exception of silver, none of the inorganics selected as COPCs were detected at concentrations determined (using the procedure outlined in Section 4.1.2) to be at concentrations greater than in the corresponding reference samples. Calcium, magnesium, potassium, and sodium were eliminated from further analysis because they are essential nutrients.

4.1.2.3 Surface Water

Surface water on-site samples (RISW-10 through 21) and reference samples (RISWBK-1 through 5) were collected from the same locations and at the same time the sediment samples were collected for the RI. Accordingly, the same basic data groupings that were used for the sediment samples were also used for surface water for the evaluation of the data. Surface water samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL metals, TPH[3], PCTs, and PAHs. The results of the chemical analyses are summarized below for each of the three water body groupings identified for evaluation. Chemicals detected in the surface water samples on OU1 are summarized in Table 4-4, which includes a summary of the frequency of detection, the arithmetic mean and range of detected con-

[3]TPH was analyzed in some surface water samples but was not evaluated in the ERA.

centrations, and the Screening Level and reference comparisons. The following sections identify the chemicals detected and the COPCs selected for evaluation in the ERA for each surface water group.

Pond. No organic chemicals were detected in the ephemeral pond surface water. The inorganic COPCs were aluminum and iron. However, neither of these COPCs were detected at concentrations determined (using the procedure outlined in Section 4.1.2) to be at concentrations greater than in the corresponding reference samples. Calcium, magnesium, potassium, and sodium were eliminated from further analysis because they are essential nutrients.

Wetland. No organic chemicals were detected in the wetland surface water. The inorganic chemicals identified as COPCs were aluminum and iron. Calcium, magnesium, potassium, and sodium were eliminated from further analysis because they are essential nutrients.

Open Water. No organic chemicals were detected in the open water surface water. The inorganic chemicals identified as COPCs were aluminum, chromium, copper, iron, lead and zinc. However, with the exception of copper and zinc, none of these COPCs were detected at concentrations determined (using the procedure outlined in Section 4.1.2) to be at concentrations greater than in the corresponding reference samples. Calcium, magnesium, potassium, and sodium were eliminated from further analysis because they are essential nutrients.

4.1.3 Identification of Exposure Pathways and Receptors for Analysis

In this section of the ERA, the potential pathways by which ecological resources may be exposed to the COPCs at WRF are discussed. Exposure pathways were identified based on the consideration of (1) the source/mechanism of chemical release; (2) the medium (or media) of chemical transport; (3) the point of potential contact by the receptor organism; and (4) the route of exposure at the contact point. Potentially complete exposure pathways and potential receptor groups were identified for evaluation in the ERA based on consideration of the available habitat, and the type, extent, magnitude, and location of potential chemical contamination.

As previously discussed (Section 4.1.1.2), a variety of terrestrial and aquatic species are associated with OU1. Figure 4-1 provides a conceptual model identifying potential contaminant sources and the routes by which these chemicals could be transported to potential receptors at OU1. Table 4-5 identifies the potential exposure pathways by which potential ecological receptors could be exposed to COPCs at OU1 and, in general terms, the pathways selected for evaluation in the ERA. A brief rationale for the selection/exclusion of each potentially complete exposure pathway is also summarized in this table. The following sections provide a more detailed discussion and evaluation of the pathways by which potential receptors could be exposed to COPCs in surface water, sediment, and soil and discusses the exposure pathways selected for evaluation.

4.1.3.1 Aquatic and Terrestrial Plants

Aquatic and terrestrial plants are important components in any ecosystem because they provide food and cover for many wildlife species. WRF supports a variety of different plant species characteristic of both upland and wetland areas.

Terrestrial plants at OU1 may be exposed to COPCs in soil as a result of direct contact and subsequent uptake via roots or direct foliar uptake. Aquatic plants in the wetland area of OU1 and adjacent to the small pond may also be exposed to chemicals in sediment and/or mobilized in surface water. However, very little information is available to evaluate exposures via foliar uptake or via contact with surface water. Accordingly, only potential risks from direct contact with chemicals in surface soil via root uptake were evaluated in the ERA.

Potential risks to terrestrial plants were evaluated in the Risk Characterization Section (Section 4.4) by comparing the chemical concentrations measured in surface soil with available toxicity data from the scientific literature. Because of limitations in the available toxicity data, no specific plant species were selected for evaluation. Instead, the assessment evaluated the potential for adverse effects to herbaceous plant communities.

4.1.3.2 Soil Invertebrates

Soil invertebrates may be exposed to chemicals in surface soil via dermal absorption and the ingestion of contaminated soils. Accordingly, the potential for the COPCs to adversely affect soil invertebrates was evaluated. Earthworms were selected as the receptor species for evaluating the potential for adverse effects to soil invertebrates because they have direct contact with soil and are sensitive to chemicals in soil, relative to other soil invertebrates. Furthermore, earthworms serve an important ecological role in the aeration of soils and cycling of nutrients and act as an important food source for carnivorous species (e.g., shrews). Lastly, toxicity data for earthworms are available in the scientific literature.

Potential risks to earthworms were evaluated in the Risk Characterization Section (Section 4.4) by comparing the chemical concentrations measured in surface soil with available toxicity values from the scientific literature.

4.1.3.3 Terrestrial Wildlife

Terrestrial wildlife occurring at WRF may be exposed to COPCs by several pathways, including the ingestion of contaminated sediment, soil, surface water, or food while foraging or grooming and the dermal absorption of chemicals from soil, sediment, or surface water.

Among these potential exposure pathways, the greatest potential for exposure to chemicals is likely to result from the ingestion of chemicals that have accumulated in food. This conclusion is based on both the potential for some chemicals to accumulate to higher concentrations in food than in the abiotic media from which they originate and on the relatively high ingestion rate of food as compared to the ingestion rate of most abiotic media. For example, small mammals or birds could be exposed to chemicals that have accumulated in the aquatic food web from the ingestion of fish or aquatic invertebrates or to chemicals in soil from the ingestion of soil invertebrates. Accordingly, the potential for the exposure of terrestrial wildlife to chemicals in food was considered for evaluation.

The following sections review the COPCs in the surface soil, sediment, and surface water and identify those having the potential to accumulate in the terrestrial and/or aquatic food webs. However, the potential for adverse effects to ecological receptors from accumulation in the food web may not be fully addressed by the OU1 data for the following reasons:

- The distribution of many chemicals having the potential to bioaccumulate is unlikely to be limited to the OU1 area.
- OU1 represents only an isolated portion of a drainage basin likely to be affected by chemical contamination.
- Many species potentially affected by bioaccumulative compounds are likely to forage throughout WRF and evaluation of only OU1 would not accurately represent the potential for exposure to bioaccumulative chemicals.

Accordingly, the evaluation of these chemicals will be deferred until the site-wide ERA. All chemicals likely to accumulate in the food webs will be evaluated as part of the site-wide ERA,which will provide a more accurate representation of the potential for exposure and accumulation of these chemicals in the terrestrial and aquatic food webs. The following sections identify the COPCs detected in OU1 which have the potential to bioaccumulate.

Accumulation of Chemicals From Surface Soil. The chemicals identified as COPCs in surface soil were quantitatively and qualitatively evaluated to determine which chemicals are most likely to accumulate in the terrestrial food web. The octonal/water partition coefficients[4] (expressed as Log K_{ow}) for all organics selected as COPCs were first reviewed. A log K_{ow} of greater than 3.5 was considered for further evaluation based on Garten and Trabalka (1983), which indicates such chemicals have the potential to bioaccumulate.

[4]The octanol/water partition coefficient of an organic chemical characterizes the propensity of a chemical to partition into the lipid fraction of an organism, and thus, the potential for a chemical to bioaccumulate in an organism.

There are no values similar to a log K_{ow} for inorganics with which to evaluate terrestrial bioaccumulation potential. However, bioconcentration factors (BCFs) for certain terrestrial species are available that can be used as an indicator of the potential for chemicals to bioaccumulate from surface soil to terrestrial receptors. Earthworms were selected as an indicator of accumulation from surface soil into fauna because they have direct dermal contact with and ingest large amounts of soil, there is an extensive database of the accumulation potential of chemicals from surface soil into earthworms, and earthworms are an important food source for a number of terrestrial species and represent a potential exposure pathway in the terrestrial food web. As a result, the inorganic COPCs BCFs for earthworms were reviewed as an indicator of the potential for chemicals to accumulate from soil into the terrestrial food web. Inorganics with BCFs greater than 1 were identified for analysis in the terrestrial food web.

The potential also exists for bioconcentration and subsequent accumulation of chemicals in terrestrial plants. However, plant uptake factors were not incorporated into the screening procedure because information in Baes et al. (1984) indicates the bioconcentration of inorganics from surface soil is less in plants than earthworms.

Following the initial screening procedures described above, several additional factors were considered to further identify chemicals having the potential to accumulate. Available information in the scientific literature was first used to identify through which pathways (if any) these chemicals are likely to accumulate. This is because some chemicals may not accumulate under conditions specific to the receptors and/or conditions being evaluated. For example, some chemicals are readily metabolized by the organism of concern and, therefore, do not accumulate. The frequency of detection was also considered when identifying the potential for chemicals to accumulate in the food web, based on the observation that a low frequency of occurrence will minimize the potential for exposure and the subsequent potential for a chemical to accumulate in the food web.

PAHs, bis(2-ethylhexyl)phthalate, and PCB-1260 each have a log K_{ow} above 3.5 and there is the potential for these organic chemicals to bioaccumulate based on the K_{ow} screening procedure outlined above. However, information from the scientific literature indicates that PAHs are metabolized by terrestrial species and do not accumulate in the terrestrial food web (Eisler, 1987a). Bis(2-ethylhexyl)phthalate also has a Log K_{ow} above 3.5. Information from the scientific literature also indicates that phthalates do not readily accumulate in the terrestrial food web because they are metabolized by organisms (ATSDR, 1993a,b) and this chemical also was not selected for evaluation as a bioaccumulative compound.

PCB-1260, detected in four of 27 surface soil samples in the OU1 Area, has the potential to bioaccumulate in the terrestrial food web. Accordingly, this chemical will be evaluated in the facility-wide ERA. It should be noted, PCB-1260 was also detected in the Main Ditch area of OU3, and thus, the potential exposure of most higher trophic-level species following accumulation in the food web would not be limited to OU1.

Earthworm BCF data were reviewed to determine which inorganic COPCs had the greatest potential to bioconcentrate from soil to earthworms. BCF data suggest the COPCs mercury and zinc are the metals with the greatest potential to accumulate in earthworms (Laird and Kroger, 1981, Eisler, 1987b, Beyer 1990, and Beyer and Stafford, 1993) because they have BCFs greater than one. However, mercury was detected in only one of 27 sample locations, suggesting a very limited potential for accumulation of this chemical in the terrestrial food web. Meanwhile, ATSDR (1992) indicates that zinc does not readily accumulate in terrestrial food webs and the potential for this chemical to accumulate in the terrestrial food web was not selected for evaluation in the facility-wide ERA.

Accumulation of Chemicals From Sediment and Surface Water. Organic and inorganic chemicals selected as COPCs in sediment and/or surface water were reviewed for their potential to accumulate in aquatic and/or terrestrial food webs. In the case of organics, a log K_{ow} greater than 3.5 was initially considered for further evaluation based on Garten and Trabalka (1983), which indicates such chemicals have the potential to bioaccumulate. Inorganic chemicals reported in the scientific literature to have a BCF of greater than 300 for aquatic fauna were also initially selected for evaluation. Aquatic plants, though potentially a route of exposure for herbivorous species (e.g.,

dabbling ducks), are unlikely to represent an important route of exposure given the more limited potential of chemicals to accumulate in plant material. Accordingly, aquatic plants were not incorporated into the screening procedure. Based on the results of this screen, chemicals identified as having the greatest potential to accumulate are identified below for sediment and surface water.

- Sediment: All of the PAH COPCs detected in the wetland area sediment and the open water area sediment each have a log K_{ow} above 3.5. However, information from the scientific literature indicates that PAHs do not readily accumulate in the terrestrial food web because they are metabolized into nontoxic byproducts and eliminated by higher trophic level species (e.g., birds and mammals)(Eisler, 1987a). There is, however, the potential for predators that consume lower trophic-level species to be exposed to these chemicals because of the inability of some lower-level organisms, particularly bivalves, to metabolize these compounds (Eisler, 1987a). For example, some carnivorous avian species could be exposed to PAHs from the ingestion of these benthic invertebrates. Accordingly, PAHs will be evaluated as part of the facility-wide assessment.

  PCB-1260, detected in both the wetland area and in one of nine samples in the open water area, has the potential to bioaccumulate in the terrestrial food web. Accordingly, this chemical will be evaluated in the facility-wide ERA. It should be noted, PCB-1260 was also detected in the Main Ditch area of OU3, and thus, the potential exposure of most higher trophic-level species following accumulation in the food web would not be limited to OU1.

  Zinc, which was identified as a COPC in the open water area sediment, has a BCF greater than 300 for some aquatic species and was the only inorganic COPC which could have the potential to accumulate in aquatic life. However, zinc was detected at a maximum concentration which is not elevated above background, and it is reasonable to conclude this analyte is occurring at local concentrations and would not represent a bioaccumulation risk in the aquatic environment. Accordingly, no inorganic chemicals detected in sediment were identified as having the potential to accumulate.

- Surface Water: No organic chemicals were detected in the surface water of the pond, wetland area, or open water area. Of the inorganic COPCs, zinc has a BCF greater than 300 for some aquatic species and could have the potential to accumulate in aquatic life. However, zinc was detected at concentrations less than chronic federal AWQC, and it is reasonable to conclude this compound would not accumulate in the aquatic environment at the detected concentrations. Accordingly, no organic or inorganic chemicals in surface water were identified as having the potential to accumulate in the aquatic environment.

- Direct Exposure to Chemicals in Abiotic Media: In addition to the ingestion of chemicals from food items, terrestrial wildlife could be exposed to chemicals from the ingestion of surface water, surface soil, and/or sediment while foraging and grooming. Several COPCs were detected in these media so the exposure pathways are potentially complete. However, the foraging range of many wildlife species is larger than OU1 and many of the COPCs detected in OU1 are also likely to occur at other locations on WRF. Further, many of the chemicals identified as COPCs in the abiotic media could have the potential to bioaccumulate, which is likely to represent a much greater source of potential exposure than through the ingestion of most abiotic media. For these reasons, the potential for adverse effects to terrestrial wildlife from the ingestion of abiotic media will be deferred until the facility-wide assessment.

  In addition to the pathways discussed above, terrestrial wildlife may be exposed to chemicals via the inhalation of chemicals in air and/or via the dermal absorption of chemicals in surface soil/sediment. The quantification of receptor-specific exposures via these pathways was not selected for evaluation because of a lack of appropriate exposure data. However, exposures via these pathways are expected to be insignificant in comparison to food and surface soil ingestion.

4.1.3.4 Aquatic Life

Aquatic life could potentially be exposed to chemicals in OU1 by direct contact with contaminated water and sediment, respiration of chemicals in water, and ingestion of contaminated sediments and food. Aquatic life also could be exposed to chemicals via the ingestion of chemicals that have accumulated in the food web. As discussed earlier, the potential for adverse effects to terrestrial life from the ingestion of chemicals in aquatic life will be evaluated in the facility-wide ERA and was not considered further in this assessment. Potential risks to aquatic life were evaluated in the Risk Characterization section (Section 4.4) of the ERA by comparing concentrations of the COPCs identified in surface water, surficial runoff, and sediment to applicable toxicity values derived in the Ecological Effects Assessment section (Section 4.3). Because the toxicity data being used in the ecological risk assessment were designed to evaluate the potential for adverse effects to aquatic communities, no specific aquatic species were selected for evaluation and the assessment evaluated the potential for adverse effects to the overall aquatic community.

4.1.4 Identification of Assessment and Measurement Endpoints

The potential for adverse effects to ecological resources is dependent on the ecological receptor species and chemicals present on the site, and the pathways by which the ecological resources could be exposed to the COPCs. Section 4.1.1 preliminarily identified ecological resources occurring on the site that could be adversely affected by the presence of chemicals. Section 4.1.2 preliminarily identified the COPCs present in each of the on-site media. Finally, Section 4.1.3 preliminarily identified the potential exposure pathways by which ecological receptors could be exposed to COPCs, based on information about the presence of ecological resources on site and on information about the presence of COPCs in each sampled environmental media. This section of the report summarizes the specific ecological parameters for each of the evaluated receptors by identifying the assessment endpoint, the hypothesis being tested in the investigation, and measurement endpoints selected for the evaluation of the assessment endpoints.

Assessment endpoints are defined as the ecological effects in the receptor species selected for evaluation. The evaluation of the potential for ecological effects to occur is one factor in the decision making process regarding the need for further investigation and/or remediation (Suter, 1993). For example, the reproductive capability of the receptor species and/or population may be an assessment endpoint selected for evaluation. Measurement endpoints are the outcomes of the methods or means by which the assessment endpoints are approximated or represented (Suter, 1993). Measurement endpoints are generally surrogates for assessment endpoints and are necessary because, in most cases, assessment endpoints cannot be directly measured or observed. Typically, the measurement endpoints are the result of or outcome of the field and/or laboratory methods used to evaluate the assessment endpoints. For example, the measurement endpoint for the evaluation of the potential for adverse effects to receptor organisms, populations, and/or communities may be the concentration of a chemical measured in an abiotic media to which the receptor species could be exposed compared to an applicable toxicity value and/or may be the result of a fish population survey from the area of concern.

The assessment and measurement endpoints selected for evaluation in the OU1 ERA are summarized in Table 4-6. In addition, Table 4-6 states formal testable hypotheses for each of the assessment endpoints selected for evaluation.

4.2 EXPOSURE ASSESSMENT

The purpose of the exposure assessment is to identify the concentration and/or dose of the COPC to which ecological resources selected for evaluation could be exposed. The following sections discuss the evaluation of exposure and identify the exposure concentrations selected for the evaluation of potential adverse effects to each of the ecological receptor groups/organisms selected for evaluation.

4.2.1 Terrestrial Life

4.2.1.1 Terrestrial Plants

Inorganic chemical concentrations measured in surface soil collected from potential source areas throughout the OU1 Area were used to evaluate the potential for adverse effects to terrestrial plants.

Maximum chemical concentrations measured in surface soil samples are given in Table 4-2. The maximum concentration was used to screen the potential for chemicals to adversely affect terrestrial plants because, based on the immobility of plants, exceedance of a toxicity value at a sample location indicates the potential for adverse effects at that location. If the maximum concentration exceeds the toxicity value, the overall proportion of sample locations where the toxicity value is exceeded is then considered to evaluate the potential for adverse effects at the community level.

4.2.1.2 Soil Invertebrates

Inorganic chemical concentrations measured in surface soil collected from potential source areas throughout the OU1 Area were used to assess the potential for adverse effects to terrestrial invertebrates. Maximum detected concentrations in surface soil are given in Table 4-2. As for terrestrial plants, the maximum concentration was used for the initial evaluation because, based on the relative immobility of most terrestrial invertebrates, exceedance of a toxicity value at a sample location indicates the potential for adverse effects at that location. If the maximum concentration exceeds the toxicity value, the overall proportion of sample locations where the toxicity value is exceeded is then considered to evaluate the potential for adverse effects at the population level.

4.2.2 Aquatic Life

4.2.2.1 Sediment

Chemical concentrations measured in sediment from the small pond and wetland drainage on OU1 and from Marumsco Creek and the Occoquan Bay adjacent to OU1 were used to evaluate the potential for adverse effects to benthic organisms. Maximum chemical concentrations measured in sediment samples are given in Table 4-3. The maximum concentration was used for the initial evaluation because, based on the relative immobility of most aquatic invertebrates, exceedance of a toxicity value at a sample location indicates the potential for adverse effects at that location. The potential for adverse effects at the community level can then be evaluated by identifying the overall proportion of sample locations where the toxicity value is exceeded.

4.2.2.2 Surface Water

Chemical concentrations measured in surface water samples taken from OU1 at the same locations as sediment samples were used to evaluate the potential for adverse effects to aquatic life. In addition, chemical concentrations measured in storm water runoff collected from OU1 were used to evaluate the potential loading of chemicals into OU1 surface water. Average concentrations measured in surface water samples and surficial runoff samples are given in Tables 4-4, respectively. Based on the mobility of most aquatic species and the transient nature of surface water, particularly flowing water, the average chemical concentrations measured in the surface water samples best represent the exposure concentrations to which the aquatic life in a water body could be exposed and were selected for evaluation.

4.3 ECOLOGICAL EFFECTS ASSESSMENT

4.3.1 Terrestrial Life

Toxicity criteria have not been developed by USEPA for terrestrial species. Consequently, toxicity data in the scientific literature were reviewed to characterize the toxicity of the COPCs selected for evaluation. Toxicity values selected for the evaluation of the potential for adverse effects are referred to as toxicity reference values (TRVs) and represent concentrations of the COPCs that are protective of the ecological receptors being evaluated.

4.3.1.1 Terrestrial Plants

TRVs reported by Will and Suter (1994a) to be protective of terrestrial plants were used to assess the potential for the inorganic COPCs to adversely affect terrestrial plants. TRVs were established by Will and Suter (1994a) at a level associated with a twenty percent reduction in growth or yield, which is consistent with other screening level benchmarks for ecological risk assessment and with the current regulatory approach. Very few toxicity values have been developed for organic chemicals and the toxicity database is inadequate for the evaluation of potential adverse effects to terrestrial plants from the

presence of organic chemicals in surface soil. Accordingly, only the potential adverse effects of inorganic chemicals to terrestrial plants were evaluated in the present assessment. Terrestrial plant TRVs were not available for iron. Because of the absence of a toxicity value for iron, the potential for this chemical to adversely affect terrestrial plants could not be further evaluated in the ERA and there is uncertainty associated with the potential for iron to adversely affect this potential receptor.

There are limitations associated with the toxicity values available for terrestrial plants. The majority of the plant toxicity information available from the scientific literature is for inorganic COPCs and has been based on the evaluation of potential adverse effects to agricultural crops from the presence of inorganic chemicals in surface soil. Furthermore, the types of adverse effects measured to develop these toxicity values range from subtle (such as reduced growth) to severe (such as death). Also, phytotoxicity varies with the plant species and with the availability and form of a given chemical. If a chemical is more bioavailable to a plant for absorption or uptake (such as through increased solubility in soil), the phytotoxic potential of the chemical increases. Availability and chemical form are affected by factors such as soil pH, moisture, temperature, microbial activity, and interaction with other chemicals. In the absence of site-specific information on the bioavailability of the chemicals to plants, it is assumed in this assessment that their availability is similar to studies reported in the literature. Thus, toxicity may be over- or underestimated depending, in part, on the extent to which site-specific chemical availability differs from studies reported in the literature. Finally, Will and Suter (1994a) indicate that terrestrial plant TRVs that are exceeded by background levels may be a poor measure of risk to the plant community. The TRVs derived by Will and Suter (1994a) will be used whether or not they exceed background because of a lack of other relevant toxicity data, however, the uncertainties associated with the use of these values will be noted when a background concentration for a COPC exceeds a TRV.

4.3.1.2 Soil Invertebrates

TRVs reported by Will and Suter (1994b) to be protective of earthworm populations were used when available to assess the potential for inorganic chemicals to adversely affect earthworms. Will and Suter (1994b) established these TRVs at a level associated with a twenty percent reduction in growth, reproduction, or activity, which is consistent with other screening level benchmarks for ecological risk assessment and with the current regulatory approach. In the absence of TRVs reported by Will and Suter (1994b), toxicity values reported in the scientific literature were used to evaluate the potential for adverse effects to soil invertebrates. Soil invertebrate TRVs were not available for acetone, PAHs (other than fluorene), PCB-1260, bis(2-ethylhexyl)phthalate, and for the inorganic chemicals, aluminum, beryllium, iron, manganese, selenium, and vanadium. Because of the absence of toxicity values, the potential for these chemicals to adversely affect soil invertebrates could not be further evaluated in the ERA and there is uncertainty associated with the potential for these chemicals to adversely affect this potential receptor.

There are limitations associated with the toxicity values available for earthworms. The toxicity data base is limited, and the types of adverse effects measured to develop these toxicity values range from subtle (such as reduced growth) to severe (such as death). Furthermore, toxicity varies with the species of earthworm and with the availability and form of a given chemical. If a chemical is more bioavailable, the toxic potential of the chemical increases. Availability and chemical form are affected by factors such as soil pH, moisture, temperature, microbial activity, and interaction with other chemicals. In the absence of site-specific information on the bioavailability of the chemicals, it is assumed in this assessment that their availability is similar to studies reported in the literature. Thus, toxicity may be over- or underestimated depending in part on the extent to which site-specific chemical availability differs from studies reported in the literature. Finally, Will and Suter (1994b) indicate that terrestrial plant TRVs that are exceeded by background levels may be a poor measure of risk to the soil invertebrates. The TRVs derived by Will and Suter (1994b) will be used whether or not they exceed background because of a lack of other relevant toxicity data, however, the uncertainties associated with the use of these values will be noted when a background concentration for a COPC exceeds a TRV.

4.3.2 Aquatic Life

4.3.2.1 Sediment

Two sources of toxicity data were used to identify the potential for chemicals in sediment to cause adverse effects to benthic communities. The USEPA Office of Water has developed draft sediment quality criteria (SQC) that represent the Agency's best recommendation of the concentrations of a substance in sediment that will not unacceptably affect benthic organisms (USEPA, 1993). The methodology used to generate the proposed criteria is called the equilibrium partitioning (EqP) approach and applies only to non-ionic organic chemicals. Draft freshwater sediment criteria have recently been developed for three PAHs (fluoranthene, phenanthrene, and acenaphthene) and two pesticides (aldrin and dieldrin). In addition to the draft criteria, Effects Range-Low (ER-L) and Effects Range-Median (ER-M) values reported in Long and Morgan (1990) and subsequent updates in Long et al. (1995) were employed as TRVs to determine if chemicals in the sediments are likely to impact aquatic communities. Effects range values were derived from the compilation of the available sediment toxicity data for a chemical. The ER-L value is equivalent to the lower 10th percentile of the available toxicity data, which is estimated to be the approximate concentration at which effects are likely to occur in sensitive life stages and/or species. The ER-M value is equivalent to the median of the available toxicity data, which is estimated to be the approximate concentration at which effects are likely to occur in most species.

Available USEPA EqP draft criteria and ER-L/ER-M values were used to evaluate the potential for adverse effects to benthic communities. In the case where both USEPA EqP draft criteria and ER-L/ER-M values are available for a chemical, the lower of the two values was used to conservatively evaluate the potential for adverse effects to benthic communities. For these chemicals, freshwater EqP draft criteria were compared to the ER-L/ER-M values used to evaluate the potential for adverse effects to aquatic life in OU1. In the absence of the above guidelines, available toxicity values from the scientific literature were used as TRVs.

4.3.2.2 Surface Water

Federal AWQC were developed by USEPA for the protection of aquatic life and were used to assess potential impacts to aquatic species. Both chronic and acute freshwater AWQC were used to evaluate the potential for adverse effects to aquatic life from chemicals measured directly in the surface water bodies associated with OU1, while only acute freshwater AWQC were used to evaluate the potential for adverse effects to aquatic life from storm water runoff. Acute AWQC were used for the surface water bodies because a storm event was occurring at the time of sampling and there is the potential for a "pulse" of chemicals to have been released in surface water as a result of increased surficial runoff. Following the same rationale, the acute AWQC were used to evaluate the potential for surficial runoff to adversely affect aquatic life. Chronic freshwater AWQC also were used for the surface water bodies in case the detected concentrations are indicative of longer-term exposure. The hardness calculated for the open water area adjacent to OU1 was 82 mg/l as $CaCO_3$, which was used to derive hardness-dependent criteria for this water body. The hardness for the surficial runoff was assumed to be 100 mg/l as $CaCO_3$. No hardness-based criteria were detected in either the ephemeral pond or wetland area.

4.4 RISK CHARACTERIZATION

In this section of the ERA, the potential exposure concentrations derived in Section 4.2 are compared with the TRVs derived in Section 4.3 to evaluate the potential for adverse effects to ecological resources from exposure to the COPCs.

Estimated exposure concentrations for the COPCs are compared to TRVs by creating a ratio of the estimated exposure concentration to the TRV. This ratio is termed the Environmental Effects Quotient (EEQ). If the EEQ is less than or equal to 1.0 (indicating the exposure concentration is less than the TRV) then adverse effects are considered unlikely. If the EEQ is greater than 1.0 (indicating the exposure concentration is greater than the TRV), there is a potential for adverse effects to occur. The confidence level of the conclusion increases as the magnitude of the ratio departs from 1.0. For example, there is greater confidence in a risk estimate where the EEQ is 0.1 or 10, than in a EEQ which is closer to 1.0. USEPA Region III Guidelines (USEPA, 1994b) summarizes the level of the EEQ exceedance by stating that an EEQ greater than 1.0 indicates a "potential risk", an EEQ greater than 10 indicates a

"moderately high potential risk", and an EEQ greater than 100 indicates an "extreme risk". This interpretation of the magnitude of exceedance will be used along with a spatial evaluation of contamination to evaluate risks to ecological resources. The uncertainties associated with the risk estimates are briefly discussed below and are discussed in greater detail in Section 4.5.

4.4.1 Terrestrial Plants

Twelve inorganic chemicals were identified as COPCs and were compared to available plant TRVs in Table 4-7. As discussed in Section 4.3.1.1, adverse effects associated with exposure to iron and all organic COPCs were not evaluated in this assessment because TRVs could not be found for these chemicals in the scientific literature. Thus, there is uncertainty associated with the lack of toxicity information available for these surface soil COPCs.

The maximum detected concentrations of aluminum, chromium, manganese, selenium, vanadium, and zinc exceeded the available terrestrial plant TRVs. Of these chemicals, the maximum surface soil concentration of aluminum exceeded the TRV to the greatest extent (EEQ of 326), followed by chromium, vanadium, selenium, zinc, and manganese (EEQ of 96.7, 26.6, 24.5, 6.0, and 2.9, respectively). Concentrations of aluminum, chromium, and vanadium exceeded the plant TRVs at all surface soil sample locations suggesting the potential for adverse effects at all locations. It should be noted, however, concentrations of all chemicals which exceeded TRVs did not statistically exceed those detected at reference sample locations. In fact, with the exception of the high concentration of chromium detected at sample location RISS55 (97 mg/kg; see Appendix B.1) adjacent to AREE 1, the maximum detected concentrations of all three chemicals fell within 10 to 12% of the maximum concentration detected at background locations. These results suggest the majority of detected concentrations of these three chemicals are likely to be reflective of regional, not OU1-related concentrations. As noted in Section 4.3.1.1, Will and Suter (1994a) indicate that terrestrial plant TRVs that are exceeded by background levels may be a poor measure of risk to the plant community because inorganic chemicals detected in background locations at concentrations above TRVs are likely to be reflective of the local/regional soil type, in which case plants are likely to be adapted to these levels. Section 4.5.3 of the ERA should be referred to for a discussion of the uncertainties associated with the use of these toxicity values.

Selenium, zinc, and manganese were also detected at concentrations above the TRVs. However, the detected concentrations of these chemicals exceed plant TRVs at only a limited number of sample locations suggesting the extent of adverse effects, if occurring, is likely to be limited. Selenium exceeded the plant TRVs at sample locations RISS21 and 22 associated with AREE 6A and at sample location RISS24 associated with AREE 6B. Selenium, however, was not detected at any other sample location. Zinc exceeded the plant TRVs at sample locations RISS1, 4, 55, and 56, all of which are on or close to AREE 1. Finally, manganese exceeded the plant TRVs at sample location RISS-9 adjacent to AREEs 2 and 5. The elevated concentrations at these sample locations are likely to reflect contamination from past activities and adverse effects, if occurring, would be limited to the area around these sample locations. It should be noted, however, the limited exceedances of selenium, zinc, and manganese did not cause the overall detected concentrations of these compounds to statistically exceed concentrations detected at reference sample locations suggesting the detected concentrations are reflective of regional and not site-related concentrations.

4.4.2 Soil Invertebrates

Organic and inorganic chemicals identified as COPCs were compared to available earthworm TRVs in Table 4-8. As discussed in Section 4.3.1.2, the only organic chemical for which a TRV could be found in the scientific literature was fluorene. Because the maximum concentration of this COPC is below the available TRVs, it is reasonable to conclude this organic chemical will not adversely affect soil invertebrates. There is, however, uncertainty associated with the lack of toxicity information available for the majority of organic COPCs, particularly with respect to the PAHs.

The available earthworm TRVs were exceeded by the maximum surface soil concentrations of chromium (EEQ of 242), and to a lesser extent, mercury (EEQ of 1.2) and zinc (EEQ of 1.5). Chromium concentrations exceeded the earthworm TRVs at all sample locations (see Appendix B.1). However, with the exception of the high concentration of chromium detected at sample location RISS55 (97 mg/kg; see Appendix B.1) adjacent to AREE 1, the detected concentrations of this chemical fell within 10% of

the maximum concentration detected at background locations, suggesting the detected concentrations of chromium at most locations are similar to background. Zinc concentrations exceeded the TRV at two sample locations in AREE 1 (RISS1 and 2), while mercury exceeded the TRV at only one sample location (RISS4). This indicates a very limited potential for adverse effects from these chemicals. It should be noted, however, the limited exceedances of chromium and zinc did not cause the overall detected concentrations of these compounds to statistically exceed concentrations detected at reference sample locations, suggesting the detected concentrations are reflective of regional and not site-related concentrations.

4.4.3 Aquatic Life

4.4.3.1 Sediment

In this section, the COPCs in the sediments of OU1 are compared to available TRVs in Table 4-9. A detailed discussion of these comparisons is presented below for each of the surface water groupings.

Ephemeral Pond. No organic chemicals were identified as COPCs in the ephemeral pond sediment. Meanwhile, the following seven inorganic compounds were identified as COPCs: aluminum, barium, beryllium, chromium, cobalt, iron, and vanadium. The maximum detected concentrations of chromium and iron did not exceed their respective TRVs. TRVs were not available for aluminum, barium, beryllium, cobalt, and vanadium, and there is uncertainty associated with the potential for these chemicals to adversely affect aquatic life. However, the concentrations of all of the inorganic COPCs were determined (using the procedure outlined in Section 4.1.2) not to exceed those detected at reference sample locations, suggesting the detected concentrations of these chemicals are reflective of regional and not site-related concentrations.

Wetland. Five PAHs and PCB-1260 were identified as COPCs in the wetland sediment. With the exception of indeno(1,2,3-c,d)pyrene, the maximum detected concentrations of all PAHs exceeded the ER-Ls (EEQs ranging from 99.4 for acenaphthene to 11.5 for anthracene), while the ER-Ms were exceeded by only the maximum detected concentrations of acenaphthene (EEQ of 3.2) and 1-methylnapthalene (EEQ of 3.6). The maximum detected concentration of PCB-1260 also exceeded the ER-L (EEQ of 5.7), but remained below the ER-M (EEQ < 1).

With the exception of iron, which just exceeded the available TRV (EEQ of 1.2), none of the inorganic chemicals were detected in sediment at concentrations exceeding the available TRVs. However, TRVs were not available for aluminum, beryllium, cobalt, and vanadium, and there is uncertainty associated with the potential for these chemicals to adversely affect aquatic life.

Open Water. Four PAHs, DDT, its breakdown products DDD and DDE, and PCB-1260 were identified as COPCs in the open water area sediment. The maximum detected concentrations of all four PAHs exceeded the ER-Ls (EEQs ranging from 446.9 for acenaphthene to 6.5 for anthracene), while the ER-Ms were exceeded by the maximum detected concentrations of acenaphthene (EEQ of 14.3) and 2-methylnapthalene (EEQ = 2.9). DDT, DDD, and DDE were detected at maximum concentrations above the ER-Ls (EEQs ranging from 18.0 for DDT to 4.1 for DDE). Finally, the maximum detected concentration of PCB-1260 exceeded the ER-L (EEQ of 3.7), but remained below the ER-M (EEQ < 1).

The ER-L or other available TRVs were exceeded by the maximum concentrations of copper, iron, manganese, nickel, silver, and zinc (EEQs ranging from 3.5 for silver to 1.1 for copper, nickel, and zinc). TRVs were not available for aluminum, beryllium, cobalt, and vanadium, and there is uncertainty associated with the potential for these chemicals to adversely affect aquatic life.

Summary and Discussion of Sediment Results. The results of the sediment analysis suggest that aquatic life will not be adversely affected by chemicals in the sediments of the ephemeral pond. There is, however, some potential for chemicals detected in the sediments of the wetlands and open water areas to adversely affect aquatic life. However, adverse effects occurring in these water bodies are likely at only a limited number of areas given the low frequency of occurrence of most chemicals.

Of the organic compounds detected in the sediments at the wetland and open water areas, the greatest potential for adverse effects to aquatic life at OU1 is from the presence of PAHs. Several of the PAHs were detected at concentrations above the ER-M, indicating the potential for adverse effects to most aquatic life. However, these exceedances occurred at only a limited number of sample locations in the wetland/open water area suggesting adverse effects, if occurring, are likely to be localized. Acenaphthene, which was detected at two sample locations in the wetland area (RISD11 and 12) and at a single location in the open water area (RISD18), was detected at the highest concentration relative to the TRV, and thus, has the greatest potential to adversely affect aquatic life. The detected concentrations of acenaphthene exceeded the ER-M at both of these areas. The PAH 1-methylnaphthalene was also detected at concentrations above the ER-L at both sample locations in the wetland area (RISD11 and 12), and exceeded the ER-M (RISS12) at one of these sample locations. Finally, the PAH 2-methylnaphthalene was detected at a single sample location in the open water area (RISD18) at a concentration above the ER-M. All other PAHs were detected at concentrations exceeding only the ER-L values, suggesting the potential for adverse effects only to sensitive aquatic species.

PCB-1260 and DDT/DDD/DDE were also detected at a limited number of sample locations. PCB-1260 was detected at two sample locations in the wetland area (02SE02 and 02SE04)[5] and in one sediment sample (RISD20) collected from the open water area. DDT and/or its degradation products DDD and DDE were detected at a single location (RISD19) in the sediment associated with the open water area. However, based on the detected concentrations of both PCB-1260 and the DDT compounds, which exceeded only the ER-L values, it is reasonable to conclude that adverse effects, if occurring, would be limited to sensitive aquatic organisms.

A limited number of inorganic chemicals exceeded the available TRVs in the wetland and open water areas. Iron exceeded the available TRVs in both the wetland and open water area while copper, manganese, nickel, silver, and zinc exceeded the TRVs in only the open water area. However, the level of exceedance (EEQ < 3.5) suggests only a limited potential for adverse effects to aquatic life. Further, with the exception of silver, the concentrations of all these chemicals were determined (using the procedure outlined in Section 4.1.2) not to exceed those detected at reference sample locations, suggesting the overall detected concentrations are reflective of regional and not site-related concentrations. Silver, which was detected at concentrations above background, was detected at only a single sample location (RISD17).

When evaluating the results of the sediment data, consideration needs to be given to the likely origin of the chemicals detected in sediment. All of the organic chemicals detected at concentrations above the available toxicity values were also detected in the surface soils of OU1 suggesting they may originate from OU1. In fact, in some cases there appears to be a spatial relationship between the occurrence of chemicals in sediment and those in surface soil. For example, DDT, DDD, and DDE were detected both in surface soil at sample locations adjacent to AREE 1 (DDT was detected at RISS1, 55, 56; DDD was detected at RISS1, 4, 55, 56; and DDE was detected at RISS4, 55, and 56) and in sediment at RISD19, which is in Marumsco Creek immediately downgradient of AREE 1. The spatial trend was not apparent for some other chemicals such as PCB-1260 and 1-methylnaphthalene. However, Marumsco Creek and the Occoquan Bay are components of a highly urbanized watershed, are likely to receive chemicals from a variety of different sources, and some chemicals present in these water bodies are likely to be originating from areas other than OU1. For example, acenaphthene and PCB-1260 were both detected at locations upgradient of the sample locations in Marumsco Creek and are likely to have originated from locations other than OU1. The results of the clam samples analyzed for te RI indicate that higher concnetrations of pesticides were detected in upgradient locations in Marumsco Creek and decreased in downgradient locations. This suggests that off-site sources are contributing to the chemical concentrations detected in Marumsco Creek and that impacts from WRF may not be the sole source for these chemicals. A full analysis of these data will be presented in the RI report for WRF. Although the origin of the chemical does not affect the

[5]PCB-1260 was detected at the two sediment locations sampled in 1993 during the Phase 1 Site Investigation but was not detected in the two sediment samples collected in the same drainage during the Remedial Investigation.

potential for adverse effects, it may affect the evaluation of remedial alternatives and should be considered when evaluating these options.

Following completion of the draft ERA, newly-derived sediment toxicity values developed specifically for freshwater environments were obtained. The newer values, derived by Smith et al. (1996), are termed threshold effect levels (TELs) and are intended to estimate the concentration of a chemical below which adverse biological effects only rarely occur. To evaluate the effect of these newer toxicity values on risk estimates, available TELs were screened against the detected concentrations of all COPCs. It should be noted, however, for the organic COPCs detected in OU1 sediments, TELs were available only for the pesticides and PCBs. TELs were available for the same inorganic COPCs as ER-Ls.

TELs were similar to ER-Ls, as were corresponding risk estimates. None of the COPCs detected at maximum concentrations below the ER-Ls were at maximum concentrations above the TELs. For chemicals with maximum detected concentrations greater than the ER-Ls, TELs were lower than ER-Ls for PCB-1260 (TEL, 0.00341 mg/kg), DDD (TEL, 0.00354 mg/kg), DDT (TEL, 0.007 mg/kg), and copper (TEL, 35.7 mg/kg) while TELs were greater than ER-Ls for DDE (TEL, 0.00142mg/kg), nickel (TEL, 18 mg/kg), and zinc (TEL, 123 mg/kg). The EEQs shifted slightly based on differences in TELs for all chemicals detected at maximum concentrations exceeding the ER-Ls. EEQs decreased slightly for PCB-1260 in the wetland (3.8 from 5.7 for the ER-L comparison) and the open water area (2.5 from 3.7 for the ER-L comparison), DDD in the open water area (4.8 from 8.5 for the ER-L comparison), DDT in the open water area (2.6 from 18.0 for the ER-L comparison), and copper in the open water area (1.0 from 1.1 for the ER-L comparison). EEQs increased slightly for DDE in the open water area (6.3 from 4.1 for the ER-L comparison), nickel in the open water area (1.25 from 1.1 for the ER-L comparison), and zinc in the open water area (1.3 from 1.1 for the ER-L comparison). These changes, however, do not alter the overall conclusions of the sediment analysis in the ERA.

4.4.3.2 Surface Water

In this section of the ERA, the COPCs in the surface water of OU1 are compared to available TRVs in Table 4-10. A detailed discussion of these comparisons is presented below for each of the surface water groupings.

Ephemeral Pond. No organic chemicals were identified in the ephemeral pond surface water, while the inorganic compounds aluminum and iron were identified as COPCs. The arithmetic mean aluminum concentration[6] exceeded the chronic AWQC (EEQ of 6.3) but remained below the acute AWQC (EEQ < 1.0), while the arithmetic mean iron concentration remained below the chronic AWQC. It should be noted however, on site aluminum concentrations did not exceed those detected at reference sample locations, suggesting the detected concentrations of this chemical are reflective of regional and not site-related concentrations.

Wetland. No organic chemicals were identified as COPCs in the wetland surface water, while the inorganic compounds aluminum and iron were identified as COPCs. The arithmetic mean concentrations of both aluminum and iron exceeded the chronic AWQC (EEQ of 22.4 for aluminum and 2.4 for iron). The arithmetic mean concentration of aluminum also exceeded the acute AWQC (EEQ of 2.6). An acute AWQC was not available for iron.

Open Water. No organic chemicals were identified as COPCs, while six inorganic compounds were identified as COPCs in the wetland surface water. The arithmetic mean concentration of aluminum exceeded both the chronic and acute AWQC (EEQ of 23.4 for the chronic AWQC and 2.7 for the acute AWQC). The arithmetic mean concentrations of iron and lead also exceeded the chronic AWQC, though to a lesser extent than aluminum (EEQ of 2.8 for iron and 1.3 for lead). It should be noted however, the concentrations of aluminum, iron, and lead were determined (using the procedure outlined in Section 4.1.2) not to exceed those detected at reference sample locations, suggesting the detected concentrations of these chemicals are reflective of regional and

[6]The maximum detected concentration was used because only one sample was taken and a mean concentration could not be calculated.

not site-related concentrations. None of the other inorganic COPCs in the wetland surface water exceeded the available AWQC.

Summary and Discussion of Surface Water Results. The results of the surface water analysis indicate a very limited potential for adverse effects to aquatic life. No organic chemicals were detected in any of the surface water bodies sampled. Of the inorganic chemicals detected in surface water, aluminum was detected at the highest concentrations relative to the TRVs, exceeding the chronic AWQC in all three of the sampled water bodies (EEQ of up to 23.4) and exceeding the acute AWQC in the wetland and open water areas (EEQ of up to 2.7). Iron was also detected at concentrations exceeding the chronic TRV in the wetland and open water areas (EEQ of up to 2.8), while lead was detected at concentrations exceeding the TRV in the open water area (EEQ of up to 2.4). Neither of these chemicals, however, were detected at concentrations exceeding the acute TRVs.

The above comparison indicates the potential for adverse effects to aquatic life from the presence of three inorganic chemicals in the surface water of OU1. However, several factors must be considered when evaluating risks. Precipitation events occurred for several days prior to and during the collection of surface water samples and field notes indicate a relatively high silt content in the surface water samples. Further, the concentrations of the inorganic chemicals detected in the ephemeral pond and the open water were determined (using the procedure outlined in Section 4.1.2) not to exceed the concentrations detected at reference sample locations. These results suggest elevated inorganic concentrations may have resulted from runoff and sediment suspension during the storm event. While these concentrations are an accurate representation of chemical concentrations during storm events, they are unlikely to be representative of chemical concentrations that would occur during lower flow conditions.

4.4.3.3 Storm Water Runoff

No organic chemicals were detected in surface water runoff at concentrations exceeding acute AWQC (EEQ <1.0). The arithmetic mean concentration of aluminum exceeded the acute AWQC (EEQ of 24.8) to the greatest extent. The arithmetic mean concentrations of barium, chromium, copper, and zinc also exceeded the acute AWQC, though to a much lesser extent than aluminum (EEQ ranging from 1.02 for barium to 1.69 for chromium). None of the other inorganic COPCs in the storm water runoff were detected at concentrations exceeding the acute AWQC.

Storm water runoff samples suggest a limited number of inorganic chemicals, primarily aluminum, could be entering the water bodies associated with OU1 at elevated concentrations, and as discussed above, may be contributing to the elevated metals concentrations detected in surface water. However, detailed modeling which is beyond the scope of this assessment would be required to quantify the affect of surficial runoff on the chemical concentrations detected in surface water.

4.5 UNCERTAINTIES

The OU1 ERA incorporates a number of uncertainties associated with the estimates of ecological risk. The general approach in this ERA has been to err on the side of conservatism. Accordingly, the risks in this ERA are likely to be overestimated rather than underestimated. However, a complete understanding of the uncertainties associated with the risk estimates is crucial to placing the estimated risks into proper perspective. The main areas of uncertainty associated with the ERA can be grouped under the following categories:

- Environmental Sampling and Analysis and Selection of Chemicals for Analysis;
- Identification of Exposure Pathways/Receptors for Evaluation and Exposure Parameter Estimation;
- Analysis of Toxicological Data; and
- Assessment of Risks.

The major uncertainties in each of these categories are discussed in the following sections.

4.5.1 Environmental Sampling and Analysis and Selection of Chemicals of Potential Concern

The major source of uncertainty in the environmental sampling and analysis is associated with the representativeness of the samples taken in surface water. As discussed in Section 4.4.4.2, surface water samples were collected during a storm event and runoff most likely contributed to the elevated inorganic chemical concentrations observed in samples taken from OU1. The likely "pulse" release of chemicals could overestimate the potential for adverse effects to aquatic life, particularly when the concentrations are being compared to chronic AWQC.

4.5.2 Identification of Exposure Pathways/Receptors for Evaluation and Exposure Parameter Estimation

A number of uncertainties are associated with the identification of potential exposure pathways selected for evaluation in the ERA. For example, the potential for adverse effects to terrestrial wildlife from the dermal absorption or inhalation of chemicals could not be evaluated because of a lack of exposure data. However, based on the COPCs detected in the sampled media, these potential exposure pathways are unlikely to occur or to result in adverse effects to terrestrial species and the inclusion of these pathways is unlikely to significantly alter the risk estimates.

4.5.3 Analysis of Toxicological Data

There are a number of uncertainties associated with the toxicity values used for the evaluation of potential adverse effects to ecological receptors. There is uncertainty associated with the applicability of the available toxicity data to the species occurring on WRF. For example, the National Oceanic Atmospheric Administration (NOAA) ER-L/ER-M values were used to evaluate the potential for adverse effects to benthic organisms in many of the ephemeral surface water bodies on WRF. These toxicity values were derived largely for brackish water habitats and may not be relevant to the aquatic life occurring in the freshwater bodies on WRF. Similarly, Federal AWQC were used to evaluate the potential for adverse effects to aquatic life from the presence of chemicals in surface water. However, many of the species for which the AWQC were designed may not be representative of species actually occurring in the water bodies associated with OU1. Depending on the species occurring in these water bodies, these toxicity values may over- or underestimate the potential for adverse effects to aquatic life. Given the relatively conservative nature of the toxicity values, however, it is likely the potential for adverse effects was overestimated rather than underestimated.

There is also uncertainty associated with the use of some toxicity values that are below the concentrations of inorganic chemicals detected at reference sample locations. This was most apparent in the use of terrestrial plant and soil invertebrate toxicity values. Will and Suter (1994a, b) indicate both terrestrial plant and soil invertebrate toxicity values that are exceeded by background levels may be a poor measures of risk to the soil invertebrates, assuming these concentrations are reflective of naturally occurring levels and not widespread contamination. Will and Suter's conclusion is based on the assumption that biota occurring in an area will be adapted to naturally occurring levels of these chemicals in the environment. Toxicity values less than background levels were used in the ERA because of a lack of other relevant toxicity data, however, the potential for overestimated of risks should be accounted for when making risk management decisions.

4.5.4 Assessment of Risks

There are uncertainties associated with the assessment of risks in the ERA. The most apparent uncertainty is the extrapolation of assumptions about the potential for adverse effects from individual organisms to populations or communities. For the higher trophic level terrestrial species, the ERA made conclusions about the potential for adverse effects to individual organisms. Very few models are available to extrapolate the potential for adverse effects from the individual level to the population or community-level. Because of the limited availability of such models, certain assumptions had to be made about the overall potential for adverse effects to ecological receptors. It was generally assumed if there is no potential for direct adverse effects to individual organisms then it is also unlikely for there to be the potential for direct adverse effects to populations or communities. Similarly, it was assumed that if there is the potential for adverse effects to individual organisms there is also the potential for adverse effects to populations or communities. Risks may have been overestimated by this latter assumption.

4.6 SUMMARY OF THE ECOLOGICAL RISK ASSESSMENT

Based on an analysis of the wildlife species associated with OU1 and the COPC detected in environmental media, the following endpoints were selected for evaluation in the ERA:

- Adverse effects to terrestrial plant communities from direct contact with chemicals in surface soil;
- Adverse effects to terrestrial invertebrate communities (as represented by earthworms) from direct contact with chemicals in surface soil;
- Adverse effects to aquatic life from exposure to chemicals in sediment; and
- Adverse effects to aquatic life from exposure to chemicals in surface water.

Several pathways by which ecological resources could be adversely affected via accumulation in terrestrial and aquatic food webs were also identified (see Table 4-5). However, the evaluation of bioaccumulation in the OU1 ERA would not accurately represent bioaccumulation at WRF for the following reasons: (1) the distribution of many chemicals at WRF having the potential to bioaccumulate is unlikely to be limited to the OU1 area, (2) OU1 represents only an isolated portion of a drainage basin likely to be affected by chemical contamination originating from this area, and (3) many species potentially affected by bioaccumulative compounds are likely to forage throughout the facility and not just at OU1. Accordingly, the analysis of bioaccumulative pathways was deferred until the site-wide assessment where these risks could be more accurately addressed.

Absolute conclusions regarding the potential for chemicals at OU1 to adversely affect ecological resources cannot be made because of the many uncertainties surrounding the estimates of toxicity and exposure. However, several general conclusions can be made regarding the potential for adverse effects to ecological resources and these conclusions are summarized below.

Terrestrial plants were selected for evaluation based on their potential to be exposed to chemicals in surface soil. Comparison of detected concentrations to literature-based toxicity values suggests the potential for aluminum, chromium, manganese, selenium, vanadium, and zinc to adversely affect terrestrial plants at most sample locations. However, concentrations of these chemicals detected at most locations approximate those at reference sample locations, indicating the majority of detected concentrations of these chemicals are reflective of regional and not OU1-related concentrations. There is the potential for selenium, zinc, and manganese to adversely affect terrestrial plants at a limited number of the sampled locations in OU1.

The toxicity database is inadequate for the evaluation of potential adverse effects to terrestrial plants from the presence of organic chemicals or iron in surface soil. Accordingly, there is uncertainty associated with the potential for these chemicals to adversely affect terrestrial plants.

Soil-dwelling invertebrates may be exposed to chemicals in surface soil and were selected for evaluation. As for terrestrial plants, only limited applicable toxicity data were available in the scientific literature for the organic COPCs and there is uncertainty associated with the lack of toxicity information available for most organic COPCs. The results of the comparison of detected concentrations to available literature-based toxicity values suggests there is the potential for chromium and, to a much lesser extent, mercury and zinc, to adversely affect terrestrial plants. However, if adverse effects are occurring, they are likely to be localized based on the limited number of literature-based toxicity value exceedances and/or the presence of these chemicals at concentrations approximating background at most sample locations.

Three water bodies were identified for analysis in the OU1 ERA: a small ephemeral pond immediately to the southeast of Lake Road, a drainage ditch downgradient of the ephemeral pond, and the Marumsco Creek/Occoquan Bay area adjacent to OU1. The results of the sediment analysis suggest that aquatic life will not be adversely affected by chemicals in the sediments of the ephemeral pond. There is some potential for chemicals detected in the sediments of the wetland area (acenaphthene, 1-methylnaphthalene, PCB-1260, and iron) and open water area (acenaphthene, 2-methylnaphthalene, PCB-1260, DDT/DDD/DDE, iron, copper, manganese, nickel, silver, and zinc) to adversely affect aquatic life. However, the potential for adverse effects to benthic organisms is a function of both the area im-

pacted by the contaminant (characterized by the frequency of detection) and the level of toxicity value exceedance at the locations where the chemical was detected at elevated concentrations. Based on these parameters, adverse effects, if occurring in these water bodies, are likely at only a limited number of areas given the low frequency of occurrence of most chemicals combined with the limited exceedance of literature-based toxicity values at most sample locations where chemicals were detected. Furthermore, Marumsco Creek and the Occoquan Bay are components of a highly urbanized watershed, and are likely to receive chemicals from a variety of different sources. Therefore, some chemicals present in these water bodies are likely to be originating from areas other than OU1. Although the origin of the chemical does not affect the potential for adverse effects, it may affect the evaluation of remedial alternatives and should be considered when evaluating these options.

The results of the surface water analysis indicates a very limited potential for adverse effects to aquatic life. No organic chemicals were detected in any of the surface water bodies sampled. Among the inorganic chemicals, aluminum was detected at the highest concentrations relative to federal AWQC, exceeding the chronic AWQC in all three of the sampled water bodies and exceeding the acute AWQC in the wetland and open water areas. Iron was also detected at concentrations exceeding the chronic AWQC in the wetland and open water areas, while lead was detected at concentrations exceeding the available literature-based toxicity value in the open water area. Although these results do indicate the potential for adverse effects, it should be noted that precipitation events occurred for several days prior to and during the collection of surface water samples, and field notes indicate a relatively high silt content in the surface water samples. The elevated inorganic concentrations detected in surface water are likely to have resulted from runoff and sediment suspension during the storm event and are unlikely to be representative of concentrations during lower flow conditions.

TABLE 4-1
SUMMARY OF WATER QUALITY AND WET CHEMISTRY PARAMETERS IN SURFACE WATER AND SEDIMENT
WOODBRIDGE RESEARCH FACILITY - OU1

Chemical	Number of Samples	Arithmetic Mean	Range of Detected Concentrations
Pond			
Sediment:			
Total Organic Carbon (%)	1	NC	1.49
Moisture (%)	1	NC	49.6
Surface Water:			
Temperature (°C)	1	NC	
Percent Saturation	1	NC	92.5
Conductivity (µmhos/cm)	1	NC	60
pH	1	NC	6.19
Wetland			
Sediment:			
Total Organic Carbon (%)	2	8.99	5.88 - 12.1
Moisture (%)	2	77.3	71.8 - 82.7
Surface Water:			
Temperature (°C)	2	5.43	5.06 - 5.8
Percent Saturation	2	84.4	83.2 - 85.5
Conductivity (µmhos/cm)	2	103.0	93.0 - 113.0
pH	2	6.7	6.6 - 6.8
Open Water			
Sediment:			
Total Organic Carbon (%)	9	1.23	0.102 - 5.08
Moisture (%)	9	40.7	14.4 - 82.5
Surface Water:			
Temperature (°C)	9	6.31	3.56 - 10.8
Percent Saturation	9	96.1	87.7 - 104
Conductivity (µmhos/cm)	9	275.4	201 - 314
pH	9	7.3	7.1 - 7.6

NC = Not calculated because only one sample was taken.

TABLE 4-2
SUMMARY OF CHEMICALS DETECTED IN SURFACE SOIL
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection[A]	Mean Sample Size[B]	Arithmetic Mean[C]	Range of Detection Limits	Range of Detected Concentrations	Screening Value Comparison: Screening Values[D]	Screening Value Comparison: Site > Screening?	Reference Comparison[E]: Reference Data	Reference Comparison[E]: Site > Reference?
On-site Soil									
Volatile Organics:									
* Acetone	1 / 27	27	0.0056	0.0100	0.0200	NSV	---	ND	---
Methylene chloride	5 / 27	27	0.0070	0.0100	0.0100 - 0.0200	<0.3	No	0.0200	---
Semi-Volatile Organics:									
PAHs:									
* Acenaphthene	5 / 27	27	0.851	0.133	0.185 - 10.8	0.1	**Yes**	ND	---
* Anthracene	20 / 27	27	0.614	0.0070	0.0090 - 11.7	0.1	**Yes**	0.0150 - 0.0280	---
* Benzo(a)anthracene	17 / 27	27	0.116	0.0010 - 0.130	0.0020 - 2.0	0.1	**Yes**	0.0030 - 0.0050	---
* Benzo(a)pyrene	21 / 27	27	0.133	0.0007	0.0010 - 2.40	0.1	**Yes**	0.0020 - 0.0080	---
* Benzo(b)fluoranthene	21 / 27	27	0.130	0.0010 - 0.130	0.0020 - 2.19	0.1	**Yes**	0.0013 - 0.0100	---
* Benzo(g,h,i)perylene	11 / 27	27	0.152	0.0070	0.0080 - 2.77	0.1	**Yes**	0.0110	---
* Benzo(k)fluoranthene	21 / 27	27	0.0682	0.0007 - 0.0700	0.0010 - 1.20	0.1	**Yes**	0.0010 - 0.0050	---
* Chrysene	7 / 27	27	0.144	0.0070	0.0100 - 2.62	0.1	**Yes**	ND	---
* Dibenz(a,h)anthracene	3 / 27	27	0.0386	0.0030	0.0220 - 0.698	0.1	**Yes**	ND	---
* Fluoranthene	22 / 27	27	0.298	0.0010	0.0030 - 5.05	0.1	**Yes**	0.0055 - 0.0180	---
* Fluorene	2 / 27	27	0.0613	0.0330	0.487 - 0.755	0.1	**Yes**	ND	---
* Indeno(1,2,3-c,d)pyrene	12 / 27	27	0.0938	0.0030	0.0040 - 1.70	0.1	**Yes**	0.0080 - 0.0100	---
* 1-Methylnaphthalene	2 / 27	27	0.107	0.133	0.383 - 0.842	NSV	---	ND	---
* 2-Methylnaphthalene	3 / 27	27	0.401	0.133	0.189 - 6.05	NSV	---	ND	---
* Naphthalene	7 / 27	27	0.600	0.133	0.314 - 4.97	0.1	**Yes**	ND	---
* Phenanthrene	9 / 27	27	0.427	0.0330	0.0540 - 6.29	0.1	**Yes**	0.0420 - 0.354	---
* Pyrene	12 / 27	27	0.595	0.0070	0.0090 - 12.3	0.1	**Yes**	0.0090 - 0.0230	---
Pesticides/PCBs:									
Chlordane	1 / 27	27	0.0106	0.0200	0.0250	<0.1	No	ND	---
DDD	4 / 27	27	0.0030	0.0030	0.0050 - 0.0240	<0.1	No	ND	---
DDE	3 / 27	27	0.0038	0.0030	0.0060 - 0.0520	<0.1	No	ND	---
DDT	5 / 27	27	0.0052	0.0030	0.0040 - 0.0560	<0.1	No	ND	---
* PCB-1260	4 / 27	27	0.0498	0.0130	0.0540 - 0.713	0.1 [F]	**Yes**	ND	---
Other Semi-Volatiles:									
* bis(2-Ethylhexyl)phthalate	6 / 27	27	0.548	0.140 - 0.700	0.340 - 8.20	NSV	---	ND	---
Inorganics:									
*B Aluminum	27 / 27	27	11,700	NU	6,480 - 16,300	1.0	**Yes**	6,550 - 14,350	No
Arsenic	1 / 27	27	3.63	7.50	0.643	328 [G]	No	3.80	No

TABLE 4-2
SUMMARY OF CHEMICALS DETECTED IN SURFACE SOIL
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection[A]	Mean Sample Size[B]	Arithmetic Mean[C]	Range of Detection Limits	Range of Detected Concentrations	Screening Value Comparison		Reference Comparison[E]	
						Screening Values[D]	Site > Screening?	Reference Data	Site > Reference?
Barium	9 / 26	26	35.8	40.0	51.1 - 117	440	No	67.0 - 73.4	No
*B Beryllium	27 / 27	27	0.675	NU	0.407 - 1.33	0.02	**Yes**	0.364 - 0.785	No
E Calcium	24 / 24	24	626	NU	152 - 3,580	NSV	---	486 - 1,020	No
*B Chromium	27 / 27	27	22.9	NU	7.58 - 96.7	0.0075 [H]	**Yes**	9.72 - 25.5	No
Cobalt	26 / 27	27	7.02	2.0	3.61 - 20.4	100	No	6.39 - 12.7	No
*B Copper	27 / 27	27	9.88	NU	4.04 - 20.7	15.0	**Yes**	4.83 - 12.6	No
*B Iron	27 / 27	27	18,300	NU	7,790 - 37,300	12	**Yes**	10,200 - 23,050	No
*B Lead	24 / 27	27	17.3	7.50	9.54 - 35.7	0.01	**Yes**	15.5 - 22.4	No
E Magnesium	27 / 27	27	1,350	NU	523 - 2,370	NSV	---	881 - 1,700	No
*B Manganese	25 / 25	25	157	NU	39.9 - 1,450	330	**Yes**	112 - 677	No
* Mercury	1 / 27	27	0.0526	0.100	0.121	0.058	**Yes**	ND	**Yes**
*B Nickel	27 / 27	27	8.06	NU	4.18 - 12.0	2.0	**Yes**	3.87 - 8.98	No
E Potassium	24 / 24	24	754	NU	495 - 1,130	NSV	---	358 - 597	**Yes**
*B Selenium	3 / 27	27	6.75	10.0	17.8 - 24.5	1.8	**Yes**	14.2	No
E Sodium	27 / 27	27	479	NU	271 - 991	NSV	---	380 - 487	No
*B Vanadium	27 / 27	27	36.6	NU	21.0 - 53.2	0.5	**Yes**	20.6 - 47.1	No
*B Zinc	27 / 27	27	57.4	NU	18.8 - 301	10.0	**Yes**	14.8 - 40.4	No

[A] The number of samples in which the chemical was detected divided by the total number of samples analyzed, excluding samples rejected as a result of validation.

[B] The number of samples used in calculating the mean. Non-detect samples with high detection limits were included when calculating the mean, following EPA Region III guidance.

[C] Calculated by averaging the detected concentration(s) with one-half the detection limit of non-detected sample(s).

[D] Values are Region III BTAG screening levels.

[E] Background samples consist of data from samples RISSBK-1 through RISSBK-5.

[F] Value for PCBs.

[G] Value for total arsenic.

[H] Value for total chromium.

B = The concentration for this inorganic chemical was not above the reference concentration, however this chemical was retained as a COPC (chemical of potential concern) because the maximum concentration was greater than the Region III Screening Level or no screening level was available.

E = Eliminated from consideration as a COPC because chemical is an essential nutrient.

ND = Not detected.

NSV = No screening value available.

NU = Not used. The chemical was detected in all samples, thus detection limits were not used to calculate mean concentrations.

* = Selected as a COPC.

TABLE 4-3
SUMMARY OF CHEMICALS DETECTED IN SEDIMENT
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection[A]	Mean Sample Size[B]	Arithmetic Mean[C]	Range of Detection Limits	Range of Detected Concentrations	Screening Value Comparison		Reference Comparison[E]	
						Screening Values[D]	Site > Screening?	RSAP Reference Data	Site > Reference?
Pond									
Semi-Volatile Organics:									
PAHs:									
Anthracene	1 \ 1	1	NC	NU	0.0310	0.0853	No	0.108 - 0.169	---
Benzo(a)pyrene	1 \ 1	1	NC	NU	0.0020	0.430	No	0.0290 - 0.0515	---
Benzo(b)fluoranthene	1 \ 1	1	NC	NU	0.0040	3.20	No	0.0610 - 0.0830	---
Benzo(k)fluoranthene	1 \ 1	1	NC	NU	0.0020	3.20 [F]	No	0.0170 - 0.0320	---
Fluoranthene	1 \ 1	1	NC	NU	0.0060	0.600	No	0.0550 - 0.0940	---
Inorganics:									
*B Aluminum	1 \ 1	1	NC	NU	13,200	NSV	---	10,500 - 15,200	No
*B Barium	1 \ 1	1	NC	NU	85.2	NSV	---	175	No
*B Beryllium	1 \ 1	1	NC	NU	0.747	NSV	---	0.989 - 1.26	No
*B Chromium	1 \ 1	1	NC	NU	25.0	0.005 [G]	**Yes**	21.6 - 30.1	No
*B Cobalt	1 \ 1	1	NC	NU	8.97	NSV	---	14.6 - 20.7	No
Copper	1 \ 1	1	NC	NU	19.6	34.0	No	29.8 - 41.8	No
*B Iron	1 \ 1	1	NC	NU	13,800	NSV	---	26,100 - 34,200	No
Lead	1 \ 1	1	NC	NU	16.4	46.7	No	22.8 - 42.2	No
E Magnesium	1 \ 1	1	NC	NU	2,600	NSV	---	2,470 - 3,470	No
Nickel	1 \ 1	1	NC	NU	14.7	20.9	No	19.3 - 30.0	No
E Potassium	1 \ 1	1	NC	NU	1,130	NSV	---	1,450 - 2,120	No
E Sodium	1 \ 1	1	NC	NU	657	NSV	---	932 - 1,710	No
*B Vanadium	1 \ 1	1	NC	NU	37.1	NSV	---	35.5 - 52.5	No
Zinc	1 \ 1	1	NC	NU	72.5	150	No	114 - 157	No
Wetland									
Semi-Volatile Organics:									
PAHs:									
* Acenaphthene	2 \ 2	2	1.23	NU	0.867 - 1.59	0.0160	**Yes**	0.668 - 0.919	---
* Anthracene	2 \ 2	2	0.655	NU	0.331 - 0.979	0.0853	**Yes**	0.108 - 0.169	---
Benzo(a)anthracene	2 \ 2	2	0.0210	NU	0.0160 - 0.0260	0.261	No	0.0210 - 0.0310	---
Benzo(a)pyrene	1 \ 2	2	0.104	0.0180	0.198	0.430	No	0.0290 - 0.0515	---

TABLE 4-3
SUMMARY OF CHEMICALS DETECTED IN SEDIMENT
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection[A]	Mean Sample Size[B]	Arithmetic Mean[C]	Range of Detection Limits	Range of Detected Concentrations	Screening Value Comparison: Screening Values[D]	Screening Value Comparison: Site > Screening?	Reference Comparison[E]: RSAP Reference Data	Reference Comparison[E]: Site > Reference?
Benzo(b)fluoranthene	1 \ 2	2	0.0743	0.0330	0.132	3.2	No	0.0610 - 0.0830	---
Benzo(g,h,i)perylene	1 \ 2	2	0.0978	0.0670	0.162	0.670	No	0.0460 - 0.0800	---
Benzo(k)fluoranthene	1 \ 2	2	0.0395	0.0180	0.0700	3.20 [F]	No	0.0170 - 0.0320	---
Fluoranthene	2 \ 2	2	0.0700	NU	0.0450 - 0.0950	0.600	No	0.0550 - 0.0940	---
* Indeno(1,2,3-c,d)pyrene	1 \ 2	2	0.351	0.0830	0.660	0.600	**Yes**	0.0640 - 0.112	---
* 1-Methylnaphthalene	2 \ 2	2	1.44	NU	0.479 - 2.41	0.0700 [H]	**Yes**	0.498 - 1.04	---
* Naphthalene	2 \ 2	2	1.50	NU	1.11 - 1.88	0.160	**Yes**	0.351	---
Pyrene	2 \ 2	2	0.0920	NU	0.0810 - 0.103	0.665	No	0.0530 - 0.130	---
PCBs:									
* PCB-1260	2 \ 4	4	0.0533	0.0130	0.0700 - 0.130	0.0227 [I]	**Yes**	ND	---
Inorganics:									
*B Aluminum	2 \ 2	2	13,400	NU	13,200 - 13,700	NSV	---	10,500 - 15,200	No
* Beryllium	1 \ 2	2	0.740	0.200	1.38	NSV	---	0.989 - 1.26	**Yes**
E Calcium	2 \ 2	2	3,750	NU	3,060 - 4,440	NSV	---	4,240 - 6,000	No
*B Chromium	2 \ 2	2	21.3	NU	21.2 - 21.4	0.005 [G]	**Yes**	21.6 - 30.1	No
*B Cobalt	2 \ 2	2	11.7	NU	10.2 - 13.1	NSV	---	14.6 - 20.7	No
Copper	2 \ 2	2	25.0	NU	20.7 - 29.2	34.0	No	29.8 - 41.8	No
*B Iron	2 \ 2	2	22,500	NU	20,400 - 24,500	NSV	---	26,100 - 34,200	No
E Magnesium	2 \ 2	2	2,300	NU	2,140 - 2,460	NSV	---	2,470 - 3,470	No
*B Manganese	2 \ 2	2	286	NU	284 - 287	NSV	---	912 - 1,690	No
Nickel	2 \ 2	2	17.3	NU	15.4 - 19.1	20.9	No	19.3 - 30.0	No
E Potassium	2 \ 2	2	1,010	NU	969 - 1,060	NSV	---	1,450 - 2,120	No
E Sodium	2 \ 2	2	2,550	NU	2,450 - 2,650	NSV	---	932 - 1,710	**Yes**
* Vanadium	2 \ 2	2	54.2	NU	47.6 - 60.9	NSV	---	35.5 - 52.5	**Yes**
Zinc	2 \ 2	2	92.8	NU	85.5 - 100	150	No	114 - 157	No
Open Water									
Semi-Volatile Organics:									
PAHs:									
* Acenaphthene	1 \ 9	9	0.854	0.133	7.15	0.0160	**Yes**	0.668 - 0.919	---
* Anthracene	5 \ 9	9	0.0938	0.0070	0.0410 - 0.552	0.0853	**Yes**	0.108 - 0.169	---

TABLE 4-3
SUMMARY OF CHEMICALS DETECTED IN SEDIMENT
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection[A]	Mean Sample Size[B]	Arithmetic Mean[C]	Range of Detection Limits	Range of Detected Concentrations	Screening Value Comparison		Reference Comparison[E]	
						Screening Values[D]	Site > Screening?	RSAP Reference Data	Site > Reference?
Benzo(a)anthracene	8 \ 9	9	0.0368	0.0010	0.0020 - 0.142	0.261	No	0.0210 - 0.0310	---
Benzo(a)pyrene	8 \ 9	9	0.0435	0.0007	0.0010 - 0.195	0.43	No	0.0290 - 0.0515	---
Benzo(b)fluoranthene	9 \ 9	9	0.0537	NU	0.0030 - 0.141	3.20	No	0.0610 - 0.0830	---
Benzo(g,h,i)perylene	4 \ 9	9	0.0405	0.0070	0.0590 - 0.119	0.670	No	0.0460 - 0.0800	---
Benzo(k)fluoranthene	9 \ 9	9	0.0249	NU	0.0009 - 0.0820	3.20 [F]	No	0.0170 - 0.0320	---
Chrysene	1 \ 9	9	0.0070	0.0070	0.0350	0.384	No	ND	---
Dibenz(a,h)anthracene	2 \ 9	9	0.0042	0.0030	0.0120 - 0.0150	0.0634	No	0.0130 - 0.0220	---
Fluoranthene	6 \ 6	6	0.111	NU	0.0040 - 0.259	0.600	No	0.0550 - 0.0940	---
* Fluorene	1 \ 9	9	0.0314	0.0330	0.151	0.0190	**Yes**	0.157 - 0.355	---
Indeno(1,2,3-c,d)pyrene	5 \ 9	9	0.0331	0.0030	0.0270 - 0.0940	0.600	No	0.0640 - 0.112	---
* 2-Methylnaphthalene	1 \ 9	9	0.274	0.133	1.93	0.0700	**Yes**	ND	---
Phenanthrene	1 \ 9	9	0.0197	0.0330	0.0450	0.240	No	ND	---
Pyrene	7 \ 9	9	0.112	0.0070	0.0090 - 0.419	0.665	No	0.0530 - 0.130	---
Pesticides/PCBs:									
* 4,4'-DDD	1 \ 9	9	0.0032	0.0030	0.0170	<0.016	**Yes**	ND	---
* 4,4'-DDE	1 \ 9	9	0.0023	0.0030	0.0090	0.0022	**Yes**	ND	---
* 4,4'-DDT	1 \ 9	9	0.0033	0.0030	0.0180	0.00158	**Yes**	ND	---
* PCB-1260	1 \ 9	9	0.0151	0.0130	0.0840	0.0227 [I]	**Yes**	ND	---
Inorganics:									
*B Aluminum	4 \ 4	4	8,760	NU	3,340 - 14,700	NSV	---	10,500 - 15,200	No
*B Beryllium	5 \ 9	9	0.422	0.200	0.316 - 1.26	NSV	---	0.989 - 1.26	No
E Calcium	3 \ 3	3	3,720	NU	1,360 - 5,420	NSV	---	4,240 - 6,000	No
*B Chromium	9 \ 9	9	15.9	NU	5.20 - 34.9	0.005 [G]	**Yes**	21.6 - 30.1	No
*B Cobalt	9 \ 9	9	10.6	NU	2.73 - 29.4	NSV	---	14.6 - 20.7	No
*B Copper	8 \ 8	8	16.3	NU	4.10 - 36.9	34.0	**Yes**	29.8 - 41.8	No
*B Iron	9 \ 9	9	17,200	NU	6,530 - 48,500	NSV	---	26,100 - 34,200	No
Lead	4 \ 9	9	10.1	7.50	10.6 - 35.3	46.7	No	22.8 - 42.2	No
E Magnesium	5 \ 5	5	1,900	NU	799 - 3,200	NSV	---	2,470 - 3,470	No
*B Manganese	9 \ 9	9	494	NU	125 - 895	NSV	---	912 - 1,690	No
*B Nickel	9 \ 9	9	10.4	NU	2.53 - 22.5	20.9	**Yes**	19.3 - 30.0	No

TABLE 4-3
SUMMARY OF CHEMICALS DETECTED IN SEDIMENT
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in mg/kg)

Chemical	Frequency of Detection[A]	Mean Sample Size[B]	Arithmetic Mean[C]	Range of Detection Limits	Range of Detected Concentrations	Screening Value Comparison		Reference Comparison[E]	
						Screening Values[D]	Site > Screening?	RSAP Reference Data	Site > Reference?
E Potassium	2 \ 3	3	933	100	1,140 - 1,610	NSV	---	1,450 - 2,120	No
* Silver	1 \ 9	9	0.606	0.500	3.45	1.0	**Yes**	ND	**Yes**
E Sodium	4 \ 4	4	1,330	NU	519 - 2,290	NSV	---	932 - 1,710	No
*B Vanadium	9 \ 9	9	39.4	NU	13.5 - 112	NSV	---	35.5 - 52.5	No
*B Zinc	7 \ 7	7	71.7	NU	27.5 - 158	150	**Yes**	114 - 157	No

A The number of samples in which the chemical was detected divided by the total number of samples analyzed, excluding samples rejected as a result of validation.
B The number of samples used in calculating the mean. Non-detect samples with high detection limits were included when calculating the mean, following EPA Region III guidance.
C Calculated by averaging the detected concentrations(s) with one-half the detection limit of non-detected sample(s).
D Values are Region III BTAG screening levels.
E Background concentrations consist of data from samples RISDBK-1 through RISDBK-5.
F Value for benzo(b)fluoranthene.
G Value for total chromium.
H Value for 2-Methylnaphthalene.
I Value for PCBs.

B = The concentration for this inorganic chemical was not above the reference concentration, however this chemical was retained as a COPC (chemical of potential concern) because the maximum concentration was greater than the Region III Screening Level or no screening level was available.
E = Eliminated from consideration as a COPC because chemical is an essential nutrient.
NC = Not calculated because sample size equals one.
ND = Not detected.
NSV = No screening value available.
NU = Not used. The chemical was detected in all samples, thus detection limits were not used to calculate mean concentrations.
* = Selected as a COPC.

TABLE 4-4
SUMMARY OF CHEMICALS DETECTED IN SURFACE WATER
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in ug/L)

Chemical	Frequency of Detection[A]	Mean Sample Size[B]	Arithmetic Mean[C]	Range of Detection Limits	Range of Detected Concentrations	Screening Value Comparison		Reference Comparison[E]	
						Screening Values[D]	Site > Screening?	Reference Data	Site > Reference?
Pond									
Inorganics:									
*B Aluminum	1 / 1	1	NC	NU	547	25.0	**Yes**	1,230 - 1,930	No
E Calcium	1 / 1	1	NC	NU	2,020	NSV	---	18,800 - 22,200	No
*B Iron	1 / 1	1	NC	NU	705	320	**Yes**	1,905 - 2,510	No
E Magnesium	1 / 1	1	NC	NU	1,250	NSV	---	5,970 - 7,500	No
Manganese	1 / 1	1	NC	NU	28.3	14,500	No	176 - 303	No
E Potassium	1 / 1	1	NC	NU	2,010	NSV	---	2,870 - 3,670	No
E Sodium	1 / 1	1	NC	NU	1,380	NSV	---	12,500 - 16,500	No
Wetland									
Inorganics:									
* Aluminum	2 / 2	2	1,950	NU	1,800 - 2,100	25.0	**Yes**	1,230 - 1,930	**Yes**
E Calcium	2 / 2	2	3,700	NU	3,470 - 3,920	NSV	---	18,800 - 22,200	No
* Iron	2 / 2	2	2,440	NU	2,110 - 2,770	320	**Yes**	1,905 - 2,510	**Yes**
Lead	2 / 2	2	1.40	NU	1.20 - 1.60	3.2	No	1.30 - 1.90	No
E Magnesium	2 / 2	2	1,950	NU	1,840 - 2,070	NSV	---	5,970 - 7,500	No
Manganese	2 / 2	2	73.7	NU	56.1 - 91.2	14,500	No	176 - 303	No
E Potassium	2 / 2	2	2,780	NU	2,650 - 2,910	NSV	---	2,870 - 3,670	No
E Sodium	2 / 2	2	2,900	NU	2,480 - 3,320	NSV	---	12,500 - 16,500	No
Open Water									
Inorganics:									
*B Aluminum	9 / 9	9	2,040	NU	927 - 5,070	25.0	**Yes**	1,230 - 1,930	No
Barium	9 / 9	9	42.2	NU	30.9 - 69.9	10,000	No	37.7 - 41.8	No
E Calcium	9 / 9	9	17,000	NU	15,100 - 20,200	NSV	---	18,800 - 22,200	No
*B Chromium	1 / 9	9	5.68	10.0	11.1	2.0[F]	**Yes**	10.8	No
* Copper	3 / 9	9	5.07	5.0	6.10 - 17.6	6.5	**Yes**	ND	**Yes**
*B Iron	9 / 9	9	2,770	NU	1,310 - 6,900	320	**Yes**	1,905 - 2,510	No
*B Lead	9 / 9	9	3.32	NU	1.40 - 8.40	3.2	**Yes**	1.30 - 1.90	No

TABLE 4-4
SUMMARY OF CHEMICALS DETECTED IN SURFACE WATER
WOODBRIDGE RESEARCH FACILITY - OU1
(Concentrations in ug/L)

Chemical	Frequency of Detection[A]	Mean Sample Size[B]	Arithmetic Mean[C]	Range of Detection Limits	Range of Detected Concentrations	Screening Value Comparison		Reference Comparison[E]	
						Screening Values[D]	Site > Screening?	Reference Data	Site > Reference?
E Magnesium	9 / 9	9	5,650	NU	4,930 - 6,970	NSV	---	5,970 - 7,500	No
Manganese	9 / 9	9	195	NU	103 - 373	14,500	No	176 - 303	No
E Potassium	9 / 9	9	4,010	NU	3,400 - 5,070	NSV	---	2,870 - 3,670	**Yes**
E Sodium	9 / 9	9	12,600	NU	11,100 - 14,700	NSV	---	12,500 - 16,500	No
Vanadium	2 / 9	9	6.54	10.0	10.8 - 13.1	<10,000	No	ND	**Yes**
* Zinc	8 / 9	9	24.8	20.0	20.6 - 40.1	30.0	**Yes**	ND	**Yes**

[A] The number of samples in which the chemical was detected divided by the total number of samples analyzed, excluding samples rejected as a result of validation.

[B] The number of samples used in calculating the mean. Non-detect samples with high detection limits were included when calculating the mean, following EPA Region III guidance.

[C] Calculated by averaging the detected concentrations(s) with one-half the detection limit of the non-detected sample(s).

[D] Values are Region III BTAG screening levels.

[E] Background concentrations consist of data from samples RISWBK-1 through RISWBK-5.

[F] Value for chromium VI.

B = The concentration for this inorganic chemical was not above the reference concentration, however this chemical was retained as a COPC (chemical of potential concern) because the maximum concentration was greater than the Region III Screening Level or no screening level was available.

E = Eliminated from consideration as a COPC because chemical is an essential nutrient.

NC = Not calculated because sample size equals one.

ND = Not detected.

NSV = No screening value available.

NU = Not used. The chemical was detected in all samples, thus detection limits were not used to calculate mean concentrations.

* = Selected as a COPC.

Table 4–5. Potential Exposure Pathways for Ecological Receptors at the OU1 Area

Potential Receptors	Exposure Route	Pathway(s) Selected for Evaluation?	Comments
AIR			
Terrestrial wildlife	Inhalation	No	Not evaluated because the OU1 Area is mostly covered with vegetation, and exposure to chemicals via the wind entrainment of surface soil is not expected to be significant.
SURFACE SOIL			
Terrestrial plants	Direct contact (root uptake)	Yes	Pathway potentially complete; selected for quantitative evaluation.
	Direct contact (foliar uptake)	No	Not evaluated because applicable exposure and toxicity data could not be found in the scientific literature.
Terrestrial invertebrates (e.g., earthworms)	Ingestion and direct contact (dermal absorption)	Yes	Pathways potentially complete; selected for quantitative evaluation.
Terrestrial wildlife (e.g., mammals, birds)	Ingestion	No	Pathway potentially complete; however, exposure pathway will be evaluated as part of facility-wide assessment and was not selected for evaluation in present assessment.
	Direct contact (dermal absorption)	No	Not evaluated because applicable exposure data could not be found in the scientific literature. In addition, pathway is most likely insignificant in comparison to the ingestion of contaminated food.
FOOD			
Terrestrial wildlife (e.g., mammals, birds)	Ingestion	No	Pathway potentially complete; however, exposure pathway will be evaluated as part of facility-wide assessment and was not selected for evaluation in present assessment.
Aquatic life in surface water bodies of the OU1 Area	Ingestion	No	Pathway potentially complete; however, exposure pathway will be evaluated as part of facility-wide assessment and was not selected for evaluation in present assessment.
SURFACE WATER			
Terrestrial wildlife	Ingestion	No	Pathway potentially complete; however, exposure pathway will be evaluated as part of facility-wide assessment and was not selected for evaluation in present assessment.
	Direct contact (dermal absorption)	No	Not evaluated because applicable exposure and toxicity data could not be found in the scientific literature; however, pathway is not likely to result in significant risks because exposure is likely to be limited.

Table 4–5. Potential Exposure Pathways for Ecological Receptors at the OU1 Area (Continued)

Potential Receptors	Exposure Route	Pathway(s) Selected for Evaluation?	Comments
Aquatic life in surface water bodies of the OU1 Area	Ingestion, respiration, and direct contact (dermal absorption)	Yes	Pathways potentially complete; selected for quantitative evaluation.
Wetland/aquatic plants along the surface water bodies of the OU1 Area	Direct contact (root and foliar uptake)	No	Pathway not evaluated because applicable exposure and toxicity data could not be found in the scientific literature.
SEDIMENT			
Terrestrial wildlife (e.g., mammals, birds)	Ingestion	No	Pathway potentially complete; however, exposure pathway will be evaluated as part of facility-wide assessment and was not selected for evaluation in present assessment.
	Direct contact (dermal absorption)	No	Not selected for evaluation because applicable exposure and toxicity data could not be found in the scientific literature; however, pathway is not likely to result in significant risks because exposure is likely to be limited.
Benthic-dwelling aquatic life in the surface water bodies of the OU1 Area	Ingestion, respiration, and direct contact (dermal absorption)	Yes	Pathways potentially complete; selected for quantitative evaluation.

Table 4–6. Assessment Endpoints for Ecological Risk Assessment of the OU1 Area

Receptor of Concern	Exposure Pathway Evaluated	Assessment Endpoint[a]	Testable Hypothesis	Measurement Endpoint	Data Available
Terrestrial plants	Root uptake of chemicals from surface soil	Decline in growth or yield of terrestrial plants	Ha: The concentration of chemicals of potential concern in the surface soil exceeds a level known to be toxic to terrestrial plants	Compare chemical concentrations in surface soil at potentially impacted locations to toxicity benchmarks in literature	Site-specific surface soil chemical data from potentially impacted locations and reference locations
Soil invertebrates (earthworms)	Ingestion and dermal absorption of chemicals from surface soil	Decline in growth, reproduction, or soil aeration activity of soil invertebrates	Ha: The concentration of chemicals of potential concern in soil exceeds a level known to be toxic to soil invertebrates	Compare chemical concentrations in surface soil at potentially impacted locations to toxicity benchmarks in literature	Site-specific surface soil chemical data from potentially impacted locations and reference locations
Aquatic life	Ingestion, respiration, and dermal absorption	Decline in abundance and diversity of aquatic community	Ha: The concentration of chemicals of potential concern in surface water exceeds a level known to be toxic to aquatic life	Compare chemical concentrations in surface water at potentially impacted locations to toxicity benchmarks in literature	Site-specific surface water chemical data from potentially impacted locations and reference locations
Benthic-dwelling aquatic life	Ingestion, respiration, and dermal absorption	Decline in abundance and diversity of benthic macroinvertebrate community	Ha: The concentration of chemicals of potential concern in sediment exceeds a level known to be toxic to benthic macroinvertebrates	Compare chemical concentrations in sediment at potentially impacted locations to toxicity benchmarks in literature	Site-specific sediment chemical data from potentially impacted locations and reference locations

[a]Evaluation of the assessment endpoints for the OU1 ERA is based solely on literature-based toxicity values and the measurement of chemical concentrations in abiotic media; no site-specific biota sampling data were included in the OU1 ERA.

TABLE 4-7
COMPARISON OF MAXIMUM SURFACE SOIL CONCENTRATIONS TO TERRESTRIAL PLANT TRVs FOR CHEMICALS OF POTENTIAL CONCERN DETECTED AT OU1
(Concentrations in mg/kg)

Chemical	Maximum Surface Soil Concentration	Terrestrial Plant TRV [A]	Environmental Effects Quotient (EEQ) [B] Ratio of Maximum Detected Surface Soil Concentrations of Terrestrial Plant TRVs
Inorganics: [C]			
B Aluminum	16,300	50	**326**
B Beryllium	1.33	10	0.1
B Chromium	96.7	1	**96.7**
B Copper	20.7	100	0.2
B Iron	37,300	NA	---
B Lead	35.7	50	0.7
B Manganese	1,450	500	**2.9**
Mercury	0.121	0.3	0.4
B Nickel	12.0	30	0.4
B Selenium	24.5	1	**24.5**
B Vanadium	53.2	2	**26.6**
B Zinc	301	50	**6.0**

[A] Values from Will and Suter (1994a).

[B] Ratios greater than one are indicated with boldface type.

[C] Organic COPCs are not included in this table because terrestrial plant TRVs are not available for organic compounds.

B = The concentration for this inorganic chemical was not significantly greater than the reference concentration, but the maximum concentration was greater than the Region III screening level, and the chemical was retained as a COPC.

NA = Insufficient data to derive a TRV.

TABLE 4-8
COMPARISON OF MAXIMUM SURFACE SOIL CONCENTRATIONS TO EARTHWORM TRVs FOR CHEMICALS OF POTENTIAL CONCERN AT OU1
(Concentrations in mg/kg)

Chemical	Maximum Surface Soil Concentration	Earthworm TRV[A]	Environmental Effects Quotient (EEQ)[B] Ratio of Maximum Detected Surface Soil Concentrations of Earthworm TRVs
Organics:[C]			
Fluorene	0.755	30	<0.01
Inorganics:			
B Aluminum	16,300	NA	---
B Beryllium	1.33	NA	---
B Chromium	96.7	0.4	**242**
B Copper	20.7	50	0.4
B Iron	37,300	NA	---
B Lead	35.7	500	0.1
B Manganese	1,450	NA	---
Mercury	0.121	0.1	**1.2**
B Nickel	12.0	200	0.1
B Selenium	24.5	NA	---
B Vanadium	53.2	NA	---
B Zinc	301	200	**1.5**

[A] TRV from the method of Will and Suter (1994b).

[B] Ratios greater than one are indicated with boldface type.

[C] Organic COPCs for which there was insufficient data to derive a TRV are not included in this table.

B = The concentration for this inorganic chemical was not significantly greater than the reference concentration, but the maximum concentration was greater than the Region III screening level, and the chemical was retained as a COPC.

NA = Insufficient data to derive a TRV.

TABLE 4-9

COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS TO SEDIMENT TRVs FOR CHEMICALS OF POTENTIAL CONCERN AT OU1

(Concentrations in mg/kg)

Chemical	Maximum Sediment Concentration	Long and Morgan (1990)/Long et al. (1995) Sediment Quality Guidelines		Other Guidelines	Environmental Effects Quotient (EEQ)[A]		
		ER-L	ER-M		Ratio of Maximum Sediment Concentrations to ER-L	Ratio of Maximum Sediment Concentrations to ER-M	Ratio of Maximum Sediment Concentrations to Other Guidelines
Pond							
Inorganics:							
B Aluminum	13,200	—	—	—	—	—	—
B Barium	85.2	—	—	—	—	—	—
B Beryllium	0.747	—	—	—	—	—	—
B Chromium	25.0	81	370	—	0.3	0.1	—
B Cobalt	8.97	—	—	—	—	—	—
B Iron	13,800	—	—	20,000 [B]	—	—	0.7
B Vanadium	37.1	—	—	—	—	—	—
Wetland							
Semi-Volatile Organics:							
PAHs:							
Acenaphthene	1.59	0.016	0.5	—	**99.4**	**3.2**	—
Anthracene	0.979	0.0853	1.1	—	**11.5**	0.9	—
Indeno(1,2,3-c,d)pyrene	0.660	0.665 [C]	2.6 [C]	—	1.0	0.3	—
1-Methylnaphthalene	2.41	0.07 [D]	0.67 [D]	—	**34.4**	**3.6**	—
Naphthalene	1.88	0.16	2.1	—	**11.8**	0.9	—
PCBs:							
PCB-1260	0.130	0.0227 [E]	0.18 [E]	—	**5.7**	0.7	—
Inorganics:							
B Aluminum	13,700	—	—	—	—	—	—
Beryllium	1.38	—	—	—	—	—	—
B Chromium	21.4	81	370	—	0.3	0.1	—
B Cobalt	13.1	—	—	—	—	—	—
B Iron	24,500	—	—	20,000 [B]	—	—	**1.2**
B Manganese	287	—	—	460 [B]	—	—	0.6
Vanadium	60.9	—	—	—	—	—	—
Open Water							
Semi-Volatile Organics:							
PAHs:							
Acenaphthene	7.15	0.016	0.5	—	**446.9**	**14.3**	—
Anthracene	0.552	0.0853	1.1	—	**6.5**	0.5	—
Fluorene	0.151	0.019	0.54	—	**7.9**	0.3	—
2-Methylnaphthalene	1.93	0.07	0.67	—	**27.6**	**2.9**	—
Pesticides/PCBs:							
4,4'-DDD	0.0170	0.002	0.02	—	**8.5**	0.9	—
4,4'-DDE	0.0090	0.0022	0.027	—	**4.1**	0.3	—
4,4'-DDT	0.0180	0.001	0.007	—	**18.0**	2.6	—
PCB-1260	0.0840	0.0227 [E]	0.18 [E]	—	**3.7**	0.5	—
Inorganics:							
B Aluminum	14,700	—	—	—	—	—	—
B Beryllium	1.26	—	—	—	—	—	—
B Chromium	34.9	81	370	—	0.4	0.1	—
B Cobalt	29.4	—	—	—	—	—	—
B Copper	36.9	34	270	—	**1.1**	0.1	—
B Iron	48,500	—	—	20,000 [B]	—	—	**2.4**

TABLE 4-9
COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS TO SEDIMENT TRVs FOR CHEMICALS OF POTENTIAL CONCERN AT OU1
(Concentrations in mg/kg)

Chemical	Maximum Sediment Concentration	Long and Morgan (1990)/Long et al. (1995) Sediment Quality Guidelines		Other Guidelines	Environmental Effects Quotient (EEQ)[A]		
		ER-L	ER-M		Ratio of Maximum Sediment Concentrations to ER-L	Ratio of Maximum Sediment Concentrations to ER-M	Ratio of Maximum Sediment Concentrations to Other Guidelines
B Manganese	895	---	---	460 [B]	---	---	**1.9**
B Nickel	22.5	20.9	51.6	---	**1.1**	0.4	---
Silver	3.45	1	3.7	---	**3.5**	0.9	---
B Vanadium	112	---	---	---	---	---	---
B Zinc	158	150	410	---	**1.1**	0.4	---

[A] Ratios greater than one are indicated with boldface type.

[B] Value represents lowest effect level from OMEE (1993).

[C] Value for pyrene.

[D] Value for 2-methylnaphthalene.

[E] Value for total PCBs.

B = The concentration for this inorganic chemical was not above the reference concentration.

ER-L = Effects Range - Low. Concentration of chemical in sediment above which there is the potential for adverse effects to sensitive benthic organism life stages and/or species.

ER-M = Effects Range-Median. Concentration of chemical in sediment above which there is the potential for adverse effects to most benthic organisms.

--- = No applicable toxicity values available.

TABLE 4-10

COMPARISON OF MEAN CONCENTRATIONS TO SURFACE WATER TRVs FOR CHEMICALS OF POTENTIAL CONCERN DETECTED IN OU1

(Concentrations in ug/L)

Chemical	Arithmetic Mean Surface Water Concentration	Surface Water TRVs[A]		Environmental Effects Quotient (EEQ)[B] Ratio of Arithmetic Mean Surface Water Concentrations to TRVs	
		Chronic	Acute	Chronic	Acute
Pond					
Inorganics:					
B Aluminum	547 [C]	87	750	**6.3**	0.7
B Iron	705 [C]	1,000	NA	0.7	---
Wetland					
Inorganics:					
Aluminum	1,950	87	750	**22.4**	**2.6**
Iron	2,440	1,000	NA	**2.4**	---
Open Water[D]					
Inorganics:					
B Aluminum	2,040	87	750	**23.4**	**2.7**
B Chromium	5.68	11	16	0.5	0.4
Copper	5.07	10	15	0.5	0.3
B Iron	2,770	1,000	NA	**2.8**	---
B Lead	3.32	2.5	63	**1.3**	<0.1
Zinc	24.8	90	99	0.3	0.3

[A] US EPA Ambient Water Quality Criteria (1992, 1996).

[B] Ratios greater than one are indicated with boldface type.

[C] Value is the maximum detected concentration because only one sample was taken and a mean concentration could not be calculated.

[D] Hardness dependent TRVs were calculated using 82 mg/L as CaCO3.

B = The concentration for this inorganic chemical was not above the reference concentration.

NA = No applicable toxicity values available.

--- = EEQ could not be calculated.

5.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Potential ARARs will be used to support decisions on the ultimate selection of remedial actions necessary at WRF OU1. Although WRF is not an NPL site, the NCP remedial selection process is being followed as a model. For an NPL site, the identification of ARARs would be achieved by examining the body of federal, state, and local environmental laws, regulations, and standards. The identification of ARARs is an iterative process and may be more detailed in the future. The final determination of ARARs will be made by the Army after public review, as a part of the final selection of the remedial action and will be documented in the decision document. Listed below are the three elements of ARARs and the three types of ARARs (USEPA, 1988).

5.1.1 Three Elements of Applicable or Relevant and Appropriate Requirements

1. **Applicable Requirements** are those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law, that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

2. **Relevant and Appropriate Requirements** are those same standards mentioned above that, while not "applicable" at the site, address problems or situations sufficiently similar to those encountered at the site that their use is well-suited to the particular site. The determination of relevant and appropriate is a two-step process: 1) determining if a requirement is relevant and 2) determining if a requirement is appropriate. A requirement that is judged to be both relevant and appropriate must be complied with to the same degree as if it were applicable.

3. **To-Be-Considered Requirements** (TBCs) are other nonpromulgated advisories or guidance issued by state or federal governments that are not legally binding and do not have the status of ARARs. TBC requirements are evaluated along with ARARs in determining site requirements. They complement but do not override ARARs. They may be used in guiding decisions for clean-up levels or methodologies for which mandatory standards are not available.

5.1.2 Three Types of Applicable or Relevant and Appropriate Requirements

1. **Chemical-specific:** health- or risk-based numerical values limiting the amount of a contaminant that may be released to, or allowed to remain in, the environment during and upon successful completion a remedial action. These include Safe Drinking Water Act Maximum Contaminant Levels (MCLs).

2. **Location-specific:** those requirements that may restrict or prohibit remedial action because of the site's location, such as a floodplain, wetland, or historical area.

3. **Action-specific:** remedial technology- or activity-based requirements that may include, for example, removal actions, National Pollutant Discharge Elimination System (NPDES) permit effluent standards, or incinerator destruction standards.

5.2 WOODBRIDGE RESEARCH FACILITY OPERABLE UNIT ONE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The federal ARARs presented in Section 5.1 were analyzed together with state and local ARARs to determine which need to be attained at WRF OU1. Preliminary determinations are discussed below and are summarized in Table 5-1.

5.2.1 Chemical-Specific Applicable or Relevant and Appropriate Requirements

5.2.1.1 Groundwater Applicable or Relevant and Appropriate Requirements

The chemical-specific groundwater ARARs for this project are the MCLs. The MCLs are used as water quality standards for the protection human health from the consumption of groundwater that is/or may be used as a drinking water source.

5.2.1.2 Sediment Applicable or Relevant and Appropriate Requirements

Elevated levels of inorganic and organic compounds have been detected in the sediment at OU1. There is a limited potential for adverse affects to occur from exposure to these compounds for ecological receptors. The sediment TBC guidance is the USEPA Region III, BTAG clean-up standard for PCBs in sediment of 1.0 ppm to be protective of ecological receptors.

5.2.1.3 Subsurface Soil Applicable or Relevant and Appropriate Requirements

Elevated levels of PCBs have been detected in subsurface soil at AREE 1 at concentrations greater than 50 ppm. TSCA and the Virginia Hazardous Waste Management Regulations (VHWMR) mandate the removal and disposal of PCB contaminated soils above this level. Therefore, this must be considered as an ARAR for the site. In addition, TSCA 40 CFR 761.125 has set the standard for clean-up in soils that may remain at a site at 10.0 ppm PCB. This standard will be used as the lower limit for a clean-up standard for the soils at OU1. In addition, the Virginia Solid Waste Management Regulations (VSWMR) have established criteria to determine areas that may be classified as open dumps and regulated under these regulations. This regulation also sets requirements for clean-up and corrective actions for open dumps. Therefore, this regulation is an ARAR for the site.

5.2.1.4 Surface Water Applicable or Relevant and Appropriate Requirements

The migration of elevated concentrations of inorganic and organic compounds from storm water run off and/or migration via groundwater discharge may affect surface water quality in the vicinity of OU1. Therefore, the AWQCs are the ARARs for surface water.

5.2.2 Location-Specific Applicable or Relevant and Appropriate Requirements

Location-specific ARARs set restrictions on remedial action activities depending on the characteristics of a site or its immediate environs. For example, in compliance with the VSWMRs, debris present in wetland areas must be removed to protect ecological receptors. The location-specific ARARs that may be considered depending on the remedial action taken at OU1 are listed in Table 5-1.

5.2.2.1 Cultural and Historical Considerations

Preliminary investigation has indicated that no cultural or historic points are in the area potentially affected by a remedial action at OU1. If a remedial action is selected, consultation with the State Historic Preservation Office will occur (in compliance with 36 CFR Part 800).

5.2.2.2 Rare, Threatened or Endangered Species

The existence of only one endangered species (bald eagle [*Haliaeetus leucocephalus*]), has been confirmed at WRF. No known bald eagle nests occur at WRF, though a communal bald eagle roost is present on Mason Neck, located to the east of the facility. Eagles are known to frequently travel between Mason Neck and WRF. If a remedial action is selected and implemented, any work performed that may impact the activities of the bald eagle will be coordinated with the USFWS.

If a remedial action alternative that requires site modifications is selected, regulations promulgated under the Endangered Species Act of 1973, Bald and Golden Eagle Protection Act of 1940, the Migratory Bird Treaty Act of 1918, and the regulations for the protection of threatened and endangered species with the Virginia Code, Section 29.563, may be ARARs.

5.2.3 Action-Specific Applicable or Relevant and Appropriate Requirements

Action-specific ARARs for this project are limited to alternatives involving engineered actions on-site, and any activities conducted off site. This would include such things as proper management and transportation of hazardous wastes, and proper health and safety assurances during site construction. Since PCBs have been detected that exceed the land ban restrictions, those soils may be removed and disposed off site. Therefore, the VHWMR would be ARARs.

TABLE 5-1
IDENTIFICATION OF CHEMICAL-SPECIFIC ARARs FOR GROUNDWATER AND SURFACE WATER FOR OU1

Authority	Requirement	Status	Requirement Synopsis
Federal Regulatory Requirement	Safe Drinking Water Act (SDWA)- Maximum Contaminant Levels (MCLs), (40 CFR 141.11 - 141.16)	Relevant and Appropriate	MCLs regulate the concentration of common organic and inorganic contaminants in public drinking water supplies based on health effects and technical capabilities. MCLs may also be considered relevant and appropriate for groundwater aquifers potentially used for drinking water. The MCLs have been used as a screening guidance to evaluate the need for institutional controls at WRF due to risks associated with groundwater. Since the MCLs have been exceeded for some compounds at the WRF, institutional controls will be established to assure that the groundwater will not be developed as a water supply source at the site.
	Clean Water Act (33 U.S.C. 1314), U.S. EPA Office of Water, Federal Ambient Water Quality Criteria (AWQC)	Relevant and Appropriate	Federal AWQCs are surface water criteria developed for protection of human health, freshwater and marine aquatic life. These standards also apply to any stormwater or applied water that flows from the regulated unit to the land surface.
State Regulatory Requirement	Virginia Water Quality Standards (VR 680-21-00 – 680-21-08/9 VAC 25-260-140)	Relevant and Appropriate	The State of Virginia regulates inorganic and organic contaminants in surface water for protection of aquatic life and human health. These standards also apply to a small mixing zone in which wastewater mixes with the receiving water body. This may be appropriate if it is determined that contaminated groundwater is discharging to a surface water body at some point during the long-term monitoring program.
	Virginia Pollutant Discharge Elimination System (VPDES), (VR 680-14-01)	Applicable	Any treated groundwater, decontamination water or other wastewater to be discharged to surface waters must meet effluent discharge limits established by the Water Division of the VADEQ. Site-specific limits may be established following receipt of initial design and estimated discharge rates of the treatment unit. This may be applicable if water generated during removal actions at OU1 and/or decontamination water generated during any remedial action conducted at the site is discharged to the WRF surface water bodies and/or adjacent surface water bodies.
	Virginia Regulations for the Control and Abatement of Air Pollution (VR 120-01-01 through VR 120-08-0605/9 VAC 5-10-10 through 9 VAC 5-80-350)	Applicable	Any emission from the disturbance of soil or water must meet the standards for the toxic pollutant particulate, and volatile organic compounds.
	Antidegradation Policy for Surface Waters (VR 680-21-00/9 VAC 25-260-10 et seq.)	To be considered	Surface water quality must not be degraded by discharge, except when the discharge is justifiable to provide necessary economic or social development in the area where the waters are located. Any discharge to State waters will be governed under VPDES.

TABLE 5-1 (Continued)
IDENTIFICATION OF CHEMICAL-SPECIFIC ARARs FOR SOIL AND SEDIMENT FOR OU1

Authority	Requirement	Status	Requirement Synopsis
Federal Criteria, Advisories and Guidance	Toxic Substance Control Act (TSCA)	Applicable	TSCA disposal requirements are applicable if disposal of material contaminated with PCBs at concentrations of 50 ppm or greater occurred after February 17, 1978. PCBs have been detected in subsurface soil at OU1 at concentrations greater than 50 ppm, therefore this ARAR is relevant and appropriate for the removal and disposal of PCB contaminated sediment.
	Toxic Substance Control Act (TSCA) 40 CFR 761.125	Applicable	TSCA cleanup standard for soils set at 10 ppm allowable left in place at a site where a cleanup occurred.
	USEPA, Region III, Guidance Memorandum (1996)	To Be Considered	The USEPA, Region III, Biological Assisstance Technical Group (BTAG) recommends a cleanup standard of 1.0 ppm PCBs in sediment to be protective of ecological receptors at a site.
State Regulatory Requirement	Virginia Solid Waste Management Regulation (9 VAC 20-80)	Applicable	This regulation sets forth criteria and standards to determine if an area is classified as an unpermitted open dump and sets the requirements for clean up and corrective action. These regulations were used to classify areas within OU1 as well as the need for corrective action at OU1. VSWMR is also applicable for the disposal of PCB-contaminated soil and sediment.
	Virginia Hazardous Waste Management Regulation (9 VAC 20-60-10 et seq.)	Relevant and Appropriate	This regulation sets forth criteria and standards to determine if an area contains materials that would be classified as hazardous and sets the requirements for closure and, corrective action and disposal. These regulations were used to classify the materials detected at OU1 for the WRF.
	Virginia Regulations for the Control and Abatement of Air Pollution (VR 120-01-01 through VR 120-08-0605/9 VAC 5-10-10 through 9 VAC 5-80-350)	Applicable	Any emission from the disturbance of soil or water must meet the standards for the toxic pollutant particulate, and volatile organic compounds.

TABLE 5-1 (continued)
IDENTIFICATION OF LOCATION-SPECIFIC ARARs FOR OU1

Authority	Requirement	Status	Requirement Synopsis
Federal Regulatory Requirement	RCRA – Location Standards (40 CFR 264.18)	Applicable	This regulation outlines the requirements for constructing a RCRA facility on a 100-year floodplain. The facility must be designed, constructed, operated, and maintained to avoid washout by a 100-year flood, unless waste can be removed safely before floodwater can reach the facility, or no adverse effects on human health and the environment would result if washout occurred. Any waste that is disposed of off-site will be placed in a regulated facility that meets these location standards and is in compliance with these regulations.
	Executive Order 11988: Floodplain Management	Relevant and Appropriate	Any activity located in a floodplain must comply with the provisions of the order. The order requires that federal activities in floodplains must reduce the risk of flood loss, minimize the impact of flood on human safety, health and welfare, and preserve the natural and beneficial values served by floodplains. Since remedial actions are planned at OU1 that are within floodplains, this Order must by complied with.
	Executive Order 11990: Protection of Wetlands (40 CFR 6, Appendix A)	Relevant and Appropriate	Federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands. All wetlands that are disturbed due to the remedial actions taken at OU1 will be restored per this order.
	Clean Water Act, Section 404 (40 CFR 230.10; 33 CFR 320-330)	Relevant and Appropriate	This regulation prohibits discharge of dredge or fill material into wetlands without a permit. It provides for the enhancement, restoration, or creation of alternate wetlands. Any wetlands disturbed due to remedial actions at OU1 of the WRF will be restored per this guidance and no fill material will be placed in the wetlands without a permit.
	Fish and Wildlife Coordination Act (16 USC 661 et seq.)	Relevant and Appropriate	Actions that will impact fish and wildlife must include action to protect affected fish and wildlife resources. The remedial actions conducted at the WRF will be coordinated with the USFWS.
	Endangered Species Act of 1973 (16 USC 1531 et seq; 50 CFR 402)	Relevant and Appropriate	This law requires that action be taken to conserve endangered or threatened species. In addition, actions must not destroy or adversely modify critical habitat. Consultation with the Department of the Interior will be established to ascertain that proposed actions will not affect any listed species.
	Migratory Bird Treaty Act (16 USC 703 et seq)	Relevant and Appropriate	Any action taken or funded which results in the killing, hunting, taking, or capturing of any migratory bird, nest, or egg is unlawful. No action will be performed at the WRF that will affect any migratory bird and/or its habitat.
	Bald and Golden Eagle Protection Act (16 USC 668 et seq)	Relevant and Appropriate	This law requires that action be taken to conserve the endangered bald and golden eagles. In addition, actions must not destroy or adversely modify critical habitat. Consultation with the Department of the Interior will be established to ascertain that proposed actions will not affect any critical habitat.

TABLE 5-1 (Continued)
IDENTIFICATION OF LOCATION-SPECIFIC ARARs FOR OU1

Authority	Requirement	Status	Requirement Synopsis
Federal Regulatory Requirement (continued)	National Archaeological and Historic Preservation Act (16 USC 469); National Historic Landmarks Program (36 CFR 65)	Relevant and Appropriate	Federal agencies must take action to recover and preserve artifacts within areas where action may cause irreparable harm, loss, or destruction of significant artifacts. Any archaeological and /or historic landmarks that may be discovered during remedial actions will be preserved per this regulation.
State Regulatory Requirement	Chesapeake Bay Preservation Act (Virginia Code Section 10.1-2100)	Applicable	Establishes criteria for land use and development in environmentally sensitive areas, which may impact water quality. These criteria are established on a statewide basis, but implemented locally. Remedial actions are being conducted near the Occquan Bay. Therefore, these regulations may be applicable to the WRF.
	Virginia Endangered Species (Virginia Code Section 29.1-563 et seq.)	Applicable	Prohibits acts, which directly or indirectly harm, or injure a threatened or endangered species. Protects critical wildlife habitat. Any remedial action taken at the WRF will be conducted in such a manner as to assure that endangered species (if applicable) will be protected during and after the remedial action is performed.
	Virginia Department of Game and Inland Fisheries, (Code of Virginia, Section 29.1-100 et seq.)	Applicable	The Department of Game and Inland Fisheries must be notified prior to any remedial action at a site to evaluate if any rare, threatened, or endangered animal species or their habitats will be impacted by the remedial action s. The department will be notified prior to any activities that will be performed at OU1 for the WRF.
	Virginia Natural Area Preserves Act [VNAPA] (Code of Virginia Section 10.1-400 et seq.)	Applicable	The Department of Conservation must be notified prior to any remedial action to determine whether any ecologically significant area supporting natural heritage resources are threatened by the remedial action that will be conducted. The department will be notified prior to any activities that will be performed at OU1 for the WRF.
	Virginia Plant and Insect Species Act/ Virginia Plant and Insect Species Regulations (Virginia Code Section 3.1-1020 et seq./VR 115-04-01/ 2 VAC 5-320-10)	Applicable	The Department of Agriculture and Consumer Services must be notified to determine whether any rare, threatened, or endangered plant or insect species or their habitat(s) will be impacted by a remedial action that will be conducted at a site. The department will be notified prior to any activities that will be performed at OU1 for the WRF.
	Virginia Wetlands Act/ Virginia Wetland Regulations (Virginia Code Section 62.1-13.1 et seq./VR 450-01-0051/ 4 VAC 20-390-10 et seq.)	Applicable	Any activity to take place in, or impact on, a tidal wetland must meet the provisions of the Virginia Wetlands Act and regulations as applicable. Since remedial activities will be conducted in and near tidal wetlands at OU1, these regulations must be complied with.

TABLE 5-1 (Continued)
IDENTIFICATION OF ACTION-SPECIFIC ARARs FOR OU1

Authority	Requirement	Status	Requirement Synopsis
Federal Regulatory Requirement	National Pretreatment Standards (40 CFR 403)	Applicable	This regulation sets standards to control pollutants that pass through or interfere with treatment processes in publicly owned treatment works or which may contaminate sewage sludge. Any discharges generated from the remedial actions performed at OU1 where discharge to a POTW is required will be conducted such that the discharge is within the limits of the POTW's treatment standards.
	National Pollutant Discharge Elimination System (40 CFR 122 – 125)	Applicable	Permitting is required for pollutant discharge from any point source into U.S waters.
	RCRA Land Disposal Restrictions (40 CFR 268)	Applicable	Limits are mandated for characteristic and listed wastes prior to land disposal. All wastes disposed of off-site from OU1 will be disposed of at a regulated facility that is in compliance with these regulations.
	Department of Transportation Rules Governing the Transportation of Hazardous Materials (49 CFR Parts 107, 171.1-.500)	Relevant and Appropriate	Will be the responsibility of disposal organization to ensure that all waste haulers are properly registered for hauling hazardous waste and follow applicable regulations.
	Executive Order 11990: Protection of Wetlands (40 CFR 6, Appendix A)	Relevant and Appropriate	Federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands. All wetlands that are disturbed due to the remedial actions taken at OU1 will be restored per this order.
State Regulatory Requirement	VHWMR/RCRA Standards Applicable to Generators of Hazardous Waste (VR 672-10-1/9 VAC 20-60-10 et seq.)	Applicable	This regulation establishes hazardous waste identification, manifesting, transport, recordkeeping and reporting requirements. This regulation will be compiled with for the management of wastes generated through the removal actions that are proposed for OU1.
	VHWMR/RCRA Standards for Permitted Hazardous Waste Facilities - Storage in Containers and Tanks (VR 672-10-1/9 VAC 20-60-10 et seq.)	Applicable	Requirements for storage of hazardous waste in containers and tanks are identified. This regulation will be compiled with for the removal actions that are proposed for OU1.
	Virginia Solid Waste Management Regulations; Closure and Post-Closure Care (9 VAC 20-80-240)	Applicable	This regulation provides process-specific closure/post-closure requirements for open dumps. The remedial action proposed for OU1 has been designed to comply with these regulations.

TABLE 5-1 (Continued)
IDENTIFICATION OF ACTION-SPECIFIC ARARs FOR OU1

Authority	Requirement	Status	Requirement Synopsis
State Regulatory Requirement (Continued)	Virginia Solid Waste Management Regulations - Soil, Debris and Sludge Deposit Requirements (VR 672-20-10/9 VAC 20-80-10 et seq.)	Applicable	This law regulates "special wastes". Soil containing less than 50 ppm TPH and 10 ppm BTEX may be clean-filled. When soils with contaminants exceed this level but do not contain more than 500 ppm TPH, they may be placed in a sanitary landfill.
	Virginia Regulations Governing Transportation of Hazardous Materials (VR 672-30-1/9 VAC 20-110-10 et seq.)	Relevant and Appropriate	Any transportation of hazardous materials within the Commonwealth of Virginia must meet all of the requirements of these regulations as well as those outlined in Part VI and VII of the Virginia Hazardous Waste Managment Regulations.
State Regulatory Requirement (continued)	Virginia Erosion and Sediment Control Law/Virginia Erosion and Sediment Control Regulations (Sections 10.1-560 et seq./VR 626-02-00/4 VAC 50-30-10 et seq.)	Relevant and Appropriate	An erosion and sediment control plan must be submitted for review by the soil and water conservation district or locality prior to engaging in any land-disturbing activity. An erosion control structure will be constructed at OU1. Therefore, this regulation will be complied with for the remedial actions that will be conducted at OU1.
	Coastal Management Plan; Federal Coastal Zone Management Act (16 U.S.C. 1451 et seq; NOAA Regulations on Federal Consistency with approved State Coastal Zone Management Programs, 40 CFR 930)	Relevant and Appropriate	Activities impacting the resources governed by these statutes must comply with state requirements. An erosion control structure will be constructed that may impact the Occoquan Bay near OU1. Therefore, these regulations must be complied with.
	Virginia Pollutant Discharge Elimination System (VEPDES), (VR 680-14-01)	Applicable	Any treated groundwater, decontamination water or other wastewater to be discharged to surface waters must meet effluent discharge limits established by the Water Division of the VADEQ. Site-specific limits may be established following receipt of initial design and estimated discharge rates of the treatment unit. This may be applicable if water generated during removal actions at OU1 and/or decontamination water generated during any remedial action conducted at the site is discharged to the WRF surface water bodies and/or adjacent surface water bodies.
	Virginia Pretreatment Standards (Permit Regulation, Part VIII)	Applicable	General and categorical standards are mandated for industrial dischargers to POTW. Any water that is generated during the remedial actions conducted at OU1 will comply with these regulations if applicable

6.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

6.1 INTRODUCTION

Potential remedial action alternatives for WRF OU1 are developed in this section. Once developed, they are screened in Section 7.0, and those not eliminated will undergo a detailed analysis in Section 8.0. This three-staged process constitutes the FFS for OU1 at WRF. WRF is not an NPL site; however, the remedy selection process used for CERCLA sites will be used here as a model. The three-stage CERCLA evaluation process for remedy selection is outlined in the NCP, Subpart E-Hazardous Substance Response (40 CFR 300.430e). Additional guidance used in this FFS was obtained from "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, 1988).

The objective of the FFS is to ensure that appropriate remedial action alternatives are developed and evaluated so that relevant information concerning remedial action options can be presented, and an appropriate remedy selected in the future. Alternatives developed in this section consider the protection of human health and the environment by eliminating, reducing, and/or controlling risks posed through each exposure pathway present at the site. This development of alternatives has been fully integrated with the site and risk characterization activities described in Sections 2 through 4 of this report. This development of alternatives is accomplished in this section by the completion of the following four tasks:

1. Remedial action objectives (RAOs) are established based on: a) risk-based clean-up objectives defined in the human health risk assessment (Section 3.0); b) risk-based clean-up objectives defined in the ecological risk assessment (Section 4.0); and c) ARARs (Section 5.0).
2. General response actions to meet these RAOs are established.
3. Within each general response action, potentially suitable remedial technologies, including innovative technologies, are identified and evaluated for their viability to the site.
4. Viable technologies are combined into remedial alternatives.

6.2 REMEDIAL ACTION OBJECTIVES

Non-numerical RAOs are established based on specific contaminants and media of concern, potential exposure pathways, and remediation goals. Numerical preliminary remediation goals (PRGs) are developed based on current information, then may be modified, as more information becomes available. Final remediation goals will be set later, when the remedy is selected. Remediation goals will establish acceptable exposure levels that are protective of human health and the environment and will consider ARARs and risk assessment results. Media specific RAOs are presented below. For all media, a fundamental RAO is that the remedy needs to be compatible with the scheduled future use of the site as a wildlife refuge managed by the USFWS.

6.2.1 Soils

RAOs for soils were presented by VADEQ (Grimes, 1997) and acknowledged by the U.S. Army (Craig, 1997) at a meeting conducted in February 1997. VADEQ's primary concern is that WRF OU1 contains seven former open dumps. Where soil contaminants exist, VADEQ has two primary concerns which are translated into RAOs: 1) storm water run-off may transport contaminants to open water bodies adjacent to OU1, and 2) percolation may leach soil contaminants to groundwater. Remedies, according to Virginia regulations (9 VAC 20-80-170 through 230), are limited to two options: removal (a.k.a., clean closure) or close in place (a.k.a. cover).

Removal: Remove surface and subsurface debris. The PRG for PCB-contaminated soils has been set at 10 ppm (Refer to Section 5.0).

Cover: Remove surface debris. Install an 18 inch low permeable soil cover with six inches of vegetated topsoil on top of the soil. The area to be covered will be determined using surface geophysical surveys to delineate the extent of buried debris.

The effectiveness of the remedy needs to be demonstrated by monitoring over four quarters for removal, or over 15 years (at a minimum) for cover.

6.2.2 Sediments

RAOs for sediments were presented by USEPA, VADEQ (Grimes, 1997) and acknowledged by the U.S. Army (Craig, 1997) at a meeting conducted in February 1997. VADEQ's primary RAO is that wetlands are considered state waters, and therefore all waste in wetlands needs to be removed; cover is not an option. Sediments in the site wetlands for OU1 are included in this category. In addition to the removal of wastes, the PRG for PCBs has been set at 1.0 ppm.

6.2.3 Surface Water

According to previous remedial investigations, surface water contaminants can be derived from the runoff from contaminated soils. Once soil contaminants have been removed and/or contained, existing surface water and sediment contaminant concentrations will no longer increase, and will likely decrease through natural attenuation, primarily dilution. Therefore, by achieving the soils RAOs (Section 6.2.1), potential contamination associated with surface water will be addressed. Risk assessment conclusions supporting these RAOs include the following:

- As described in Section 4.4.4.2, no organic COPCs were found in the surface water sampled from the ephemeral pond, wetlands, or open water. Inorganic COPCs were identified. However, because precipitation events occurred several days prior to and during the collection of surface water samples, and because field notes indicate high silt content in the samples, the risk assessment concluded that the "...results suggest elevated inorganic concentrations may have resulted from runoff and sediment suspension during the storm event and may not be representative of concentrations during lower flow conditions."

6.2.4 Groundwater

According to VADEQ (Grimes, 1996), the Initial Site Evaluation (ISE) determinations indicate that all AREEs in OU1 will require closure and post-closure care in order to comply with the VSWMRS.

Groundwater (in limited areas) contains hazardous constituents which may be migrating off site into local surface water. Future groundwater contamination may be eliminated through the implementation of the soil RAOs (Section 6.2.1). RAOs related to VADEQ's request (Grimes, 1996) for the restriction of intrusive activities (including installation of water wells) can be realized through the implementation of various institutional controls.

6.3 GENERAL RESPONSE ACTIONS

Seven general response actions have been identified by themselves or in combination, to satisfy the remedial action objectives for the WRF. They are described below:

1. No Action is a response action in which no activities would be initiated or continued at the site. The NCP requires this evaluation because it provides a baseline from which to compare the other developed alternatives.
2. Institutional Controls are response actions that reduce the exposure of humans and the environment to contaminants of concern through the use of such actions as access restrictions, provision of alternate water supplies, biota management, groundwater use restrictions, and/or monitoring of environmental media. These actions do not reduce the toxicity, mobility, or volume (mass) of hazardous material. However, institutional controls may be sufficient at sites where human health and the environment are shown to be adequately protected.
3. Containment is a response action used to prevent or minimize migration of contamination out of existing source areas. Containment actions reduce the mobility of contaminants of concern through the implementation of physical barriers.
4. Removal of Soils is a response action used to remove contaminated soils from the site. The removal of contaminated soils reduces the mass of contaminants that may migrate to the groundwater or surface water.

5. In Situ Treatment of Soils are response actions used to treat contaminated soils in place and achieve a reduction in the volume or mobility of contaminants. In-situ treatment may be accomplished through engineered actions, or intrinsically through natural attenuation.
6. Ex Situ Treatment of Soils are response actions to treat contaminated soils which have been excavated. Treatment may be accompanied with placement of treated soils on site or off site.
7. Disposal is a response action for final deposition of removed contaminated soils.

6.4 IDENTIFICATION AND EVALUATION OF TECHNOLOGIES

The objective of this section is to identify and evaluate available technologies and process options which represent the general response actions listed in Section 6.3. This objective will be accomplished using a variety of information sources including previous investigations, remedial actions at other sites, references developed by USEPA, and standard engineering references. Technologies are initially evaluated in Table 6-1, which contains the following five columns:

1. Column 1 lists the seven general response actions identified above in Section 6.3.
2. Column 2 lists potential remedial technologies that may be included within that general response action. For example, the general response action "institutional controls" includes five potential remedial technologies ranging from "access restrictions" to "monitoring."
3. Column 3 lists representative process options included under each technology. For example, the technology "access restrictions" includes three process options ranging from "fencing" to "deed restrictions".
4. Column 4 provides a brief description of each of the representative process options.
5. Column 5 provides a preliminary screening of each representative process option based on whether it is technically implementable, practical, and applicable. The three types of preliminary screening results are presented below:
   - *Potentially viable.* The process option is technically implementable and practical and is therefore retained for further consideration.
   - *Not viable.* The process option is technically implementable but impractical and is therefore eliminated from further consideration.
   - *Not applicable.* The process option is not technically implementable at the site and is therefore eliminated from further consideration.

The screening is then summarized in Section 6.4.2. Technologies which pass this screening are assembled into remedial alternatives in Section 6.5 and Table 6-2.

6.4.1 Technology Descriptions and Evaluations

As a complement to the screening conducted in Table 6-1, the following sections provide a narrative evaluation of the seven general response actions, and their respective remedial technologies and process options.

6.4.2 No Action

No Action is retained to serve as a baseline for the comparison of alternatives.

6.4.3 Institutional Controls

Institutional controls are legal or barrier restrictions on the use of land or water imposed at a site intended to reduce the dangers to the public from releases or threatened releases of environmental contaminants. Institutional controls may be used in conjunction with engineered remedial actions, or as the sole remedy when active measures are determined not to be practicable, based on balancing of tradeoffs during remedy selection. Institutional controls include such things as access restrictions, alternate water supplies, biota management, groundwater use restrictions, and monitoring.

6.4.3.1 Access Restrictions

Access restrictions include such things as fencing, posting signs, and deed restrictions.

- Fencing is designed to restrict human and animal access to designated areas. This option is retained for further evaluation. It is currently used at the site, and can also be used in the future.
- Posting signs warns both trespassers and permitted persons about site hazards. This option is retained for further evaluation.
- It is anticipated that the USFWS will take possession of this site from the US Army. Site access restrictions will be detailed in the "Letter of Transfer" that will be prepared by the Army and signed by the Department of Defense and the Department of the Interior. This "Letter of Transfer will be recorded at the local Registrar of Deeds office to insure that the institutional controls are maintained for perpetuity. This option is retained for further evaluation.

6.4.3.2 Alternate Water Supplies

The use of an alternate water supply would be necessary where existing water sources are contaminated. Because a potable water supply is available to the site, the use of an alternate water supply is not applicable, and is eliminated from further consideration.

6.4.3.3 Biota Management

Biota management is an option which seeks to prevent a non-human receptor from contacting contaminants through such things as selective elimination, relocation, or enclosure. Such actions are incompatible with expected future land use activities (i.e., a wildlife refuge), and will therefore not be considered in the detailed analysis.

6.4.3.4 Groundwater Use Restrictions

Groundwater use restrictions are legal and site management barriers to the use of groundwater. These restrictions normally are enacted to prevent the installation of groundwater supply wells and/or to prevent the use of groundwater for human consumption. These actions are applicable to the site, and will be retained for further consideration.

6.4.3.5 Environmental Monitoring

Monitoring programs, including periodic sampling of soil, sediment, storm water run-off, and groundwater would allow for the evaluation of site conditions over time, and are therefore retained. Surface water, sediment, soil, groundwater, and storm water run-off data have previously been collected as part of the RI and risk assessment. Historical data will be compared to future data to monitor site conditions and the attainment of RAOs.

6.4.4 Containment

Containment technologies are physical barriers placed around contaminated areas intended to reduce contaminant mobility. These barriers isolate the affected area, reduce exposure to humans and non-humans, and minimize transport of contaminants. While the integrity of the barrier remains intact, these types of controls can be effective. Four types of barriers are evaluated for this study: surface, vertical, horizontal subsurface, and coastal erosion control barriers.

6.4.4.1 Surface Barriers

Surface barriers limit direct contact to soil contaminants by establishing a physical barrier between the contamination and human and non-human receptors. In addition, they minimize the infiltration of precipitation into underlying contaminated soil, and thereby minimize contaminant leaching and migration to surface water and groundwater. Three types of surface barriers are considered:

1. Clay/soil covers are constructed of a single barrier of clean soil and/or clay, compacted, then covered with a vegetative layer. This process option is retained for further analysis.

2. Resource Conservation and Recovery Act (RCRA) caps consist of a vegetative/topsoil surface layer, on top of a drainage layer, on top of a synthetic geomembrane underlain by a layer of compacted clay, and a layer of soil. This cap is both more effective and costly than a clay/soil cap; however the limited contamination at the site would not warrant the selection of this process option over the clay and soil cap option, and is therefore screened out of further consideration.
3. Asphalt or concrete caps consist of the construction of a cap using asphalt or concrete. The cost and effectiveness of these caps is not an issue at WRF. Any cap to be installed at WRF must be compatible with the natural surroundings. Because this would be unsightly and cause loss of habitat, this process option is screened out of further consideration.

6.4.4.2 Vertical Subsurface Barriers

Vertical barriers are a group of technologies which, when properly constructed, could minimize the horizontal migration of groundwater contamination and soil gas. Soil gas is not an issue at WRF. Vertical barriers are a viable technology at WRF to inhibit groundwater movement. However, the RAO is not to prevent the limited existing groundwater contamination from migrating; rather, it is to limit future migration of contaminants from the soil into the groundwater and surface water. Vertical barriers are not applicable to this goal.

6.4.4.3 Horizontal Subsurface Barriers

Horizontal subsurface barriers are constructed at depth, as a "subsurface floor", to prevent contamination from moving deeper. These technologies at WRF are viable. However, because groundwater is so shallow at WRF, a surface barrier would be more cost effective than a subsurface barrier. Horizontal subsurface barriers are therefore screened out of further consideration.

6.4.4.4 Coastal Erosion Control

Coastal erosion controls are a group of technologies used to prevent the destruction of shorelines from being degraded by erosional forces. These forces include flooding, wakes created by water craft, and a-typical high tides. Two common forms of coastal erosion controls are seawalls and rip-rap. Seawalls are engineered continuous vertical barriers constructed from wood, steel, or concrete. Rip-rap is the placement of stones, concrete rubble, or similar material. The purpose of rip-rap is to dissipate the kinetic energy in the moving water to prevent sedimentation of the existing soils which makeup the shoreline. Because of lesser cost, ease of installation, and lower maintenance requirements, rip-rap will be considered over construction of a seawall. Rip-rap will be retained for further screening.

6.4.5 Removal of Soils

The remedial investigation at the WRF found isolated contamination in soil and sediment. The remedial technology of soil excavation is viable at WRF within this technology, the only viable process option was excavation with a backhoe, which will be retained for further screening.

6.4.6 In-Situ Treatment of Soils

Because AREEs 1 through 6B were disposal areas which may contain metallic debris, the extent of the disposal area will be defined in the field using surface geophysics. Located debris will either be excavated and removed and/or covered in place in accordance with VADEQ Open Dump regulations. Engineered in situ treatment is therefore not an option. Non-engineered intrinsic bioremediation is a viable process option which is retained for further evaluation.

6.4.7 Ex-Situ Treatment of Soils

The WRF RI found isolated contamination in soil and sediment. This contamination could be located and excavated. However, because the excavated soil would also contain debris from historical dumping activities, treatment of excavated soil would be difficult. Treatment technologies normally involve mixing or treating the soil/debris in a vessel. Successfully constructing and operating such an on-site system would likely be cost prohibitive. Also, operation would likely be unreliable due to the unknown amount and types of debris which would be excavated, and the problems it may cause to the on-site system. Ex situ treatment of soil is therefore screened out of further consideration.

6.4.8 Disposal

The RI at the WRF found isolated contamination in soil and sediment. This contamination could be located and excavated. Once excavated, bulk volumes of the material could be characterized for off-site disposal. Disposal of soil and sediment is retained for further evaluation.

6.5 DEVELOPMENT OF ALTERNATIVES

Remedial action alternatives are developed from the process options that passed the screening completed in Section 6.4. The alternatives are outlined in Table 6-2 and described below. They are formally defined in Section 7.0. The No Action alternative is defined by a single general response action. All other alternatives are defined by a combination of general response actions, remedial technologies, and process options.

- Alternative 1 is defined as No Action, which the NCP requires to be included to establish baseline conditions against which other remedial action alternatives may be compared. The No Action alternative excludes all activities, including institutional controls.
- Alternative 2 is defined as Institutional Controls, which includes site access restrictions, groundwater use restrictions, and environmental monitoring.
- Alternative 3 is defined as Natural Attenuation, which includes Alternative 2, plus monitoring and modeling activities which demonstrate intrinsic remediation.
- Alternative 4 is defined as Containment through Surface Cover, which includes Alternative 2, plus the installation of a soil/clay cover on top of each AREE designed to contain contaminants. It also includes excavation and disposal of the PCB-contaminated soils in selected AREEs.
- Alternative 5 is defined as Removal and Disposal, which includes Alternative 2, plus the excavation, removal, and off-site disposal of contaminated soils.
- Alternative 6 is defined as AREE-Specific Remedial Actions, which includes Alternative 2, plus installation of covers and/or excavation of AREEs.

Table 6-1
Preliminary Screening of Technologies

General Response Action	Remedial Technology	Representative Process Options	Description	Screening Comment
NO ACTION	None	Not Applicable	No action.	Potentially viable. Required by NCP as a baseline for comparison.
INSTITUTIONAL CONTROLS	Access Restrictions	Fencing	Fencing restricts direct human and inhibits animal access to areas around WRF OU1.	Potentially viable.
		Posting Signs	Posting trespassing and access restrictions signs on site to restrict human access.	Potentially viable.
		Deed Restrictions	Deed restrictions issued for property, to include restrictions on installation of wells.	Potentially viable.
	Alternate Water Supply	Potable Water Supply	Potable water supply connections to the potentially affected users.	Not applicable. Not retained because a potable water supply is available.
		New Community Well Relocation	Install new well to serve occupants within the potentially contaminated area.	Not viable. See above.
	Biota Management	Selective Elimination	Elimination of selected species (e.g., common game species) that cause migration of contaminants through bioaccumulation (ingestion) or through body surface contact.	Not applicable. Current site environmental data indicate that there is a very limited risk to biota.
		Relocation	Relocate selected biota to an off-site habitat.	Not applicable. See above.
		Capture/Enclosure	Provide temporary enclosure/captivity of selected biota until remediation is complete.	Not applicable. See above.
		Habitat Modification	Modify habitat to minimize impacts from site contaminants (i.e., setting up barriers).	Not applicable. See above.
	Groundwater Use Restrictions	Groundwater Use Restrictions	Restrict use of contaminated groundwater. Prevent installation of water supply wells.	Potentially viable. Retained to prohibit the use of WRF groundwater.
	Monitoring	Monitoring	Ongoing monitoring program at WRF including groundwater, sediments, surface water, and storm water runoff.	Potentially viable. Data from the sampling program can be used to demonstrate the effectiveness of a remedial action.

Table 6-1
Preliminary Screening of Technologies (continued)

General Response Action	Remedial Technology	Representative Process Options	Description	Screening Comment
CONTAINMENT	Surface Barriers	Clay and Soil	A single barrier cover constructed of low permeable soil, covered by a vegetative soil and drainage layer.	Potentially viable. Such a cover will contain contaminants and be compatible with future use as a wildlife refuge.
		Geosynthetic Membrane	A single barrier cap constructed of a flexible membrane liner, covered by a drainage layer and a vegetated soil.	Potentially viable. See above.
		Multimedia/RCRA	A multi-barrier cap constructed of a flexible membrane liner beneath a layer of compacted clay covered with a drainage layer and vegetated soil. Conforms to RCRA guidance.	Potentially viable. See above.
		Asphalt/Concrete	An asphalt/concrete cap barrier designed for low permeability and supporting traffic loads.	Not viable. Such a cap would achieve containment, but be incompatible with future use as a wildlife refuge.
		Reinforced Concrete	A reinforced concrete single barrier cap.	Not viable. See above.
	Vertical Sub-surface Barrier	Soil-Bentonite Slurry Wall	A slurry wall constructed by filling a vertical trench with a soil and bentonite water slurry.	Not applicable. A barrier could be installed but would not meet AVDEQ requirements for closure.
		Cement-Bentonite Slurry Wall	A slurry wall constructed by filling a vertical trench with a cement-bentonite slurry.	Not applicable. See above.
		Grout Curtains	Inject liquid, slurry, or emulsion grout through rows of vertical pipes. Soil pore space is filled, creating a low permeability barrier.	Not applicable. See above.
		Sheet Piling	Interlocking sheets of steel driven into the ground. Joints may be filled to further restrict flow. Considered to have a short life span.	Not applicable. See above.
		Cryocell Soil Freeze	Coolant is circulated through vertical pipes to convert pore water into ice.	Not applicable. See above.
	Horizontal Sub-surface Barrier	Bottom Sealing	A bottom sealing constructed by drilling from the site perimeter and injecting grout to form a horizontal or curved barrier.	Not applicable. See above.
		Grout Injection	Constructed by pressure injection of grout in closely spaced bore holes to depth.	Not applicable. See above.
		Pneumatic Sealing	Jet nozzles inject a high pressure stream of air and water to erode soil. By turning the nozzle a flat circular cavity is formed which is then grouted. Intersecting grout masses form an impermeable barrier.	Not applicable. See above.

Table 6-1
Preliminary Screening of Technologies (continued)

General Response Action	Remedial Technology	Representative Process Options	Description	Screening Comment
		Dynamic Deep Compaction	A barrier created by the compaction of subsurface zones to decrease permeability and create a temporary confining layer.	Not applicable. See above.
		Freezing	Coolant is circulated through subsurface piping to freeze ground for seepage control.	Not applicable. See above.
	Coastal Erosion Controls	Sea Walls	Sea walls are constructed of rigid materials (concrete, wood, or steel) joined to form a continuous wall, to form an erosion barrier.	Potentially viable. Can be used to protect AREE1 from future erosion.
		Rip Rap	Rip rap is constructed by piling pieces of rigid materials, usually concrete or rocks, together to form an erosion barrier.	Potentially viable. Can be used to protect AREE1 from future erosion.
REMOVAL of SOILS	Excavation	Backhoe	A backhoe is a hydraulic excavator used primarily to excavate below the natural surface.	Potentially viable. Can be used to excavate soils and conduct subsurface inspections.
		Front shovel	A front shovel is a hydraulic excavator used mostly pit excavation where the bucket load is obtained from the vertical face above and in front of the excavator.	Not viable. Not retained because excavation pits typical of this process option will not be created.
		Power shovel	A power shovel utilizes cables instead of hydraulics, and offers the largest excavation output or all process options.	Not viable. Excavation will occur in a slower more cautious manner than is appropriate for this process option.
		Draglines	Draglines operate in a similar manner as power shovels, but because it can "cast" the bucket, draglines are normally used for both digging and transporting, thereby eliminating the need for additional hauling equipment.	Not viable. Soils excavated will be hauled away, not placed in a neighboring location.
		Tractor and Scraper	Tractor-pulled scrapers are used to excavate and haul earth for such projects as highways, airports, and canals.	Not viable. See above.
IN SITU TREATMENT of SOILS	Chemical	Oxidation	The addition of an oxidizing agent to cause the contaminant to be transformed, degraded, or immobilized.	Not applicable. OU1 AREEs are disposal areas containing metallic debris that will be identified using surface geophysics. VADEQ Open Dump regulations require these areas to be excavated or capped. In situ treatment is not an option.
		Reduction	The addition of an reducing agent to cause the contaminant to be transformed, degraded, or immobilized.	Not applicable. See above.

Table 6-1
Preliminary Screening of Technologies (continued)

General Response Action	Remedial Technology	Representative Process Options	Description	Screening Comment
	Physical	Soil Flushing	The elutriation of organic and inorganic contaminants from the soil for recovery and treatment. The site is flooded with an appropriate flushing solution which mobilizes contaminants. The elutriate is collected in shallow wells or drains and is treated and or recycled into the site.	Not applicable. See above.
		Steam Flushing	Injection of steam to increase the temperature in the contaminated one, thereby increasing the volatility of the contaminants and also increasing the mobility. Used in conjunction with SVE.	Not applicable. See above.
		Hot Air Flushing	Similar in concept to steam flushing, however there is no condensation, and therefore no water to collect and treat. Used in conjunction with SVE.	Not applicable. See above.
		Soil Vapor Extraction	Series of wells operating under negative pressure to draw soil gas with volatile contaminants out of the soil for treatment.	Not applicable. See above.
	Solidification/ Stabilization	Cement	Cement is mixed into the soil and contaminants are encapsulated within the new matrix.	Not applicable. See above.
		Thermoplastic Microencapsulation	Blend soil with melted asphalt or other matrix. Liquid and volatile phases are driven off, and other contaminants are encapsulated within the new matrix.	Not applicable. See above.
		Vitrification	Contaminated soil is converted into chemically inert and stable glass after electric currents pass between inserted electrodes.	Not applicable. See above.
	Biological	Intrinsic Bioremediation	Soil remediation which relies on the innate capabilities of naturally occurring microbial communities in the absence of any engineered steps.	Potentially viable. May be effective in naturally biodegrading soil contaminated at OU1.
		Engineered Bioremediation	Soil remediation which relies on the capabilities of microbial communities, either innate or introduced, together with engineered modifications to the local environment.	Not applicable. See above.
		Phytoremediation	Use of plants to uptake contaminants or plant roots to induce a soil environment conducive to bio[redacted]dation .	Not applicable. See above.

Table 6-1
Preliminary Screening of Technologies (continued)

General Response Action	Remedial Technology	Representative Process Options	Description	Screening Comment
		Bioventing	Bioventing, or bioenhanced SVE, increases air flow through the subsurface to optimize natural aerobic biodegradation in addition to SVE of volatilized hydrocarbons.	Not applicable. See above.
	Thermal	Radio Frequency Heating	Radio frequency heating uses an array of excitor electrodes placed either vertically in the ground or horizontally on the ground. A radio transmitter is the power source. Resistance heating and dielectric heating enhance volatilization of organic contaminants. Used with SVE	Not applicable. See above.
		Resistance Heating	Electrodes are inserted in the ground and an electrical current is applied using the soil matrix as a conductor. Water in the soil matrix is the major pathway. The resistance to the flow of current in the soil causes heat to be generated, which enhances the volatilization of organic contaminants. Used with SVE.	Not applicable. See above.
EX SITU TREATMENT of SOILS	Physical/ Chemical	Soil Washing	The elutriation of organic and inorganic contaminants from the soil for recovery and treatment. The site is flooded with an appropriate flushing solution which mobilizes contaminants. The elutriate is collected in shallow wellsface drains and is treated and or recycled into the site.	Not viable. AREEs are disposal areas containing metallic debris that will be identified using surface geophysics. Excavation and removal of debris will also remove contaminated soils. Ex situ treatment will be hampered by the presence of this disposed debris.
		Solidification	Cement is mixed into the soil. Contaminants are encapsulated within the new matrix.	Not viable. See above.
		Vitrification	Contaminated soil is converted into chemically inert and stable glass after electric currents pass between inserted electrodes.	Not viable. See above.
	Biological	Composting	Excavated soils are mixed with bulking agents and organic amendments to enhance the porosity of the matrix. Waste piles are turned and watered and microbial communities degrade organic contaminants.	Not viable. See above.
		Landfarming	Landfarming is similar to composting, except whereas composting is all done above the surface, landfarming is designed to till contaminated soil into existing soil while maximizing aeration for biodegradation.	Not viable. See above.

Table 6-1
Preliminary Screening of Technologies (continued)

General Response Action	Remedial Technology	Representative Process Options	Description	Screening Comment
		Controlled Solid Phase Biological Treatment	This process option is similar to landfarming, but is more engineered as it is designed as beds with leachate collection systems. Leachate is collected treated and reapplied to the soils being treated.	Not viable. See above.
		Slurry Phase Biological Treatment	Excavated soils are mixed with water to produce to lower the viscosity. The slurry is then maintained in suspension in a reactor vessel and mixed with nutrients and oxygen.	Not viable. See above.
	Thermal	Low Temperature Thermal Desorption	Excavated soil is heated to 200 to 600°F on a moving bed. Off gases are then treated.	Not viable. See above.
		High Temperature Thermal Desorption	Excavated soil is heated to 600 to 1,000°F on a moving bed. Off gases are then treated.	Not viable. See above.
		Pyrolosis	Chemical decomposition caused by heat in the absence of oxygen.	Not viable. See above.
		Incineration	Rotary kilns with afterburners operating at temperatures between 1,400 and 2,200°F.	Potentially viable. Off site incinerators may be required for contaminated soils with concentrations > 50 ppm PCBs.
Disposal	Landfill	Off site	Disposal of excavated soils in an engineered and permitted landfill.	Potentially viable. Off site landfills are available for contaminated soils.
		On site	Disposal of excavated soils in an engineered and permitted landfill to be constructed on the WRF site.	Not viable. Construction and maintenance of an on-site landfill is inconsistent with future site use as a nature preserve.

Table 6-2

Development of Remedial Action Alternatives

General Response Action	Remedial Technologies	Process Options	Alternatives					
			1	2	3	4	5	6
No Action	No Action	No Action	•					
Institutional Controls	Access Restrictions	Fencing		•	•	•	•	•
		Posting						
		Deed Restrictions						
	Groundwater Use Restrictions	Groundwater Use Restrictions		•	•	•	•	•
	Environmental Monitoring	Groundwater, Surface Water, Sediment Monitoring, and storm water		•	•	•	•	•
Containment	Surface Cover	Clay/Soil				•		•
Removal of Soils	Excavation	Backhoe				•	•	•
In Situ Treatment of Soils	Natural attenuation	Intrinsic Bioremediation			•	•		
Disposal of Soils	Disposal	Off-site landfill				•	•	•

7.0 SCREENING OF REMEDIAL ACTION ALTERNATIVES

Six remedial action alternatives were developed in Section 6.0 and will undergo a preliminary screening in this section. Those alternatives passing this screening will then undergo a detailed analysis in Section 8.0. As appropriate, and to the extent that sufficient information is available, the short- and long-term aspects of the following three criteria have been used to guide this screening, as defined by the NCP (40 CFR 300.430(e)(7)):

- Effectiveness: This criterion focuses on the degree to which an alternative reduces toxicity, mobility, or volume through treatment; minimizes residual risks and affords long-term protection; complies with ARARs; minimizes short-term impacts; and how quickly it achieves protection. Alternatives providing significantly less effectiveness than other more promising alternatives may be eliminated. Alternatives that do not provide adequate protection of human health and the environment will be eliminated from further consideration.
- Implementability: This criterion focuses on the technical feasibility and availability of the technologies that each alternative would employ and the administrative feasibility of implementing the alternative. Alternatives that are not technically or administratively feasible or that would require equipment, specialists, or facilities that are not available within a reasonable period of time may be eliminated from further consideration.
- Cost: The costs of construction and any long-term costs to operate and maintain the alternatives will be considered. Costs that are grossly excessive compared to the overall effectiveness of alternatives may be considered as one of several factors used to eliminate alternatives. Alternatives providing effectiveness and implementability similar to that of another alternative by employing a similar method of treatment or engineering control, but at greater cost, may be eliminated.

7.1 ALTERNATIVE 1: NO ACTION

7.1.1 Description

Under the No Action Alternative, no remedial action is undertaken to remedy the contamination at the site. The No Action Alternative excludes all activities, including institutional controls such as monitoring and restrictions on groundwater use.

7.1.2 Effectiveness

With no treatment undertaken, the No Action Alternative does not reduce contaminant toxicity, mobility, or volume "through treatment." No treatment-related residuals are generated, all existing waste is left untreated, and the magnitude of risk posed by the site goes unchanged from what is described in the risk assessments (Sections 3.0 and 4.0). No actions or controls are initiated to manage this risk, and therefore this alternative affords no long-term protection of human health and the environment. ARARs not complied with include: MCLs for groundwater, AWQCs for surface water, VADEQ Open Dump Closure Requirements, and TSCA PCB concentrations in soils. With no actions taken, no short-term impacts are caused.

7.1.3 Implementability

The technical feasibility of implementing No Action Alternative is considered high, because it does not require any activities to be either initiated or continued (with the exception of a site evaluation report that must be submitted to USEPA whenever wastes are left in place at a site). The administrative feasibility of implementing this alternative is considered low, because it provides no increased protection.

7.1.4 Cost

The No Action Alternative has no capital costs associated with it, since it does not require any activities to be initiated. Because contaminants are left in place, a site evaluation report must be submitted every 5 years. The estimated cost of this report is $30,000, or approximately $6,000/year.

7.2 ALTERNATIVE 2: INSTITUTIONAL CONTROLS

7.2.1 Description

Institutional controls are legal or barrier restrictions on the use of land or water imposed at an environmentally contaminated site that are designed to reduce the dangers from releases or threatened releases of environmental contaminants. Under the Institutional Controls Alternative, the remedial technologies and process options to be implemented include the following:

- Access Restrictions: Access restrictions to the soils and groundwater would be implemented. Prohibitions on unauthorized digging or drilling shall be initiated and maintained. This alternative may include the posting of signs prohibiting excavation, digging, etc. without authorization. Authorization could then require testing and monitoring to ensure the safety of workers.
- Groundwater Use Restrictions: Groundwater beneath WRF is contaminated in isolated locations. Restrictions on the usage of this groundwater would need to be implemented. No groundwater at the WRF site is currently used for drinking water. Restrictions would be placed in the deed to the property, if the Army transfers the property to an entity other than the U.S. Government. The deed restriction will describe the fact that OU1 had isolated groundwater contamination and shall not be used as a drinking water source.
- Monitoring: Environmental monitoring of groundwater, surface water, sediment, and storm water runoff would be initiated for a period of 15 years (at a minimum). For preliminary cost estimating purposes, the monitoring program shown in Table 7-1 is anticipated.

7.2.2 Effectiveness

With no treatment undertaken, the Institutional Controls Alternative does not reduce contaminant toxicity, mobility, or volume "through treatment." No treatment-related residuals are generated, all existing waste is left untreated, and the magnitude of risk posed by the site goes unchanged from what is described in the risk assessments (Sections 3.0 and 4.0). However, actions and controls are initiated to manage human health risks, and therefore this alternative does afford long-term protection of human health. No actions or controls are initiated which afford long-term protection of the environment. ARARs not complied with include: MCLs for groundwater, AWQCs for surface water, VADEQ Open Dump Closure Requirements, and TSCA PCB concentrations in soils. Minimal activities (e.g., monitoring, posting signs) would be undertaken, causing no short-term impacts.

7.2.3 Implementability

The technical feasibility of implementing the Institutional Controls Alternative is considered high, because the required activities, monitoring and site control, are easily implemented at the present time and will continue to be in the future. The administrative feasibility of implementing this alternative is considered moderate. It provides increased protection of human health, but no increased protection to the environment.

7.2.4 Cost

Estimated capital costs for the Institutional Control Alternative are limited to the construction of 9 monitoring wells and should total around $120,000. Estimated annual operation and maintenance costs related to monitoring should also total around $140,000.

7.3 ALTERNATIVE 3: NATURAL ATTENUATION

7.3.1 Description

Under the Natural Attenuation Alternative, the general response actions to be implemented include all institutional control activities described in Alternative 2, together with natural attenuation. Natural attenuation achieves the reduction of contaminant concentrations through any combination of the following natural activities, which occur in the absence of engineered actions:

- Biodegradation is achieved when naturally-occurring microbial communities degrade organic contaminants as a means of obtaining energy and materials necessary for cell growth. Inorganics are not degraded, but may be incorporated into cell mass, and in doing so become less mobile.
- Dilution is the reduction of contaminant concentrations in groundwater or surface water which occurs when additional mass loading of contaminants is declining, relative to additions of water.
- Volatilization reduces contaminant concentrations when organics transform from a dissolved state to a gaseous phase in soil void space, then are released naturally into the ambient air.
- Adsorption is achieved when contaminants become bound to the soil matrix and cease to migrate with groundwater or surface water.
- Chemical reactions reduce contaminant concentrations by transforming them into different species as a result of contaminant interactions with other in situ chemicals.
- Phytoremediation uses existing plants and trees to incorporate contaminants into their plant structure, and/or to create an environment conducive to biodegradation around the root zone.

Natural attenuation differs from no action in that it requires thorough documentation of the roles, if any, being played by the above processes. Data from field tests, analytical data, and modeling are necessary to predict the viability of this alternative. If found to be viable and implemented, the effectiveness of the alternative must also be verified through environmental sampling, monitoring, and modeling (NRC, 1993).

- Sampling is necessary to obtain periodic data on environmental contaminant concentrations to confirm what is being degraded as well as what is being created as by-products.
- Monitoring field parameters including temperature, moisture, oxygen content, and pH provides information necessary for gauging the performance of biological communities.
- Modeling uses the data gathered from the sampling and monitoring, together with other site data, to demonstrate that degradation rates and pathways will reduce contaminant concentrations as originally predicted.

7.3.2 Effectiveness

The Natural Attenuation Alternative does reduce contaminant toxicity, mobility, and volume through the naturally-occurring treatment processes listed in Section 7.3.1. However, because those processes have not been quantified and modeled, the degree to which they are occurring or may occur is unknown. Likewise, types, quantities, and risks of any residuals created by those processes are unknown. At the cessation of this alternative, the residual amount of existing waste which would be left untreated is unknown. Any change in the magnitude of risk posed is unknown. This alternative includes the implementation of institutional controls described in Section 7.2, and those actions and controls afford long-term protection of human health, but not the environment. Minimal activities (e.g., monitoring, posting signs) will be undertaken causing no short-term impacts. ARARs not complied with now include: MCLs for groundwater, AWQCs for surface water, VADEQ Open Dump Closure Requirements, and TSCA PCB concentrations in soils.

7.3.3 Implementability

The technical feasibility of implementing the Natural Attenuation Alternative is considered high, because the required activities, monitoring, modeling, and site control, are easily implemented currently and will continue to be in the future. The administrative feasibility of implementing this alternative is considered low for the following reasons: inadequate data and modeling exists and it provides an unknown increase in protection to the environment.

7.3.4 Cost

The effectiveness and implementability problems associated with the Natural Attenuation Alternative caused it to be screened out, and therefore no costs were calculated.

7.4 ALTERNATIVE 4: CONTAINMENT THROUGH SURFACE COVER

7.4.1 Description

Under the Containment through Surface Cover Alternative, the general response actions to be implemented include all institutional control activities described in Alternative 2, together with surface covers placed on each AREE. Surface covers will be constructed of clean soil obtained from uncontaminated areas of WRF. Each cover will be a minimum of two feet thick, and will be designed at a grade which maximizes runoff, and minimizes erosion. In addition, PCB-contaminated soils in AREE 1 will be excavated and disposed of off site.

7.4.2 Effectiveness

With the exception of the PCB hot spot in AREE 1, the Containment through Surface Cover Alternative does not reduce contaminant volume. It will likely minimize contaminant mobility through site treatment. Surface covers would be placed on each AREE, and this treatment should not generate any treatment-related residuals. All existing waste is left untreated. However, the magnitude of risk posed by the site (as described in the risk assessments, Sections 3.0 and 4.0) is substantially reduced for three reasons: 1) the implementation of institutional controls (Section 7.2) affords long-term protection of human health; 2) surface covers minimize any potential exposure humans or animals may have with contaminated surface soils; and 3) surface covers control infiltration of precipitation and runoff thereby minimizing contaminant leaching from soils into groundwater or surface water. With soil contaminants contained, the ARARs for groundwater and surface water will eventually be achieved as contaminants no longer leach into them, and existing concentrations dilute. Compliance with all ARARs is expected. Short-term impacts from construction activities will occur, and will be managed to minimize harm to wildlife and their habitat.

7.4.3 Implementability

The technical feasibility of implementing the Containment through Surface Cover Alternative is considered high, because its required activities are standard construction practices, and the site presents no barriers to their completion. The administrative feasibility of implementing this alternative is also considered high.

7.4.4 Cost

Estimated capital costs for the Containment through Surface Cover Alternative are based on the construction of several soil covers which total approximately $1,500,000. Estimated annual operation and maintenance costs are related to environmental monitoring and maintenance of the covers, and are estimated to total $130,000.

7.5 ALTERNATIVE 5: REMOVAL AND DISPOSAL

7.5.1 Description

Under the Removal and Disposal Alternative, the general response actions to be implemented include excavation of contaminated soil, followed by off-site disposal. Because the site will be a wildlire refuge in the future, excavated areas will not be refilled with clean soil, but simply regraded to a stable slope.

7.5.2 Effectiveness

The Removal and Disposal Alternative reduces contaminant toxicity, mobility, and volume on site through the actions of excavation and off-site disposal. The goal to remove all existing waste currently in place may be unmet because soil contamination exists in isolated locations, without a pattern of consistency or homogeneity, implying that all contamination may not have been identified. However, based on the site history and knowledge that disposal occurred in discrete areas, contamination not iden-

tified during the RI may be accounted for by "over excavating" the disposal areas. The effectiveness of the excavation is therefore considered high.

The magnitude of risk posed by the site would likely be reduced because most of the contaminants would be removed. With soil contaminants removed, the ARARs for groundwater and surface water will eventually be achieved as contaminants no longer leach into them, and existing concentrations dilute. Short-term impacts from construction activities will occur, and will be managed to minimize harm to wildlife and their habitat.

7.5.3 Implementability

The technical feasibility of implementing the Removal and Disposal Alternative is considered high, because its required activities are standard construction practices, and the site presents no barriers to their completion. A minor implementability problem relates to the poor roads near AREE 1. This road would need to be improved to facilitate commercial vehicles providing off-site transportation to disposal facilities. Off-site transportation and disposal is easily implementable. The administrative feasibility of implementing this alternative is also considered high due to the certainty in its effectiveness and the likelihood of receiving regulatory approval.

7.5.4 Cost

Estimated capital costs for the Removal and Disposal Alternative are based on excavation, removal, and off-site disposal of soils at a hazardous waste landfill. Total costs for this alternative should be between $6 and $8 million. The estimated annual Operation and Maintenance costs for this alternative is $140,000.

7.6 ALTERNATIVE 6: AREE-SPECIFIC REMEDIAL ACTIONS

7.6.1 Description

Under the AREE-Specific Remedial Actions Alternative, the general response actions to be implemented include all institutional control activities described in Alternative 2, together with tasks listed in Table 7-2.

7.6.2 Effectiveness

The AREE-Specific Remedial Action Alternative reduces contaminant toxicity, mobility, and volume through the actions of excavation and off-site disposal. The goal is to remove most of the existing debris and contaminated soil currently in place and provide covers in AREEs 1 and 6A. The effectiveness of the alternative is considered high.

The magnitude of risk posed by the site would likely be reduced because most of the contaminants would be removed. With soil contaminants removed, the ARARs for groundwater and surface water will eventually be achieved as contaminants no longer leach into them and existing concentrations dilute. Short-term impacts from construction activities will occur, and will be managed to minimize harm to wildlife and their habitat.

7.6.3 Implementability

The technical feasibility of implementing the AREE-Specific Remedial Actions Alternative is considered high, because the required activities are standard construction practices, and the site presents no barriers to their completion. A minor implementability problem relates to the poor roads near AREE 1. This road would need to be improved to facilitate commercial vehicles providing off-site transportation to disposal facilities. Off-site transportation and disposal is easily implementable. The administrative feasibility of implementing this alternative is also considered high due to the certainty in its effectiveness.

7.6.4 Cost

Estimated capital costs for the AREE-Specific Remedial Actions Alternative are based on geophysical studies of the majority of OU1, removal and disposal activities for each of the AREEs, and the construction of two engineered covers. The budgetary costs estimate for these tasks is $1,150,000. Es-

timated annual operation and maintenance costs are related to environmental monitoring and maintenance of the covers and totals approximately $60,000.

Table 7-1

Monitoring Program Assumed for WRF OU1

Medium	Frequency	Sample Locations			Analyses
Groundwater	Twice a Year for 15 Years	AREE 1	1 upgradient 3 downgradient	MW-7 MW-76, 79, 80	PAHs TAL metals
		AREE 2/5	1 upgradient 5 downgradient	MW-68 MW- 74, 81, 82, and 2 new deep wells	pesticides/PCBs
		AREE 3	1 upgradient 3 downgradient	1 new well MW-69 and 2 new wells	Water quality parameters (chloride, iron, manganese, phenols, sodium, sulfate) Field parameters used to indicate contamination (pH, specific conductance, TOC, TOX)
		AREE 4	1 upgradient 3 downgradient	MW-64 MW-65, 66, 67	
		AREE 6A	1 upgradient 3 downgradient	1 new well MW-65, 69 and 1 new well	
		AREE 6B	1 upgradient 3 downgradient	MW-60 MW-75 plus 2 new wells along the Marumsco Creek	
Surface Water	Every 5th year	AREE 1 AREE 2/5		Occoquan Marumsco	same as groundwater
Sediments	Every 5th year	AREE 1 AREE 2/5		Occoquan Marumsco	same as groundwater, except no water quality or field parameters
Storm Water Runoff	Every 5th year	AREE 1 AREE 2/5		Occoquan Marumsco	same as groundwater, except no water quality or field parameters

Table 7-2

Tasks Associated with Alternative 5

	Tasks	AREE							
		1	6A	2/5	3	4	6B	7	OU1
1	Clean Up All Visible Debris along the shoreline	•							•
2	Clean Up All Visible Debris on Land	•	•	•	•	•	•	•	•
3	Clean Up All Visible Debris in Wetland	•	•	•					
4	Rip-rap along shoreline	•							
5	Install additional wells		•	•	•		•		
	Clean Closure								
6	Geophysical Survey			•	•	•	•		
7	Dig Test Pits at anomalies			•	•	•	•		
8	Expand digging to remove all buried debris			•	•	•	•		
9	Remove PCBs to <1.0 ppm in sediments, 2' BGS	•		•	•	•	•		
10	Remove PCBs to <10 ppm in soils	Hot Spot		•	•	•	•		
11	Restore wetlands with soil and plants	•		•	•	•	•		
12	Demonstrate effectiveness through 4 quarters of monitoring			•	•	•	•		
	Capping								
13	Geophysical Survey to Define Disposal Border	•	•						
14	Clear and grub	•	•						
15	Slope Stabilization	•	•						
16	Cap and revegetate	•	•						
17	Long-term monitoring for 15 years	•	•						

8.0 DETAILED ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

8.1 INTRODUCTION

Five remedial action alternatives (Alternative 1, No Action; Alternative 2, Institutional Controls; Alternative 3, Containment through Surface Removal and Hot Spot Removal; Alternative 4, Removal and Disposal; and Alternative 5, AREE-Specific Remedial Actions) passed the preliminary screening in Section 7.0 and will undergo a detailed analysis in this section. The purpose of this section is to analyze these five alternatives in enough detail so they may be objectively compared and the most appropriate alternative selected. The detailed analysis consists of an assessment of the individual alternatives (Section 8.2) against specific evaluation criteria, and a comparative analysis (Section 8.3) that focuses upon the relative performance of each alternative. The results of this analysis provide the basis for the selection of a remedial action. However, the extent to which alternatives are analyzed is dependent on the limitations of currently available data.

Excerpted below are the nine NCP evaluation criteria (40 CFR 300.430(e)(9)(iii)) that encompass statutory requirements, technical evaluation, cost, and institutional considerations. Of these nine criteria, only the first seven will be evaluated in this report. The last two criteria, State Acceptance and Community Acceptance, will be evaluated after the state regulators and community members have had a chance to review and comment on the Proposed Plan.

Threshold Criteria

1. Overall Protection of Human Health and the Environment: Alternatives shall be assessed to determine whether they can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site. This is accomplished by eliminating, reducing, or controlling exposures to levels established during development of remediation goals. Overall protection of human health and the environment draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

2. Compliance with ARARs: The alternatives shall be assessed to determine whether they attain applicable or relevant and appropriate requirements under federal environmental laws and state environmental or facility siting laws, or provide grounds for invoking one of the waivers.

Primary Balancing Criteria

1. Long-Term Effectiveness and Permanence: Alternatives shall be assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered, as appropriate, include:

   - Magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of the residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.
   - Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste.

2. Reduction of Toxicity, Mobility, or Volume through Treatment: The degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume shall be assessed, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following:

   - The treatment or recycling process the alternative employs and materials that will be treated;

- The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled;
- The degree of expected reduction in toxicity, mobility, or volume of the waste due to treatment or recycling, and the specification of which reductions are occurring;
- The degree to which the treatment is irreversible;
- The type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents; and
- The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

3. Short-Term Effectiveness: The short-term impacts of alternatives shall be assessed considering the following:

   - Short-term risks that might be posed to the community during implementation of an alternative;
   - Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures;
   - Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and
   - Time until protection is achieved.

4. Implementability: The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors as appropriate:

   - Technical feasibility, including technical difficulties and unknowns in association with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial action, and the ability to monitor the effectiveness of the remedy.
   - Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies
   - Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and the availability of prospective technologies.

5. Cost: The types of cost that shall be assessed include the following:

   - Capital costs, including both direct and indirect costs;
   - Annual operation and maintenance costs; and
   - Net present value of capital and O&M costs.

Modifying Criteria

1. State Acceptance: Assessment of state concerns may not be completed until comments on the FFS are received but may be discussed, to the extent possible, in the Proposed Plan issued for public comment. The state concerns that shall be assessed include the following:

   - State's position and key concerns related to the preferred alternative and other alternatives; and

- State comments on ARARs or the proposed use of waivers.

2. Community Acceptance: The assessment includes determining which components of the alternative interested persons in the community support, have reservations about, or oppose. The assessment may not be completed until comments on the proposed plan are received.

8.2 ASSESSMENT OF INDIVIDUAL ALTERNATIVES

This section provides an assessment of the five retained remedial action alternatives against the seven NCP criteria identified in Section 8.1. These alternatives represent a range of strategies that address human health and environmental concerns. Although the selected alternative will be further refined during the pre-design phase, the description of alternatives and analysis below reflect the fundamental components of the various approaches being considered for this site. This analysis is abbreviated in Table 8-1, and fully described in the text that follows.

8.2.1 Alternative 1: No Action

8.2.1.1 Description

The No Action alternative excludes all remedial measures, including existing institutional controls. No activities would be initiated or continued at the site. Existing site restrictions, including security personnel and fencing, would terminate. The NCP requires this evaluation because it provides a baseline from which to compare the developed alternatives.

8.2.1.2 Overall Protection of Human Health and the Environment

Because no remedial action is undertaken, long-term human health and environmental risks for the site essentially are the same as those identified in the baseline risk assessments. An additional future risk may exist if groundwater wells are installed and used. This alternative does not prohibit future groundwater use at the site and thus may fail, at some point in the future, to protect human health.

8.2.1.3 Compliance with Applicable or Relevant and Appropriate Requirements

Location-specific ARARs exist because debris is present in wetlands and is required to be removed. This ARAR would not be achieved by this alternative. Action-specific ARARs exist because the sites are classified by VADEQ as open dumps and actions are required to close these dumps. This ARAR would not be achieved by this alternative. Chemical-specific ARARs which would not be complied with include: MCLs for groundwater, AWQC for surface water, and TSCA PCB concentrations in soils.

8.2.1.4 Long-Term Effectiveness and Permanence

With no treatment undertaken, the No Action Alternative does not reduce contaminant toxicity, mobility, or volume "through treatment." No treatment-related residuals are generated, all existing waste is left untreated, and the magnitude of risk posed by the site goes unchanged from what is described in the risk assessments (Sections 3.0 and 4.0). No actions or controls are initiated to manage this risk, and therefore this alternative affords no long-term protection of human health and the environment.

8.2.1.5 Reduction of Toxicity, Mobility, or Volume through Treatment

The No Action Alternative provides no reduction in toxicity, mobility, or volume of the contaminants "through treatment".

8.2.1.6 Short-Term Effectiveness

Because no action is taken, there are no additional risks posed to the community, the workers, or the environment as a result of this alternative being implemented.

8.2.1.7 Implementability

The technical implementability of the No Action Alternative is considered high, because it does not require any activities to be either initiated or continued (with the exception of a site evaluation report that must be submitted to USEPA). The administrative implementability of alternative is considered low, because it provides no increased protection.

8.2.1.8 Cost

As detailed in Appendix C, Table C-1, the annual O&M cost of Alternative 1 is estimated to be $7,200. There are no capital costs. The present worth cost is $74,734 (15 years, 5%).

8.2.2 Alternative 2: Institutional Controls

8.2.2.1 Description

The Institutional Controls Alternative establishes legal and barrier restrictions on the use of land and groundwater at OU1 to reduce the dangers from releases or threatened releases of environmental contaminants. Under the Institutional Controls Alternative, the remedial technologies and process options to be implemented include the following:

Site Access Restrictions: Access restrictions to the soils would be implemented as follows:

- Site access restrictions will be detailed in the "Letter of Transfer" that will be prepared by the Army and signed by the Department of Defense and the Department of the Interior. This "Letter of Transfer" will be recorded at the local Registrar of Deeds office to insure that the institutional controls are maintained for perpetuity.
- Prohibitions on unauthorized digging or drilling would be initiated and maintained. Access restrictions will be communicated to all employees and enforced through appropriate administrative channels.
- Signs would be posted which State that excavation and digging are prohibited within OU1, without proper authorization. Authorization and approval may be contingent upon testing and monitoring to ensure the safety of workers. The AREEs within OU1 are regulated through the VSWMRs and the Virginia Hazardous Waste Management Regulations (VHWMRs). Any disturbance of the dumps (with the exception of cover and erosion maintenance) would be in violation of these regulations.

Groundwater Restrictions: Groundwater beneath OU1 is contaminated in isolated locations, and therefore restrictions on its usage needs to be implemented.

- Prohibitions on the use of groundwater for purposes other than environmental sampling will be initiated and maintained. These site restrictions will be detailed in the "Letter of Transfer" as described above. Prohibitions would be promulgated in the site's Master Plan, as supervised by either the Army, or the next expected manager, the USFWS. Prohibitions would be communicated to all employees and enforced through appropriate administrative channels.
- Restrictions would be placed in the deed to the property if the Army transfers the property to an entity other than the U.S. Government. The deed restriction will describe the fact that OU1 had isolated groundwater contamination, and should not be used.

Monitoring: Monitoring to evaluate long-term changes in the site environmental conditions is necessary in order to assure that instituitonal controls are adequate to protect human health and the environment. The monitoring plan for OU1 is described below.Groundwater beneath OU1 is contaminated in isolated locations, and therefore restrictions on its usage needs to be implemented.

- Semi-annual monitoring of groundwater would be initiated and maintained in accordance with the VSWMRs for a default period of 15 years (shorter or longer as VADEQ deems necessary). In addition, monitoring of surface water, stormwater runoff, and sediments would be conducted annually for five years. These monitoring data will be reviewed at the end of the first and fifth years and every five years thereafter in order to determine the need for continued monitoring. Groundwater is assumed to discharge to the adjacent water bodies, i.e. Marumsco Creek and the Occoquan Bay. Groundwater would be monitored through a system of wells located in upgradient and downgradient areas at each AREE. The shallow groundwater at OU1 is assumed to be tidally influenced. In order to design an effective groundwater monitoring system, these tidal influences must be understood. A pre-

design study to evaluate the tidal influences on groundwater has been prepared and is presented in Appendix C. The initial groundwater monitoring program shown in Table 8-2 is proposed. No costs associated with the pre-design study have developed for this FFS.

8.2.2.2 Overall Protection of Human Health and the Environment

Under the Institutional Controls Alternative, protection of human health is achieved through the implementation of site restrictions and groundwater use restrictions. According to the human health risk assessment (Section 3.0), one pathway of concern was ingestion and dermal exposure to contaminated groundwater (residential exposure). These institutional controls would be designed to prevent this pathway from being completed, and thereby provide protection of human health. No actions are taken to protect the environment from risks discussed in the ecological risk assessment (Section 4.0).

8.2.2.3 Compliance with Applicable or Relevant and Appropriate Requirements

Location-specific ARARs exist because debris is present in wetlands and is required to be removed. This ARAR would not be achieved by this alternative. Action-specific ARARs exist because the sites are classified by VADEQ as open dumps and actions are required to close these dumps. This ARAR would not be achieved by this alternative. Chemical-specific ARARs which would not be complied with include: MCLs for groundwater, AWQC for surface water, and TSCA PCB concentrations in soils.

8.2.2.4 Long-Term Effectiveness and Permanence

With no treatment undertaken, the Institutional Controls Alternative does not reduce contaminant toxicity, mobility, or volume "through treatment." No treatment-related residuals are generated, all existing waste is left untreated, and the magnitude of risk posed by the site goes unchanged from what is described in the risk assessments (Sections 3.0 and 4.0). However, actions and controls are initiated to manage this risk, and therefore, this alternative affords long-term protection of human health and the environment.

The Institutional Controls Alternative will effectively prevent exposure to contaminated groundwater. These restrictions are expected to be effective in the long-term, as the site is managed by the Army, and the Army is a reliable enforcement mechanism. Thus, the adequacy and reliability of the institutional controls for restricting groundwater use is considered high. The same assessment applies to the expected future site manager, the USFWS. An assessment of the reliability of a future site manager who is not a U.S. Government agency is not possible.

8.2.2.5 Reduction of Toxicity, Mobility, or Volume through Treatment

The Institutional Controls Alternative provides no reduction in toxicity, mobility, or volume of the contaminated groundwater "through treatment."

8.2.2.6 Short-Term Effectiveness

The Institutional Controls Alternative protects the community in the short-term by imposing restrictions on site and groundwater use. Because no groundwater or soils will be removed, this alternative creates no additional risks on the community, workers, or the environment due to remedial activities.

8.2.2.7 Implementability

The Institutional Controls Alternative is considered easy to implement. Actions to be taken are limited to the addition of warning signs, the prevention of site and groundwater usage to be regulated by the Army and/or USFWS, and the implementation of a comprehensive monitoring program. Having a government agency responsible assures the public of continued implementation of the monitoring program under oversight from state and federal regulatory agencies.

8.2.2.8 Cost

As detailed in Appendix C, the Institutional Controls Alternative has a capital cost of $121,776 (Table C-2), and annual O&M cost of $143,081 (Table C-3). Together these two costs translate into a present worth cost is $1,606,911 (15 years, 5%).

8.2.3 Alternative 3: Containment through Surface Cover and Hot Spot Removal

8.2.3.1 Description

Under the Containment through Surface Cover Alternative, protection of human health and the environment is achieved through the construction and maintenance of surface covers on each AREE, together with all institutional control activities described in Section 8.2.2.1, and excavation and disposal of PCB-contaminated soils (Hot Spot) in AREE 1. Surface covers will be constructed of 18 inches of low permeable soil with 6 inches of topsoil on top of the low permeability soil. Each cover will be designed at a grade that maximizes runoff and minimizes erosion. Prior to construction, each area will be cleared of existing trees and shrubs. Following construction, each area will be revegetated in accordance with future site use plans and the needs of local habitats.

Closure is the activity of installing the soil covers. Post closure is the monitoring and facility maintenance activities conducted after these covers are in place. Post closure activities, which will be performed for a period of 15 years, are intended to: ensure that the covers perform as designed; ensure the covers are repaired when necessary; minimize the need for further maintenance; and control, minimize, or eliminate further hazardous substance escape.

8.2.3.2 Overall Protection of Human Health and the Environment

Protection of human health and the environment is achieved to a high degree by this alternative. The soil covers prevent contact between contaminated surface soils and humans or animals. Construction and maintenance of these covers will minimize percolation of precipitation through the contaminated subsurface soils, and thereby minimize leaching of contaminants into groundwater and surface water. As stated in the human health risk assessment, the major potential risk to human health is from exposure to groundwater through ingestion. This alternative prevents the completion of that hypothetical pathway through the enforcement of groundwater use restrictions described in Section 8.2.2.1.

8.2.3.3 Compliance with Applicable or Relevant and Appropriate Requirements

Location-specific ARARs exist because debris is present in wetlands and is required to be removed. This ARAR would be achieved by this alternative. Action-specific ARARs exist because the sites are classified by VADEQ as open dumps and actions are required to close these dumps. This ARAR would be achieved by this alternative. Chemical-specific ARARs would not be complied with immediately, but would eventually as contaminant mass ceases to enter groundwater and surface water. These ARARs include MCLs for groundwater and AWQC for surface water.

8.2.3.4 Long-Term Effectiveness and Permanence

With no treatment undertaken, no treatment residuals are generated. Untreated waste left on site will be controlled and contained through systems that are considered both adequate and reliable. The surface covers and site use restrictions are expected to be effective in the long-term as the site is managed by the Army, and the Army is a reliable enforcement mechanism. The same assessment applies to the expected future site manager, the USFWS. An assessment of the reliability of a future site manager who is not a U.S. Government agency is not possible.

8.2.3.5 Reduction of Toxicity, Mobility, or Volume through Treatment

The Containment through Surface Cover Alternative provides no reduction in toxicity, mobility, or volume of the contaminants "through treatment." The construction and maintenance of soil covers will minimize percolation of precipitation through subsurface soils, and in doing so prevent the contaminants from being leached out and mobilized. The existing volume of waste in the soils would remain unchanged. The existing volume of contaminants in the groundwater and surface water would decrease over time with dilution.

8.2.3.6 Short-Term Effectiveness

The short-term is the period during which the remedial action is being undertaken, in this case, the construction of surface covers and removal of the Hot Spot at AREE 1. There is a minor short-term effect due to the removal and off-site disposal of PCB-contaminated soils from AREE 1. Therefore,

there are some minor risks to the community, workers, and the environment during the disposal phase of this alternative. Overall, this alternative is considered highly effective.

8.2.3.7 Implementability

The technical feasibility of implementing the Containment through Surface Cover and Hot Spot Removal Alternative is considered high, because the required activities are standard construction practices, and the site presents no barriers to their completion. The administrative feasibility of implementing this alternative is also considered high. Risks are mitigated with a high degree of reliability.

8.2.3.8 Cost

As detailed in Appendix C, the Containment through Surface Cover Alternative has a capital cost of $2,082,399 (Table C-5), and annual O&M cost of $153,538 (Table C-6). Together these two costs translate into a present worth cost is $3,676,072 (15 years, 5%).

8.2.4 Alternative 4: Removal and Disposal

8.2.4.1 Description

Under the Removal and Disposal Alternative, protection of human health and the environment is achieved through the excavation and off-site disposal of soil contaminants. With their removal, contaminants will cease to enter groundwater and surface water, and existing aquatic concentrations of contaminants will decrease through dilution. Following excavation, areas will not be backfilled, but will be regraded and revegetated in accordance with future site use plans and the needs of local habitats.

8.2.4.2 Overall Protection of Human Health and the Environment

Protection of human health and the environment is achieved to a high degree by this alternative. Potential contact between contaminated soils and humans or animals is eliminated with the elimination of the contaminants. As stated in the human health risk assessment, the major potential risk to human health is from exposure to groundwater through ingestion. This alternative prevents the completion of that hypothetical pathway through the enforcement of groundwater use restrictions described in Section 8.2.2.1.

8.2.4.3 Compliance with Applicable or Relevant and Appropriate Requirements

Location-specific ARARs exist because debris is present in wetlands and is required to be removed. This ARAR would be achieved by this alternative. Action-specific ARARs exist because the sites are classified by VADEQ as open dumps and actions are required to close these dumps. This ARAR would be achieved by this alternative. Chemical-specific ARARs (MCLs for groundwater and AWQC for surface water) would not be complied with immediately, but would eventually as contaminant mass ceases to enter groundwater and surface water.

8.2.4.4 Long-Term Effectiveness and Permanence

With no treatment undertaken, no treatment residuals are generated. With successful excavation, no untreated waste would be left on site which requires control or containment. This action is irreversible, and considered to have a high degree of effectiveness and permanence.

8.2.4.5 Reduction of Toxicity, Mobility, or Volume through Treatment

The Removal and Disposal Alternative provides no reduction in toxicity, mobility, or volume of the contaminants "through treatment." The reduction of these factors is achieved through excavation and off site disposal of contaminants. This reduction is estimated to be a complete reduction.

8.2.4.6 Short-Term Effectiveness

The short-term is the period during which the remedial action is being undertaken, in this case, the excavation, hauling, and off-site disposal of contaminated soils. Because contaminated soil is being removed and managed, this alternative creates additional risks to the community, workers, and the environment during the construction phase. Risks to the workers would come from direct contact, spills, and inhalation of dust. Risks to the environment would come from spills and dust. Risks to the

community would come during the hauling of contaminated materials on roads, from possible spillage or generation of dust. Attempts to mitigate all of these risks will be made through planning, engineered controls, and the use of trained personnel. The effectiveness of this alternative in the short-term is therefore considered moderate.

8.2.4.7 Implementability

The technical feasibility of implementing the Removal and Disposal Alternative is considered moderate. Success requires trained personnel excavating and removing all contaminated soils. Barriers to this success may arise if unexpected or unmanageable materials are uncovered during the excavation activities. The administrative feasibility of implementing this alternative is also considered moderate, as permits and approval will be required for off-site activities.

8.2.4.8 Cost

As detailed in Appendix C, the Removal and Disposal Alternative has a capital cost of $6,741,399 (Table C-7), and annual O&M costs of $143,081 (Table C-8). The present worth cost of this alternative is $8,226,534 (15 years, 5%)

8.2.5 Alternative 5: AREE-Specific Remedial Actions

8.2.5.1 Description

Under the AREE-Specific Remedial Actions Alternative, protection of human health and the environment is achieved through the excavation and off site disposal of soil contaminants at some AREEs and surface cover of the other AREEs. With their removal or containment, contaminants will cease to enter groundwater and surface water, and existing aquatic concentrations of contaminants will decrease through dilution. Following excavation, areas will not be backfilled, but will be regraded and revegetated in accordance with future site use plans and the needs of local habitats.

8.2.5.2 Overall Protection of Human Health and the Environment

Protection of human health and the environment is achieved to a high degree by this alternative. Potential contact between contaminated soils and humans or animals is eliminated with the excavation of the contaminants and minimized on site with a surface covers where applicable. As stated in the human health risk assessment, the major potential risk to human health is from exposure to groundwater through ingestion. This alternative prevents the completion of that hypothetical pathway through the enforcement of groundwater use restrictions described in Section 8.2.2.1, Institutional Controls.

8.2.5.3 Compliance with Applicable or Relevant and Appropriate Requirements

Location-specific ARARs exist because debris is present in wetlands and is required to be removed. This ARAR would be achieved by this alternative. Action-specific ARARs exist because the sites are classified by VADEQ as open dumps and actions are required to close these dumps. This ARAR would be achieved by this alternative. Chemical-specific ARARs would not be complied with immediately, but would eventually as contaminant mass ceases to enter groundwater and surface water. These ARARs include MCLs for groundwater and AWQC for surface water.

8.2.5.4 Long-Term Effectiveness and Permanence

With no treatment undertaken, no treatment residuals are generated. With successful excavation, most waste would be removed from the site. Wastes left on site will be managed by surface covers and institutional controls. These actions are reversible, and considered to have a high degree of effectiveness and permanence.

8.2.5.5 Reduction of Toxicity, Mobility, or Volume through Treatment

The AREE-Specific Remedial Actions Alternative provides no reduction in toxicity, mobility, or volume of the contaminants "through treatment." The reduction of these factors is achieved through excavation and off-site disposal of most contaminants, and containment through cover with the contaminants left on site.

8.2.5.6 Short-Term Effectiveness

The short-term is the period during which the remedial action is being undertaken, in this case, the excavation, hauling, and off-site disposal of contaminated soils and on-site surface capping. Because contaminated soil is being removed and managed, this alternative creates additional risks to the community, workers, and the environment during the construction phase. Risks to the workers would come from direct contact, spills, and inhalation of dust. Risks to the environment would come from spills and dust. Risks to the community would come during the hauling of contaminated materials on roads, from possible spillage or generation of dust. Attempts to mitigate all of these risks will be made through planning, engineered controls, and the use of trained personnel. The effectiveness of this alternative in the short- term is therefore considered moderate.

8.2.5.7 Implementability

The technical feasibility of implementing the AREE-Specific Remedial Actions Alternative is considered moderate. Success requires trained personnel excavating and removing contaminated soils and construction of low permeable soil covers. Barriers to this success may arise if unexpected or unmanageable materials are uncovered during the excavation activities. The administrative feasibility of implementing this alternative is also considered moderate, as permits and approval will be required for off-site activities.

8.2.5.8 Cost

As detailed in Appendix C, the AREE-Specific Remedial Actions Alternative has a capital cost of $1,115,047 (Table C-9), and annual O&M costs of $59,814 (Table C-10). The present worth cost is $1,735,898.

8.3 COMPARATIVE ANALYSIS

8.3.1 Introduction

This section provides a comparative analysis of the remedial action alternatives. This analysis contrasts with the preceding analysis in which each alternative was analyzed independently without consideration of other alternatives. The purpose of this comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another so that the key tradeoffs can be identified. A summary of the analysis is provided in Table 8-3, with a complete analysis in the text that follows.

8.3.2 Overall Protection of Human Health and the Environment

Protection of human health is afforded by minimizing or eliminating human contact from site contaminants. This can be done through implementation of physical and legal barriers, or through site clean up. Because Alternative 3 includes surface covers together with site and groundwater use restrictions, it is considered to be the most protective of the five alternatives. Likewise, Alternative 2 protects human health through the implementation and enforcement of site and groundwater use restrictions. Alternatives 4 and 5 would attempt to excavate and remove soil contaminants, preempting the need for future site and groundwater use restrictions; however they are considered less protective than Alternative 3 because complete removal of contaminants may not actually occur, and those contaminants that are removed may be released during their management as spillage or dust. With the Army acting as the site manager, Alternative 2 has a high degree of reliability. Alternative 1 provides no increased protection of human health and is therefore the least desirable alternative.

Protection of the environment is less of an issue than protection of human health, according to results of the risk assessments. Protection of the environment will best be achieved through the implementation of Alternative 3 which will prevent contact between animals and contaminated surface soils and will minimize future leaching of contaminants into surface water and groundwater. Alternatives 4 and 5 may succeed in removing soil contaminants; however, because they will likely generate dust and may include spillage, they are considered less protective of the environment than Alternative 3. Alternatives 1 and 2 provide no increased protection of the environment.

8.3.3 Compliance with Applicable or Relevant and Appropriate Requirements

Location-specific ARARs apply to OU1 because debris is located in wetlands and will be required to be removed. Alternatives 4 and 5 are the only ones to take this action.

Action-specific ARARs apply to OU1 because seven of the eight AREEs within OU1 are open dumps and actions must be taken to either cover or close them. Alternatives 3, 4, and 5 take the required actions.

The chemical-specific ARARs for surface water are AWCQ. Alternatives 3, 4, and 5 are expected to achieve these criteria in the long-term, as contaminants cease to be added to the surface water. Alternatives 1 and 2 take no actions and are likely to remain in noncompliance with this ARAR.

The chemical-specific ARARs for groundwater are MCLs. Alternatives 3, 4, and 5 are expected to achieve these criteria in the long-term, as contaminants cease to be added to the groundwater. Alternatives 1 and 2 take no actions and are likely to remain in noncompliance with this ARAR.

The chemical-specific ARARs for soil are the TSCA PCB levels. Alternatives 3, 4, and 5 take the required actions. Alternatives 1 and 2 take no actions and are likely to remain in noncompliance with this ARAR.

Alternatives 1 and 2 are the least desirable because they fail to comply with several ARARs. Alternatives 3, 4, and 5 will achieve soil ARARs in the short-term, and groundwater and surface water ARARs in the long-term. Because Alternatives 4 and 5 involve excavation more excavation than Alternative 3, their likelihood of achieving water ARARs is greater than for Alternative 3.

8.3.4 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence is best achieved through the minimization of wastes left in place, the minimization of residuals generated during treatment, and the adequate and reliable control of any residuals generated or wastes left in place. None of the alternatives generates treatment residuals. Desirability, therefore, is related to the minimization and management of wastes left in place. Alternative 4 is most desirable because virtually all waste will be removed from the site. Alternative 5 removes most wastes. Alternatives 1, 2, and 3 leave all wastes in place (with the exception of the Hot Spot removal for Alternative 3), with only Alternative 3 taking control actions (surface covers) which are considered adequate and reliable. Alternatives 1 and 2 are the least desirable because they do nothing to control wastes left in place.

8.3.5 Reduction of Toxicity, Mobility, or Volume through Treatment

None of the alternatives involve any treatment; therefore, there will be no reduction of toxicity, mobility, or volume *through treatment*. However the reduction in mass achieved by Alternatives 4 and 5 inherently reduces toxicity and mobility as well. Alternative 3 involves some reduction in mass by the Hot Spot removal in AREE 1. A reduction in mobility is achieved by Alternative 3 through the implementation of surface covers which, when properly maintained, will minimize mobility as leachate is minimized. Alternatives 1 and 2 effect no changes in toxicity, mobility, or volume.

8.3.6 Short-Term Effectiveness

Short-term effectiveness is best achieved by minimizing additional risks to workers, the environment, and the local community during the remedial action. The principal threat to human health at OU1 is contact of contaminants once they have be extracted or removed. Contaminants in place are not currently a threat to human health, nor will they be in the future. Therefore, the least desirable alternative is Alternative 4, because in removing and managing site soils, workers, the local community, and the environment are afforded additional risks in the event of spillage or dust generation. Alternative 5 involves less excavation than Alternative 4. Alternatives 2, 3, and 5 involve leaving contaminants in place while conducting environmental sampling. Due to environmental sampling of contaminated media, they present a larger risk to workers than Alternative 1.

8.3.7 Implementability

Implementability is best achieved through a remedial alternative which is both technically and administratively feasible. The technical and administrative feasibility of the No Action Alternative is the highest because no coordinating, permitting, or actions are required. The Institutional Controls Alternative requires the implementation of site use restrictions, which require coordination with facility personnel, and the implementation of an on-going monitoring program. Alternative 2 is therefore highly implementable, though slightly less than the No Action Alternative. Alternatives 3, 4, and 5 require construction activities. Alternative 3's activities are all on site (with the exception of off-site disposal of the PCB Hot Spot), and therefore, are more easy to administer than either Alternative 4's or 5's, which require off-site disposal. Alternatives 3, 4, and 5 require trained personnel, in licensed vehicles, driving to a licensed facility. Alternative 5 is therefore the most difficult to implement from an administrative point because it must coordinate both on site and off-site activities. Alternative 3 requires surface covering and minimal off-site disposal of wastes, where Alternative 4 requires more excavation of buried soils and wastes than Alternative 3. Therefore, Alternative 3 is considered more technically implementable than Alternative 4.

8.3.8 Cost

Cost comparisons of the alternatives are shown in Table 8-4.

Table 8-1

Summary of Individual Analysis of Remedial Action Alternatives

NCP Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Containment through Surface Cover and Hot Spot Removal	Alternative 4 Removal and Disposal	Alternative 5 AREE-Specific Remedial Actions
1. Overall protectiveness Human Health	Does not prevent future groundwater use, and therefore does not increase the protectiveness of human health.	Does prevent future groundwater use, and therefore does increase the protectiveness of human health.	Does prevent future groundwater use and surface soil contact, and therefore does increase the protectiveness of human health.		
Environment	Existing conditions are generally protective of the environment and would remain so under this alternative.				
2. Compliance with ARARs Chemical-specific	Surface water quality standards, groundwater MCLs, and TSCA PCB levels will not be complied with.		Surface water quality standards, groundwater MCLs will achieve compliance over time.		
Location-specific	Location-specific ARARs for wetlands will not be met.		Location-specific ARARs for wetlands will be met.		
Action-specific	Action-specific ARARs for VDEQ Open Dumps will not be met.		Action-specific ARARs for VADEQ Open Dumps will be met.		
Other	No other criteria apply.				
3. Long-term Effectiveness and Permanence Magnitude of residual risk	No actions are taken which generate residuals. All waste is left in place and the risk is unchanged.	No actions are taken which generate residuals. All waste is left in place and the risk is managed through institutional controls.	No actions are taken which generate residuals. All waste is left in place and the risk is managed through institutional controls and surface covers.	The action removes all waste from the site without the generation of any residuals.	The action removes most waste from the site without the generation of any residuals. Wastes left in place will be managed through institutional controls and surface covers.
Adequacy of controls	No controls will be implemented.	Reliability of institutional controls and monitoring is adequate.	Reliability of institutional controls, monitoring, and cover maintenance is adequate.	Controls are not necessary.	Reliability of institutional controls, monitoring, and cover maintenance is adequate.
4. Reduction in Toxicity, Mobility and Volume Treatment process used and materials treated	No treatment process is used.	No treatment process is used.	No treatment process is used. Wastes are contained on site through the construction of soil covers which prevent precipitation from leaching contaminants from the soil.	No treatment process is used. Wastes are excavated and removed from the site.	No treatment process is used. Wastes are excavated and removed from the site or left in place under surface covers
Amount treated or destroyed	No treatment process is used.	No treatment process is used.	No treatment process is used.	Virtually all waste mass would be removed.	Most wastes would be removed
Degree of expected reductions in toxicity, mobility, and volume	No treatment process is used.	No treatment process is used.	High reduction in mobility. No reduction in toxicity or volume.	High reduction in volume.	High reduction in volume and mobility.
Degree to which treatment is irreversible	No treatment process is used.	No treatment process is used.	Surface covering is highly reversible.	Soil excavation is reversible, but is irreversible following off-site disposal.	Excavation and surface cover are both reversible.

Table 8-1 (Continued)

Summary of Individual Analysis of Remedial Action Alternatives

NCP Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Containment through Surface Cover and Hot Spot Removal	Alternative 4 Removal and Disposal	Alternative 5 AREE-Specific Remedial Actions
Types, quantities of residuals	No residuals generated.				
5. Short-term effectiveness Community protection	No additional protection provided.	Additional protection provided through the implementation of institutional controls.	Additional protection provided through the implementation of institutional controls and surface covers.	Community protection is decreased as contaminants are moved on road ways and may be released.	
Worker protection	No additional protection provided.	Additional protection provided through the implementation of institutional controls.	Additional protection provided through the implementation of institutional controls and surface covers.	Worker protection is decreased as contaminants are excavated, placed in trucks, moved on road ways and may be released.	
Environmental impacts	No additional protection provided.	No additional protection provided.	Additional protection provided through the construction and maintenance of surface covers.	Environmental protection is decreased as contaminants are excavated, placed in trucks, moved on road ways and may be released.	
Time until remedial action objectives are completed	Natural processes control the time required for restoration.	Natural processes control the time required for restoration.	Natural processes control the time required for restoration.	RAOs are met shortly after completion of excavation, as contaminants in groundwater and surface water dilute.	
6. Implementability Ability to construct and operate	No actions will be taken.	Easy.	Easy	Easy.	
Reliability	No actions will be taken.	Highly reliable.	Highly reliable.	Highly reliable.	
Ease of additional remediation	No actions will be taken.	Easy.	Easy.	Easy.	
Ability to monitor effectiveness	No actions will be taken.	Monitoring of institutional controls will be easy because the site is on a secured military base.	Monitoring of institutional controls and soil covers will be easy because the site is on a secured military base.	No monitoring will be necessary.	Monitoring of institutional controls and soil covers will be easy because the site is on a secured military base.
Ability to coordinate and obtain approval from other agencies	No actions will be taken.	Easy.			
Availability of off-site treatment, storage, and disposal facilities	No actions will be taken.	No TSD will be needed.	TSD will be needed and is available.		
Availability of equipment and specialists	No actions will be taken.	No equipment or specialists will be needed.	Common construction equipment will be available, as will trained personnel.	Specially trained persons in hazardous waste excavation and transportation will be required, and are available.	
Availability of technologies	No actions will be taken.	No technologies will be used.			
7. Costs Capital	$0	$121,776	$2,082,399	$6,741,399	$1,115,047
Annual O&M	$7,200	$143,081	$153,538	$143,081	$59,814
Present worth cost	$74,734	$1,606,911	$3,676,072	$8,226,534	1,735,898

Table 8-2
Monitoring Program Assumed for WRF OU1

Medium	Frequency	Sample Locations			Analyses
Groundwater	Twice a Year for 15 Years	AREE 1	1 upgradient 3 downgradient	MW-7 MW-76, 79, 80	PAHs TAL metals
		AREE 2/5	1 upgradient 5 downgradient	MW-68 MW- 74, 81, 82, and 2 new deep wells	pesticides/PCBs Water quality parameters (chloride, iron, manganese, phenols, sodium, sulfate)
		AREE 3	1 upgradient 3 downgradient	1 new well MW-69 and 2 new wells	
		AREE 4	1 upgradient 3 downgradient	MW-64 MW-65, 66, 67	Field parameters used to indicate contamination (pH, specific conductance, TOC, TOX)
		AREE 6A	1 upgradient 3 downgradient	1 new well MW-65, 69 and 1 new well	
		AREE 6B	1 upgradient 3 downgradient	MW-60 MW-75 plus 2 new wells along the Marumsco Creek	
Surface Water	Every 5th year	AREE 1 AREE 2/5		Occoquan Marumsco	same as groundwater
Sediments	Every 5th year	AREE 1 AREE 2/5		Occoquan Marumsco	same as groundwater, except no water quality or field parameters
Storm Water Runoff	Every 5th year	AREE 1 AREE 2/5		Occoquan Marumsco	same as groundwater, except no water quality or field parameters

Table 8-3
Comparative Analysis of Remedial Action Alternatives

NCP Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Containment through Surface Cover and Hot Spot Removal	Alternative 4 Removal and Disposal	Alternative 5 AREE-Specific Remedial Actions
1. Overall protectiveness	5	2	1	4	3
2. Compliance with ARARs	5	5	3	1	2
3. Long-term effectiveness and permanence	5	5	3	1	2
4. Reduction in toxicity, mobility, and volume through treatment	5	5	3	1	2
5. Short-term effectiveness	1	2	3	5	4
6. Implementability	1	2	3	4	5
7. Cost	1	2	3	5	4

Ratings are from 1 through 5, with 1 being the most desirable, and 5 being the least desirable.

Table 8-4
Summary of Capital, Annual O&M, and Present Worth Costs

Remedial Action Alternative	Capital Cost Estimate ($)	O&M Cost Estimate ($)	Present Worth Estimate[1] ($)
1. No Action	0	7,200	74,734
2. Institutional Controls	121,776	143,081	1,606,911
3. Containment through Surface Cover and Hot Spot Removal	2,082,399	153,538	3,676,072
4. Removal and Disposal	6,741,399	143,081	8,229,534
5. AREE-Specific Remedial Actions	1,115,047	59,814	1,735,898

[1] Present worth assumes a 15-year lifetime and 5% interest (discount) rate for federal money.

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APPENDIX A

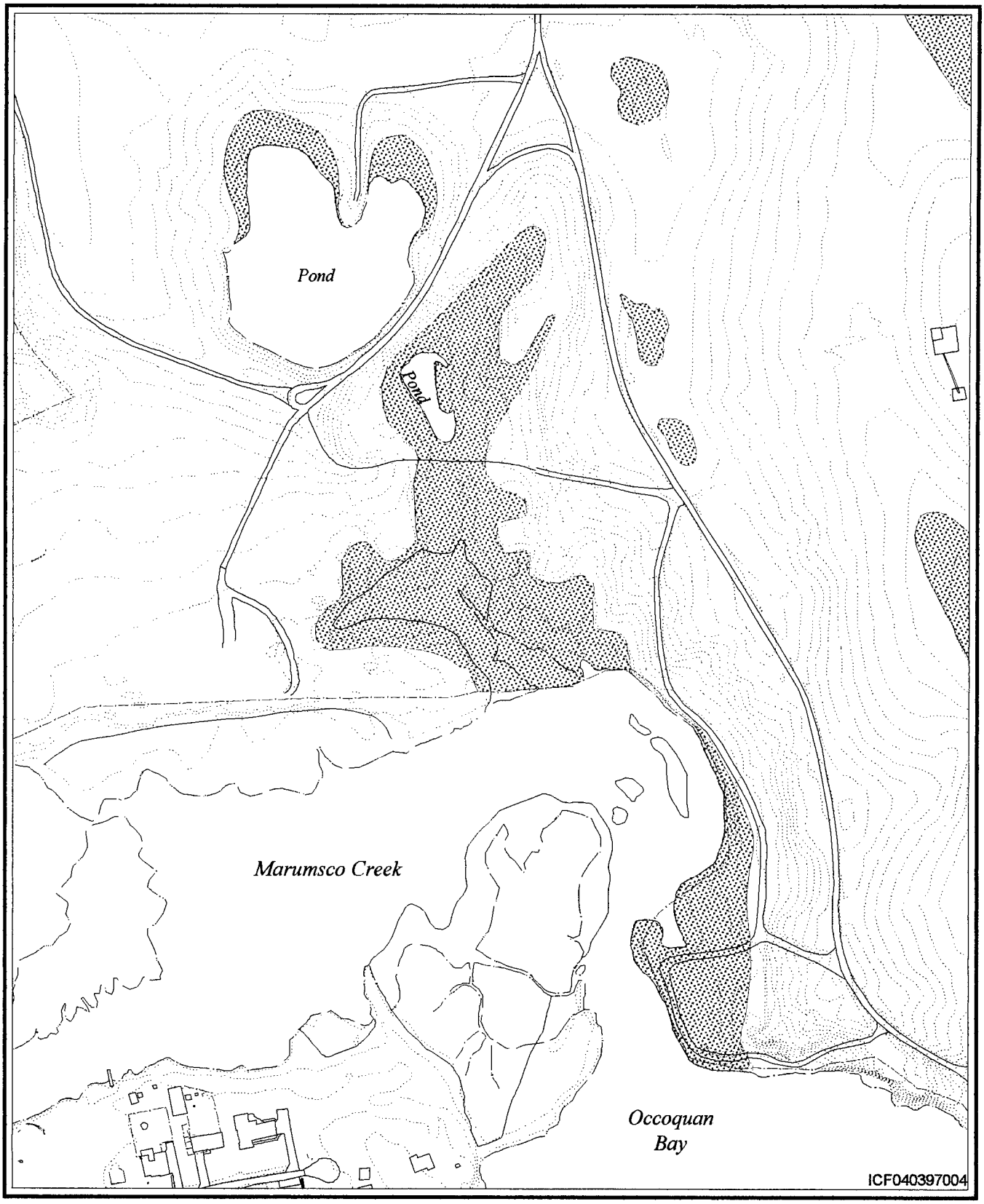
GEOLOGICAL/HYDROGEOLOGICAL INFORMATION

A-1 Wetland Delineation Map for Operable Unit One
A-2 Boring Logs
A-3 Table 1 - Water Elevation Data
A-4 Table 2 - Well Construction Data for AREE 1 Monitoring Wells

A-1

Wetland Delineation Map for Operable Unit One

Figure A-1
Wetlands in Operable Unit 1



A-2

Boring Logs

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

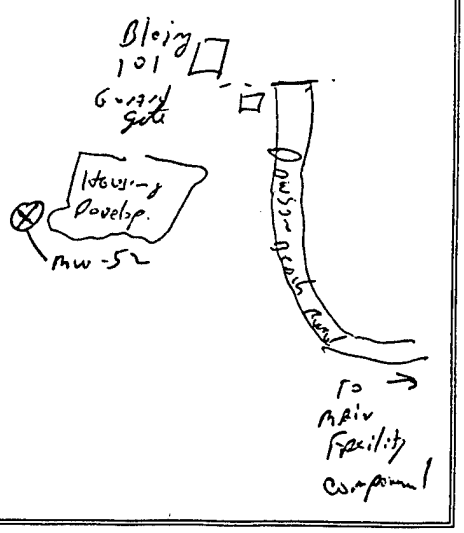
Project: WRF RI/FS	Boring: MW-52
Geologist: Jack Chojnacki / Rob Batts	Signature: Jack Chojnacki
Driller & Company: Rick Rice / HSI	Drilling Rig: Mobile B-57
Date Boring Started: 11/27/95	Completed: 11/28/95
First Encountered Water Level: 16.5'	Date: 11/27/95
Total Fluid Losses: NA	Date:
Total Fluid Losses: NA	
Casing Type: 4" Sch 40 PVC	Screened Interval: 14-24'
Geophysical Logging: None	Date: —
Depth to Bedrock: Not encountered	Ground Elev.: —
Boring Completion Information: 4" ID Monitoring Well	Date: 11/28/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/27/95	0930	1423	0	24.5'	Tremied in installation of 4" well to Bentonite seal				

Abbreviations:

Abbreviation	Meaning
Trace	10/90 %
and	50/50 %
Some	70/30 %
HSA	Hollow Stem Augers
BGS	Below Ground Surface
~	Approximately
<	Less Than
>	Greater Than
%	Percent

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-52	Project Name: WRF RI/FS		
Driller/Company: Rick Rider / Hardin Kupon	Drilling Method: HSA Sample 4.25" ID HSA overtop 8.25" ID HSA	Date Started: 11/27/95	Date Completed: 11/28/95
Total Depth: 24.5'	Depth to Bedrock: Not encountered	Water Table Depth: 16.5'	Ground Elevation: NAT
Protection Level: Modified D	H&S Monitoring Equipment: MicroTip	Logged by: Jack Chrzanowski	Checked by: Jack Chrzanowski

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0-2	MW-52A	2/5/8/7	Brownish yellow clay w/ some silt, Dry medium plasticity w/ some gray mottling	Will sample UT 1.75" by 2" OD x 2" long 4 Split-spoon sampler inside 4.25" I.D. HSA. 0952 collect MW-52A Auger Down 5'		0.0ppm	CL	10YR 6/6
5-7		9/8/8/11	Reddish Brown silty clay, Dry, Loose, Friable, grading to gray clay w/ some silt Low Plasticity, Dry	0954 Collect Split Spoon 1002 Collect Split Spoon 1012 Collect MW-52B & MW-52-BD		0.0ppm	CL	5YR 4/4
10-12	MW-52B & MW-52BD	4/6/7/8	yellowish red clay and silt, Dry. Black staining (Creosote?) ~~mottled~~ pinkish gray mottling.	1023 @ 15' Collect Split Spoon @ 15-17' Interval		0.0ppm	CL/ML	5YR 4/6
15-17		4/7/13/17 20"	3" Same as above except no Black staining 3"-14" light brownish gray Sandy clay, med. plastic, Dry Sand V.F.Gr., red mottling 14"-20" yellowish brown, sand, silty clay mixture, mostly Sand, Saturated Saturated ~~Interbedded~~ med to coarse gr	1029 Water @ 16.5'? will collect another spoon from 17 To 19' Interval		0.0ppm	CL/ML SC	2.5Y 6/2 10YR 5/4

All measurements should be recorded in feet or tenths of feet.

ε Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-52 | Project Name: WAF NT/FJ

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
17-19'	MW-52C + Physical	8/15/18/10	light Brownish gray SAND, saturated med to coarse gr, subangular, w/ some gravel subrounded to subangular.	1029 Collected Sample MW-52C for Physical Driller notes water Rose to 14.9' BGS. will set well screen from 14-24' BGS Begin To Pull 4.25" I.D. HSA 1053 4.25" I.D. Augers Pulled. MoB To Decon Pad for well materials 1215 Begin to overdrill Borehole w/ 8¼" I.D. HSAs. 1324 TD of 24.5' reached Install well casing 1328 Tremie pipe lowered to 23' BGS Begin to Install filter pack. 1335 Sand to 19' Pulled 5' of Augers 1357 Sand to 14' Pulled 5' of Augers 1419 Sand to 9' Pulled 5' of Augers		0.0ppm	GP	2.5Y 6/2

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

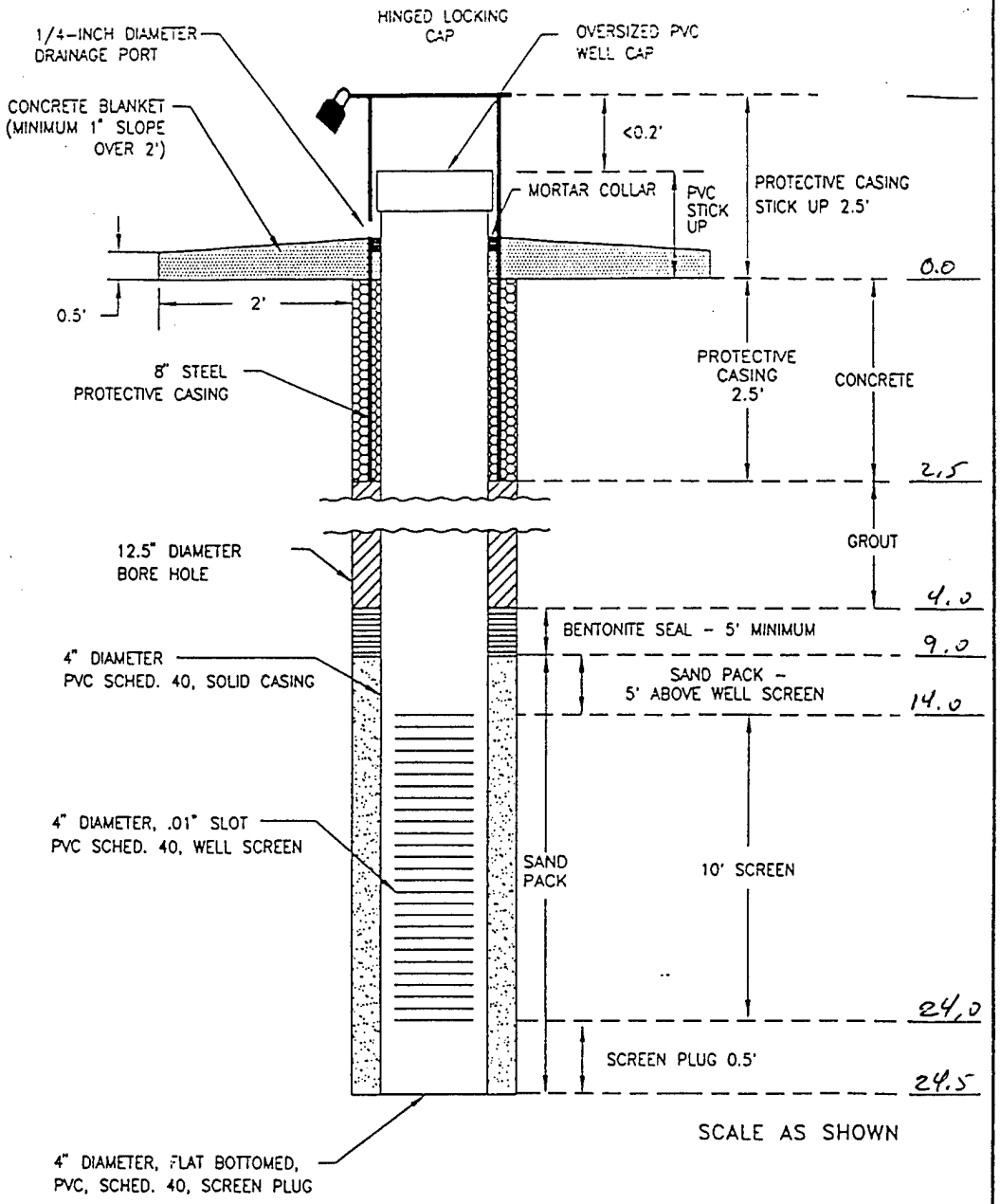
Boring No: MW-52 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MmunSELL COLOR
				1423 Installed Bentonite Seal to 4' BGS.				

All measurements should be recorded in feet or tenths of feet.

‡ Record cored intervals in this column if drilling bedrock.

5 of 5



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

Used 3 Buckets 2 1/8" Dia. Bentonite Pellets

Used 14 Bags Sieve No. 16 Solid Sand for Filter Pack

WELL NO.: MW-52

DATE COMPLETED: 11/28/85

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

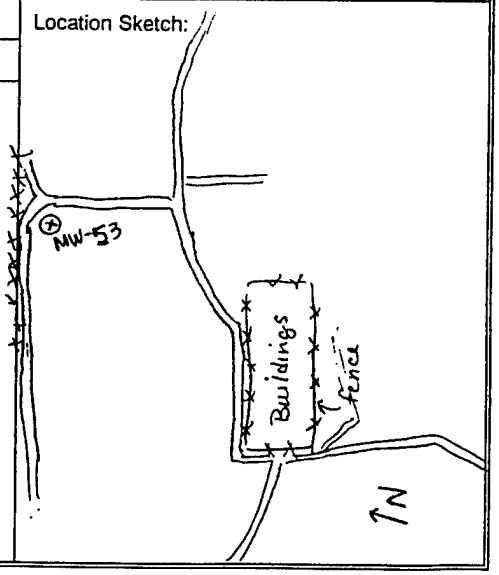
Project: WRF	Boring: MW-53
Geologist: JoAnn Stowers	Signature:
Driller & Company: Hardin Huber : Terry & Bruce	Drilling Rig: Mobile B-61
Date Boring Started: ~~8~~ 11/01/95	Completed: 11/01/95
First Encountered Water Level: 30'	Date: 11/01/95
Total Fluid Losses: 0	Date: —
Total Fluid Losses: 0	
Casing Type: PVC Schedule 40	Screened Interval: 25-35 ft.
Geophysical Logging: na	Date: —
Depth to Bedrock: na	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date: 11/01/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/01/95	1020	1200	0'	35' drilling					
11/01/95	1300	1530	0'	35' overream & well completion to bentonite seal					

Abbreviations:

Abbreviation	Meaning
%	percent
v.	very
fn	fine
gn.	grain
sn.	sized
med.	medium
lg.	large
w/	with
w/o	without
TIH	Trip into Hole
TOH	Trip out of Hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-53 | Project Name: Woodbridge Research Facility RI/FS

Driller/Company: Hardin Huber | Drilling Method: Hollow Stem Auger | Date Started: 11/1/95 | Date Completed: 11/1/95

Total Depth: 35.3 | Depth to Bedrock: NA | Water Table Depth: | Ground Elevation: NA

Protection Level: Modified D | H&S Monitoring Equipment: OVM | Logged by: J. Stevens | Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW-53 A ①	3-2-5-7	CLAYey SILT, red brown, moderately stiff, slightly moist	1030 - Collect MW-53A Auger to 5'		0.0ppm	CL/ML	7.5YR 7/2
5	MW-53 B SS ②	4-6-8-10	Same as above, but more dense, red brown	Auger to 10'		0.0ppm	CL/ML	7.5YR 7/2
10	MW-53 B ③	7-8-9-12	SAND w/ some SILT, slightly moist, color change to red brown	1100 Collect MW-53 B Auger to 15'		0.0 ppm		7.5YR 5/6
15	④	6-7-10-11	SAND, red brown, slightly moist, dense, fn to med gr, subrounded					

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

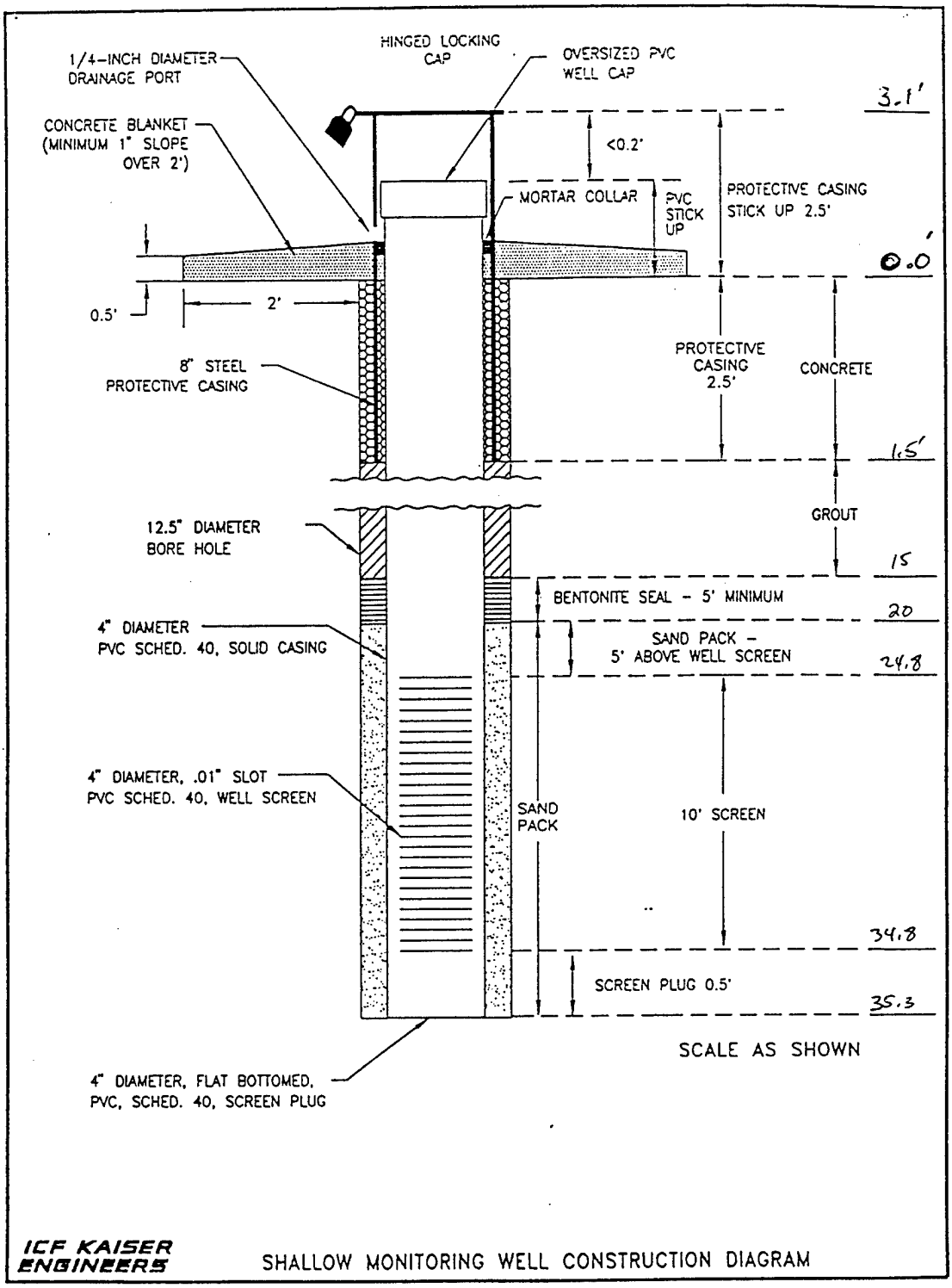
① - SP SP number

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-53 | Project Name: WRF

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	⑤	7-8-7-8	very moist, sand, red brown			0.0	SP	5yr 4/4
				Auger to 25'				
25	⑥		Pebbles, small, moist w/ 50% coarse grain sand, brown			0.0	SP	5yr 4/4
				Auger to 30'				
30	MW53C ⑦		Coarse Pebbles, saturated, w/ some silt	Collect MW53C		0.0	SP	5yr 4/4
				Auger to 35'				
35	Physical Sample		CLAY, red brown, mottled w/ light gray silty CLAY.	1130 Collect Physical Sample		0.0	SP	5yr 4/4
				TD = 35'				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

12 Bags #1 20/40 silica Sand
2 Buckets Bentonite (Baroid) 3/8" pellets
5 bgs Portland Type II Lehigh Cmt

WELL NO.: MW 53

DATE COMPLETED: 11/01/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

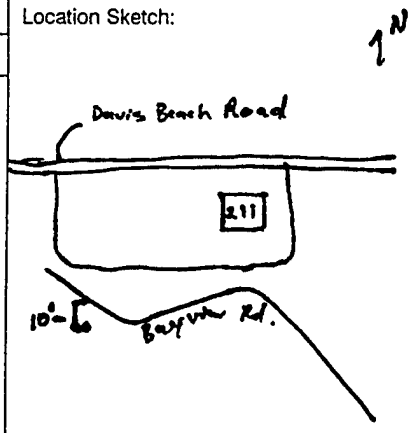
Project: WRF	Boring: MW-54
Geologist: JoAnn Stowers/Debbie Romero	Signature:
Driller & Company: Hardin Huber : Terry & Bruce	Drilling Rig: Mobile B-61
Date Boring Started: 10/31/95	Completed: 11/1/95
First Encountered Water Level: 10.3'	Date: 10/31/95
Total Fluid Losses: 0	Date:
Total Fluid Losses: 0	
Casing Type: 4" Sch. 40 PVC	Screened Interval: 17.3 - 7.3
Geophysical Logging: NA /	Date:
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date: 11/1/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
10/31/95	1615	1730	0	17'					
11/1/95	0730	0950	0	17' Over ream w 8¼" ID Auger for Well Installation to Bentonite Seal					

Abbreviations:

Abbreviation	Meaning
%	percent
Sm	Small
med	medium
lg	large
w/	with
w/o	without
v,	very
fn.	fine
gr	grain
TIH	Trip into Hole
TOH	Trip out of Hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

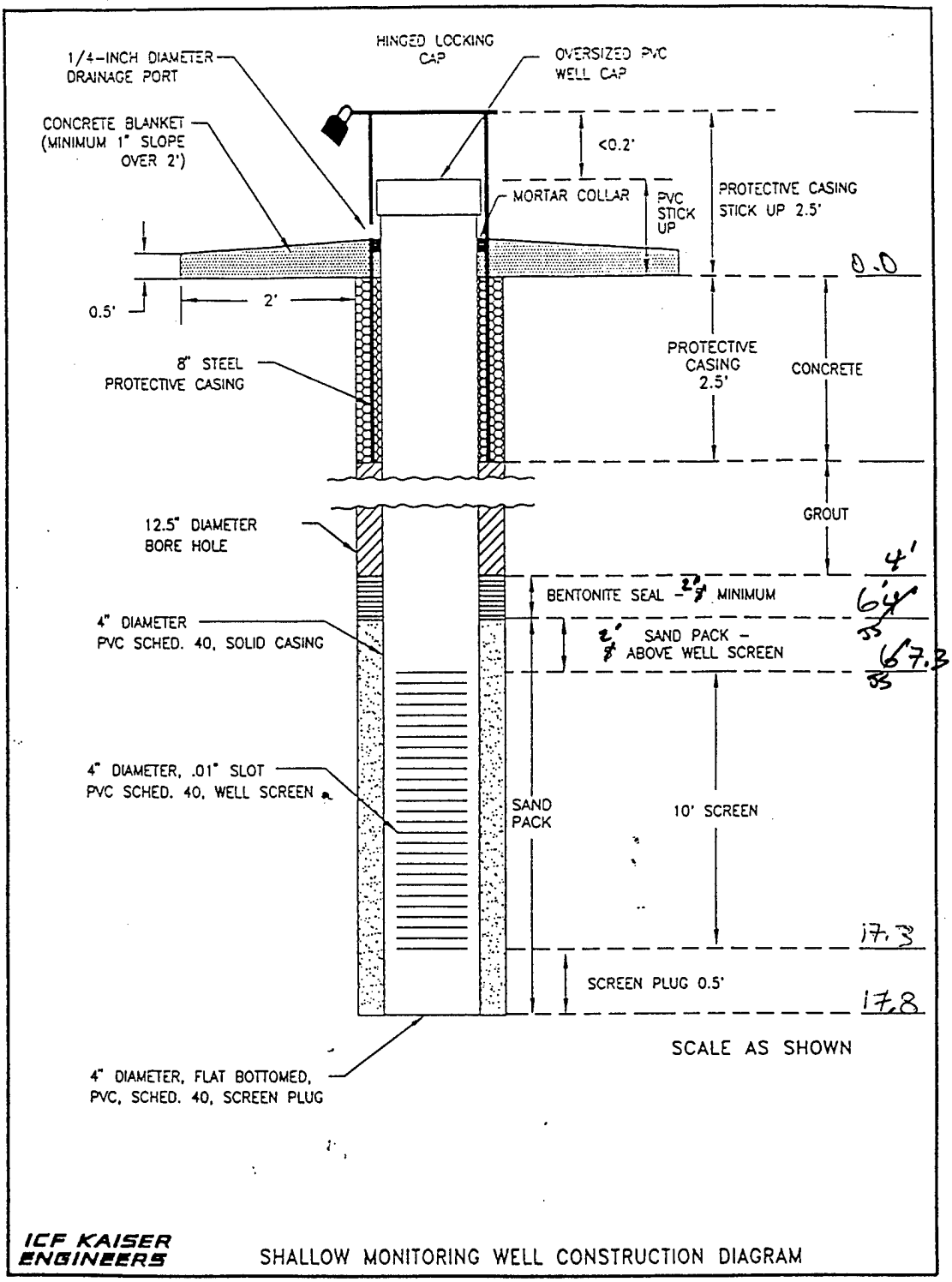
ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW 54	Project Name: WRF		
Driller/Company: Hardin Huber	Drilling Method: HSA	Date Started: 10/31/95	Date Completed: 11/1/95
Total Depth: 17.8'	Depth to Bedrock: NA	Water Table Depth: 10.2'	Ground Elevation:
Protection Level: Modified D	H&S Monitoring Equipment: OVM	Logged by: J. Stowers	Checked by: D. Yamane

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
2	MW54A	2-3-4-5 /20"	Clayey SILT, yellowish brown, moderately stiff, slightly moist 1.2' becoming increasingly stiff - clay content, increasing.	1620 - Begin drilling		0.0ppm	ML/CL	10yr 5/6
5				2-5 - HSA drilling		0.0ppm	ML/CL	7.5yr 4/6
7	MW54B	2-3-7-9 21"	CLAYey SILT, brown, stiff, slightly moist.	7-10 - HSA drilling.				
10	MW54C	6-8-5-7	Clayey SILT, to 10.3', with change @ 10.3' to Sand w/ some silt fn. to med. gr., subangular to sub rounded, brown.	H_2O @ 10.3'		0.0ppm	CL/SC	7.5yr 4/4
15	MW54 15-17'	3-44-8 physical sample	SAND, wet to saturated, brown, fn. to med. gr. subangular w/ coarse pebbles quartz	Saturated 1700 - stop drilling for the day.			SC/SP	7.5yr 4/4
20			0745 - overream to 18' to set 4" well	inside 5.4" ID augers				

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.



Well Materials: Silica Sand #1 11.5 50 16. bags
20/40 ~~#5~~ 5.5

2 buckets 3/8" Buckets Bentenite

1- 0.5' Sch 40 PVC Solid 4" Bottom Cap WELL NO.: MW-54
1- 10' Sch 40 PVC 0.01" 4" slotted Screen
1- 10' " PVC 4" Riser DATE COMPLETED: 11/1/95
1- Screw on temporary cap

Drums used for soil cuttings

Grouting - 2 bags of Portland Type II Cement
8 Gals of potable water per 94 lb bag of Cement

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

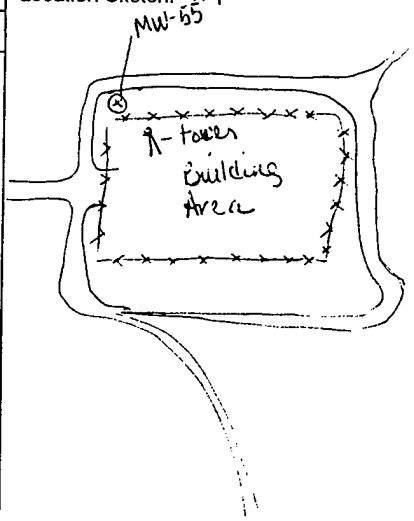
Project: WRF R1/FS	Boring: MW-55
Geologist: Debbie Romano/Dennis Batts	Signature: D. Ebert & Romano
Driller & Company: Hardin Huber - Bruce, Alonzo	Drilling Rig: Mobile B-61
Date Boring Started: 11/16/95	Completed: 11/16/95
First Encountered Water Level: 6.5 ft	Date: 11/16/95
Total Fluid Losses: n/a	Date: —
Total Fluid Losses: ——	
Casing Type: PVC Schedule 40	Screened Interval: 5-15 ft
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: Monitoring Well 4"	Date: 11/16/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/16/95	0750	0930	0	17'	4¼" auger to 17',		split spoon	17-19ft	
	0930	1020	—	—	Drillers at decon. pad.				
	1020	1205	0	15.5'	8¼" auger overream			& well installation to bentonite seal	

Abbreviations:

Abbreviation	Meaning
trace	90/10
little	80/20
some	70/30
med.	medium
fn.	fine
v.	very
w/	with
w/o	without
and	50/50
&	and
~	approximately
gr.	grain
dk	dark
lt	light

Location Sketch: N↑



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-55 Main Compound | Project Name: WRF RI/FS

Driller/Company: Hardin Huber - Bruce, Alb. | Drilling Method: Hollow Stem Auger | Date Started: 11/16/95 | Date Completed: 11/16/95

Total Depth: Split spoon 17-19' augered 4½"-17' well - 15.5 ft | Depth to Bedrock: n/a | Water Table Depth: 6.5' | Ground Elevation:

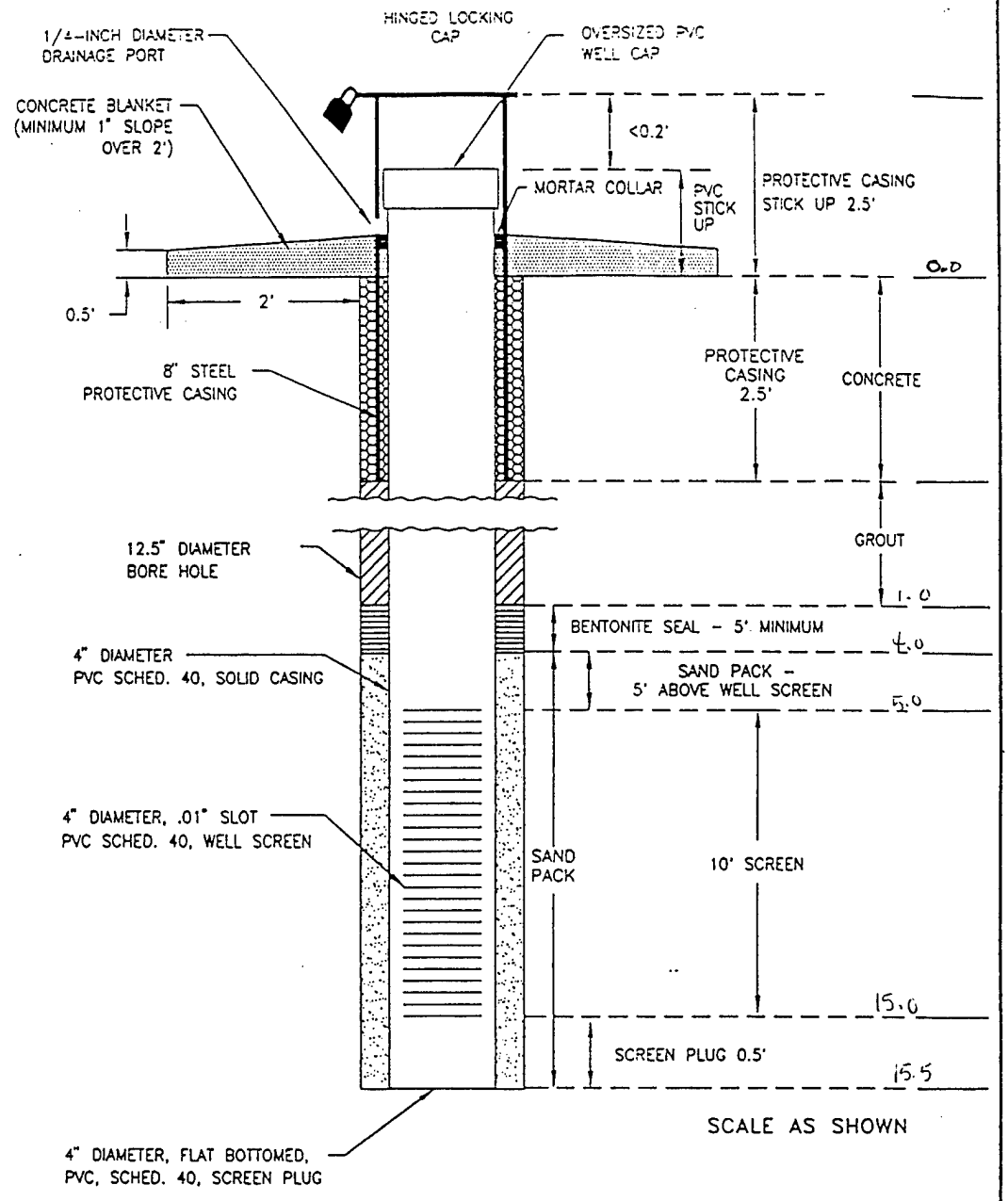
Protection Level: Modified D | H&S Monitoring Equipment: — | Logged by: Debbie Romaine | Checked by: Jack Shyman

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								
2	MW-55A 0-2' 0900	4-5-6-6 1'	Silty CLAY, brown, moist, med. plasticity, med. stiff Clayey SILT, brownish yellow w/ strong brown mottling, dry, stiff, low plasticity	Split spoon 0-2' ESE sample collected @ 0900 Auger to 5'		No OVM Quadrapole	CL ML	10YR 4/3 10YR 6/6
5		4-3-5-7 0	No recovery. Drill cuttings wet @ 6.5' Sample from cuttings at ~6.5' - Sandy CLAY, yellowish brown, wet, v.fn. sand, v. soft, little sand	split spoon 5-7' No Recovery wet at 6.5' auger to 10 ft			CL	10YR 5/6
10		6-7-6-7 2'	0-1' CLAY, brown, wet, high plasticity, mottled w/ strong brown, stiff, very thin layer of gravelly sand, wet, only ~1/8" thick 1-2' CLAY, gray, moist, stiff, high plasticity	split spoon 10-12' auger to 12'			CH SP	10YR 5/3 10YR 5/3 ~~2.5Y5/1~~
12	MW-55B 12-14' 0917	4-2-3-4 20"	CLAY, gray, wet, soft, high plasticity, color becomes dark gray at bottom of spoon.	split spoon 12-14' ESE sample collected @ 0917 auger to 15'			CH	2.5Y5/1
14							CH	2.5Y5/1 & 2.5Y4/1
15	MW-55C 15-17 0925	2-2-3-5 2'	CLAY, very dark grayish brown, wet, high plasticity very thin med. gram sand lenses towards bottom	split spoon 15-17 ft ESE sample collected @ 0925 auger to 17' Split spoon 17-19'			CH	2.5Y3/2
17	Physical sample 18-19	3-3-4-5 2'	16' CLAY, ~~gr~~ v. dk. grayish brown to v. dk gray, wet, high plasticity soft 19-22" Clayey SAND, gray, wet, fn. to med sand. 22-24" CLAY, gray, wet, high plasticity				CH SC	2.5Y3/2 to 3/1 2.5Y5/1
19								

's should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

10/20 - Set up & begin overream
1105 - PVC risers, screen plug & screen in well, depth 15.5'
1150 - ~~12~~ → 12 bags of sand, sand to 4'
1205 - 2 buckets of bentonite to 1'

1x 10' PVC screen
1x 0.5' PVC screen plug
1x 10' PVC riser



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-55

DATE COMPLETED: 11/16/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

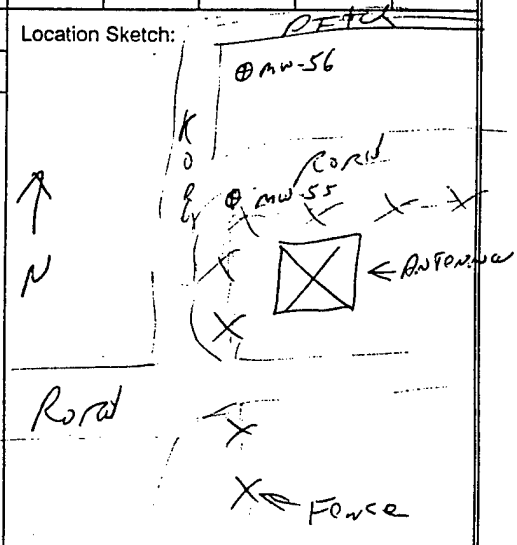
Project: WRF RI/FS	Boring: ~~MW-77~~ DB MW-56
Geologist: D. ROMANO / D. BATTS	Signature: Dennis Batts
Driller & Company: HHI / BRUCE, ALONZO	Drilling Rig: MOBILE B-57 ATV
Date Boring Started: 11/17/95	Completed: 11/17/95
First Encountered Water Level: 15'	Date: 11/17/95
Total Fluid Losses: —	Date: —
Total Fluid Losses: —	
Casing Type: PVC SCHEDULE 40	Screened Interval: 13-23'
Geophysical Logging: N/A	Date: —
Depth to Bedrock: N/A	Ground Elev.: —
Boring Completion Information: Completed as 4" monitoring well	Date: 11/17/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/17/95	1450	1550	0	20'	4 1/4" ID AUGER				
11/17/95	1605	1819	0	23.5'	8 1/4" AUGER OVERREAM & install monitoring well.				

Abbreviations:

Abbreviation	Meaning
MED.	MEDIUM
FN.	FINE
V.	VERY
GR.	GRAIN
TRACE	90/10
LITTLE	80/20
SOME	70/30
AND	50/50
DK	DARK
LT	LIGHT

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: ~~MW-77~~ MW-56 | Project Name: WRF RI/FS

Driller/Company: HHI/BRUCE, ALONZO | Drilling Method: HOLLOW - STEM AUGER | Date Started: 11/17/95 | Date Completed: 11/17/95

Total Depth: 22.5' | Depth to Bedrock: N/A | Water Table Depth: 15' | Ground Elevation:

Protection Level: MODIFIED LEVEL B | H&S Monitoring Equipment: OVM | Logged by: DENNIS BATTS | Checked by: Jack Chojnowski

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0	MW-56A 1455	3-4-5-5 11"	SILTY CLAY, INCREASING SAND TOWARDS BOTTOM (TRACE SAND), MEDIUM PLASTICITY, MOIST, YELLOWISH-BROWN (STIFF)	SPLIT SPOON 0-2' AUGER TO 5' ESE SAMPLE COLLECTED AT 1455 MW-56A		0.0	CL	10YR 5/4
5		2-6-5-7 21"	0-4" SILTY CLAY WITH TRACE SAND, YELLOWISH-BROWN, MED. PLASTICITY 4-8" SANDY CLAY, LOW PLASTICITY, STRONG BROWN, MOIST, FINE GR SAND 8-10" GRAVELLY SAND WITH SOME CLAY, FINE GRAVEL WITH SOME PEBBLES (UP TO .25"), ~~GRAY~~, STRONG BROWN, MOIST 10-21" SILTY CLAY, MEDIUM PLASTICITY, MOIST, GRAY AND BROWN MOTTLED (STIFF)	SPLIT SPOON 5-7' AUGER TO 7'		0.0	CL CL SW CL	10 YR 5/4 7.5YR 5/6 2.5Y 6/1
10	MW-56B 1540	4-3-3-5 22"	0-2" SILTY CLAY, MEDIUM PLASTICITY, MOIST, GRAY AND BROWN MOTTLED 2-4" SANDY CLAY, LOW PLASTICITY, GRAY AND BROWN MOTTLED, MOIST, FINE GR SAND 4-22" SILTY CLAY, MED. PLASTICITY, MOIST, GRAY (MEDIUM STIFF)	SPLIT SPOON 10-12' AUGER TO 12' ESE SAMPLE COLLECTED AT 1540 MW-56-B		0.0	CL CL CL	2.5Y 6/1 2.5Y 6/1
15	MW-56C 1545	2-3-2-3 24"	0-16" [redacted] CLAY, WET, GRAY, MEDIUM PLASTICITY, SOME SILT 16-24" CLAY WITH ~~TRACE~~ 2B LITTLE SAND (INCREASING TOWARD BOTTOM) WET, GRAY AND BROWN MOTTLED, MED (STIFF)	SPLIT SPOON 15-17' DRILLER SAYS WATER TABLE AT 15' AUGER TO 17' ESE SAMPLE COLLECTED AT 1545 MW-56C		0.0	CL CL	2.5Y 6/1 10YR 5/4 2.5Y 6/1
20								

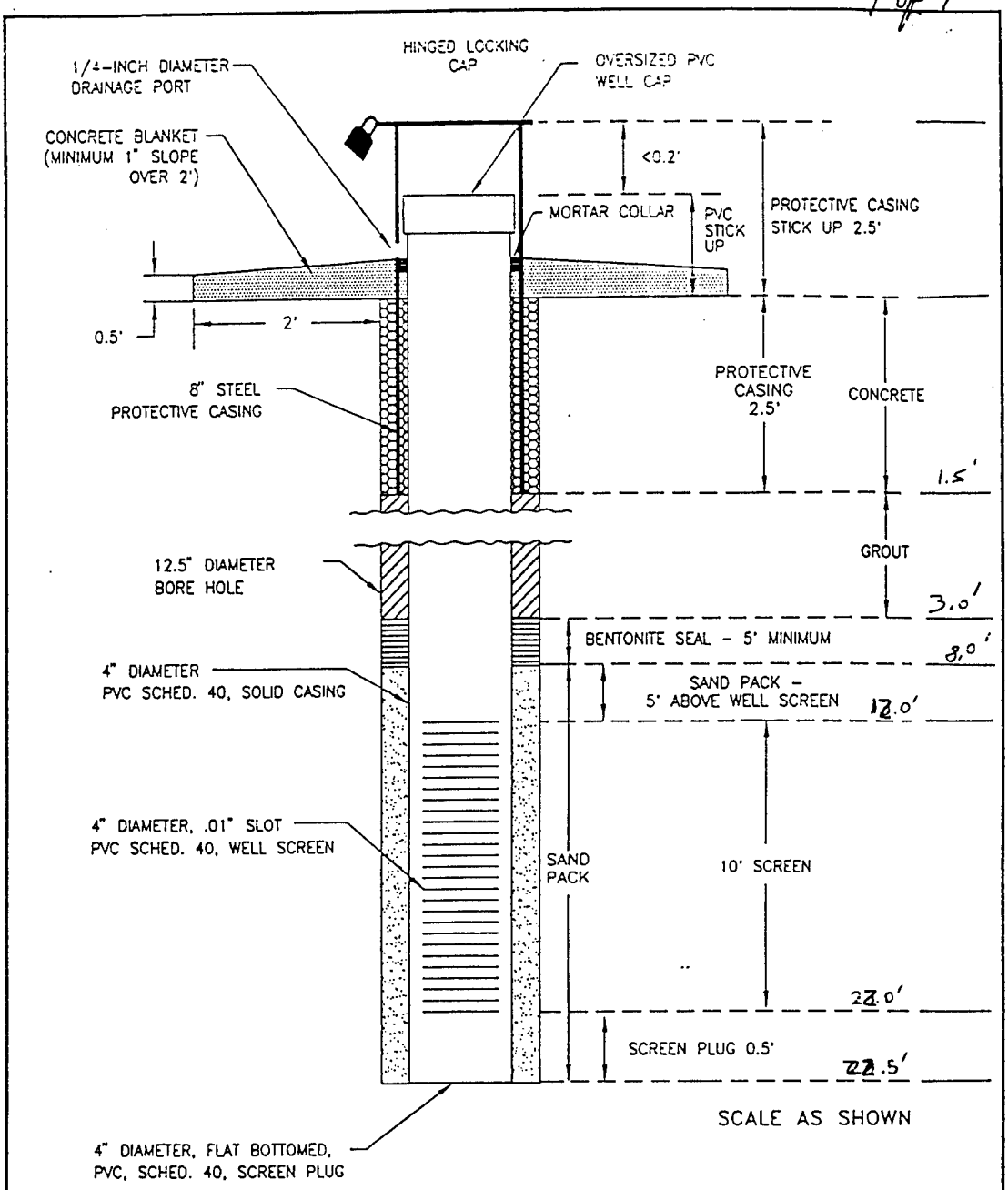
All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-56 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20	PHYSICAL SAMPLE	3-5-12-27 21"	CLAY WITH SOME SAND (FINE TO MED. GRAIN), WET, MED. PLASTICITY, SOME BROWN MOTTLING TOWARD BOTTOM GRAY W/ (VERY STIFF)	SPLIT SPOON 20-22'		0.0	CL	10YR 5/1
22				1721 Knocked at sand with a Roller cone bit.				
25			11/17/95 1605 - 8 1/4" OVERREAM TO 23.5' TD = 23.5 Begin well Installation 1650 Auger Plug sounded in auger 5' down will knock out Plug with Roller Bit. Dir our 4' of sand in auger 1707 Bottom of well @ 22' Installed well casing. Screen 12 - 22' Tremie pipe @ 20' BGS Begin Installing Filter pack 1715 4' of sand in auger. withdrew well casing.	1725 Re Installed casing cost 1' of depth Installed well screen 12-22' BGS. TIH Tremie pipe to 19' Begin Installing Filter Pack. Sand @ 19' Pulled 5' of Auger. Sand @ 13' Pulled 5' of Auger. Sand Pack @ 9' pulled 5' of Auger 1811 Filter pack Installed To 8' BGS 1819 Installed Bentonite Seal To 3' BGS				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-56

DATE COMPLETED: 11-17-95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

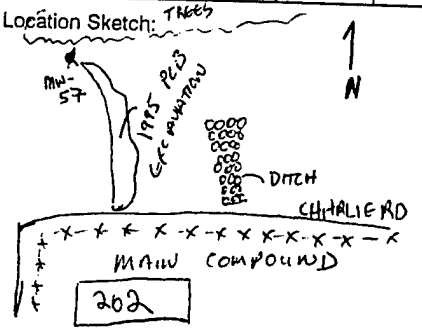
Project: WRC RI/FS	Boring: MW-73BB 57
Geologist: Jack Chojnowski / Dennis Barth	Signature: Jack Chojnowski
Driller & Company: Rick Rivor / Hardin-Hydor Inc.	Drilling Rig: B 57
Date Boring Started: 11/28/95	Completed: 11/28/95
First Encountered Water Level: 15'	Date: 11/28/95
Total Fluid Losses: N/A	Date: —
Total Fluid Losses: N/A	
Casing Type: 4" ID Sch. 40 PVC	Screened Interval: 12-22'
Geophysical Logging: None	Date: —
Depth to Bedrock: not encountered	Ground Elev.:
Boring Completion Information: 4" PVC Monitoring Well	Date: 11/28/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/28/95	0906	1042	0	20'					
11/28/95	1111	1305	0	22.5'		OVERREAM WITH 8.25" AUGER			

Abbreviations:

Abbreviation	Meaning
Trace	10/90%
and	50/50%
Some	30/70%
%	Percent
BGS	Below ground surface
HSA	Hollow stem augers

Location Sketch: TREES



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-~~53~~ 57		Project Name: WRF RI/FS	
Driller/Company: Rick Ridler / H H I	Drilling Method: HSA sample ~ 4.25" I.D. overream ~ 8.25" I.D.	Date Started: 11/28/95	Date Completed: 11/28/95
Total Depth: 22.5'	Depth to Bedrock: not encountered	Water Table Depth: 15.0'	Ground Elevation:
Protection Level: modified D	H&S Monitoring Equipment: microtip - PID	Logged by: Jack Chrysnel	Checked by: Jack Chrysnel

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0-2	MW-~~53~~A COLLECTED 0915	1-3-5-2 ~~MW-73A COLLECTED AT 0915 DB~~ 15"	CLAY WITH A LITTLE SILT, MODERATE TO HIGH PLASTICITY, DRY, BROWN WITH SOME DARK BROWN MOTTLING	Sampling w/ 2" OD X 2' length split spoon sampler inside 4.25" I.D. HSA. 0915 MW-~~53~~A 0-2' AUGER TO 5'		0.0	CL/ML	10YR 5/3
5-7	MW-~~53~~B COLLECTED 0923	3-5-6-7 21"	CLAY WITH TRACE SILT, HIGH PLASTICITY, DRY, GRAY WITH BROWN MOTTLING	SAMPLING W/ 2" OD x 2' LENGTH SPLIT SPOON SAMPLER INSIDE 4.25" ID HSA 5-7' AUGER TO 10' 0923 MW-~~53~~B		0.0	CH	2.5YR6/1
10-12		3-6-7-7 22"	SAME AS ABOVE, NO MOISTURE, HIGH PLASTICITY, GRAY WITH BROWN MOTTLING	SAMPLING W/ 2" OD x 2' LENGTH SPLIT SPOON SAMPLER INSIDE 4.25" ID HSA 10-12' AUGER TO 15' WATER AT 15.0' 0951		0.0	CH	2.5YR6/1
15-17	MW-~~53~~C MW-730 DUP COLLECTED 0955	3-7-7-7 24"	SANDY CLAY, WET, GRAY, LOW PLASTICITY SAND INCREASING TOWARDS BOTTOM (FROM 0-24")	2" OD SPLIT SPOON (2' LENGTH) 15-17' AUGER TO 20' 0955 MW-~~53~~C MW-~~53~~ DUP		0.0	SC	5Y5/1

All measurements should be recorded in feet or tenths of feet. ε Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-~~73DB~~57 Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20'	[redacted]	10-36-8-12	VERY LITTLE RECOVERY, GRAVEL WITH LITTLE SAND, GRAVEL SIZE 1/8"–1" ANGULAR TO SUB-ROUNDED, TRACE CLAY	SPLIT SPOON SAMPLE (2" OD X 2' LENGTH) FROM 20-22'		0.0	SP	5YR 5/1
22'		~0"		NO RECOVERY - NO PHYSICAL SAMPLE 1049				
25'				11/28/95 1042 - REMOVE LAST OF 4 4.25" AUGERS FROM HOLE 1111 - BEGIN 8.25" AUGER OVERREAM 1123 - ~4.5' OF WATER POURED INTO LEAD AUGER TO HOLD PLUG 2nd AUGER ADDED 1140 - AUGER FILLED TO 10' WITH WATER 3rd AUGER ADDED 1156 - AUGER FILLED TO 13.5' WITH WATER 4th AUGER ADDED 1213 - AUGER FILLED TO 19' WITH WATER 5th AUGER ADDED 1228 - TD reached. TD = 22.5' Plug up 6" in Augers TO of well Will be 22.5' Screen 12.0' — 22.0', will use 8" Roller Cone Bit To Knock out plug. 1305 - BEGIN INSTALLING CASING & ADDING FILTER PACK TREMIE PIPE LOWERED TO 20' TO INSTALL FILTER PACK 1323 - SAND TO 20'. PULLED 5' OF AUGER				

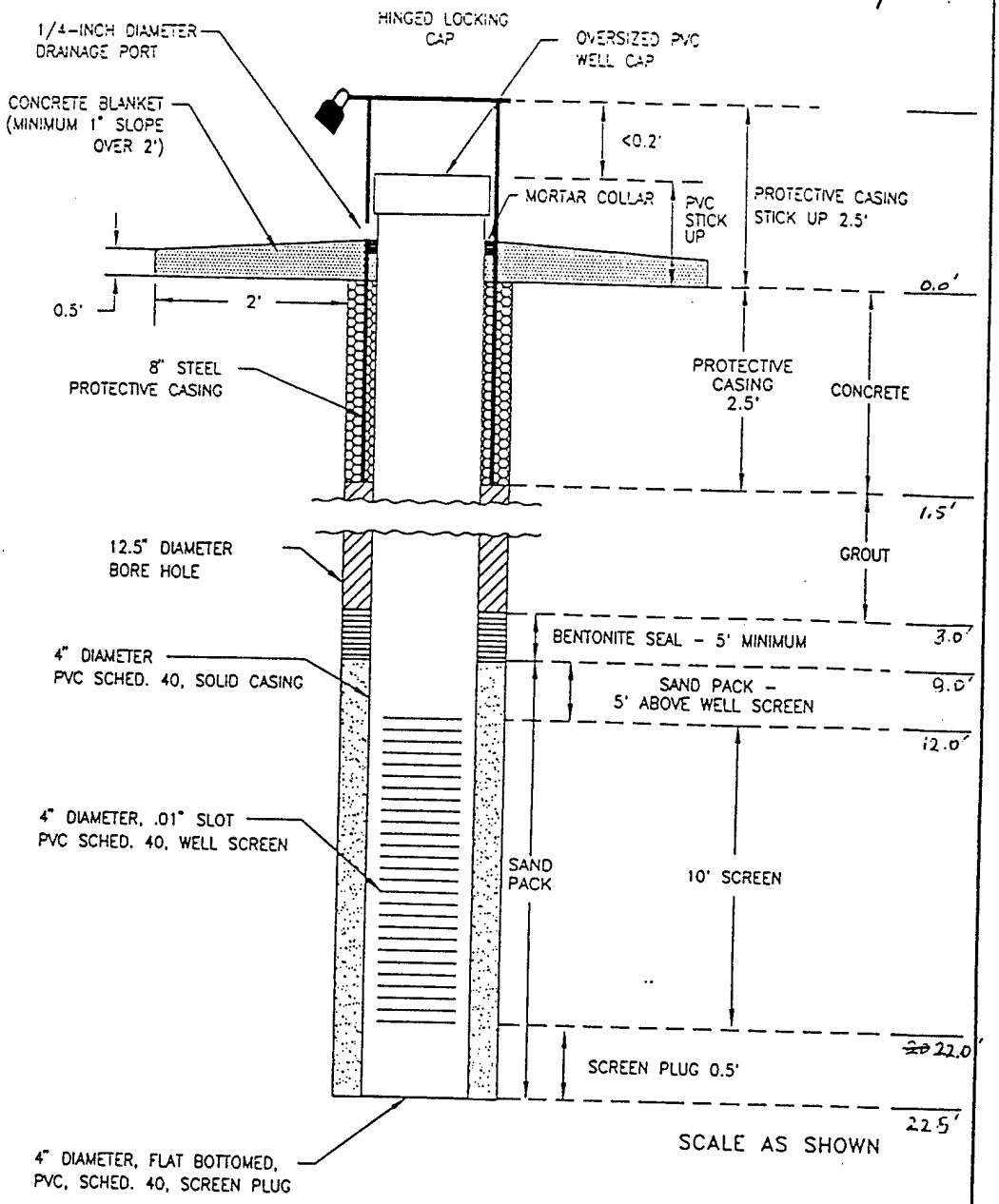
All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-57 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				1405 - SAND TO 14'. PULLED 2nd 5' OF AUGER 1421 - SAND TO 9'. PULLED 3rd 5' OF AUGER 1427 - SAND TO 8'. INSTALL BENTONITE SEAL TO 3'. 1440 - PULLED 4th 5' OF AUGER. BENTONITE SEAL IS TO 6'. 1449 - BENTONITE SEAL IS TO 3'. 1455 - PULLED LAST 5' OF AUGER. 15 BAGS OF SAND (#1) 3 BUCKETS OF BENTONITE PELLETS DSI BRAND SHUR-PEL 3/8"				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-57

DATE COMPLETED: 11/28/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

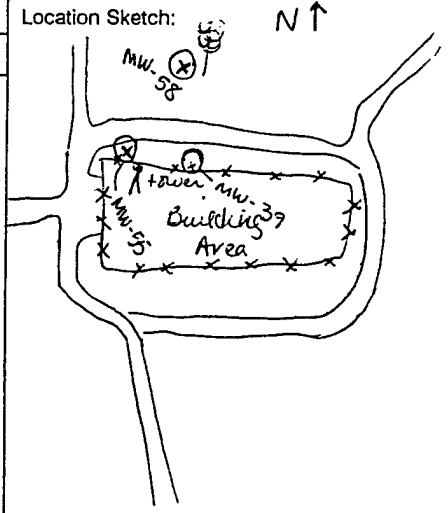
Project: WRF - RI/FS	Boring: MW-58 Main Compound
Geologist: DENNIS BATTS/DEBBIE ROMANO	Signature: Dennis Batts
Driller & Company: H&H / BRUCE	Drilling Rig: MOBILE B-57 ATV
Date Boring Started: 11-16-95	Completed: 11-16-95
First Encountered Water Level: 4'	Date: 11-16-95
Total Fluid Losses: N/A	Date: ———
Total Fluid Losses: ———	
Casing Type: PVC SCH. 40	Screened Interval: 4-14'
Geophysical Logging: N/A	Date: ———
Depth to Bedrock: N/A	Ground Elev.:
Boring Completion Information: 4" MONITORING WELL	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11-16-95	1500	1545	0	14.5'	4 1/4" ID AUGER				
	1545	1710	0	14.5'	8 1/4 ID AUGER (OVER-REAM). well installed to bentonite seal.				

Abbreviations:

Abbreviation	Meaning
trace	90/10
little	80/20
v.	very
some	70/30
fn	fine
med.	medium
dk	dark
lt.	light
w/	with
w/o	without
gr.	grain

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

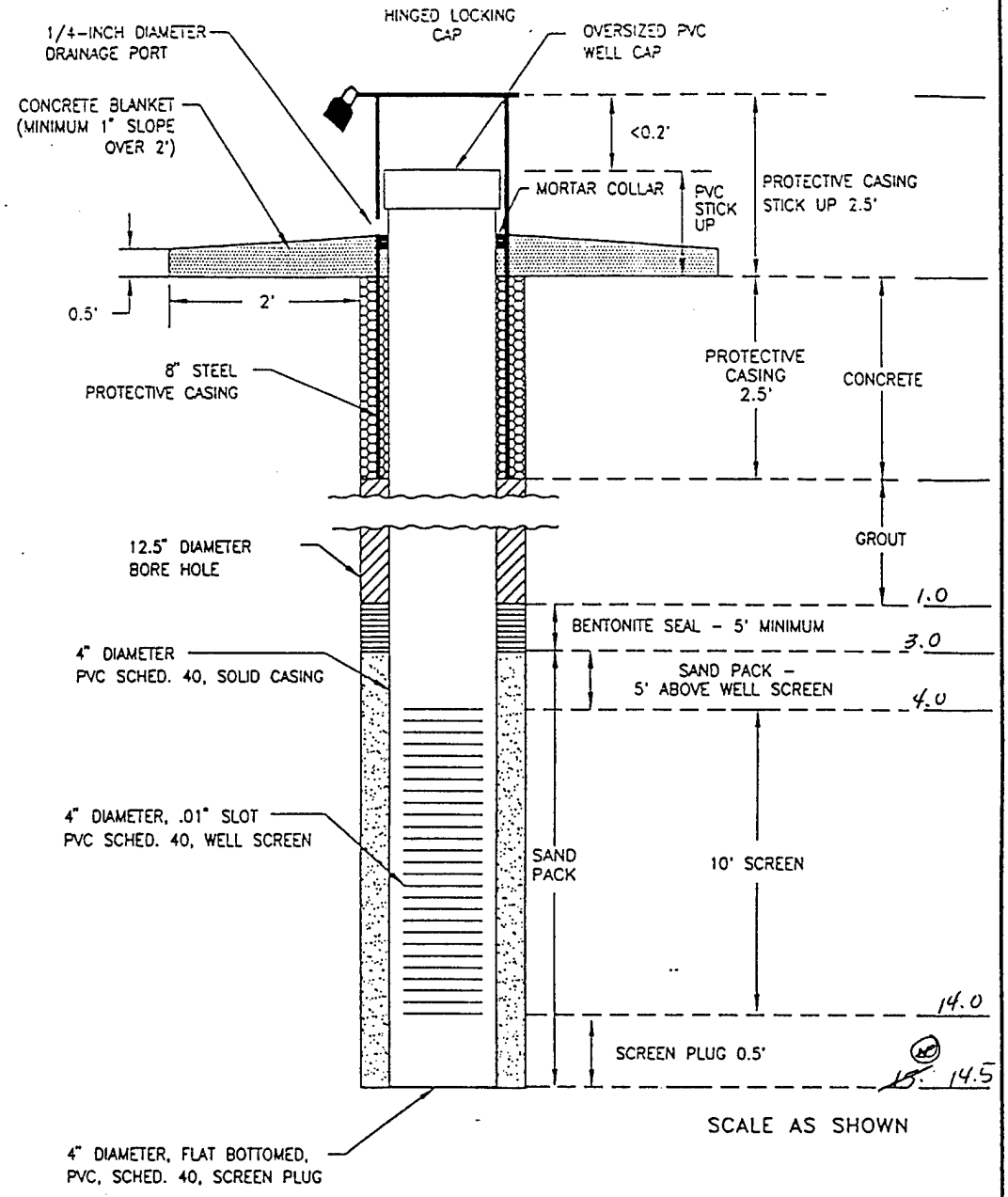
ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-58 Main Compound		Project Name: WRF RI/FS	
Driller/Company: BRUCE / H&H	Drilling Method: HOLLOW-STEM AUGER	Date Started: 11-16-95	Date Completed: 11/16/95
Total Depth: 14.5'	Depth to Bedrock: N/A	Water Table Depth: 4'	Ground Elevation:
Protection Level: MODIFIED LEVEL B	H&S Monitoring Equipment: ——	Logged by: D. BATTS	Checked by: P. Thompson

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MmunSELL COLOR
0	MW-58A 0-2' 1530	4-7-9-10 18"	Clayey SILT grading to all SILT, dk. yellowish brown, slightly moist at top 2", then dry, very low plasticity at top, no plasticity at for rest of spoon,	Split spoon 0-2' auger to 5'		NO OVM AVAILABLE	ML	10YR 4/4
2				driller says soil cuttings wet at 4'				
5	MW58 B 5-7' 1540	8-12-14-16 16"	Sand with little silt grading to gravelly sand, medium dense sand, yellowish-brown, wet, bottom 5" is gravelly sand with slightly more silt, sand fine to medium grain	Split spoon 5-7' auger to 7'			[redacted] SM	10YR5/4
7	MW-58C 7-9' 1545	11-15-15-14 24"	Sand with silt(little), 4" clay lens at top, reddish brown, back to gravelly sand (5"), yellowish-brown, then rest is finer-grain silty sand, gray, wet, medium dense	Split spoon 7-9' auger to 9'			CL SM SW	5YR 5/4 10YR 5/4 2.5YR 6/1
9								
10	9-11' PHYSICAL SAMPLE	4-9-7-11 15"	Sand. Top 2" clayey sand, dk yellowish-brown, sand grading to finer grained (very fine) sand with some silt, bottom 4" very fine sand, gray with brown mottled medium dense sand, wet	Split spoon 9-11' auger to 14.5'			SM	10YR4/6 2.5YR6/1
11								
15			11/16/95 1630 - Installed screen & riser. 1635 - Poured 2 bags of sand down borehole to prevent heaving sands 1637 - Added 10½ bags of sand, sand to 3' 1705 - Added 2 buckets of bentonite, bentonite to 1'					

All measurements should be recorded in feet or tenths of feet. ε Record cored intervals in this column if drilling bedrock.

1 x 10' PVC screen
1 x 10' PVC riser
1 x 0.5' PVC screen plug.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-58

DATE COMPLETED: 11/16/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

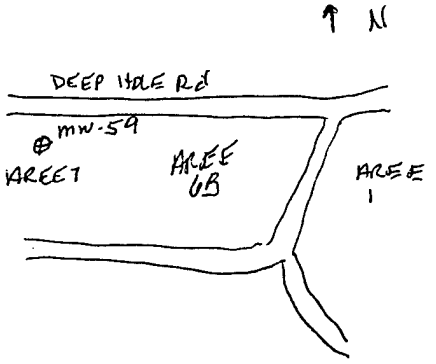
Project: WRF RI/FS	Boring: MW-59 AREE 7
Geologist: Debbie Romano/Jack Chojnowski	Signature: Deborah J Romano
Driller & Company: Bruce, Alonzo - Hardin-Huber	Drilling Rig: Mobile B-61
Date Boring Started: ~~11/14/95~~ OK 11/15/95	Completed: 11/15/95
First Encountered Water Level: 26 ft	Date: 11/15/95
Total Fluid Losses: n/a	Date: —
Total Fluid Losses: n/a	
Casing Type: PVC Schedule 40	Screened Interval: 22-32.0 ft
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information:	Date:

Date	Time		Depth of Drilling Per Shift (ft)		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/15/95	0800	0945	0	~~31~~ 29 OK	4¼" ID auger, split spoon 29-31'				
11/15/95	1045	1145	0	15	8¼" ID auger, overream (break for lunch at 1145)				
11/15/95	1255	1555	15	32.5	8¼" ID auger overream well installed to bentonite seal				

Abbreviations:

Abbreviation	Meaning
trace	90/10
little	80/20
some	70/30
v.	very
fn	fine
med.	medium
dk.	dark
lt.	light
w/	with
w/o	without
gr.	grain

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-59 (Alonzo, Henry)
Project Name: WRF RI/FS
Driller/Company: Bruce, Alonzo - Hardin-Hueben
Drilling Method: Hollow Stem Auger
Date Started: ~~11/14/95~~ 11/15/95
Date Completed: 11/15/95
Total Depth: 32.5 ft
Depth to Bedrock: n/a
Water Table Depth: 26 ft
Ground Elevation:
Protection Level: Modified D
H&S Monitoring Equipment: OVM
Logged by: Debbie Romano
Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								
2'	MW-59A 0-2' 0818	3-8-11-11 20"	Silty CLAY, strong brown, med. plasticity, stiff, dry grading to SILT w/ little f. v. fn. gr. sand (at ~10") strong brown, no plasticity, very stiff. dry	Split spoon 0-2" Collect ESE sample 0-2' 0818 MW-59A auger to 5' 4¼" ID		0	CL-ML	7.5 YR 5/6
5		9-9-14-16 21"	Silty CLAY, brown w/ little strong brown (7.5 YR 5/6) mottling, dry very stiff, low plasticity	split spoon 5-7' auger to 10' 4¼" ID		0	CL	7.5 YR 5/3
7'				Soil cuttings at 9', slightly clay high plasticity				
10		3-3-5-7 2'	CLAY, lt. olive brown, wet, v. high plasticity, soft to med. stiff.	split spoon 10-12' Auger to 15' 4¼" ID		0	CH	2.5 Y 5/3
12'								
15		9-12-9-13 18"	SAND, fn gr., to Silty SAND, strong brown, dry med. dense (0-11")	split spoon 15-17' auger to 20' 4¼" ID		0	SM	7.5 YR 4/6
17'			Clayey SILT, strong brown, at ~11-16", dry, low to med. plasticity				ML	
20			Silty SAND, 16-18", dry, strong brown, fn. gr. sand.				SM	

All measurements should be recorded in feet or tenths of feet.
‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

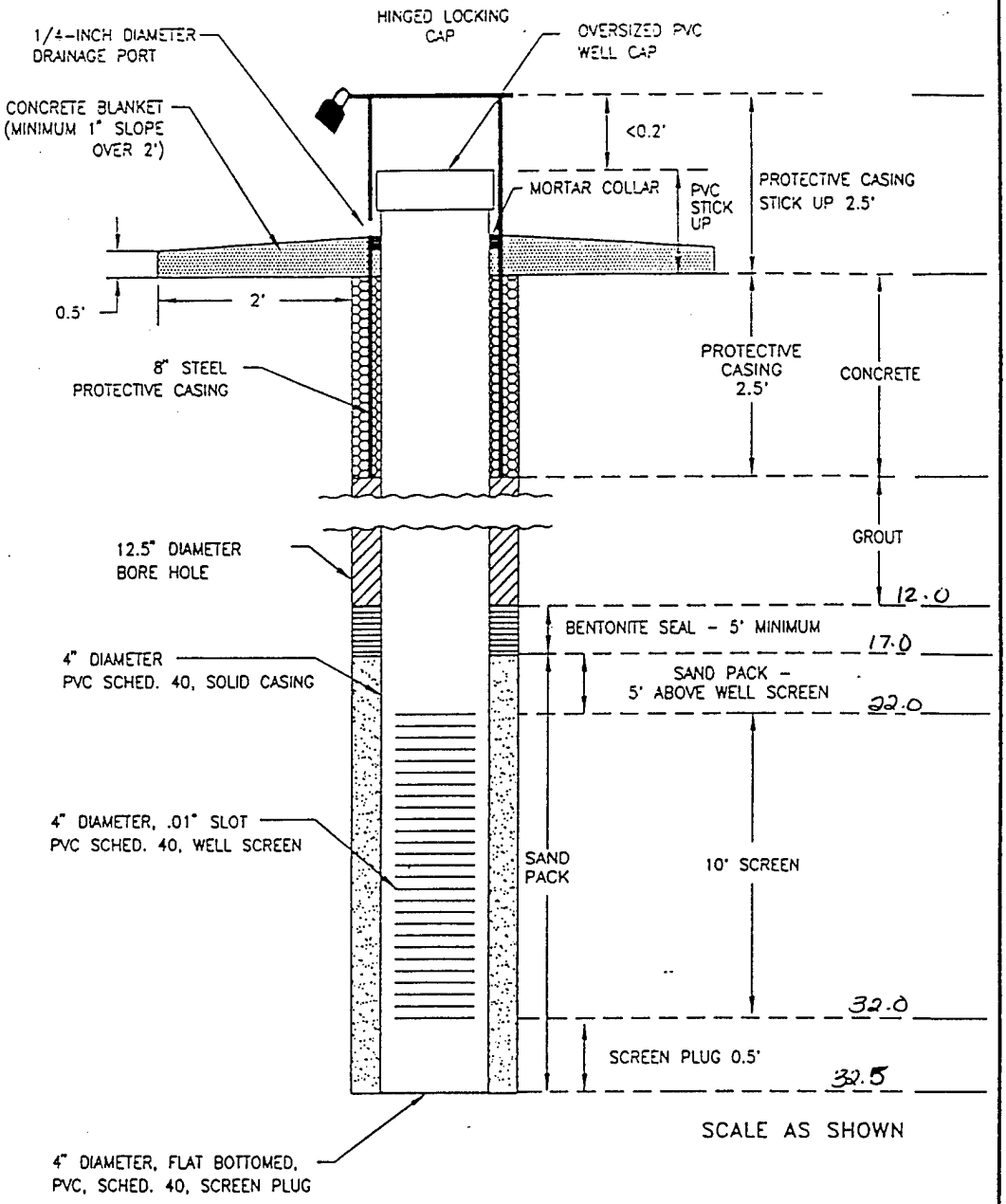
Boring No: MW-59 AREE 7 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20		5-12-22-27	Top 20" - CLAY, dry, reddish brown, v. high plasticity very stiff	Split spoon 20-22' auger to 25'		0	CH	5YR 4/3
22'		2'	Very thin layer, oxidized, sandy SILT, yellowish red, ½" thick				ML	5YR 4/6
			20-24" - Silty SAND, fn. gr to med. grain, brown, trace fn. gravel, moist.				SM	7.5YR 5/3
25				Hit water 26'				
	MW-59B 25-27' 0913	8-11-12-12 1'	Silty SAND, lt. yellowish brown, fn to med. grain sand, Wet, trace coarse sand, med. dense.	split spoon 25 to 27' auger to 27'		0	SM	10YR 6/4
27	Physical Sample 27-29'	4-8-9-11 18"	Silty SAND, lt. yellowish brown, fn to med. gr. sand, trace coarse sand, wet, med. dense	split spoon 27-29' auger to 29' Physical sample collected		0	SM	10YR 6/4
29'			color changes to 2.5Y 6/3 lt. yellowish brown towards bottom of spoon; sand becomes coarser towards bottom of spoon; a reddish brown clay stringer at ~9"-12"					10YR 6/4 2.5Y 6/3
30	MW-59C 29-31' 0938	7-8-10-10 20"	Same as above, but sand is mostly fn. to med grain, wet	split spoon 29-31' ESE sample collected @ 0938, 29-31', MW-59C		0	SM	
			Clay stringer 2.5Y 6/2 lt. brownish gray & reddish brown occurs ~10-14", wet.					
35			11/15/95					
			1045- ~~Begin overreaming w/ 8¼" ID auger.~~ Pull up 4¼" ID augers.					
			1115- Begin overreaming w/ 8¼" ID augers.					
			1145- Break for lunch, 3 augers in hole.					
			1255- Resume overreaming					
40			1330- Augered to 32.5 ft.					

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

1335- Put PVC screen & casing in well.
Augers are full of water to prevent heaving sands
1 bag of sand added directly after knocking the plug out.
1410- 3 bags of sand in, 30' to sand, 1 augers out
1505- 18' to sand, 3 augers out
1540- 16 bags of sand in, sand to 17'.

1 x 10' PVC screen
3 x 10' PVC riser
1 x .5' PVC screen plug
} Schedule 40



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-59

DATE COMPLETED: 11/15/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

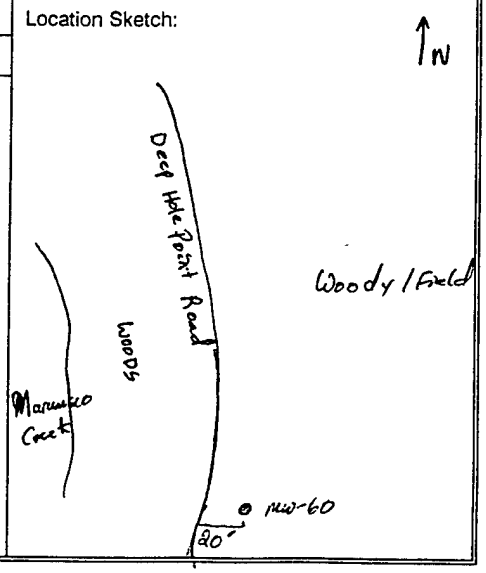
Project: WRF	Boring: MW-60
Geologist: J. Stevens	Signature:
Driller & Company: Harden Hubes	Drilling Rig: B-61
Date Boring Started: 11/02/95	Completed: Abandoned 11-7
First Encountered Water Level: 33'	Date: 11/02/95
Total Fluid Losses: 0	Date: —
Total Fluid Losses: 0	
Casing Type: 4" Sch 40 PVC	Screened Interval: ~~30~~ 40
Geophysical Logging: NA	Date:
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: 4" Monitor well	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/02/95	1250	1730	0	37.5					
11/03/95	1030	Begin Overream							
	0	40	0	40					
		1140	Break for Lunch						

Abbreviations:

Abbreviation	Meaning
v.	very
fn.	fine
gr	grain
sm	small
md	medium
lg	large
w/	with
w/o	without
%	percent
TIH	Trip into Hole
TOH	Trip out of Hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-60	Project Name: WRE		
Driller/Company: Hardy Huber	Drilling Method: HSA	Date Started: 11/02/95	Date Completed: Abandoned
Total Depth: 40'	Depth to Bedrock: NA	Water Table Depth: 33'	Ground Elevation:
Protection Level: Modified D	H&S Monitoring Equipment: OVM	Logged by: JC Sk	Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	2-3-6-4 MW60 A	→ /14"	SILTY CLAY, yellowish brown, medium stiff, slightly moist	1255 - Collect MW-60 A		—	CL	10YR 6/4
			1.5' - mottled w/ gray silty clay.	Auger to 5'				
5	MW 60B	4-6-9-9 /16"	See as above w/ increasing silt content (mottled gray silty clay, stiff, slightly moist. w/ fn. gn Sand (trace) - high plasticity toward end of spoon	1300 - Collect MW-60B		—	CL/ML	
				Auger to 10'				
10		2-2-2-4 /20"	CLAY, wet @ 10.5', saturated @ 11.0' light grayish brown, soft creamy textured,	1310 5 - Collect sp sp Sample		—	CL	10YR 6/2
15		4-5-5-9	CLAY @ 16.5 to reddish brn stiff sand, no plasticity, clay sand - fn to f.v.fn. gn. highly oxidized layer			—	ML/SC	5YR 4/4
20		9-7-7-6	Same as above, but very moist to wet, silt content increased, clay content					

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.

- OVM NOT WRG PROPERLY

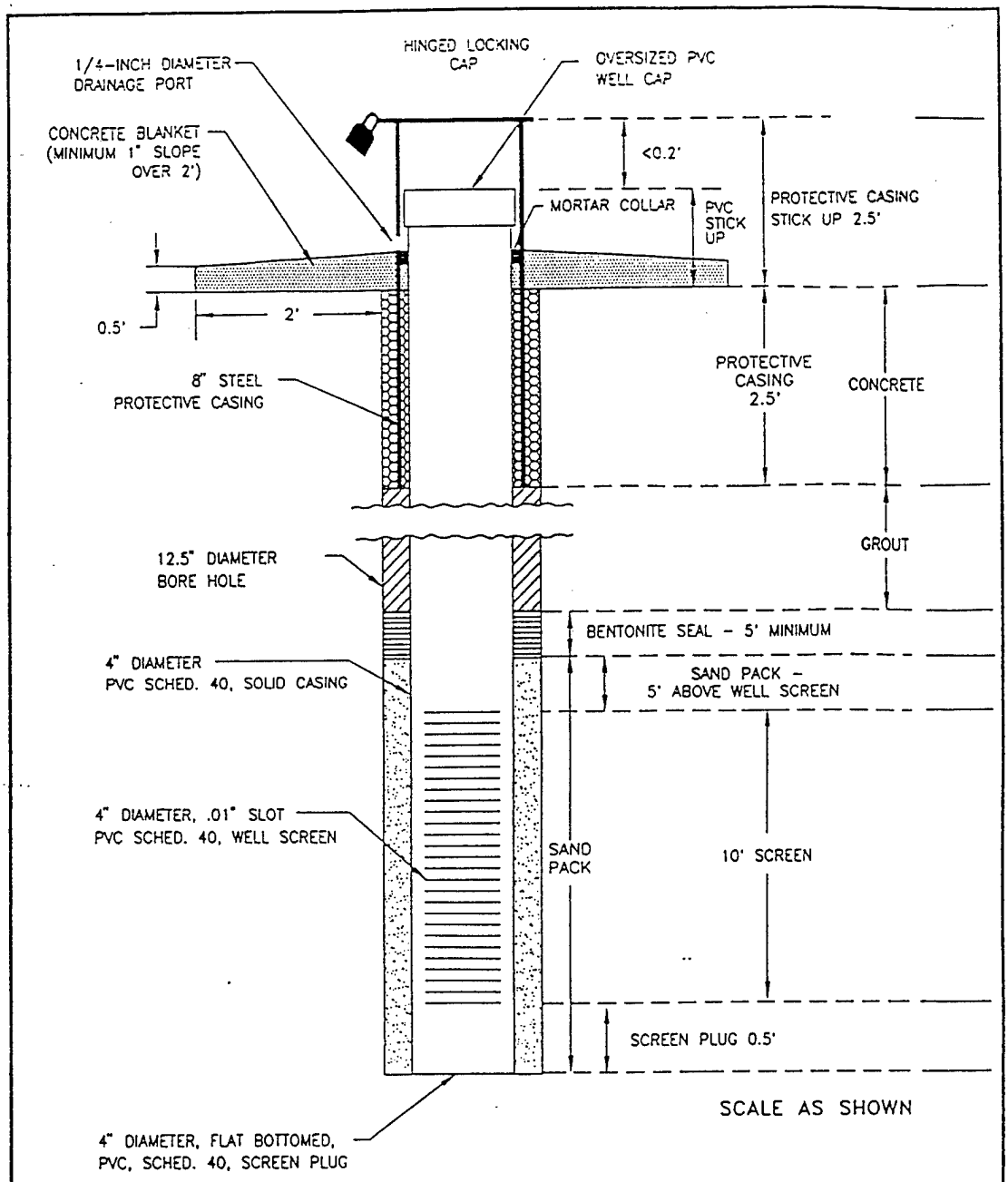
ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW60 | Project Name: WRF

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				Augr to 25'				
25	2-2-4-6	2.0' rec.	CLAY w/ silt zones horizontally throughout sample, v. moist, med. stiff light reddish brown			—	CL ML	5YR 6/3
				Augr to 30'				
30	4-5-6-6		Same as above w/ less silt, and carbon frags.			—	CL	
				Water @ 33'				
				Augr to 35'				
35	4-6-8=10 MW60C	24" rec	SAND w/ some silt, fine toned qu sand, wet to saturated, organics - carbon fragments up to 2" diameter, quartz pebbles up to ¼" diam. STRONG BROWN.					
	Physical Sample					—	SC	7.5YR 5/6
	8-12-19-21		37-37.6 - supersaturated ~~loam~~ Silty clay, 37.6-37.0 - gray clay mottled w 5% percent loam, 37.0-36.0 - quartz pebbles, v. coarse gr. sand. quartz up to 1" diameter.					

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

11/3/95 - 1030 - Began overreaming w/ 6¼" ID augers to 40' where screen will be set (30-40') bgs.



ICF KAISER ENGINEERS

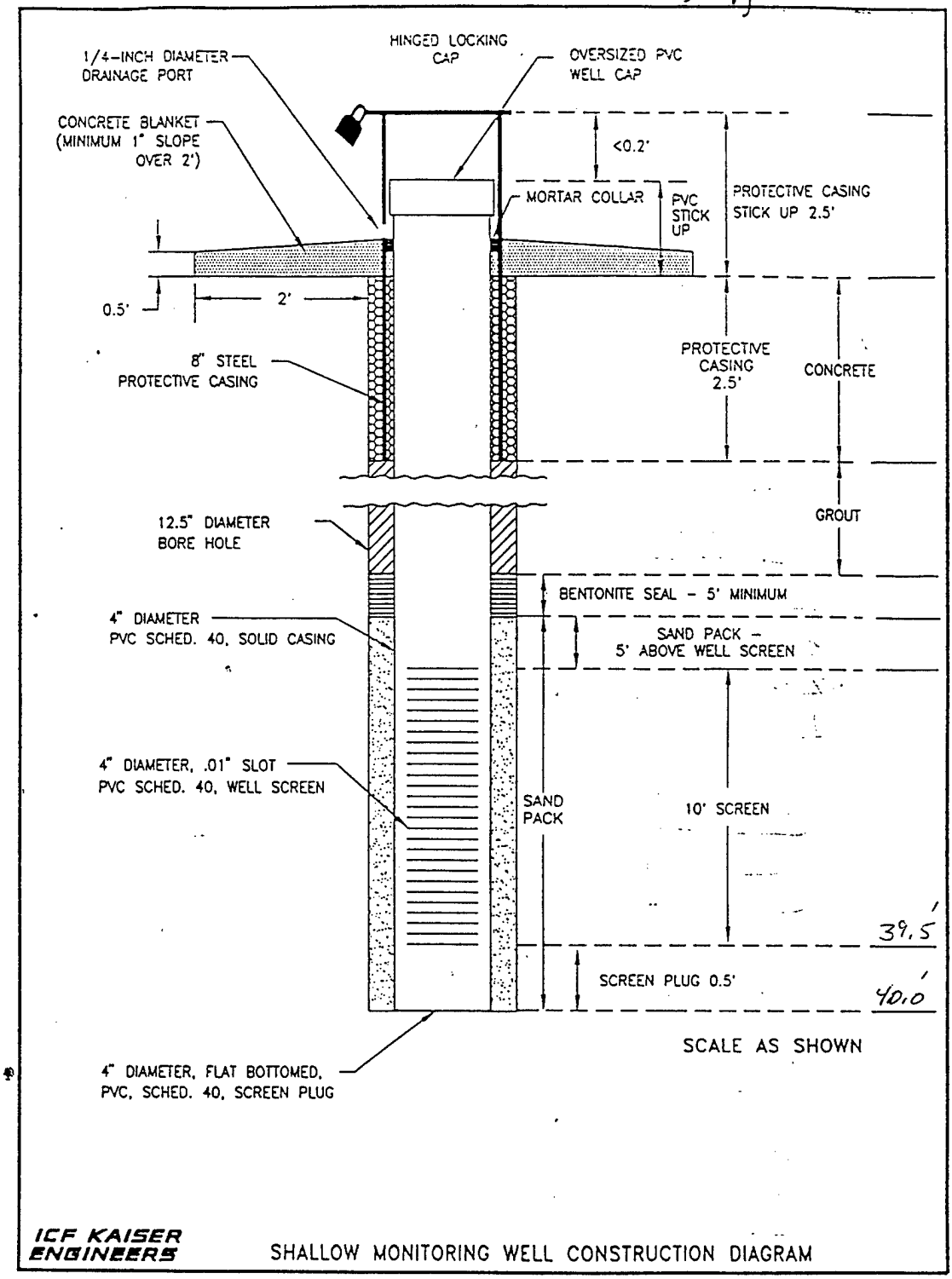
SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

1330 – Back from Lunch & continue overream w/ 8¼" ID Augers
– Slow drilling @ 25-30' took 20 minutes for 5'
– rig overheating
1330 – center plug stuck 3' from bit augers w/ 3' mud behind it.
1500 – @ 40' – Hole is filled w/ stuff – will clean out (flush) Monday.

WELL NO.: MW-60

DATE COMPLETED: 11/3/95

MW-60 (ABANDONED) pg 5 of 5



1330 - 1430 - Use mud pan ≈ 250 gal to contain approved water used to flush boring to install PVC Sch 40. Screen & riser to appropriate depth - 39.5' - 29.5' (screen range).

1430 - End flushing boring & break down of equipment used & rods, hoses, etc.

WELL NO.: MW-60

1525 - after 4 bags sand used, b/c sand is bridged in the auger & protect auger to free sand & try to knock bridge out DATE COMPLETED: _____
w/ trench pipe.
Knock some of sand out but go back to fill another tank)

703 934-3508

to flush sand down to bottom of boring

1715 Sand free light to reach bottom of boring - take a long time to fill

1745 - After tremieing 20 bags sand, sand only @ 32'. Lost 12 bags like not brought top of sand up at all. Natural conduit ~ 32'.

1750 ICF & HH rob to office. Discuss well & decide to abandon well & offset 20' upgradient & install new well using mud rotary.

11/7/95

0730 Abandon MW-60. Pull PVC casing. Tremie cement grout in to seal borehole. Tremie grout begin w/ tremie @ 30'.

Mix Batch 1

4 bags 100 lb Portland Lehigh Cement
32 gals approved water
~~20~~ lbs bentonite
13 wt of grout.

mix Batch 2

0750 4 bags 100 lbs Portland Lehigh Cement
30 (35) gals approved water
18 ~~12.5~~ lbs bentonite (powdered Sactrate)
12.5 wt of grout.

1815 Mix Batch 3

4 bags 100 lbs Portland Lehigh Cement
32 gals approved water
19 lbs bentonite (powdered Sactrate)
12.8 wt of grout

Fluid losses = 400 gals.

30 - Break down equipment, load augers, clean pumps & hoses, etc.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

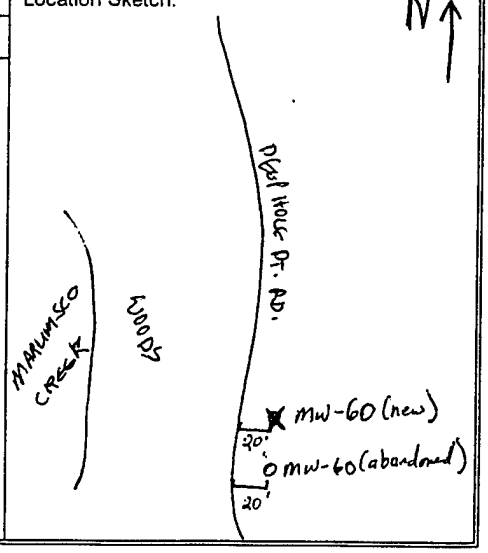
Project: WRF RI/FS	Boring: MW-60 (New)
Geologist: J. STOWERS / D. BATTS	Signature:
Driller & Company: HHI	Drilling Rig: Mobile B-90
Date Boring Started: 12/12/95	Completed: 12/13/95
First Encountered Water Level: ~ 34	Date: 12/13/95
Total Fluid Losses: ~ 100 gals.	Date: 12/13/95
Total Fluid Losses: —	
Casing Type: Sch 40 PVC	Screened Interval: 34-44
Geophysical Logging: none	Date: —
Depth to Bedrock: not encountered	Ground Elev.: —
Boring Completion Information: Completed as Monitoring Well	Date: 12/13/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
12/12/95	1510	1530	0	0	— Hydraulic line torn.				
12/13/95	0840	1400	0	47'	Time includes monitoring well installation				

Abbreviations:

Abbreviation	Meaning
v.	very
fn.	fine
gr.	grain
sm.	small
med.	medium
lg.	large
w/	with
w/o	without
%	percent
90/10	trace
80/20	little
70/30	some
50/50	and
TIH	Trip into Hole
TOH	Trip out of Hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-60	Project Name: WRF RI/FS		
Driller/Company: HHI	Drilling Method: Mud Rotary	Date Started: 12/13/95	Date Completed: 12/13/95
Total Depth: 44.5'	Depth to Bedrock: NA	Water Table Depth: 34'	Ground Elevation: —
Protection Level: Modified D	H&S Monitoring Equipment: Miran 1A	Logged by: J. S[illegible]	Checked by: Jack Chapman

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
			Topsoil, silt - clayey silt	1520 - During set-up the hydraulic hose broke (face),				
				12/13/95 0740 - Begin drilling —		—	ML/CL	+ 10YR 4/4
5			SILTY, CLAY, brownish yellow w/ little fine sand	- Begin suction from mudpan.		—	ML/CL	10 yr 4/4
10			With change ~ 7-11'	Add 1-10' rod; Circulate fluid - stabilize boring -				
			CLAY, gray, w/ little sand, light gray				CH	10 yr 7/1
15								
20				Add 1-10' rod Circulate boring.				

All measurements should be recorded in feet or tenths of feet. ε Record cored intervals in this column if drilling bedrock.

Note: All lithologic descriptions are based on returns into mudpan from boring.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-60 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
25				STILL IN CLAY @ 27'				
				Circulate boring				
				0945 collect 4" id - split sample				
30	(1)	6-5-6-7 /2'	Top 0.2' - SILT, strong brown mottled w/ CLAY, brown, medium stiff, dry to slightly moist	Hit ground @ 31'			nil/cm	7.5 YR 4/6
			Bottom 1.2' - CLAY, brown, slightly moist, medium stiff, fat, medium plasticity.				CH	7.5 YR 5/3

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

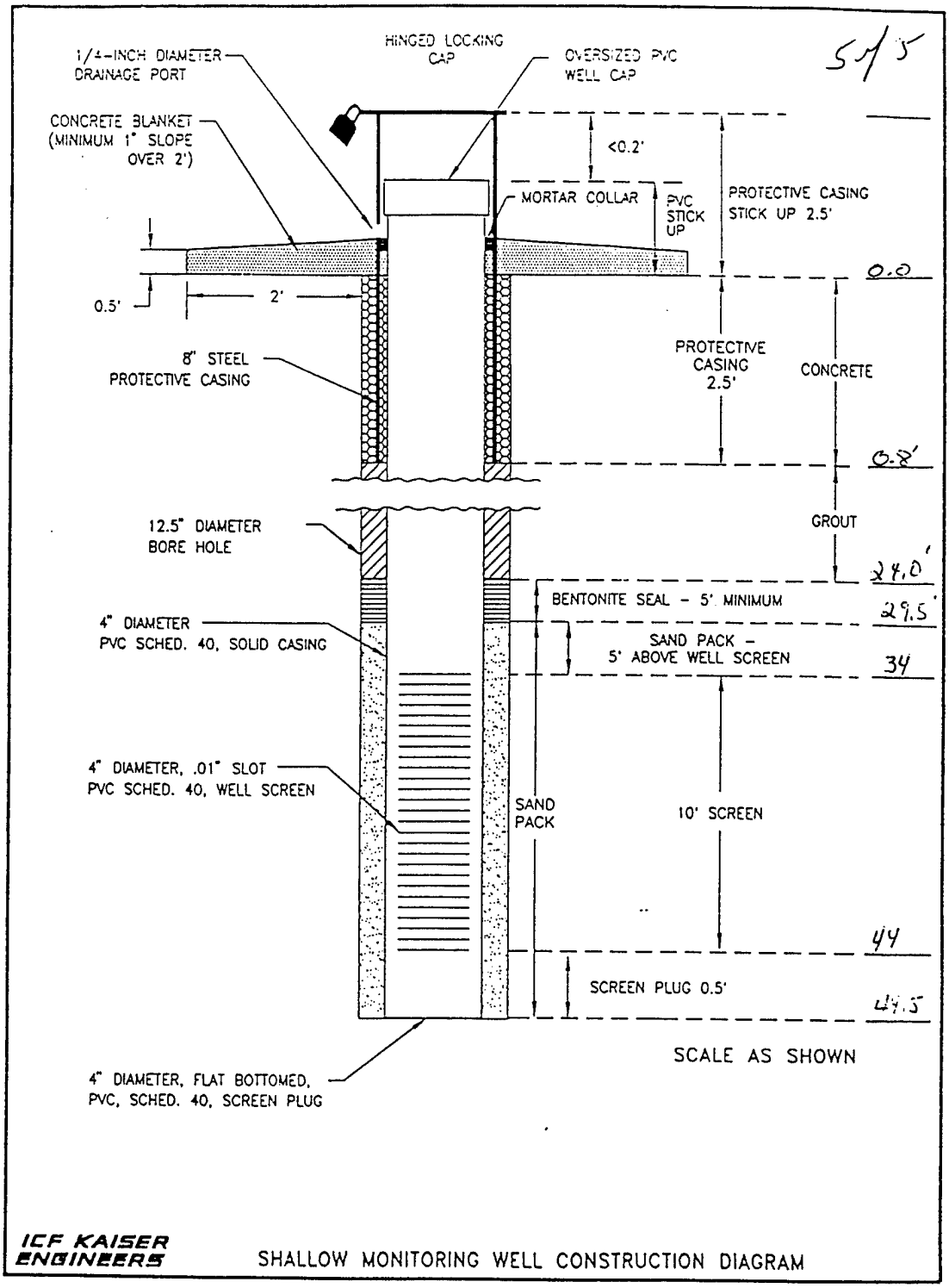
ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-60 | Project Name: WRE R1/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
			Gravel w/ sand, Gravel (quartz & metamorphic), up to 3/4" diam., wet, w/ coarse gn. sand, wet					
45 44-45'	(2)	12-16 16:4"	SAND, medium to coarse grn, wet, w/ quartz gravel (up to 1/4" diam.), S.rounded, poorly sorted, Bluish gray.	Outer of gravel ~ 43' - Circulate, bring; set screen from 35-45			SP	GLEY 2 7/5PB
				Ilmr Bajo well installation.				
				4 94 lb bags Length Portland Cement Type I				

All measurements should be recorded in feet or tenths of feet.

ε Record cored intervals in this column if drilling bedrock.



5 of 5

ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

16 50 lb bags sand
— buckets bentonite.

WELL NO.: MW-60

DATE COMPLETED: 12/13/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

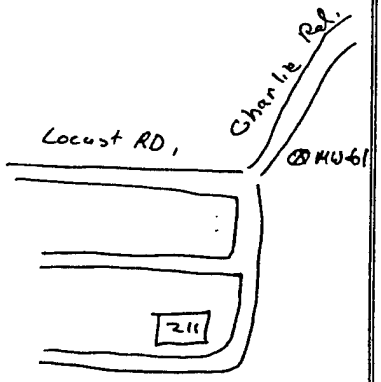
Project: WRF	Boring: MW-61
Geologist: J. Stowers / D. Romano	Signature: Jo A Stowers
Driller & Company: Hardin Huber	Drilling Rig: Mobil B-61
Date Boring Started: 11/02/95	Completed: 11/02/95
First Encountered Water Level: 14'	Date:
Total Fluid Losses: 0	Date:
Total Fluid Losses: 0	
Casing Type: 4" SCH 40 PVC	Screened Interval: 21'-11'
Geophysical Logging: NA	Date:
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date: 11/2/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/2/95	0800	0850	0	20'					
	0900	0955	Overream w/ 8¼" (0 augers)						
	1000	1110	Well Completion						

Abbreviations:

Abbreviation	Meaning
%	Percent
V.	very
fn.	fine
gn.	grain
sm.	small
med.	medium
lg.	large
TIH	Trip into Hole
TOH	Trip out of Hole
w/	with
w/o	without

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-61 | Project Name: WRF

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW-61A ①	2-4-6-7 /15"	CLAYEY SILT, yellowish brown, med stiff to stiff, med plasticity, slightly moist	0810 - Collect MW 61-A Auger to 5'		0.0 ppm	ML/CL	10yr 5/4
5	MW-61B ②	4-3-9-10 /17"	CLAYEY SILT to 5.5' (same as above) changing to CLAYEY SANDY SILT @ 5.5' w/ increasing fine sand to 7', Strong brown, med dense, low plasticity, slightly moist.	0820 - Collect MW61-B Auger to 10'		3.2 ppm†	ML/CL/SC	7.5yr 4/6
10	MW-61C ③	8-14-11-12	SAND, strong brown, fn to med gr, well graded, subrounded to subangular, dense, w/ some clayey SILT, increasing coarse grained from 11-12', very moist	- Hit water @ ≈ 14'				
15	MW-61C ④	5-2-7-6	SAND / mixed w/ fg coarse quartz pebbles up to 5mm dia, poorly graded, well to sub rounded	0825 - Collect MW 61C		0.0	SP	7.5yr 4/4
20								

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

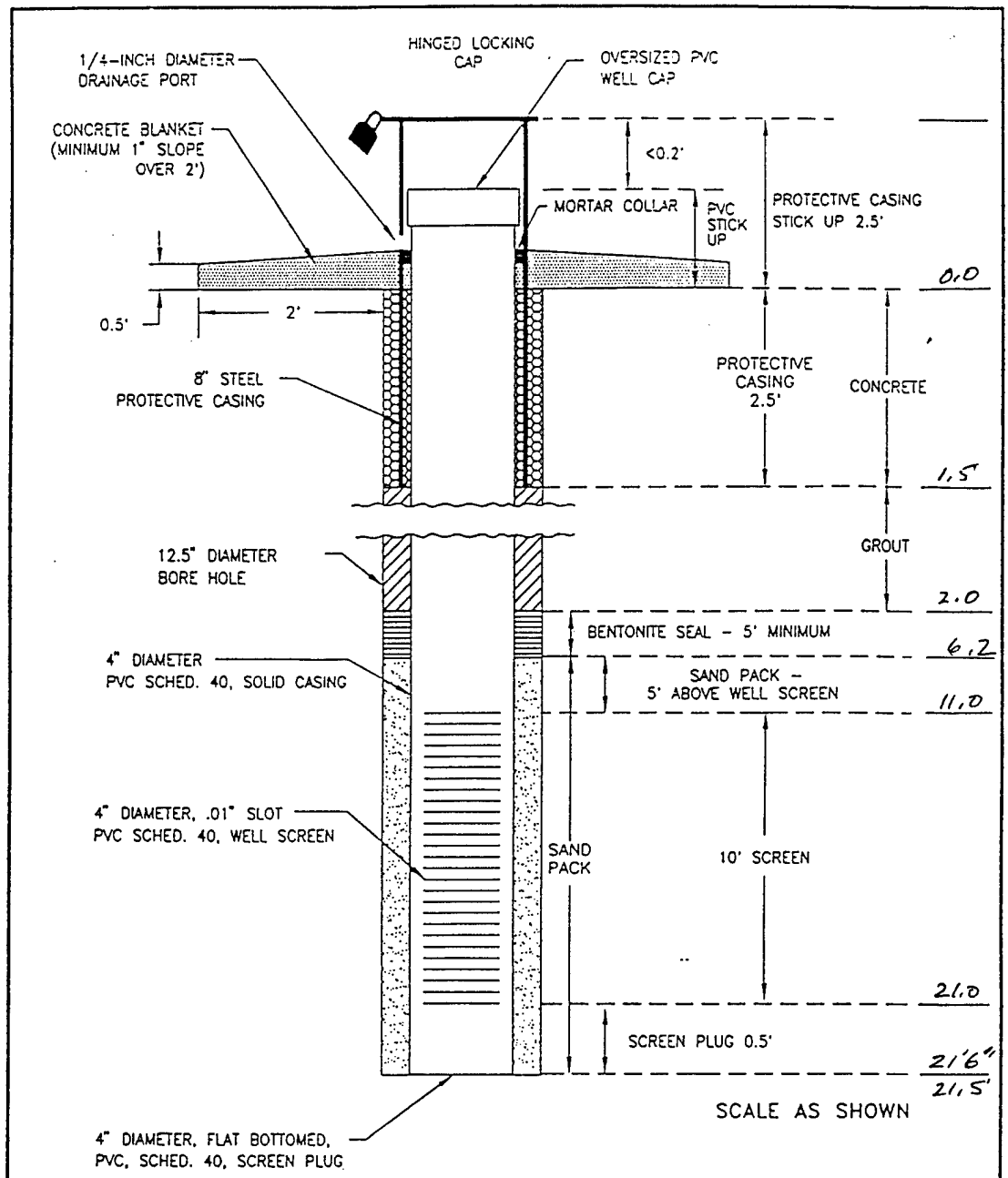
† Moisture is a possibility for ppm reading on MW-61B; lighter color.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW61 | Project Name: WRF

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
22	MW61 Physical Sample	8/14/5/6	21.5 - 22' SILTY CLAY, moderately plastic, moist to wet,	0840 Drill to 21' - TOH Auger and overream w/ 8¼" ID auger to prepare for MW installation TD = 22' Fillum w/ Sand to 21.5' to set screen @ 20.0'		0.0	SP	7.5YR 4/6
25								

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



Well Materials:

1 - 10' Sch 40 0.01ϕ slotted screen
1 - 10' " ——— riser
1 - 3' " ——— riser
1 - end cap 0.5'
1 - ~~bottom plug~~ locking cap (B)
14 - 50 lb bgs #1 20/40 Silica Sand
1 - 50 lb bucket 3/8" bentonite pellets
bags Portland Type II Cement (Lehigh)
2 - 55 gal drum cuttings.

WELL NO.: MW 61

DATE COMPLETED: 11/02/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

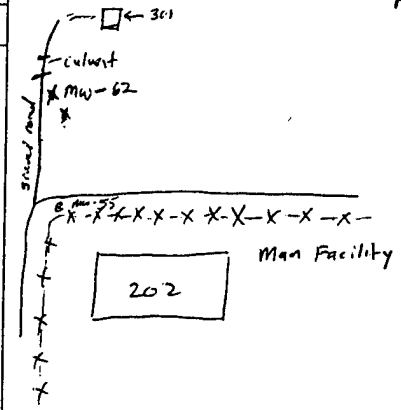
Project: WRF RI IFS	Boring: MW-62
Geologist: J. STOWERS	Signature: Jo Ann Stowers
Driller & Company: Hardin Huber	Drilling Rig: ATV Mod. 1 B-80
Date Boring Started: 11/30/95	Completed: 12/6/95
First Encountered Water Level: ~37'	Date: 12/5/95
Total Fluid Losses: 175 gals	Date: 12/5/95
Total Fluid Losses: —	
Casing Type: Sch 80 PVC 4" Diameter	Screened Interval: 30-40
Geophysical Logging: NA	Date: —
Depth to Bedrock: NA	Ground Elev.: —
Boring Completion Information: Completed as 4" PVC monitoring well	Date: 12/6/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/30/95	1400	1700	0	26'	Includes ~~mobilization~~ grouting is 17' bgs				
12/5/95	0900	1000			Set up; Flush boring				
	1000	1045			Load equipment and mob to decon pad (truck got stuck)				
	1045				Decon				
	1320		26-40'		Begin drilling w/ 10" H.S.A.				
	1510	1600			Begin well installation				

Abbreviations:

Abbreviation	Meaning
v. fn.	very fine
gr.	grain
w/	with
w/o	without
%	percent
lt.	light
dk.	dark
90/10	trace
80/20	little
70/30	some
50/50	and
TIH	Trip into Hole
TOH	Trip out of Hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-62 | Project Name: EURF RI/FS | Page 2 of 2

Driller/Company: Hardin Harper | Drilling Method: Mud Rotary | Date Started: 11/30/95 | Date Completed: 12/6/95

Total Depth: 40.5 | Depth to Bedrock: N/A | Water Table Depth: 33' | Ground Elevation:

Protection Level: Modified D | H&S Monitoring Equipment: HNU | Logged by: J. STOWERS | Checked by: Jack Chrysanth.

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				1425 - Mob rig to MW-62 location; position mudpan over boring.		Connect hoses,		
				1450 - Begin filling mud pan		+ 1000 gals		
5			SILTY CLAY with some SAND (fn.gn.), yellowish brown					10yr5/4
10			CLAY, grey, w/ some fn.gn. SAND	Circulate boring - added 1-10' rod			CL	2.5yr 6/2
15			CLAY, gray to light gray	1510 Rig blew a hydraulic line.				
				1530 Mechanic already on-site plugged leak; will get a new hose to replace leaky one by 12/1.				
20				Driller says feels like gravel @ 19'				

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-62 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				Outer gravel @ 22'; Will collect split-spoon sample 22-24'.			CH	10 yr 7/1
	①	5-6-4-5 1.4'	CLAY, gray w/ little fn. gn. SAND from 23.7, moist	2 very small (0.2' lenses (SAND fn. gn) from 22-22'.		throughout		continuous
25	②	55-5-5 1.8'	CLAY, gray, fat w/ some fn. gn. SAND fr 25.2 to 25.4.	WILL INSTALL OUTER CASING TO 26'			CH	10 yr 7/1
				1640. Outer casing installed to 26' welded a 6' section to 20' section				
				1710 - Mixed up grout mud batch w/ 50 gal. H_2O. Grout came up to 16' from ground surface Will top the rest of the hole tomorrow since it's getting too dark to finish tonight				
				600 gal H_2O used for drilling 200 gal H_2O left in mudpan. Pack up at 1730.				
				12/1/95 0700 - Present to begin mixing second batch of grout 0800 Still mixing grout, used 75 gals of grout; 6 bags to grout to surface. 0840. Clean mudpan out and hosed 0900 - Load mudpan onto rig 0910 - Load Hawing bit on fork lift to mob to decon pad				

All measurements should be recorded in feet or tenths of feet.

‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

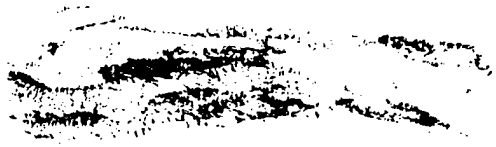
Boring No: MW-62 | Project Name: WRF/R.I.I=5

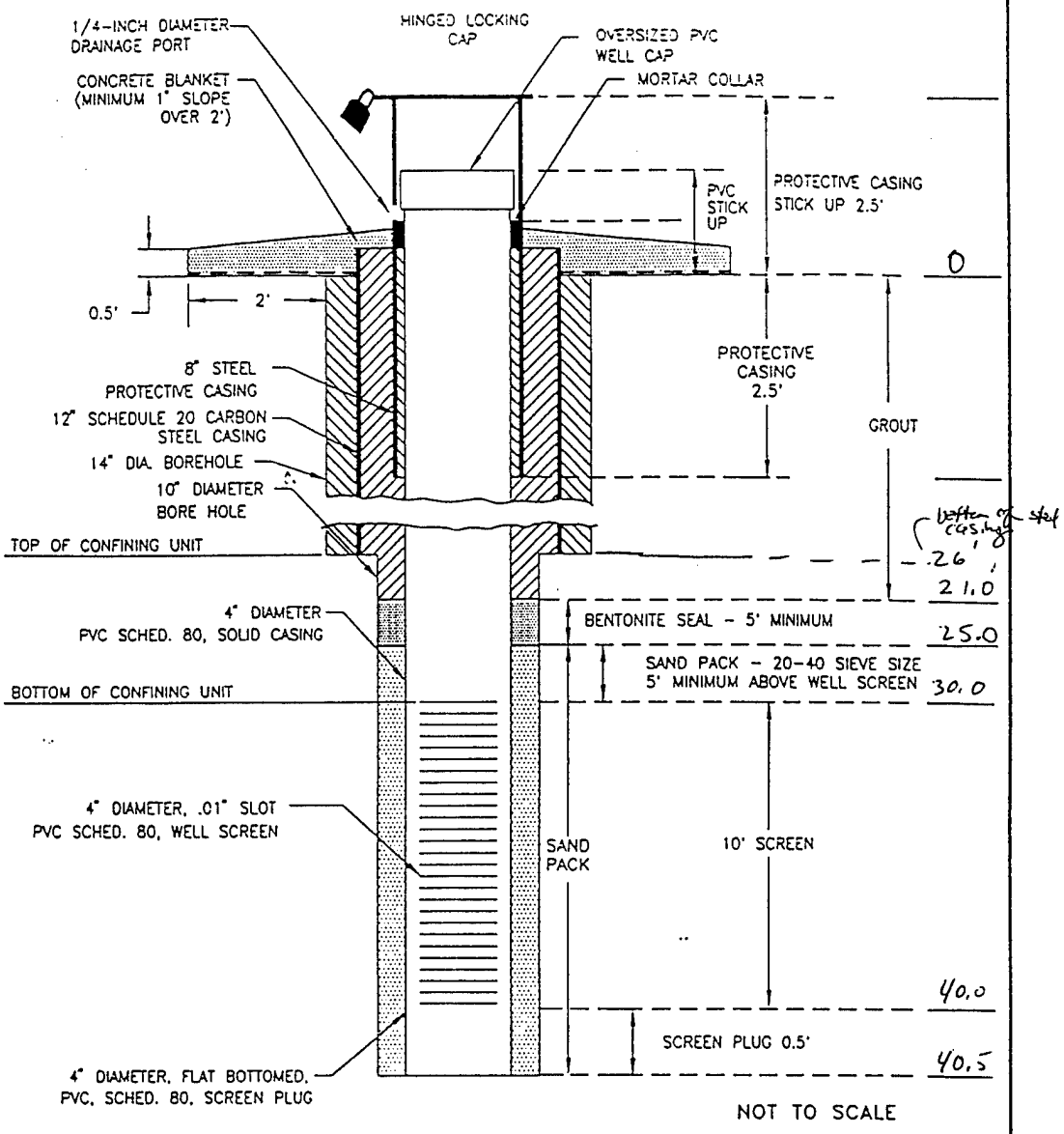
DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				12/5/95 @ MW-62 to flush boring and to drill & continued aquifer RQD - end flushing) used = 250 to 300 gals - Load rods, augers etc on rig to decon.				
				1320 - Begin drilling.				
				- Drilled hit sand between 26 and 30'. Will Collect split spoon 30-32'				
30	(3)	3-4-5-6 / 2'	CLAY, gray slight to low plasticity, medium stiff, moist, fat,	1340			CH	10yr5/1
				30-32' mel CLAY; Drill to 35' and collect wooden spoon				
			- SAND in sieve, course gr.	Hit Sand between 32' and 35'				
35	(4)	12-11-15-9 / 10.9'	SAND, fn. to med. gr. quartz, wet, subrounded, gray, w/trace gray CLAY	Will drill to 40' and collect split-spoon.			SP	10yr5/1
40	(5)	5-6-8-8	CLAY, gray, moist, low plasticity, fat stiff to very stiff.	Even thin water sand layer = 6' or less. It is a confined aquifer and will be screened from 30-40'			CH	10yr5/1
				1430 - ~~Collect Physical Sample~~ No physical sample from screened interval collected; Condition borings.				
				1510 - Begin well installation.				
				1580 - Begin filter pack installation.				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

1530 - Pump out mud pan. 1545 - Clean hoses, load rods, etc. to rod to decon Pad.

12/6/95 0800 Mix Grout. Tremie from ft.
Batch #1
33 gals approved water
4 (94 lb bags Portland Cement I
4 lbs powdered Bentonite





ICF KAISER ENGINEERS

DEEP MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-62

DATE COMPLETED: 12/6/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

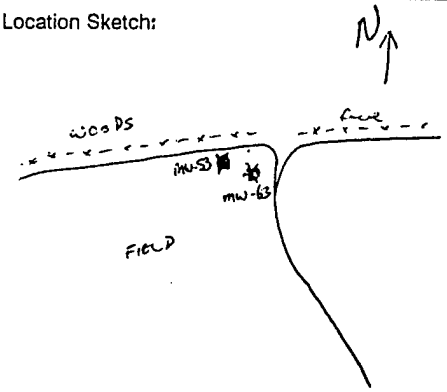
Project: WRF RI/FS	Boring: MW-63
Geologist: P. Thompson / J. Stowell	Signature:
Driller & Company: Hardin Huber	Drilling Rig: Mobil B-80 ATV
Date Boring Started: 11/27/95	Completed: 12/6/95
First Encountered Water Level: ~ 12-13'	Date: 11/27/95
Total Fluid Losses: 150 gals	Date: —
Total Fluid Losses: —	
Casing Type: 4" Sch 80 PVC	Screened Interval: 40-50
Geophysical Logging: none	Date: —
Depth to Bedrock: not encountered	Ground Elev.: —
Boring Completion Information: Completed as monitoring well	Date: 12/6/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/27/95	0930	1120	0	40'	Set up				
	1120				Begin drilling				
11/28/95	0730	0840			Mob to site; change out bit; repair mud pan pump				
	0840	1100	34'	60'	Fill mud pan + prepare to drill; drill from 34'-60'				
	1115	1600			Trip rods out of hole; set casing installation				
12/6/95	1005				Set up over MW-63; Position mud pan, flush borings.				

Abbreviations:

Abbreviation	Meaning
v.	very
fn.	fine
gr.	grain
sm	small
med	medium
lg.	large
w/	with
w/o	without
%	percent
tr/tc	trace
10/20	little
20/30	some
50/50	and
TIH	Trip in to hole
TOH	trip out of hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

12' to bit to top of rod

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-63		Project Name: WRF RI/FS	
Driller/Company: Hardin Huber	Drilling Method: Mud Rotary	Date Started: 11/27/95	Date Completed: 12/6/95
Total Depth: 50.5'	Depth to Bedrock: NA	Water Table Depth: 13'	Ground Elevation: —
Protection Level: Modified D	H&S Monitoring Equipment: microT.p	Logged by: J. Stevens	Checked by: Jack Chrysanth.

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				1045 - Set up mud rotary equipment. Begin w/ 750 gals Fill mudpan - 250 gal capacity ; Center bit (14" OD) mudpan annulus				
5 ~~10~~			CLAY, strong brown, w/ trace to little fn gn sand	using 230 sieve			CL	10 yr 5/4
			SAND content increasing to ≈ 50% fn gn sand ↓	1150 - Add 1 - ~~20~~ 10' rod			CL	
10 ~~20~~			SAME AS ABOVE. 12' - Driller hit sand & gravel					
15 ~~30~~			SAND, coarse, yellowish red, poorly graded w/ little clay.				Sp	5 yr 5/8
20								

All measurements should be recorded in feet or tenths of feet. ε Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-63 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
			SAND, coarse gr. yellowish red, poorly graded w/ little to trace Cmy.	Add 1 - 10' rod 1330 Fill support truck tank + 250 gals w/ approved water.				
25				1330 Lost 5' of boring due to heaving sands - TD of boring @ 22'				
				Mix bentonite w/ approved water for hole stabilization @ 22' used 1-50 lbs. w/ = 100 gals H_2O				
				1335 Begin pumping drill fluid down boring; begin drilling @ 22'				
30			SAND, very coarse gr to coarse grain, poorly graded, w/ some gravel.	Gravel not coming up into mud pan; its sinking to bottom of boring.				
			Gravel @ ≈ 33'	Bit jumping; hit gravel, very rough drilling				
35				1350 - Attempt to flush hole out; Bit is clogged w/ gravel. Use 1" dia rods to clear bit out; Circulate fluid through borehole to stabilize hole. Drill to 40'. Mix another batch of drill fluid to stabilize hole before TOH to trip in sampling rods &				
			Driller says hit finer gr. sand @ ≈ 37'; possibly clay; driller confirms not clay @ 37'	1435 - Spoon split-spoon pump bentonite drill fluid down borehole.				
			Sand and gravel 39-43 ft	Pulling rods to drive spoon				

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

55' - 250 gals bentonite
34' - 50 gals grout
24' - 50 gals grout } 8 bags + Cmt

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-63 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
43			Sand and gravel 39-43'	1510 - Drag bit cannot drill through gravel zone; Trip rods out of hole ≈ 40' and change to roller bit. Drillers will bring roller bit tomorrow.				
				1545 - After tripping rods; bit out, hole caved in to 34'. Clean up drill location and mob to field office.				
45	1	10.4'	Top 0.2' - GRAY SANDY CLAY, fn. gr. SAND low to medium plasticity w/ some gravel up to 3/4" dia. (quartz) Bottom 0.2' CLAYEY SILT - dk. strong brown w/ little sand fn. gr., no plasticity w/ some sandy lenses (yellowish)	11/28/95 0730 Began to change-out bit + 250 gals				
				0745 Mix bentonite ½ bag ≈ 40 gals water; pump it to the (loose) fix				
	2	35-25-20-20 / 0.8'		0840 - Fill mud pan; prepare to drill w/ ~100 gals water. used 3 more bags of bentonite				
				0845 - @ 40' add 1-10' rod for a total of 52' of rod including				
50			Top 0.2' - Gray SANDY CLAY mottled w/ strong brown stain; clayey SILT w/ some gravel up to 0.02' dia. Bottom 0.6' - light yellowish Br. Sandy gravel w/ trace silt, wet; quartz gravel (50%) up to ½" dia. Getting progressively grayer toward bottom of spoon. STILL IN GRAVEL	0850 - Color change to gray between 43 and 45'.				
				0900 - Drilled to 45', will drive split spoon 45-47' to confirm clay.				
								7.5 yr 5/6 (strong brown clay)
				52' - Rough drilling; still in gravel; gray shells showing in mud pan				10 yr 6/3 (sand)
				Slow drilling 52' -				
				1115 - Trip rods out of hole				
			58' - Still gravel. Stop drilling at 58'.	1135 - Drillers head to decon pad to get casing. Casing arrived @ site. Drillers weld 39' of casing together and center down borehole. pump bentonite slurry (thick) into annular space around casing to 60' to put a seal at top of potential screen interval.				
				1230 - Lunch;				

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

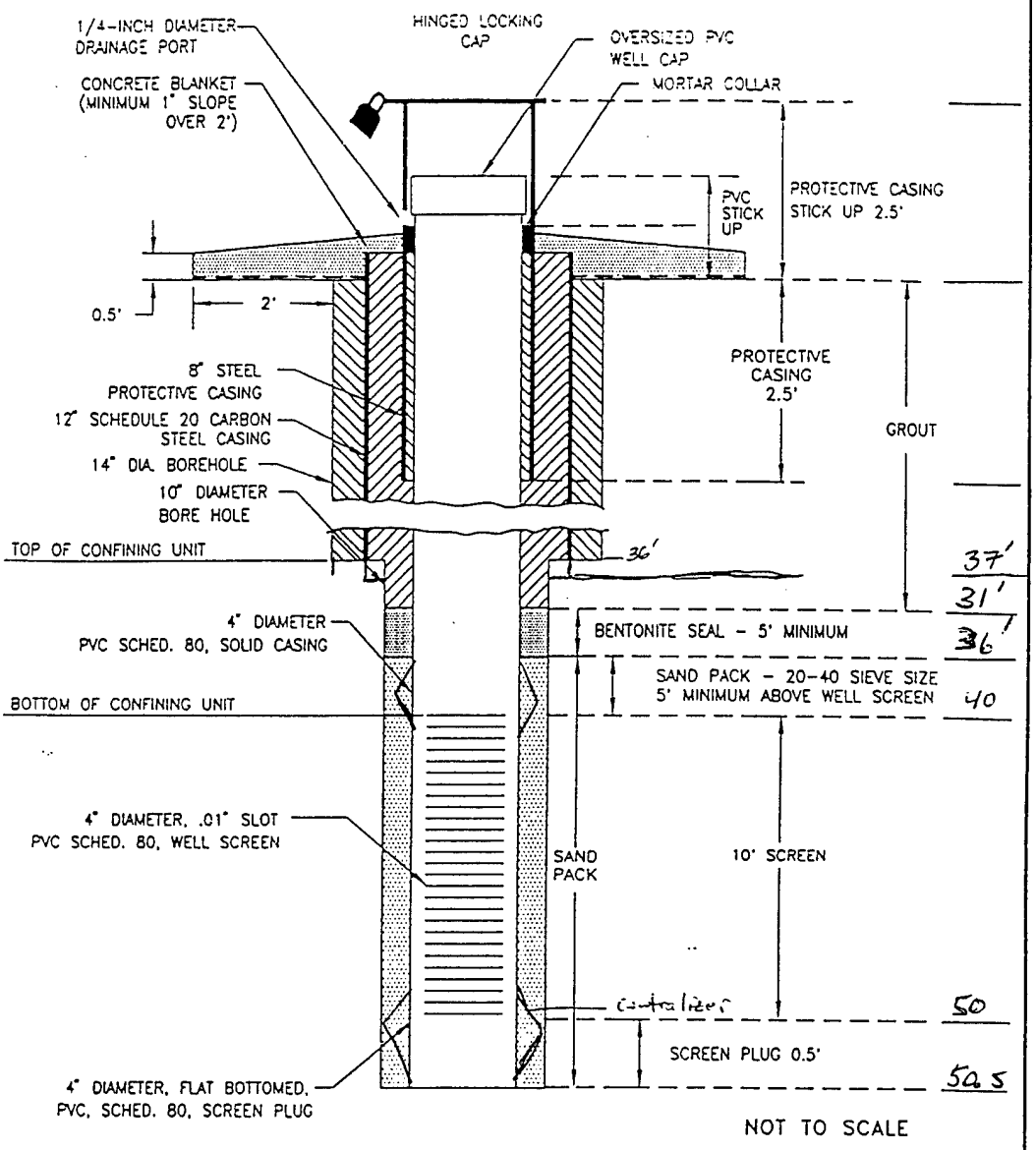
Boring No: MW-63 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				12/6/95 1005 - Set up mud pan, position rig over boring; 1015 - Begin flushing out bentonite slurry (37-42'), Hole stayed open to 57' Flush with clean fresh water - flush rods every 10' on the way to TD 1100 - Used ~ 250 gals during flushing; will use another 250 gals. 1130 - Used ~ 700 gallons of approved water to flush boring; will need another 250 gals. before filter pack installation. 1300 - Trip gals out of boring after flushing = 250 more gallons for a total of 1000. 1330 - Tremie set @ 57'. Begin pouring 3/8" chips to fill space - approx 1 bag of 3/8" chips to 55' Then 15 bags of Sand 20/40 to install filter pack to 36' 1350 Bentonite Seal Installed using 2 buckets of 3/8" pellets 1635 - Shovel out mud pan - prepare to grout. 1650 - Begin grouting; used 1 bag Lehigh Portland Cement Type I w/ ~60 gallons approved water and ~ bags powdered bentonite. Wt of grout - 10 lbs/gal 1710 - Clean mud pan out				

All measurements should be recorded in feet or tenths of feet.

‡ Record cored intervals in this column if drilling bedrock.

6 of 6



ICF KAISER ENGINEERS

DEEP MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-63

DATE COMPLETED: 12/6/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

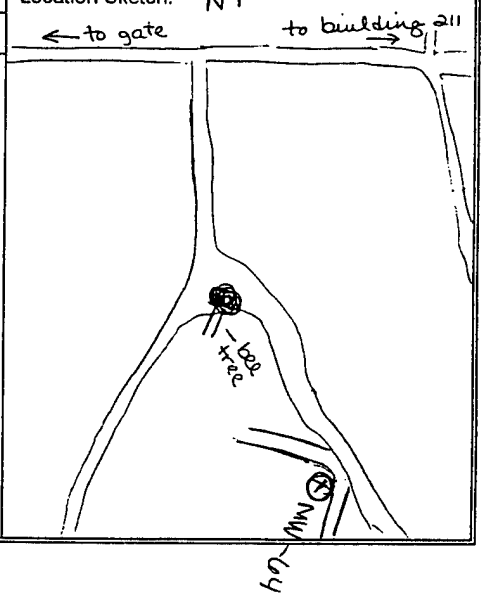
Project: WRF R1/FS	Boring: MW-64
Geologist: Debbie Romano/JoAnn Stowers	Signature: Deborah J. Romano
Driller & Company: Hardin-Huber; Terry, Bruce	Drilling Rig: Mobile B-61
Date Boring Started: 11/09/95	Completed: 11/09/95
First Encountered Water Level: 17 ft	Date: 11/09/95
Total Fluid Losses: 0	Date:
Total Fluid Losses: 0	
Casing Type: PVC Schedule 40	Screened Interval: 13-23
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date: 11/10/95 completed

Date	Time Start	Time End	Depth of Drilling Per Shift Start	Depth of Drilling Per Shift End	Date	Time Start	Time End	Depth of Drilling Per Shift Start	Depth of Drilling Per Shift End
11/09/95	0850	0945	0'	27' →	5¼" auger to 25' split spoon 25'-27'				
~~11/09/95~~	~~0945~~			0					
11/09/95	1030	1130	0'	~~27~~ 7'	8¼" overream				
11/09/95	1130				Rig broken down				
11/10/95	0800				set up to drill-ream in 11				
	~~0825~~ PM				~~Augers turning~~ PM				
	0825				Augers turning				
	0915				20' overream				
	0935				Finish overream to 25'				
					knock plug out				

Abbreviations:

Abbreviation	Meaning
V	very
fn	fine
sm	small
lg	large
med.	medium
~	approximately
gr.	grain
trace	90/10
little	80/20
some	70/30
&	and
&	50/50

Location Sketch: N↑



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-64 | Project Name: WRF RI/FS

Driller/Company: Hardin Huber Terry, Bruce | Drilling Method: Hollow Stem Auger. | Date Started: 11/09/95 | Date Completed: 11/09/95

Total Depth: 22 ft | Depth to Bedrock: n/a | Water Table Depth: 17 ft | Ground Elevation:

Protection Level: Modified level D | H&S Monitoring Equipment: OVM | Logged by: Debbie Romano | Checked by: P. Thomas

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								
	MW-64A 0-2' 0910	4-5-9-11 1'	0-3" CLAY, yellowish brown, dry, medium stiff, high plasticity	Split spoon 0-2'		0	CH	10YR 5/4
2'			3-12" Silty CLAY, yellowish brown, dry, very stiff, low plasticity			0	CL	10 YR 5/4
5		11-14-21-22 20"	SILT, brown w/ 10YR 8/2 very pale brown & 7.5 YR 4/6 strong brown mottling; very stiff, dry.	Split spoon 5-7'		0	ML	10 YR 5/3
7'			Grades to SILT, strong brown w/ little light gray mottling at ~12-20". Dry, crumbles easily, hard.			0	ML	7.5YR 4/6
10		6-7-8-11 22"	0-8" SILT, light brownish gray, dry, stiff, trace clay, ~~no GW~~	Split spoon 10-12'		0	ML	10 YR 6/2
			8-13" SILT, light brownish gray, dry, stiff, trace clay, very low plasticity, few Strong ~~br~~ brown (7.5YR 5/6) mottles			0	ML	10 YR 6/2
12'			13-22" SILT, strong brown, dry, very stiff, trace clay, very low plasticity.			0	ML	7.5 YR 5/6
15	MW-64B 15-17' 0930	4-8-11-15 22"	0-4" SILT & CLAY, brown w/ strong brown mottles (7.5YR 5/6), dry, med. stiff, low-med. plasticity	Split spoon 15-17'		0	CL-ML	10YR 5/3
17'			4-22" CLAY, very stiff, brown, high plasticity, dry - slightly moist, some silt grading to trace silt towards bottom	Driller: Hit water 17'		0	CL-CH	7.5YR 4/4
20								

All measurements should be recorded in foot or tenths of feet. ε Record cored intervals in this column if drilling bedrock.

~~for 17'~~

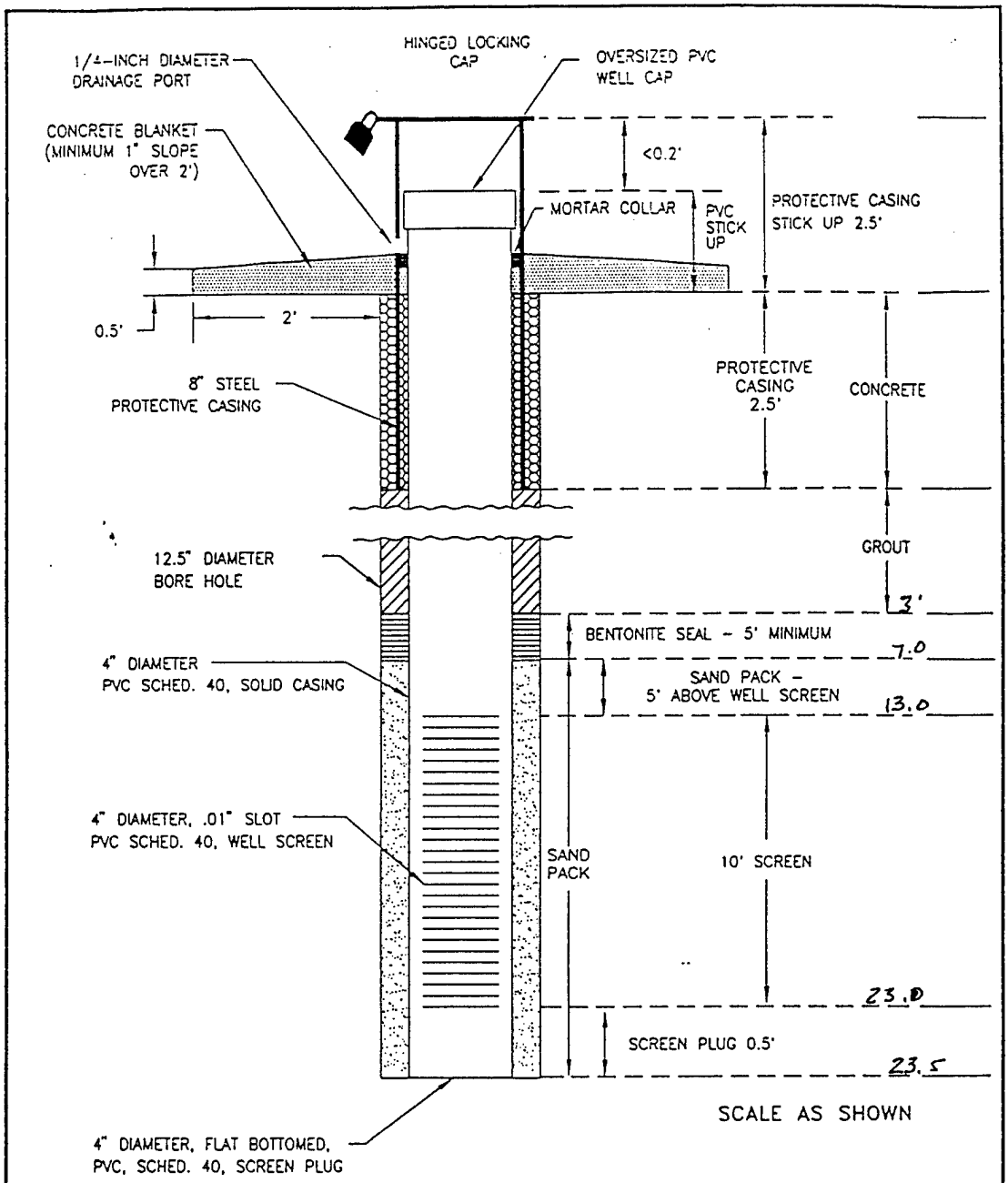
~~17' wet~~

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: ~~MW-01-02~~ MW-64 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20'	MW-64C 20-22' 0945	8-10-13-4 16"	0-11" - Sandy GRAVEL; fn to coarse sand, fine gravel brown, wet, poorly graded, med. dense, trace silt.	Split spoon 20-22'		0 (a) GC	GM	10 YR 4/3
22'			11-16" - SAND, brown, wet, little coarse grained sand, trace silt, loose.			0	SP	10 YR 5/3
25'	Physical Samples 25-27'	3-8-12-9 17"	0-2" - SAND, yellowish brown, med. to coarse grain, little silt, wet, loose	Split spoon 25-27'		0	SP	10 YR 5/8
27'			2-7" - SAND, brownish yellow, fn. to med. gr., little coarse gr. little silt, wet, loose			0	SP	10 YR 6/6
			7-17" - SAND, med. grain, light gray, wet, med. dense, little silt			0	SW	10 YR 7/2
30'			1535 Boring discontinued while overreaming @ 12'. Rig mechanical problem, possibly head gasket is blown.					
				OVR-ream to 25'				
35'			Put 10' screen & 20' riser in hole Bottom of well @ 28.5' Top of sand @ 7' Top of bentonite = 3'	1108 - Bentonite pellets in well.				
40'								

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

Well materials
10' PVC Sch 40 screen - 0.01 slot
15' PVC Sch 40 riser
15 bags silica sand
2 buckets 3/8" bentonite pellets

WELL NO.: MW-64

DATE COMPLETED: 11/10/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

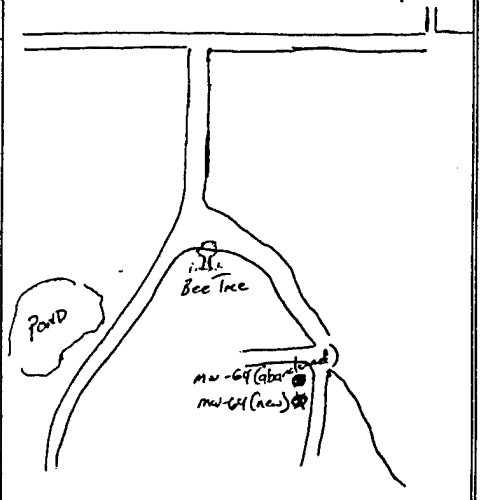
Project: WRF RI/FS	Boring: MW-64 (new)
Geologist: J. STOWERS	Signature:
Driller & Company: HHI	Drilling Rig: Mobile B-61
Date Boring Started: 12/14/95	Completed: 12/14/95
First Encountered Water Level: ~ 21'	Date: 12/14/95
Total Fluid Losses: 0	Date: —
Total Fluid Losses: 0	
Casing Type: 4" Sch. 40 PVC	Screened Interval: 18.5 - 28.5'
Geophysical Logging: NA	Date: —
Depth to Bedrock: NA	Ground Elev.: —
Boring Completion Information: 4" Monitoring Well	Date: 12/14/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
12/14/95	0945 1050	1050 1720	0	37'	Drilled Overrea	using boring	4¼" ID using 8¼	auger "ID auger	

Abbreviations:

Abbreviation	Meaning
V	Very
fn	fine
gn	grain
~	approximately
w/	with
w/o	without
90/10	trace
80/20	little
70/30	some
50/50	and
TIH	Trip into Hole
TOH	Trip out of hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-64 (new) | Project Name: UNF RI/FS

Driller/Company: HHI | Drilling Method: Hollow-stem auger | Date Started: 12/14/95 | Date Completed: 12/14/95

Total Depth: 29' | Depth to Bedrock: NA | Water Table Depth: ~21' | Ground Elevation:

Protection Level: Modified D | H&S Monitoring Equipment: MICRO TIP | Logged by: J. STOWERS | Checked by: Jack Chrysanthis

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	—	—	SILT, yellowish-brown, dry, stiff to mod stiff, slight plasticity, trace clay	0930 - Set up (position rig, unload drums, etc.) 0945 - Begin drilling. Will auger to 20' and collect sp for lithology & characterization of screened interval			ML	10yr 6/4 spoons
5			SAME as above with increased clay content (20-30%)	Add 1-5' auger				
10			Color change @ ~ 10' to brownish gray/dry	Add 1-5' auger			ML	10yr 6/2
15			Color change @ ~ 16' to light brown, moist to slightly moist	Add 1-5' auger			ML	7.5yr 6/4
			Gravel and clayey silt, light brown	Hit gravel ~ 17'			GM	7.5yr 6/4
20				- Auger to 25' to collect sp spoon.				

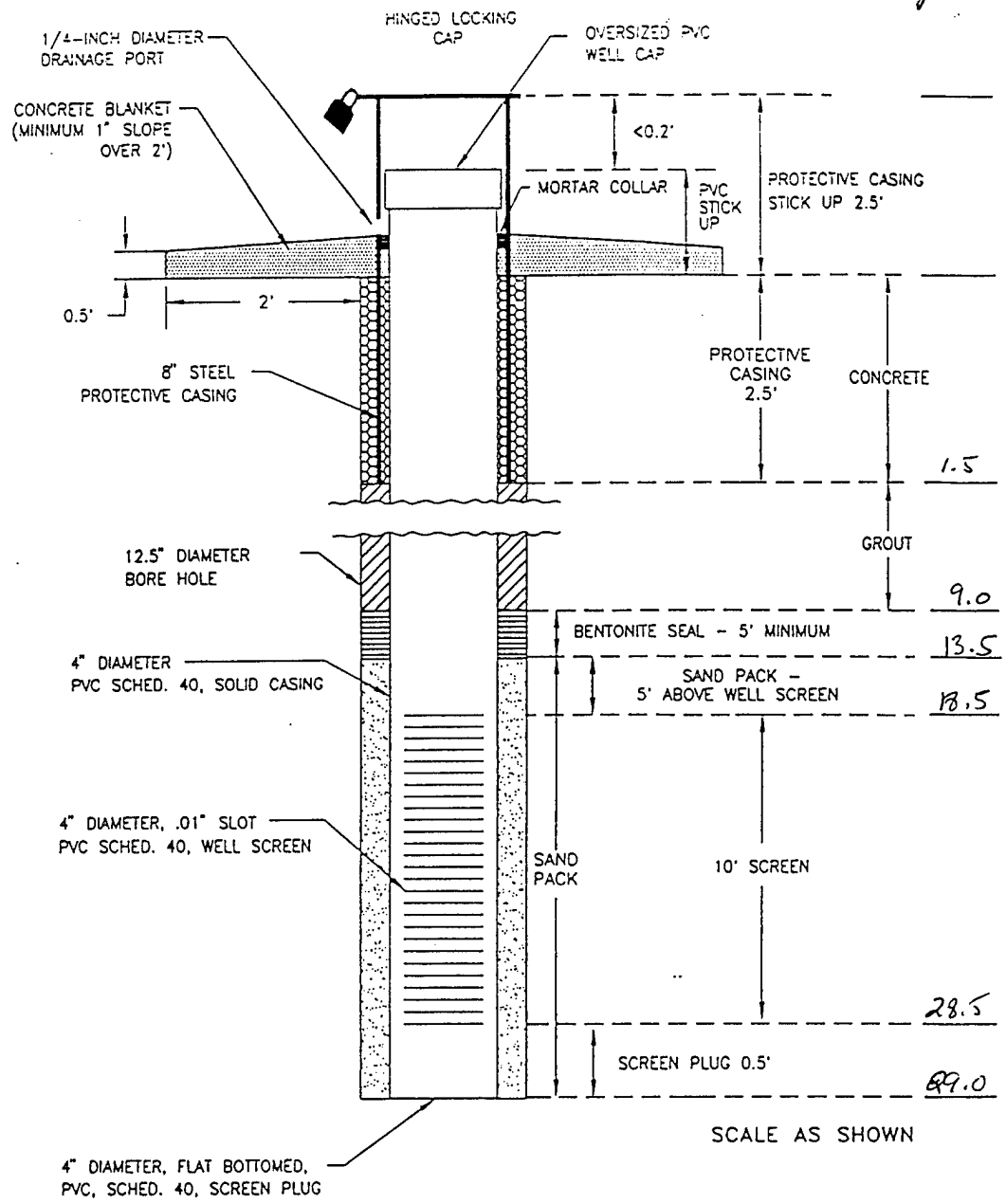
All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-64 (new) | Project Name: LRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
			Lithology change to coarse gr sand, and gravel (fan) in cuttings early part of boring.	Hit water 21-22', best cuttings were surface.		Slow response	SP	10
			→ Color change to pale brown	Wet (most cuttings) 23-24'			SP	10yr6/3
25	①	9-8-9-10 / 1.3'	SAND, wet, medium to coarse gr., Subrounded, medium dense, pale brown, poorly sorted					10yr6/3
30	②	15-20-22-24 / 2.0'	SAND and Gravel, Saturated, dense, Subrounded, pale brown, gradg toward 31' to 31-32' - pale gray gravel w/some V. coarse gr. sand w/ little gray CLAY	With soil screen 20-30'			SP	10yr6/3 10yr6/1
				1700 - Begin grouting from 9' to surface 2 94 lb bgs Lehigh Portland Cement Type I 9 lbs powdered bentonite 16 gals engineered water 13.4% grout (lbs/gal)				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-64 (nw)

DATE COMPLETED: 12/14/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

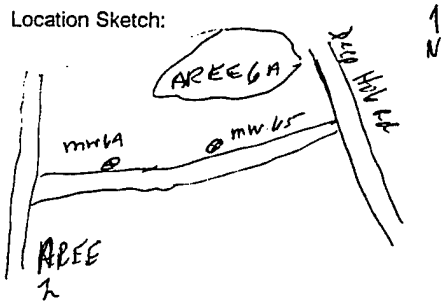
Project: INRF RI/FS	Boring: MW-65 AREE 6A
Geologist: Debbie Romano	Signature: Debbie Romano
Driller & Company: Jay - Hardin Huber	Drilling Rig: ATV Mobile B-80
Date Boring Started: 11/13/95	Completed: 11/13/95
First Encountered Water Level: 17'	Date: 11/13/95
Total Fluid Losses: —	Date: —
Total Fluid Losses: —	
Casing Type: PVC Schedule 40	Screened Interval: 14 - 24'
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/13/95	0915	1015	0	19'	4¼" ID augers & split spoon				
11/13/95	1050	1130	0	24.5'	8¼" ID overreamin; sand is 5' up in augers				
11/13/95	1320				Set augers back down w/ new plug.				

Abbreviations:

Abbreviation	Meaning
dk	dark
lt	light
trace	90/10
little	80/20
some	70/30
and	50/50
&	and
med.	medium
gr.	grain
v.	very
fn.	fine

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-05 | Project Name: WRF RI/FS

Driller/Company: Jay - Hardin Huber | Drilling Method: Hollow Stem Auger | Date Started: 11/13/95 | Date Completed: 11/13/95

Total Depth: 19' | Depth to Bedrock: n/a | Water Table Depth: 17' | Ground Elevation:

Protection Level: Modified D | H&S Monitoring Equipment: OVM | Logged by: Debbie Romano | Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								
2	MW-65A MW-65AD 0-4' 0925	1-22-3 9" / 1-2-2-2 17"	CLAY, yellowish brown, soft, slightly moist, highly plastic, some lt. gray mottling towards bottom. 0-4" - CLAY, gray, moist, soft, highly plastic 4-17" - Silty CLAY, v. dk. gray, slightly moist, high plasticity, little natural organics, soft.	Split spoon 0-2' and 2-4' composite for MW-65A and MW-65AD auger to 5' 4¼" ID. ESE		0	CH	10 YR 5/6
4						0	CH / CL	5Y 6/1 / 2.5Y 3/1
5		2-1-1-2 24"	0-21" - CLAY, v. dk. gray, moist, high plasticity, soft	split spoon 5-7' auger to 10' 4¼" ID			CH / CL	2.5Y 3/1
7			21-24" - ~~Sandy~~ CLAY, v. dk. gray, v. moist to wet, high plasticity, little v. fn. gr. sand.					
10	MW-65B 0950 10-12'	1-2-2-3 15"	0-12" CLAY, gray, high plasticity, soft, slightly moist	split spoon 10 to 12' auger to 15'		0	CH / CL	5Y 5/1
12			12-15" Sandy CLAY, gray, v. fn to fn sand, soft to med. stiff, v. moist, med. to high plasticity.					
15	MW-65C 15-17 1010	~~1-2-8-7~~ 24" 22"	~~0-2" CLAY, yellowish brown, soft, high plasticity, v. moist~~ (DR) 0-19" SAND & CLAY, gray, wet, high plasticity, v. fn. to fn. sand, v. moist	split spoon 15-17' water at 17'		0	SC-CL	~~10YR 5/6~~ (DR) 5Y 6/1
17	Phys. Cell Sample 17-19'	1-3-5-7 24"	19-22" - Gravelly SAND w/ little clay; lt. yellowish brown, wet, med. to coarse gr. sand, fine gravel, v. loose.	split spoon 17-19'			GC	10 YR 6/4
19			0-4" - Gravelly SAND, med. to coarse sand, wet, trace clay, very loose, lt. yellowish brown			0	GC	10 YR 6/4
20			4-6" - CLAY, black, v. moist, soft, high plasticity				CH	~~2.5Y 2.5/1~~
			6-8" CLAY, gray, w/ little v. fn. sand, wet, high plasticity				CH	5Y 6/1
			8-24" SAND, lt. yellowish brown w/ strong brown mottling, v. moist to wet fn. sand w/ little clay, to med. plasticity				SC	2.5Y 6/3 w/ 7.5YR 5/1

All measurements should be recorded in feet or tenths of feet. Record cored intervals in this column if drilling bedrock.

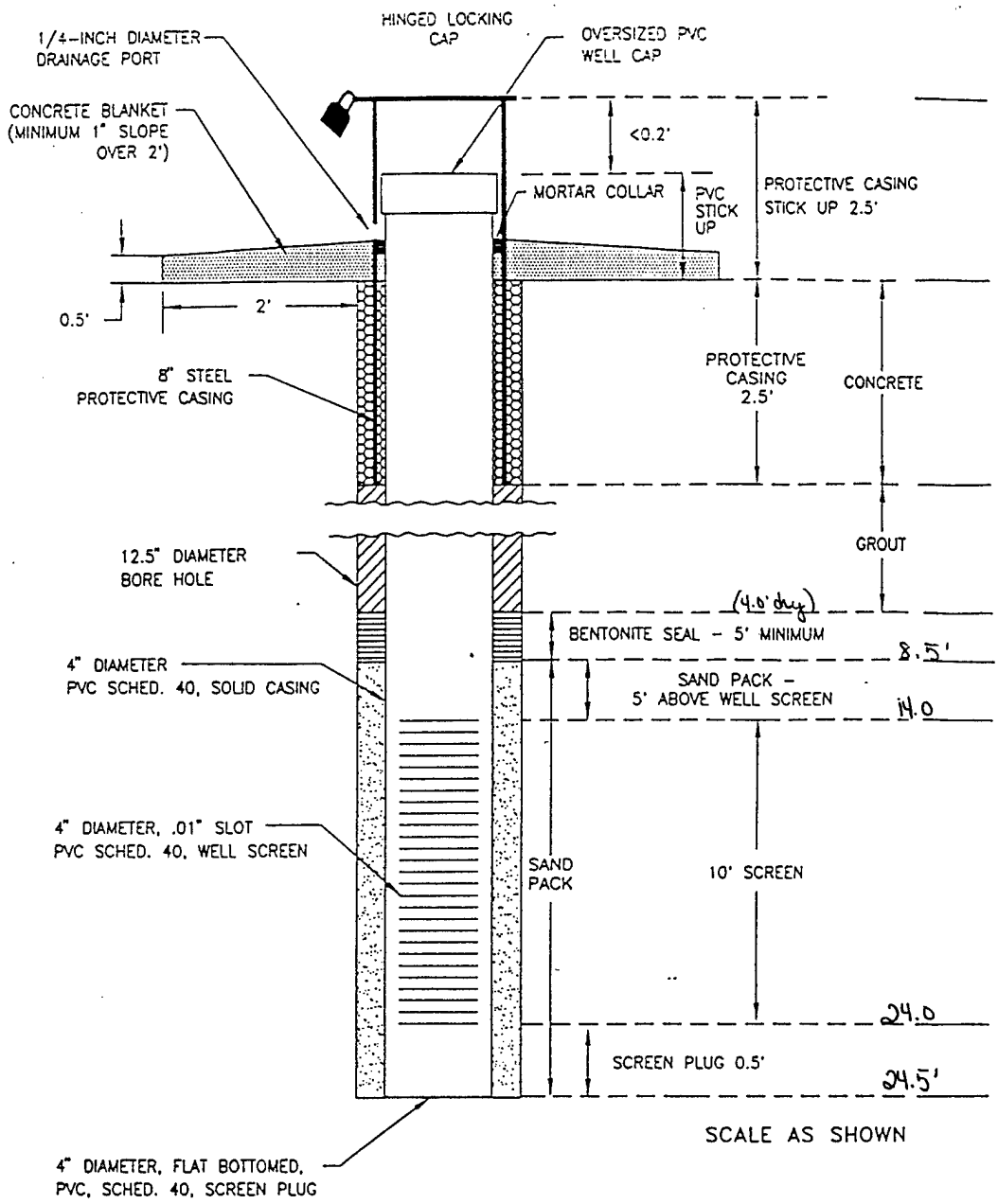
ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-65 AREE 6A | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
			NOTES:					
			1130 - Overreamed to 24.5'. Sand is up in auger 5'. Will return after lunch to wash out hole					
			1320 - Pull up augers, took out wooden plug from the top of the 5th auger.					
			1345 - Put a new plug in the bottom (lead) auger, and sent augers down again.					
			1355 - Overreamed to 24.5'. No heaving sands this time.					
			1415 - PVC casing put down borehole.					
			2 x 10' PVC riser 1 x 10' PVC screen } Sched. 40 1 x 0.5' PVC screen plug					
			1420 - Added 2 bags of sand Pulled 1 auger out					
			1455 - 2nd auger out, 1 bags of sand in, Sand at 15'					
			1510 - 3rd auger out, 13 bags in, sand at ~10'					
			1515 - 13 Bags of sand in, sand at 8.5'					
			1520 - 2 buckets of bentonite pellets in, 4th auger out					
			1525 - 3 buckets of bentonite in, bentonite up to 3'10" (4')					
			14:00					
			13 bags of sand (20/40)					
			3 buckets of bentonite 3/8"					

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

11/13/95 Water level - 3.86'



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-65

DATE COMPLETED: 11/13/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

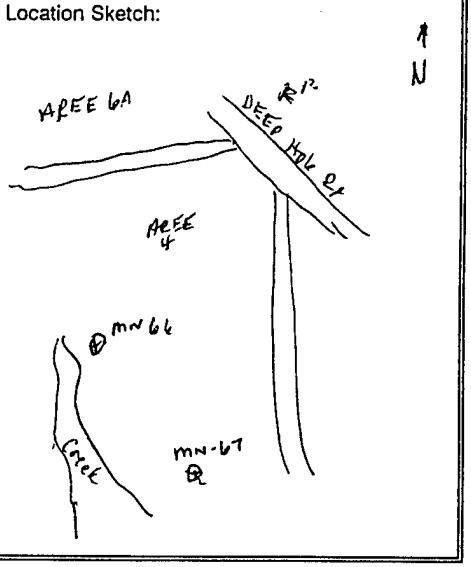
Project: WRF RI/FS	Boring: MW-66 (AREE 4)
Geologist: Debbie Romano/JoAnn Stowers	Signature: Deborah L Romano
Driller & Company: Hardin Huber - Darin & Jay	Drilling Rig: Mobile B-80, ATV
Date Boring Started: 11/10/95	Completed: 11/10/95
First Encountered Water Level: 6 ft	Date: 11/10/95
Total Fluid Losses: —	Date: —
Total Fluid Losses: —	
Casing Type: PVC Schedule 40	Screened Interval: 6 - 16.0 ft
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/10/95	1440	1505	0	10'	4¼" to 10'	ID auger	& split spoon sampling ~10-14'		
11/10/95	1520	1015	0	16.5'	8¼" well	ID auger installed	overream to bentonite seal.		

Abbreviations:

Abbreviation	Meaning
v	very
fn	fine
lg	large
sm	small
w/	with
w/o	without
~	approximately
trace	90/10
little	80/20
some	70/30
and	50/50
&	and
gr.	grain
%	percent
lt.	light

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-66 (AREE 4) | Project Name: WRF RI/FS

Driller/Company: Hardin Huber-Jay, Darin | Drilling Method: Hollow Stem Auger | Date Started: 11/10/95 | Date Completed: 11/10/95

Total Depth: 16.5 | Depth to Bedrock: n/a | Water Table Depth: 6 ft | Ground Elevation:

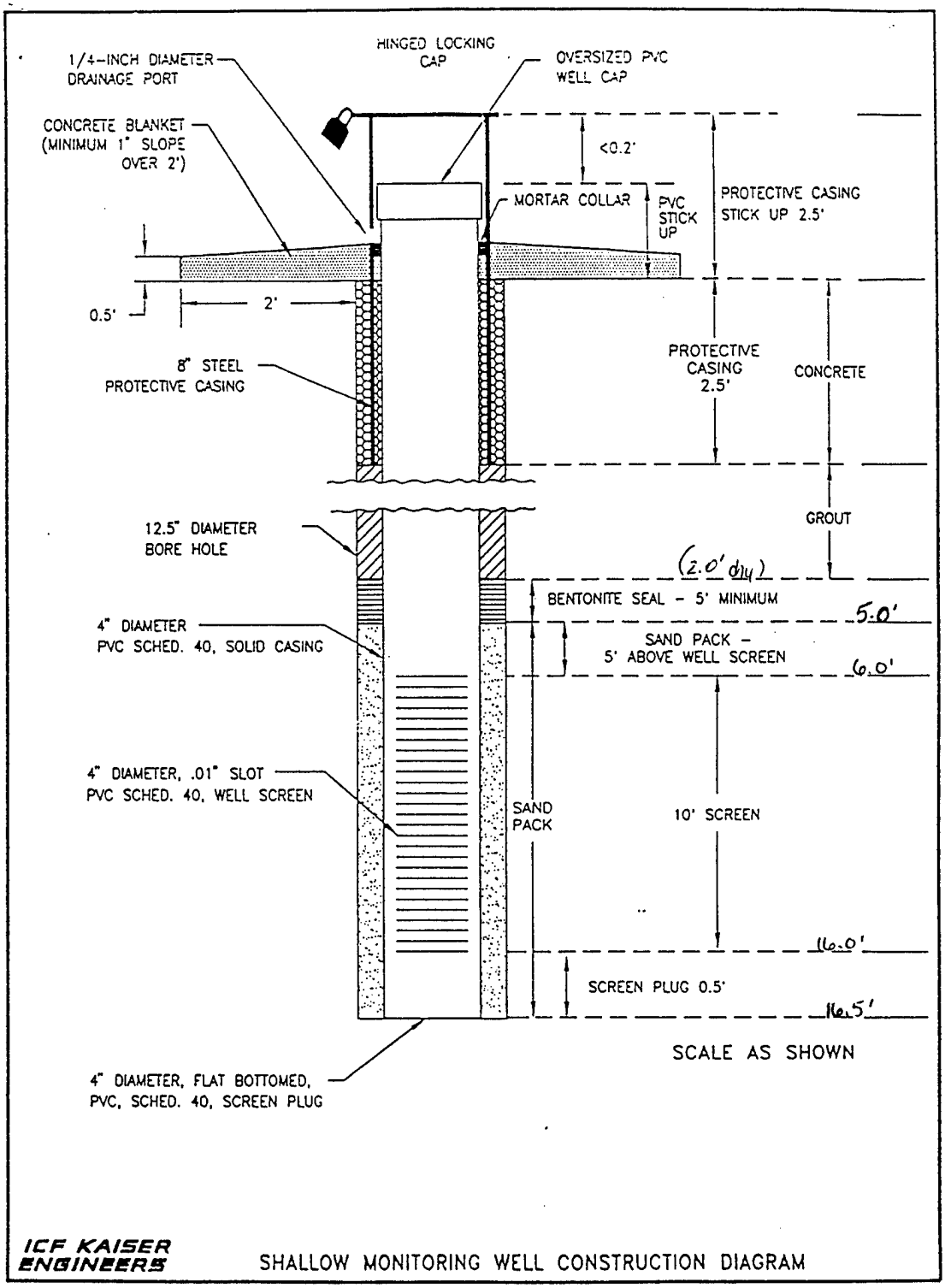
Protection Level: Modified D | H&S Monitoring Equipment: OVM | Logged by: Debbie Romano | Checked by: P. Thompson

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0'	MW-66A 0-2' 1445	3-3-4-5 17"	0-6" SILT, brown, w/ trace clay, very low plasticity, soft, dry	Split spoon 0-2' ESE Sample collected @ 1445, MW-66A		0	ML	10YR 4/3
2'			6-12" SILT, yellowish brown, soft, slightly moist;				ML	10YR 5/4
			12-17" Clayey SILT, brown, slightly moist, low plasticity				ML	7.5YR 5/4
5'	MW-66B 5-7' 1450	4-7-15-12 ~~12~~ 1'	0-2" - SAND, gray, fine, very moist to wet, trace silt, loose	Split spoon 5-7' ESE Sample collected @ 1450 MW-66B Hit water 6'		0	SW	5Y 6/1
			2-7" - SAND, pale brown, fine, little silt, very moist to wet, loose				SM	10YR 6/3
7'			7-12" - SAND, yellowish brown, fn. to coarse w/ fn. gravel & little silt; some mottling of 7.5YR 4/6 strong brown, black organics; gravel may be quartz, very moist to wet, subangular sand, med.-dense				SM	10YR 5/4
10'	MW-66C 10-12' 1455	8-16-14-8 17"	0-2" - SAND, yellowish brown, fn. sand, little silt, wet, med. dense.	Split spoon 10-12' ESE sample collected @ 1455 MW-66C		0	SM	10YR 5/4
			2-17" - SAND, pale brown, wet, fn to very coarse, trace fine gravel, little silt, med. dense, subangular sand				SM	10YR 6/3
12'	Physical sample	9-11-12-11 19"	0-6" - Sandy CLAY, yellowish brown, V. fn. sand, high plasticity, wet, grading to ↓	split spoon 12-14' Physical sample collected		0	CL	10YR 5/4
14'			6-12" Clayey SAND, V. fn to fn. sand, wet, yellowish brown med. dense				SC	10YR 5/4
			12-19" SAND w/ little ~~silt~~ clay, lt. yellowish brown, fn. to V. coarse grain sand, wet, subangular, med. dense				SC	10YR 6/4
				1535 - Add 1st bag of sand.				
				1545 - 1st auger off, 14' to sand, 4 bags				
				1555 - 2nd auger off, 10' to sand, 7 bags				

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

10' screen PVC sched 40
10' riser PVC sched. 40
0.5' plug PVC sched. 40

1605 - 12 bags of sand, sand to 5.0'
1610 - 3 buckets of bentonite pellets, dry pellets to 2.0'



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-06

DATE COMPLETED: 11/10/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

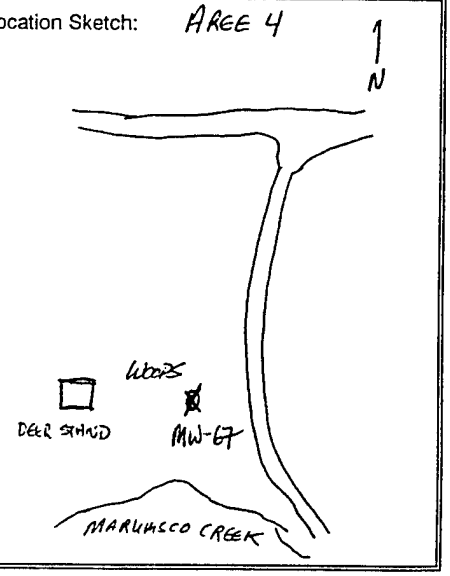
Project: WRF	Boring: MW-67 Area 4
Geologist: Jo Ann Stowers / Debbie Romano	Signature:
Driller & Company: Hardin Huber	Drilling Rig: ATV - B-80
Date Boring Started: 11/10/95	Completed: 11/10/95
First Encountered Water Level: 8'	Date:
Total Fluid Losses: 0	Date:
Total Fluid Losses: 0	
Casing Type: NA	Screened Interval: 6.5 - 16.5
Geophysical Logging: NA	Date:
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: 4" Monitoring well	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/10/95	1050	1132	0	16'					

Abbreviations:

Abbreviation	Meaning
v.	very
fn.	fine
gn.	grain
med.	medium
w/	with
w/o	without
%	percent
trace	90/10
little	80/20
some	70/30
and	50/50
TIH	Trip into hole
TOH	Trip out of hole

Location Sketch: AREA 4



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-67 | Project Name: WRF

Driller/Company: Hardin Hyden | Drilling Method: Hollow-stem Augers | Date Started: 11/10/95 | Date Completed: 11-10-95

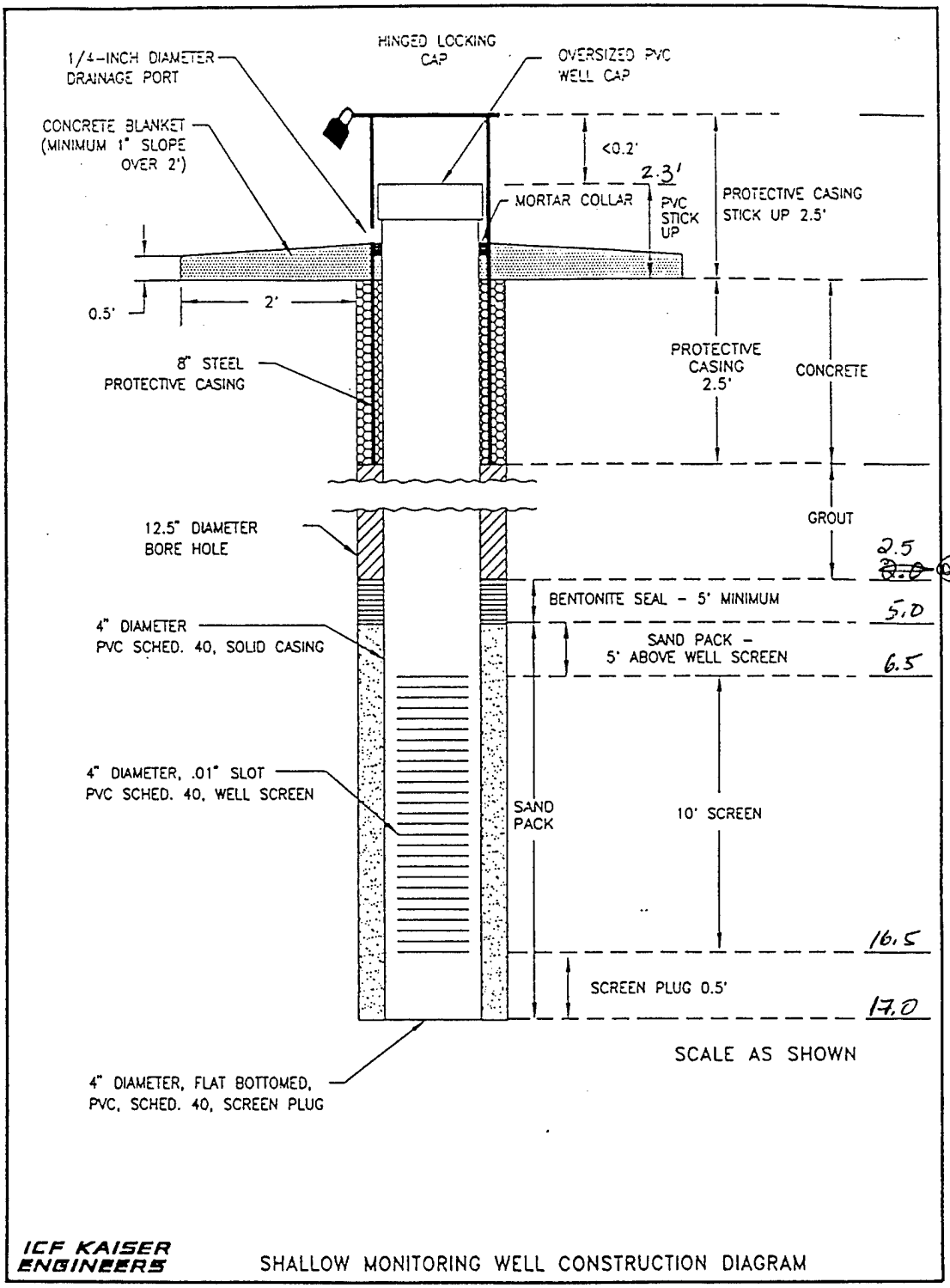
Total Depth: | Depth to Bedrock: NA | Water Table Depth: 8' SS 6' | Ground Elevation: NA

Protection Level: Modified D | H&S Monitoring Equipment: OVM | Logged by: T. Stowers | Checked by: T. Thomas

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW-67A 0-2'	3-3-5-6 / 16"	0.0 - 0.2' - Topsoil, silt, dk yellowish brown, slightly moist to dry, no plasticity, medium stiff 0.2' - bottom of spoon - CLAYey SILT, yellowish brn., slightly moist, low plasticity, dense	1100 - Collect ESE MW-67A Augs to 5'		0.0 ppm	ML	10yr 3/4 10yr 5/6
5	MW-67B 5-7	4-11-13-12	Brown clayey SILT, stiff, very moist to wet @ 6.5' slight to little plasticity, w fine gn. sand (little) 6.2' - SILTY SAND, w little to trace quartz pebbles.	1115 Collect ESE MW-67B Augs to 10' Cuttings coming up V. moist to wet @ 6' downward to end of boring		0.0 ppm	ML/CL	10yr 4/3
10	MW-67C 10-12	5-7-13-14	SILTY SAND, wet, light yellowish brown, no plasticity, loose, subangular w/ gray coarse sand strings @ ≈ 11'	1120 Collect ESE MW-67C		0 ppm	SM	10yr 6/4
	12-14' Typical Sample	7-12-11-11	SAND w/ some SILT, wet to saturated, med to coarse gn, subangular poorly graded				SM	10yr 5/4
15								
20								

All measurements should be recorded in feet or tenths of feet.

‡ Record cored intervals in this column if drilling bedrock.



1145 - Begin MW-67 well Installation

TD = 17.0' Use tremie 2" dia to tremie sand. Tremie placed @ 15' below ground.

12 50lb bags #1 20/40 Silica Sand.

2 buckets 3/8" bentonite pellets

WELL NO.: MW-67

DATE COMPLETED: 11/10/95

1 - 10' 0.01 sch 40 slotted screen (4")

1 - 10' PVC sch 40 4" riser

1 - 0.5' bottom cap

1 - loose fitting locking cap.

1200 Take off 1 Bag - 15' on column Top of sand @ ~14' after 2 bgs sand.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

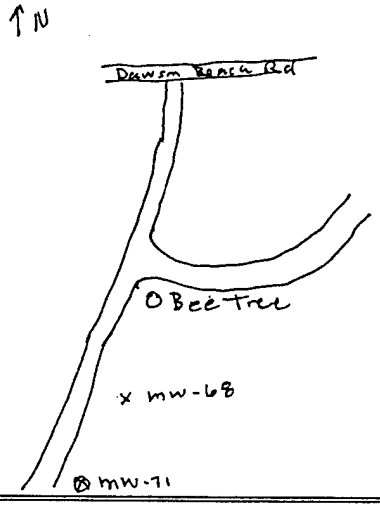
Project: NRF RI	Boring: MW-68 - AREE 2
Geologist: J. Stowers / D. Romano	Signature:
Driller & Company: ~~11/2/95~~ Hardin Huber	Drilling Rig: B-61
Date Boring Started: 11/2/95	Completed: 11/03/95
First Encountered Water Level: 9' 11"	Date: 11/2/95
Total Fluid Losses: 0	Date:
Total Fluid Losses: 0	
Casing Type: 4" Sch 40 PVC	Screened Interval: 7-17'
Geophysical Logging: NA	Date:
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: 4" Sch 40 0.01 screen	Date: 11/3/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/2/95	1630	1730	0	27'					

Abbreviations:

Abbreviation	Meaning
%	percent
v.	very
fn.	fine
gr.	grain
sm	small
med.	medium
lg.	large
w/	with
w/o	without
TIH	Trip into Hole
TOH	Trip out of Hole
T.D	Total Depth

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-68		Project Name: WRF	
Driller/Company: Hardin Huber	Drilling Method: HSA	Date Started: 11/2/95	Date Completed: 11/03/95
Total Depth: 17.5' TD of MW-68	Depth to Bedrock: NA	Water Table Depth: ~9'	Ground Elevation:
Protection Level: Modified D	H&S Monitoring Equipment:	Logged by: J. Stowers	Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW68A(AD)	2-2-4-5 Composite ESE MW68AD 4-6-7-8 /39" rec	Silty CLAY, yellowish brown, med stiff, slightly moist w/ trace organics	1635 - collect MW68AD (0-4') & MW-68A		–	CL	10yr 5/6 10yr 5/4
				Auger to 5'				
5	MW68 (2)	5-6-12-13	SAME AS ABOVE but increased density @ 5-7' sample, Lg rock frag (1.5" dia) quartz, lg organic (carbon frag = 1" dia) @ 6.6', slightly moist to dry. High Fe content			–	CL	10yr 5/4
			- CLAYEY SAND @ ~9'	Auger to 10'				
10	(3) MW68-B	6-8-8-8 20"	CLAYEY SAND, yellowish brn, grading to clayey SAND, pale brown @ ~11', v. moist to wet, medium dense	– Water @ ~9-11'				10yr 5/6 10yr 6/3
				Auger to 15'		–		
15	(4)	2-2-3-4 14"	SANDY CLAY, gray, mod soft, med plasticity w/ some v. fn. gr. sand, wet	Auger to 20'				
20	MW68-C	3-7-9-6	CLAYEY SAND ~ 80% CLAY, yellowish brn, wet, No plasticity, poorly graded, fn. to med gr.				SP	

All measurements should be recorded in feet or tenths of feet.

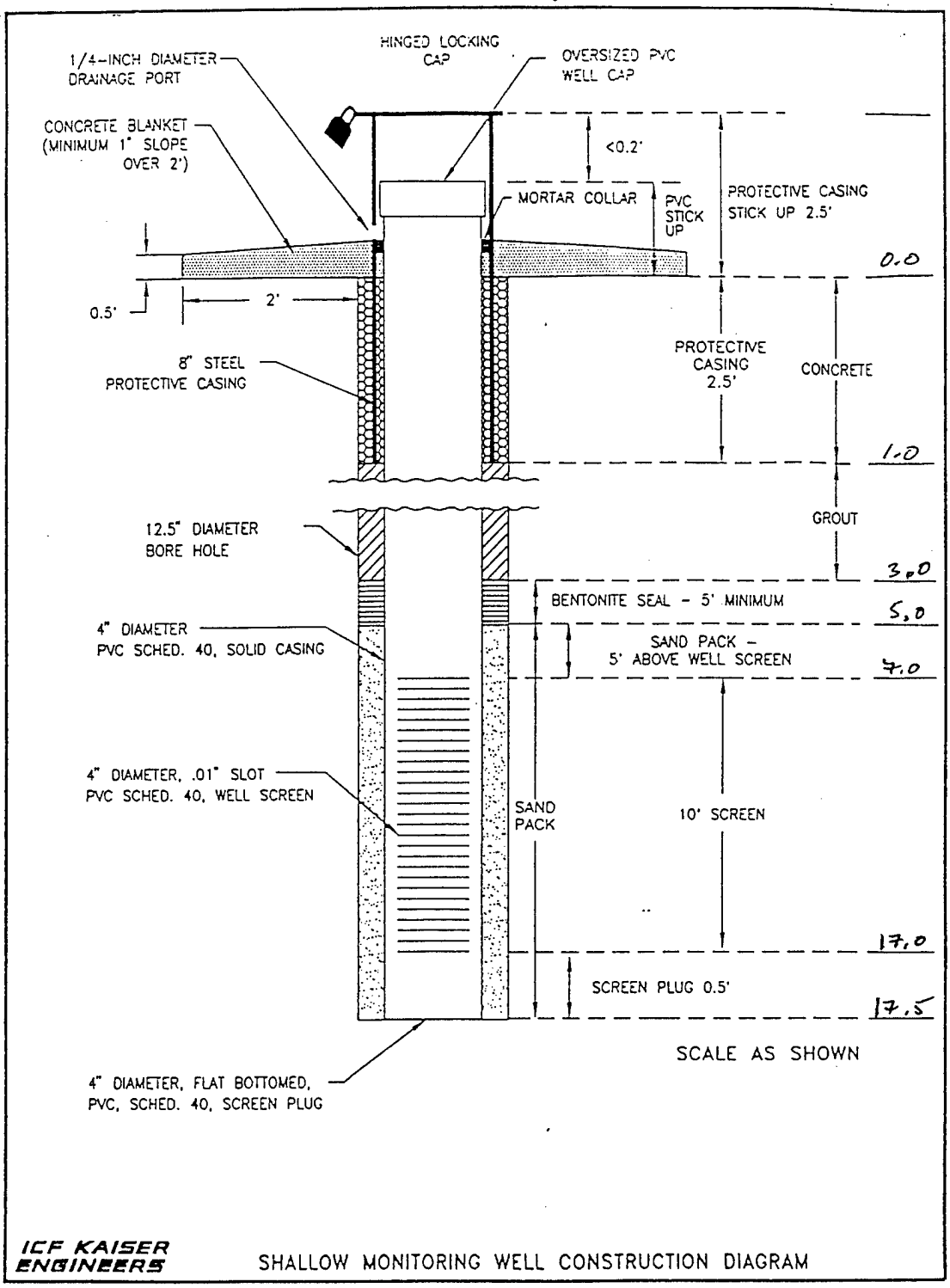
‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-67 | Project Name: WRF

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				Drill to 25'				
25	⑥	5-7-10-11	CLAY, gray, stiff, med to high plasticity, moist to very moist.			0.0 ppm	CL	2.5Y 6/1 gray 5/5B
			TD of Boring					
30			Set well screen fm 7-17' bgs					

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

Completed Bentonite Seal @ 0900

1-bucket bentonite

13 bags #1 20/40 Silica Sand

1 = Sch 40 0.01" slotted Screen - 10'-4" dia

1 = Sch 40 riser

1 - bottom cap (PVC)

1 well cap 4"

WELL NO.: MW-68

DATE COMPLETED: 11/03/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

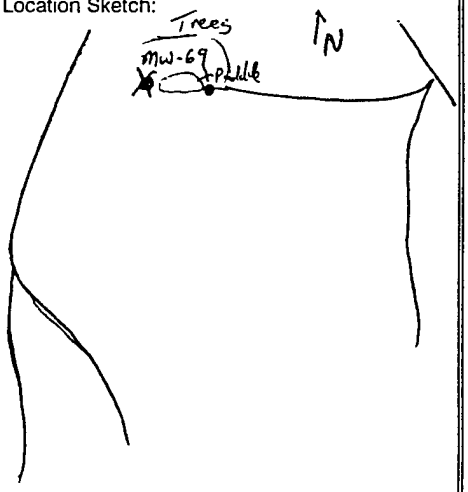
Project: WRF RI/FS	Boring: MW-69
Geologist: J. Stowers	Signature:
Driller & Company: Hardin Hudson	Drilling Rig: Mobil B-80 ATV
Date Boring Started: 11/20/95	Completed:
First Encountered Water Level: ~23'	Date: 11/20/95
Total Fluid Losses: 0	Date: 11/20/95
Total Fluid Losses: 0	
Casing Type: 4" PVC Sch 40	Screened Interval: 20-30'
Geophysical Logging: NA	Date: NA
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date: NA

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/20/95	0930	1030	0	29'	Drill w/ 4¼" ID augers; 1030-1100 decon				
	1100	1145	0	30.5'	Overream w/ 8¼" ID augers				
	1310	1445			Backed rig to set well plug = 6' up auger column - take augers off and get new plug to re-overream.				
	1445	1630			Monitor Well Installation				

Abbreviations:

Abbreviation	Meaning
v.	very
fn.	fine
gr.	grain
sm.	small
med.	medium
lg.	large
w/	with
w/o	without
~	percent
70	trace
90/10	little
80/20	some
70/30	and
50/50	
TIH	Trip into HH
TOH	Trip out of HH

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-69	Project Name: WRF RI/FS		
Driller/Company: Hardin Hubbs	Drilling Method: Hollow-stem Auger	Date Started: 11/20/95	Date Completed: 11/21/95
Total Depth: 29.5	Depth to Bedrock: NA	Water Table Depth: 23	Ground Elevation:
Protection Level: Modified D	H&S Monitoring Equipment: OVM	Logged by: J. Stowers	Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW-69A	2-3-7-9 / 1.0'	0.0 - 0.2' - Clayey silt, dk grayish brown, moist, stiff, low to medium plasticity 0.2 - 1.0 - CLAY, yellowish brown, slightly moist, stiff, low to medium plasticity, mottled w/ light gray silt	0955 - Collect MW-69A Augr to 5'		0.0ppm	CL	10yr 4/4 10yr 5/4 10yr 6/1
5	MW-69	2-2-2-3 1.2'	CLAYEY SILT, grayish brown, moist, medium STIFF, slight plasticity.	0958 - Collect 2nd spoon - No sample will be submitted. Augr to 10'		0.0ppm	CL/ML	10yr 5/2
10	MW-69	1-2-1-2 0.8'	SILT, very dark grayish brown, almost peat consistency, very moist, highly organic w/ wood fragments, soft - Gray silty clay - v. moist @ 12-13' (loose	1002 - Collect 3rd spoon Augr to 15'		0.0ppm	ML	10yr 3/2
15	MW-69	1-2-1-2 2.0'	SILT, very dark grayish brown, moist to very moist, highly organic w/ root fragments throughout sample, soft	Augr to 20'		0.0ppm	ML	10yr 3/2
20								

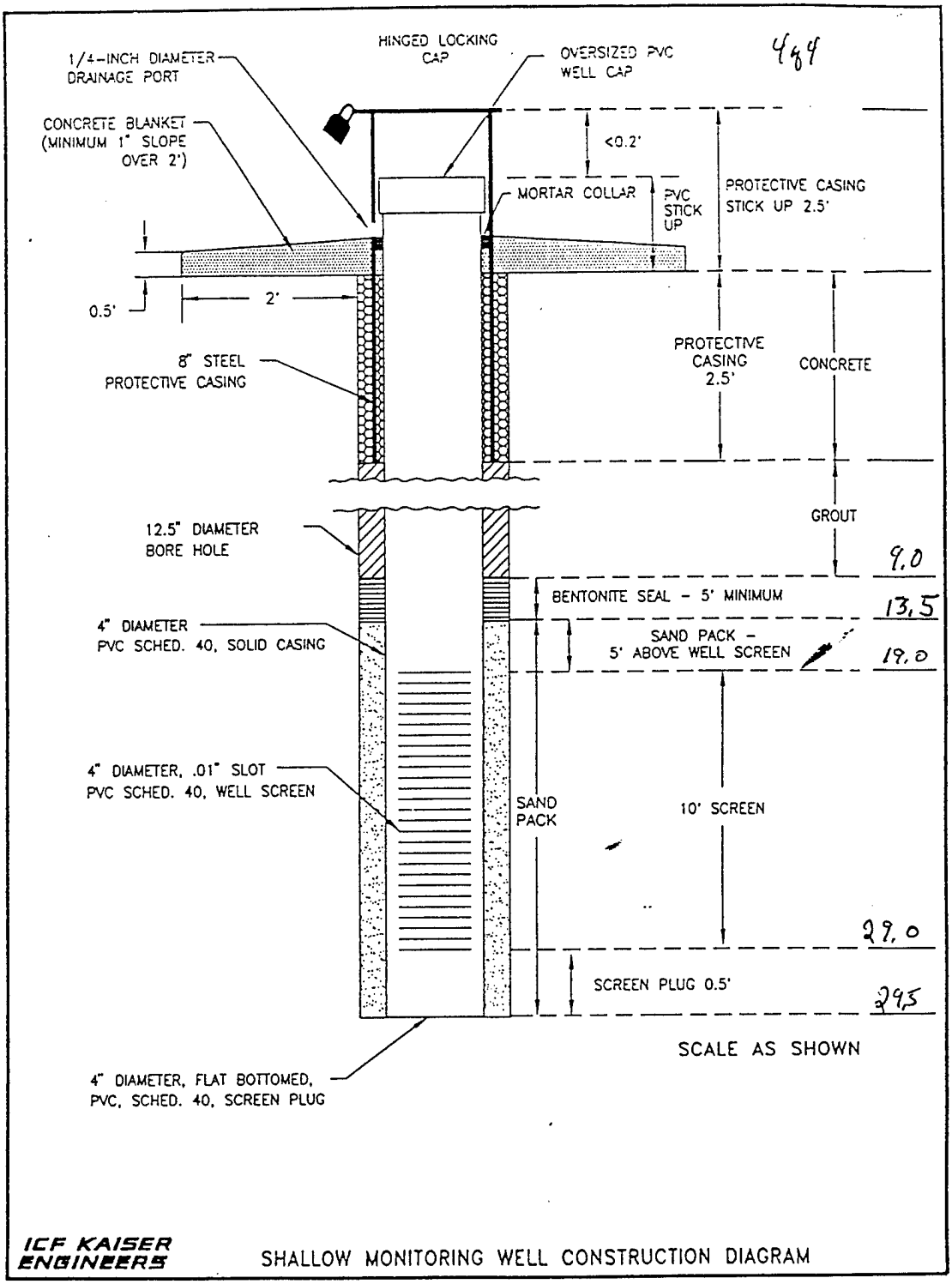
All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-69 | Project Name: HRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW-69	1-2-1-2 1.3'	SILTY CLAY, v. moist to moist, soft, gray, no to slight plasticity	- Water in boring @ 22'		0.0 ppm	CL	10yr 5/1
				23' - Driller says gravel in boring - Hit water & upper sand depth				
25	MW-69B	5-4-6-7 1.5'	SAND, fine to coarse gr, wet, medium dense, subangular, poorly sorted, w/ little silty clay matrix, w/ dark gravel (straw) at base.	1018 - Collect ESE MW-69 B (25-27') good sand		0.0	SP	10yr 5/1
	MW-69C	4-6-7-9 2.0'	Same As Above but w/ 1' very coarse sand layer @ 27.0 - 27.4'	1022 - Collect ESE MW-69C (27-29')		0.0 ppm	SP	10yr 5/1
30				Physical Sample - compacted w/ dark sediment from screened interval from 25-29'				
				TD = 29 w/ 4¼" Auger				
35				1100 - Begin overreaming w/ 8¼" ID augers.				
				1145 - Lunch				
				1310 - Back @ MW-69 - Sand has caved in will not come out - pull augers, clean out hole & augers and put new plug in & overream.				
				1420 - Beg. well installation. 1425 Used another 10' of rock only 20 on rig - 1' of sand up in auger				

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.



494

Well Materials

1 - 10' 4"ID Sch 40 PVC 0.01" slotted screen
2 - 10' 4"ID Sch 40 PVC riser
1 - 2' 4" ID sch 40 PVC riser
— 50 lb. bgs #1 20/40 Silica Sand
— ⅜" bentonite pellet buckets
1 - 4" ID end cap
1 - locking cap

WELL NO.: MW-69

DATE COMPLETED: _____

Tremie @ 27' w/ 6 augers a column under beginning filter pack installation
1505 - Begin tremieing sand. 1515 Take off 1 auger @ 4 bags - sand @ = 26'

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

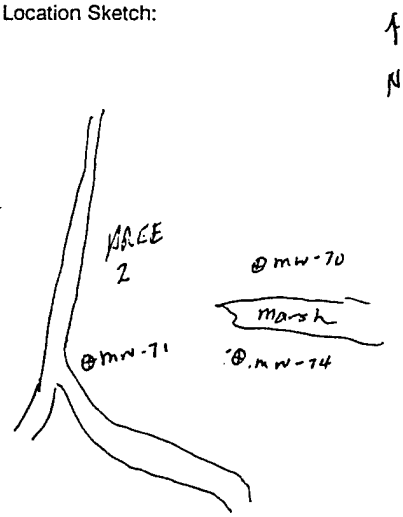
Project: WRF RI/FS	Boring: MW-70
Geologist: Jack Chapman/SRT	Signature: Jack Chapman
Driller & Company: Tony Mier / Hardin Drilling	Drilling Rig: Mobile B-61
Date Boring Started: 11/13/95	Completed: 11/13/95
First Encountered Water Level: ~ 8'	Date: 11/13/95
Total Fluid Losses: —	Date: —
Total Fluid Losses: —	
Casing Type: Sch 40 PVC 4" Diameter	Screened Interval: 5-15'
Geophysical Logging: None	Date: —
Depth to Bedrock: not encountered	Ground Elev.: —
Boring Completion Information: Completed as monitoring well	Date: 11/13/95

Date	Time Start	Time End	Depth of Drilling Per Shift Start	Depth of Drilling Per Shift End	Date	Time Start	Time End	Depth of Drilling Per Shift Start	Depth of Drilling Per Shift End
11/13/95	1350		0	15.5	Sampled w/ 4.25" ID HSA Reamed w/ 8.25" ID HSA Completed as monitoring well				

Abbreviations:

Abbreviation	Meaning
HSA	Hollow Stem Auger
~	Approximately
BGS	Below ground surface

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-70	Project Name: WAFAC/FS		
Driller/Company: Terry Mice/Hardin Hanson	Drilling Method: HSA sample 4¼" ID; overdrilled 8¼" ID	Date Started: 11/13/95	Date Completed: 11/13/95
Total Depth: 18.5'	Depth to Bedrock: Not Encountered	Water Table Depth: 8'	Ground Elevation:
Protection Level: modified D	H&S Monitoring Equipment: OVM	Logged by: Joel Chapman/L.	Checked by: P Thompson

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0	MW-70A 1355	2/2/3/4 18"	0-2 Strong Brown clay, w/some silt High Plasticity Dense.	Will sample to TD w/ 2" OD x 24" split spoon sampler inside 4¼" ID HSA. 1350 Begin Drilling 1355 split spoon 0-2' BGS Auger down 5' 1402 split spoon 5-7' BGS Auger down 5' Driller notes water @ 8' 1407 split spoon 10-12' BGS Auger down 2' Split spoon 12-14' to collect physical @ 1412 Withdraw 4¼" auger. Driller goes to install 8¼" ID HSA. Will overdrill to 15.5' & set well screen from 5-15' BGS				7.5yr 4/6
5	MW-70B 1402	4/6/5/8 20"	5-6 ~~Sandy~~ Strong Brown Sandy clay, Dense, Low Plasticity 6-7 Strong Brown Silty Sand, Saturated, Sand VF gr, ~~To medium~~ FC and med gr.					7.5yr 4/6
10	MW-70C 1407	10-12' 5/7/11/12 24"	Sand med to coarse gr saturated, sub angular grains, Dark yellowish Brown					10yr 4/6
15	Physical Sample 1412	20/19/14/12 24"	12-14 Gravelly Sand, Saturated Dark yellowish Brown, w/ cobbles Subangular to Subrounded.				GP	

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.

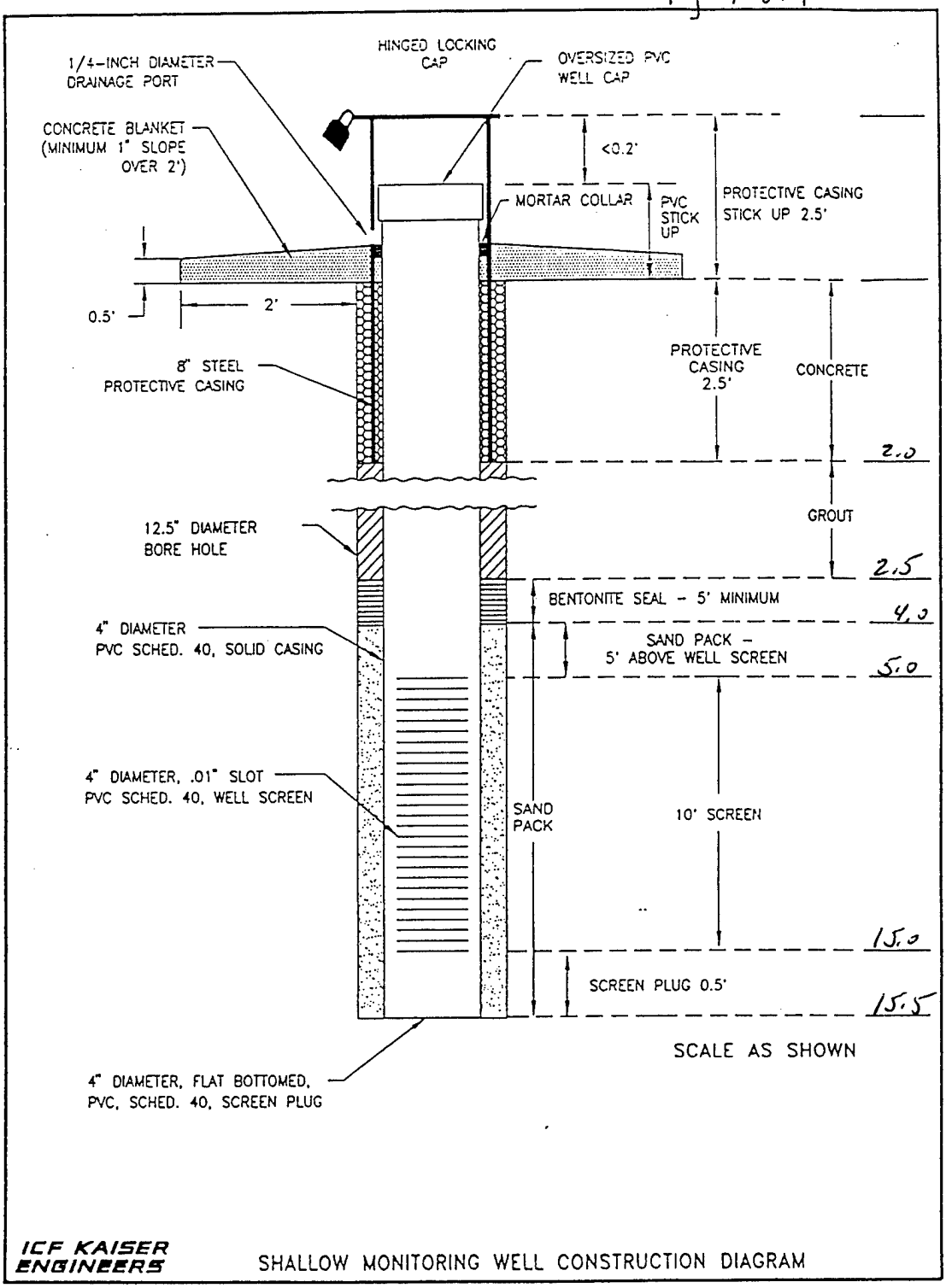
ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-70 | Project Name: WRF RE/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ǂ	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				1450 Set up + Drilled out Borehole w/ 8 1/4" ID HSA. Installed well Plus Tw lead auger. 1507 TD = 15.5' BGS Installed well Casing Screen @ 3-15' BGS. 1511 Lower Tremie pipe To 13' BGS into auger 1523 Sand @ 9' BGS Pulled 5' of Auger 1537 Sand @ 4' Pulled 5' of Auger 1541 Installed Bentonite Seal TO 2.5' BGS Pulled 5' of auger 1542 - Site cleanup Hydrated Pellets				

All measurements should be recorded in feet or tenths of feet.

ǂ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

2 Bags #1 Sand 20/40 Silica Sand
1 Bucket Bentonite 3/8" Pellets

WELL NO.: MW-70

DATE COMPLETED: 11/13/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

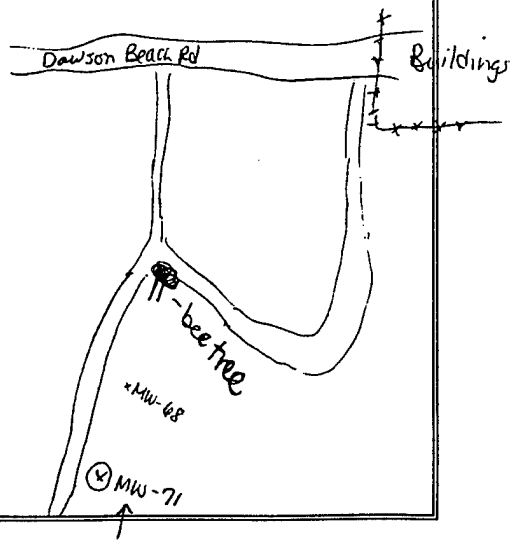
Project: WRF RI/FS	Boring: MW-71
Geologist: Debbie Romano/JoAnn Stowers	Signature: Deborah J Romano
Driller & Company: Hardin-Huber/Terry & Tom	Drilling Rig: Mobile B-61
Date Boring Started: 11/07/95	Completed: 11/07/95
First Encountered Water Level: 7 ft	Date: 11/07/95
Total Fluid Losses: n/a	Date: —
Total Fluid Losses: n/a	
Casing Type: PVC Schedule 40	Screened Interval: ~~5-15 ft~~ 5.5-15.5 ft
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: 4" monitoring well completed	Date: 11/08/95

Date	Time		Depth of Drilling Per Shift (ft)		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/07/95	1030	1130	0	15	6¼" auger				
	1300	1420	0	16	overream & well installation up to bentonite seal.				
11/08/95	0700		—	—	Grout up MW-71				

Abbreviations:

Abbreviation	Meaning
v.	very
fn.	fine
med.	medium
%	percent
w/	with
w/out	without
lg.	large
TIH	trip into hole
TOH	trip out of hole
&	and
and	50/50
tr.	trace (90/10)
some	(70/30)
gr.	grain
little	(80/20)
~	approximately

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-71 | Project Name: WRF RI/FS

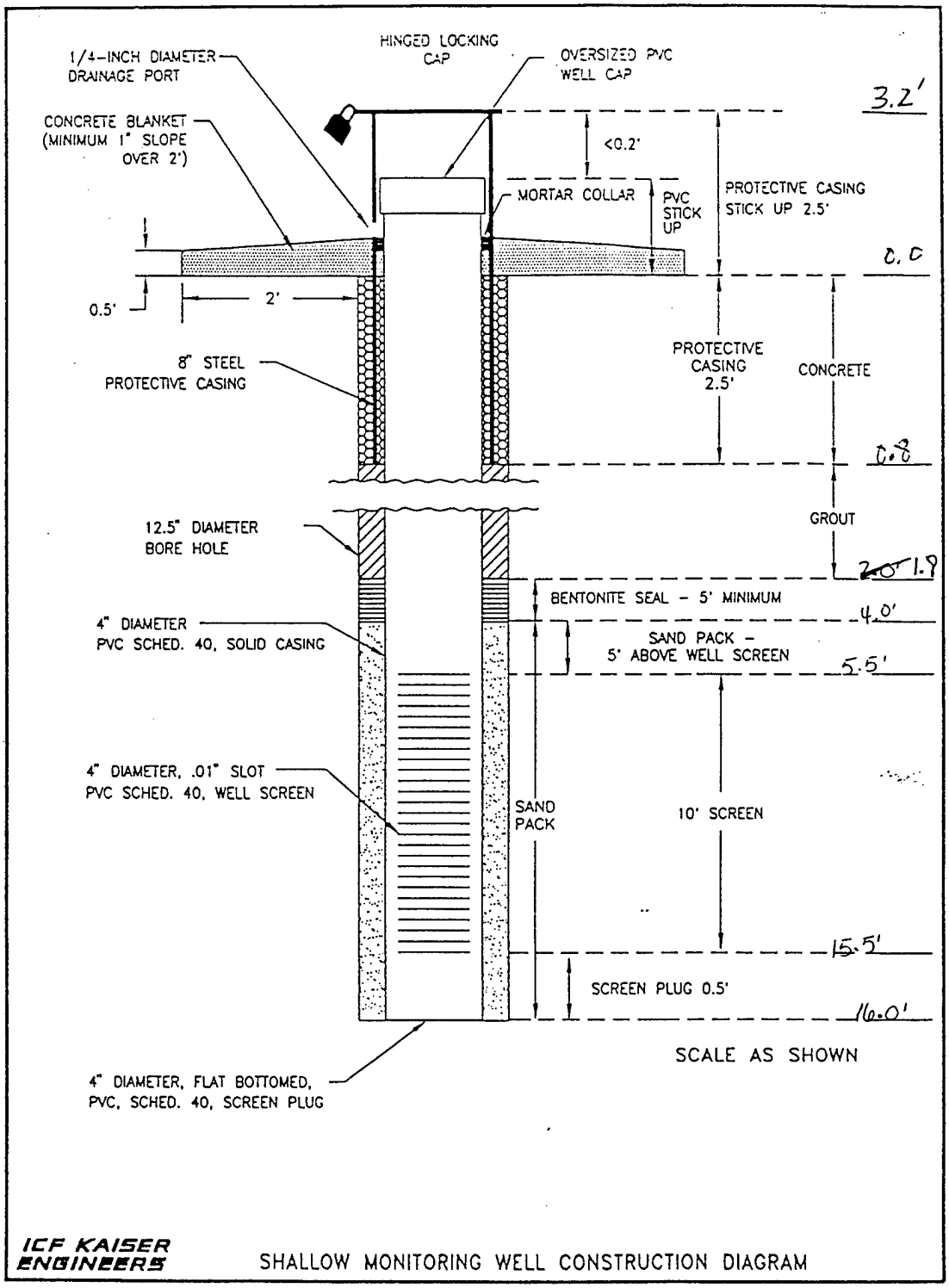
Driller/Company: Hardin-Huber/Tom & Tom | Drilling Method: Hollow Stem Auger | Date Started: 11/07/95 | Date Completed: 11/07/95

Total Depth: ~~Ran~~ (Drill) 16 ft | Depth to Bedrock: n/a | Water Table Depth: 7 ft | Ground Elevation:

Protection Level: Modified Level D | H&S Monitoring Equipment: OVM | Logged by: Debbie Romano | Checked by: P-Thomas

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								
	MW-71A	2-7-10-11 1Ft	0-6" Clayey SILT, dark grayish brown, soft, ~~trace~~ dry, low plasticity	Split spoon 0-2' and 2-4' (for duplicate sample.)		0ppm	~~Et~~ ML	10YR 4/2
	MW-71AD 2'		6-12" Silty CLAY, yellowish brown, med. stiff, slightly plastic, dry				CL	10YR 5/6
	0-4' 11:00	8-12-18-20 2'	0-1Ft SILT, v. dry, powdery, chalk-like, light gray			0ppm	ML	10YR 7/2
4'			1-2 ft Clayey SILT, ~~dark yellowish~~ brown, very low plasticity, crumbles.				ML	~~10YR~~ 7.5YR 4/4
5'	MW-71B 5-7' 1115	6-4-8-7 20"	CLAY & SAND, yellowish brown, some plasticity, soft, v.fn. gn. ~~Sand~~ to fn. gn. Sand, slightly moist. Grading to Clayey SAND, yellowish brown, fn. gn. sand, moist.	Split spoon 5-7'			SC SC	10YR 5/8
7'				Soil cuttings wet ~ 8' Water in borehole ~ 7'				
10'	MW-71C 10-12' 1130	4-8-7-11 2'	CLAY, reddish yellow, med. stiff, dry, highly plastic 0-6"	Split spoon 10-12'		OVM not working (rain)	CH	7.5YR 6/6
			6-12" Sandy CLAY, ~~reddish yellow~~ light brownish gray, med. stiff, fn. gn. sand, slightly moist; grading into ~~light~~ gray CLAY at ~ 12"				CL	2.5Y 6/2
12'			med. stiff-to stiff, med. plasticity, dry				CL	2.5Y 6/1
				4¼" ID auger to 15'				
15'	Physical sample 15-16'	4-4-4-4 2'	0-2" Clayey SAND, brown, soft, slightly moist	Split spoon only - 15-17'			SC	7.5YR 5/4
			2-6" CLAY, gray, soft, dry, highly plastic, grades to (at ~ 6") Clayey SAND, little clay, med. gn. sand, wet, loose, brown	Overream to 16'			CH	2.5Y 6/1
17'			12"-24" CLAY, light yellowish brown, soft, dry, highly plastic				SC	10YR 5/3
							CH	2.5Y 6/4

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

11/07/95
#1 sand (20/40) - 13 bags
Shur-Pel bentonite pellets 3/8" - 1½
5 gal. bucket
~2 buckets of water for bentonite)
PVC Schedule 40 riser - 10 ft section
PVC Schedule 40 screen - 10 ft section
PVC " " screen plug - 0.5 ft section

WELL NO.: MW-71

DATE COMPLETED: ~~11/08/95~~ 11/09/95 11/08/95

11/08/95
Grout added: Lehigh Portland Cement ¾ of 94lb bag mixed w/ 6 gal. of water.

Water level - 7.86' to top of protective casing

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

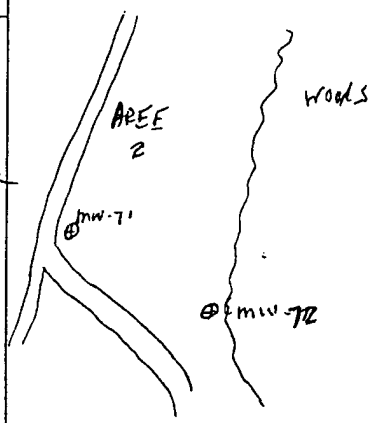
Project: WRF REFI	Boring: MW-72
Geologist: Jack Chojnowski	Signature:
Driller & Company: Terry Mice / Hamilton Hudson	Drilling Rig: Mobile B-61
Date Boring Started: 11/13/95	Completed: 11/13/95
First Encountered Water Level: 10'	Date: —
Total Fluid Losses: —	Date: —
Total Fluid Losses: —	
Casing Type: 4" PVC	Screened Interval: 8 - 18
Geophysical Logging: None	Date:
Depth to Bedrock: Not encountered	Ground Elev.:
Boring Completion Information:	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/13	0855	1014	0	18.5					

Abbreviations:

Abbreviation	Meaning
~	Approximately
Trace	Trace 10/90
And	50/50
Some	70/30
BGS	Below ground surface

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-72	Project Name: URF RI/FS		
Driller/Company: Terry Mice / Hadina Hydro	Drilling Method: HSA 4¼"ID ; 8¼" OD Rotosonic	Date Started: 11/13/95	Date Completed: 11/13/95
Total Depth: 19.5	Depth to Bedrock: Not encountered	Water Table Depth:	Ground Elevation:
Protection Level: Modified D	H&S Monitoring Equipment: OVM	Logged by: Jack Ohanian/Steve	Checked by: P. Thomas

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	~~MW-75A~~	3/5/7/4 6"	0-1' Yellowish Brown, silty clay, Damp High Plasticity 1-2' Brown sandy silt and clay F gr, subangular, Damp.	Will sample to total depth with 2"OD x 24" split spoon Sampler inside 4¼"ID HSA 0959 collect 0-2' split spoon Auger down 5'			ML/SC	7.5YR 4/4 10YR 5/4
5	MW-75A 0905	9/11/9/10 24"	Light yellowish Brown, Sandy silt and clay, clay low to moderate plasticity, Sand V. F. gr., Dry.	0905 Collect Single MW-75A Auger down 5'				10YR 6/4
10	MW-75B 0926	5/10/10/12 24" Rec	10-11' Same as above except wet 11-12' Strong Brown, Damp to wet Sandy clay, moderate plasticity, Sand is Fine to medium gr. Subangular	0926 collect MW-75B Auger Down 5' Water @ 10' (Drillers notes) 0926 collect MW-75C from 15-17' BGS Collect Physical. 0929 withdraw 4¼" ID HSA.				10YR 5/4 7.5YR 7/8
15	MW-75C 0926 + physical	3/3/7/8 24" Rec	Dark yellowish Brown Sand, Saturated,					10YR 4/6

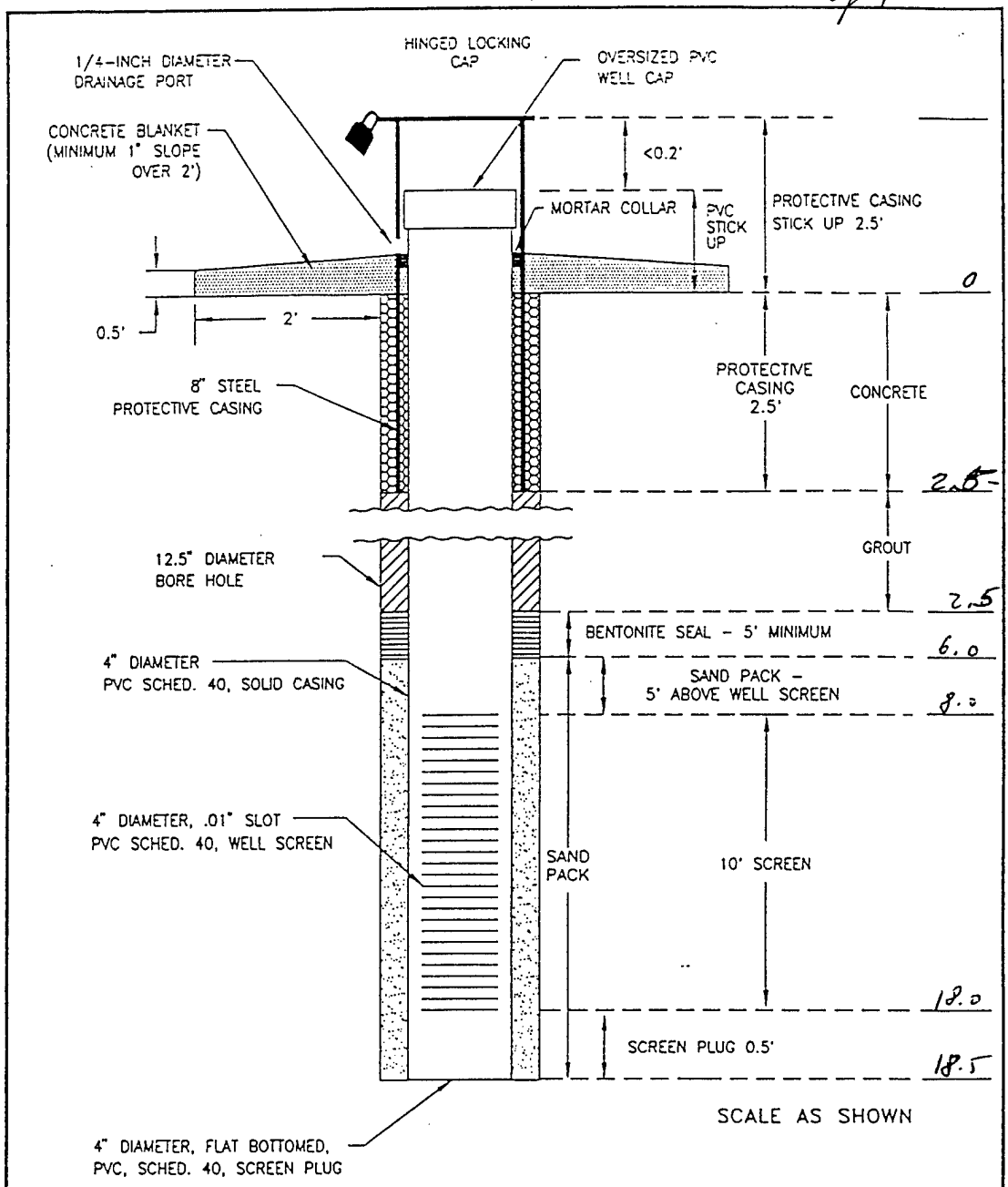
All measurements should be recorded in feet or tenths of foot. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-72	Project Name: WAF RE(F)

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				Driller goes to pick up 8¼" ID augers + well material. Add wooden plug to lead Auger.				
				0957 Begin To overream Borehole w/ 8¼" ID Auger. Will set well screen from 8' - 18' BGS.				
				1014 TD = 18.5' Add water To Auger				
				Installed well Casing				
				Knocked out Plug w/ 2" Tremie				
				1019 Begin Installing F. Tex pack Via 2" Tremie @ 17' BGS				
				1023 Sand @ 14' Pulled 5' of Auger				
				1049 Sand @ 9' Pulled 5' of Auger.				
				1100 Sand @ 6' ~~Pulled~~ OC used 13 Bags				
				1100 Installed Bentonite Seal To 4' BGS Pulled 5' Auger				
				1107 Backfilled To 2.5' BGS				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

3 Buckets 3/8" Bentonite Pellets
130 ass #1 20/40 Sieve Sand
10' 0.1" Slot Screen 4" OD
10' PVC Riser 4" OD

WELL NO.: MW-72

DATE COMPLETED: 11/13/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

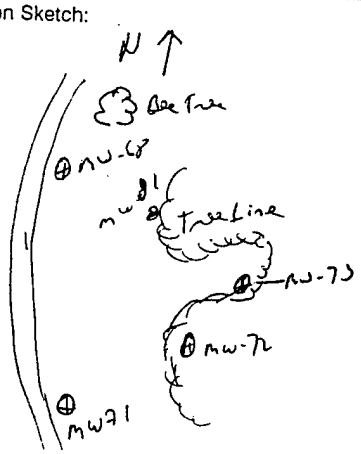
Project: WRF RI/FS	Boring: MW-73
Geologist: JACK CHOYNOWSKI / DENNIS BATTS	Signature: Dennis Batts
Driller & Company: RICK RIDER / HARDIN HUBER, INC.	Drilling Rig: B-57
Date Boring Started: 11/29/95	Completed: 11/30/95
First Encountered Water Level: 13'	Date: 11/30/95
Total Fluid Losses: N/A	Date: —
Total Fluid Losses: N/A	
Casing Type: PVC SCHEDULE 40	Screened Interval: 13.5 - 23.5'
Geophysical Logging: NONE	Date: —
Depth to Bedrock: NONE ENCOUNTERED	Ground Elev.: —
Boring Completion Information: Completed as monitoring well	Date: 11/30/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/29/95	1556	1700	0	15'		4.25" ID HSA (SPLIT SPOON 15-17')			
11/30/95	0745	0807	0	15'					
11/30/95	0810	1208	0	25'		8.25" ID HSA OVERREAM			

Abbreviations:

Abbreviation	Meaning
~	Approximately
Trace	90/10 %
and	50/50 %
some	70/30 %
BGS	Below ground surface
&	and
W/	WITH
gr	grain

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

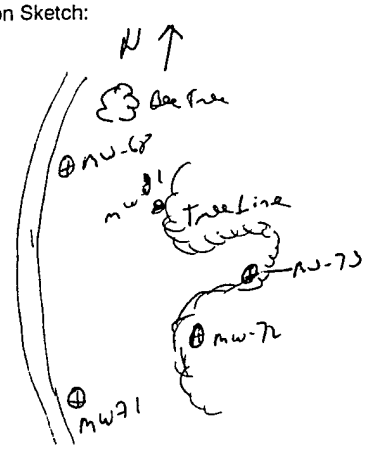
Project: WRF RI/FS	Boring: MW-73
Geologist: JACK CHOYNOWSKI / DENNIS BATTS	Signature: Dennis Batts
Driller & Company: RICK RIDER / HARDIN HUBER, INC.	Drilling Rig: B-57
Date Boring Started: 11/29/95	Completed: 11/30/95
First Encountered Water Level: 13'	Date: 11/30/95
Total Fluid Losses: N/A	Date: —
Total Fluid Losses: N/A	
Casing Type: PVC SCHEDULE 40	Screened Interval: 13.5 - 23.5'
Geophysical Logging: NONE	Date: —
Depth to Bedrock: NONE ENCOUNTERED	Ground Elev.: —
Boring Completion Information: Completed as monitoring well	Date: 11/30/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/29/95	1556	1700	0	15'		4.25" ID HSA (SPLIT SPOON 15-17')			
11/30/95	0745	0807	0	15'					
11/30/95	0810	1208	0	25'		8 25" ID HSA OVERREAM			

Abbreviations:

Abbreviation	Meaning
~	Approximately
Trace	90/10 %
and	50/50 %
some	70/30 %
BGS	Below ground surface
&	and
W/	WITH
gr	grain

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-73	Project Name: WRF RI/FS		
Driller/Company: RICK RIDER/HARDIN-HUBER, INC	Drilling Method: HOLLOW STEM AUGER	Date Started: 11/29/95	Date Completed: 11/30/95
Total Depth: 24' TD	Depth to Bedrock: not encountered	Water Table Depth: 13.0	Ground Elevation: —
Protection Level: MODIFIED LEVEL D	H&S Monitoring Equipment: MICROTIP PID	Logged by: D. BATTS	Checked by: Jack Claymonville

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ¢	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0			LOCATION FOR MW-73 IS FORMER LANDFILL SITE. BOREHOLE SITE HAD TO BE BACK-HOED TO REMOVE DEBRIS (DOWN TO 5' BGS). TOP 5' FEET OF SOIL IS NOW FILL.	AUGER TO 5'				
5								
5-7'	MW-73A	3-3-2-12	0-4" SLOUGH	SPLIT SPOONED 5-7'		0.0	CL	10 YR 7/1
7	1609	16"	4-15" SANDY CLAY, DRY, MEDIUM PLASTICITY, LIGHT GRAY w/SOME BROWN MOTTLING	COLLECTED SAMPLE MW-73A 1609			GC	10YR5/6
			15-16" GRAVELLY SAND WITH CLAY, DRY, YELLOWISH BROWN GRAVEL 1/8"-3/4" SUBANGULAR, SAND MEDIUM GRAIN	AUGER TO 10'				
10								
10-12'	MW-73B	4-4-5-8	SANDY CLAY, DRY, MEDIUM PLASTICITY, LIGHT GRAY, SOME BROWN MOTTLING TOWARD TOP; MODERATELY STIFF	SPLIT SPOONED 10-12' 1634		0.0	CL	10YR5/6
12	1634	18"	TOP 2" SLOUGH, CLAY W/ SOME SAND, LITTLE GRAVEL, DRY, BROWNISH YELLOW	COLLECTED SAMPLE MW-73B				10YR6/8
				AUGER TO 15'				
				DRILLER BELIEVES WATER HIT AT 13'				
15								
15-17'	MW-73C	6-5-10-7	0-8" SLOUGH	SPLIT SPOONED 15-17'		0.0	SW	10YR5/6
17	1651	18"	8-12" SAND, MEDIUM GRAIN, WET, YELLOWISH BROWN	COLLECTED SAMPLE MW-73C 1651			CL	
			12-14" SANDY CLAY, WET, MEDIUM PLASTICITY, YELLOWISH BROWN	WITH SOME GRAY MOTTLING			CH	
			14-18" CLAY, HIGH PLASTICITY, MOIST, YELLOWISH BROWN, FAT, STIFF					

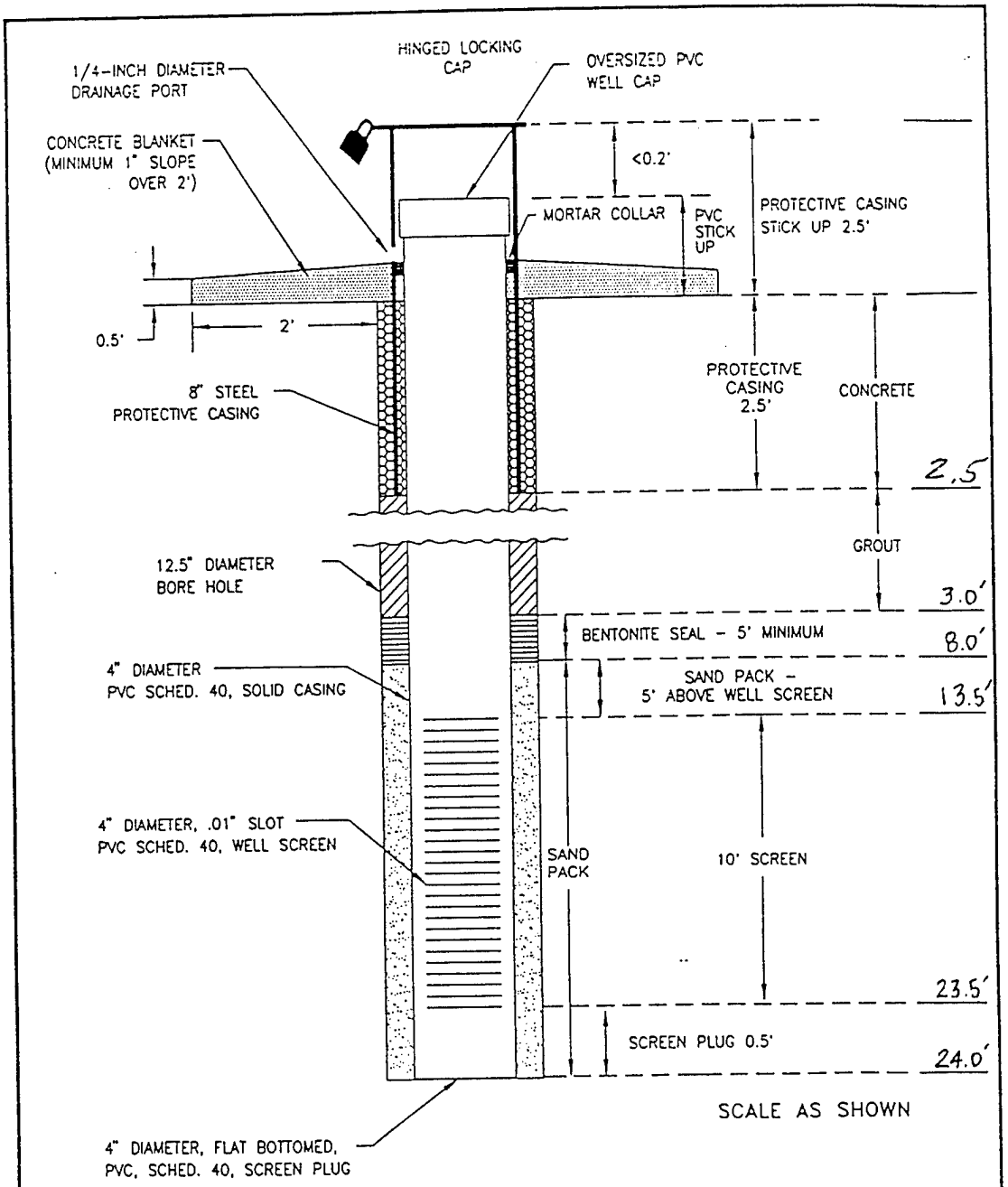
All measurements should be recorded in feet or tenths of feet. ¢ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-13 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ±	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
			11/30/95 * NOTE - WATER WITHIN 3' OF TOP OF BLOCKHOLE 15 - 50 LB BAGS #1 FILTER PACK SAND 3 - 5 GAL. BUCKETS DSI BRAND SHUR-PEL 3/8" BENTONITE PELLETS Grout ½ Bag of Cement 5 gal of water 2 lbs of Bentonite	11/30/95 0810 - BEGIN 9.25" OVERREAM 0825 - 2nd AUGER ADDED 0844 - 3rd AUGER ADDED 0906 - 4th AUGER ADDED. WATER ADDED INSIDE AUGERS 0933 - PLUG MOVED UP AUGER 1'. 5th AUGER ADDED. WATER ADDED INSIDE AUGERS. 1015 - PLUG STILL AT 1' UP AUGER. PULLED AUGERS OUT (1') TO KNOCK PLUG OUT WITH ROLLER CONE. 1033 - PLUG KNOCKED OUT. BEGIN INSTALLING CASING. TD = 24' BGS. SCREEN FROM 23.5 - 13.5'. 1045 - LOWERED TREMIE PIPE TO 22.5'. BEGIN INSTALLING FILTER PACK. 1054 - PULLED 1st 5' OF AUGER. SAND IS TO 18.5'. 1109 - PULLED 2nd 5' OF AUGER. SAND IS TO 14.5'. 1131 - PULLED 3rd 5' OF AUGER. SAND IS TO 9.5'. 1136 - SAND IS TO 8' BGS. BEGIN INSTALLING BENTONITE SEAL. 1201 - PULLED 4th 5' OF AUGER. BENTONITE IS TO 1208 - BENTONITE TO 3'. PULLED LAST OF 5' AUGERS. DRILLERS CLEANING UP WELL SITE AND MOBING TO DEPOT PAD.				

All measurements should be recorded in feet or tenths of feet. ± Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-73

DATE COMPLETED: 11/30/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

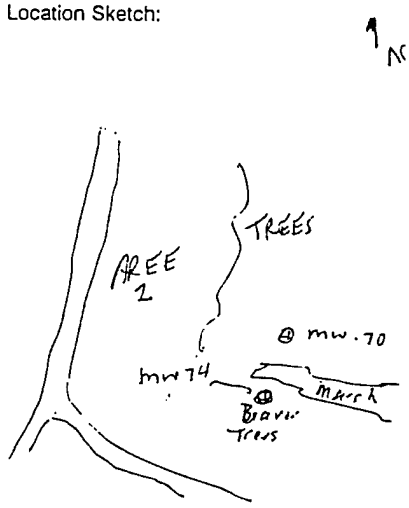
Project: WRF RI/FS	Boring: MW-74
Geologist: Jack Chojnacki/Dawn Bates	Signature: Jack Chojnacki
Driller & Company: Jay Corron/Harden-Huber	Drilling Rig: Mob B-80 (ATV)
Date Boring Started: 11/9/95	Completed: 11/09/95
First Encountered Water Level: 13 ft	Date: 11/09/95
Total Fluid Losses:	Date:
~~Total Fluid Losses:~~	
Casing Type: PVC 4" Diam w/ 0.1" Slot Screen	Screened Interval: 10-20'
Geophysical Logging: none	Date: —
Depth to Bedrock: not encountered	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/9/95	1435	1515	0	20'	4¼"	auger to 20'		split spoon	20-22'
11/09/95	1550	1619	0	20.5	8¼"	auger diameter			

Abbreviations:

Abbreviation	Meaning
~	Approximately
Trace	~~Zero to~~ 90/10
and	50/50
Some	70/30
BGS	Below ground surface
TIH	Trip into Hole
TOH	Trip out of Hole
&	and
med	medium
lg	large
gr.	grain
@	at

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-74	Project Name: WRF RI/FS		
Driller/Company: Jay Corron/Hardin Hudson	Drilling Method: HSA 4¼"ID; Overream 8¼"ID	Date Started: 11/9/95	Date Completed: 11/09/95
Total Depth: 20'	Depth to Bedrock: not encountered	Water Table Depth: 13'	Ground Elevation:
Protection Level: Modified D	H&S Monitoring Equipment: OVM	Logged by: Jack Chaynowski	Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0-2	MW-74A 1445 0-2'	2-3-3-6 8"	0-2' SILT w/ trace fn. sand, light ~~olive~~ olive brown, dry, soft, crumbles.	4 Tilling @ 2"OD X 2'/auger split spoon sample inside 4¼"ID HSA. Begin drilling collect 1445 sample 0-2' Advance Auger 5'. Collect Sample @ 5-7' 1450 split spoon 5-7'		0	ML	2.5Y 5/4
5	MW-74B 2-4' 1450	4-3-6-5 17"	0-4" Silty CLAY, yellowish brown, slightly moist, low plasticity 4-12" ~~Silty~~ SAND, greenish gray w/ strong brown mottles, fn sand, moist, low plasticity 12-17" SAND w/ some silt, lt. yellowish brown, fn. sand wet, loose.			0	CL SC SM	10YR 5/4 Grey 6/5G 2.5Y 6/4
10		5-3-7-6 ~~24~~ 2'	0-8" - CLAY w/ trace v. fn. sand, dry - slightly moist, yellowish brown, low-med plasticity, med. stiff. ~~8-24"~~ 8-18" - CLAY, moist, high plasticity, gray. 18-24" - Sandy CLAY, moist, fn. sand, high plasticity	split spoon 10-12' Driller: water at 13'		0	CL CH CL	10YR 5/4 5Y 6/1 5Y 6/1
15	MW-74C Composite w/ 20-22' MW-74CD 1515	5-6-8-13 18"	0-4" - Clayey SAND, lt. olive gray, wet, loose, low to med plasticity, fn. sand 4-6" - Clayey SAND, lt. yellowish brown, wet, loose fn to med. grain 6-18" - SAND, lt. olive brown, little clay, wet, med. dense, fn. to med. grain	Split spoon 15-17' Sample: 1515 composited 15-17' w/ 20-22' MW-74C and MW-74CD		0	SC SC ~~SC~~ SP	5Y 6/2 2.5Y 6/4 2.5Y ~~5/3~~

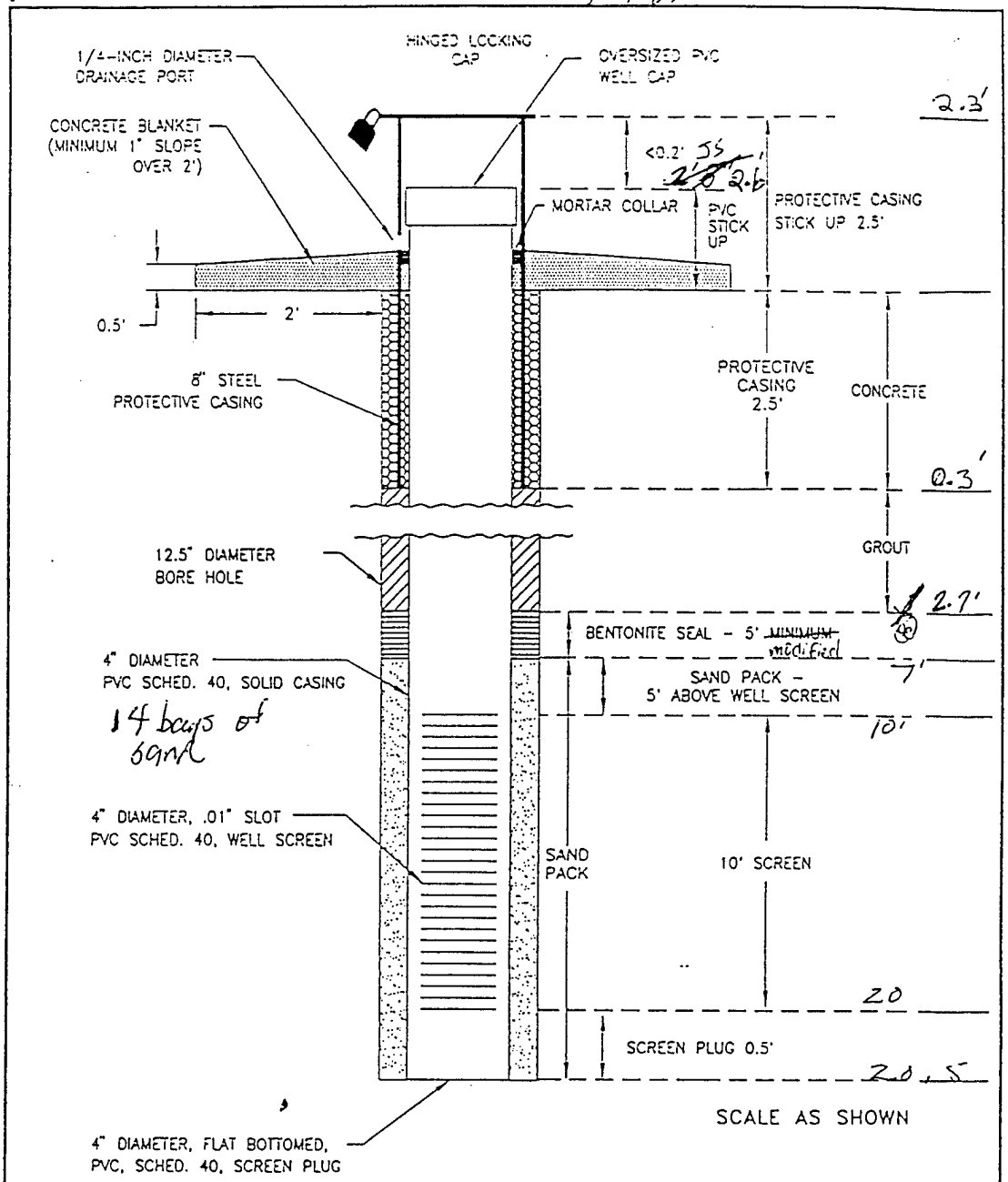
All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-74 | Project Name: WRF RI(F)

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MmunSELL COLOR
~~20~~								
22	MW-74C 15-17 & 20-22' 1515 and MW-74CD	5-7-6-7 2'	0-14"- SAND, v. fn. grain, trace clay, v. moist lt. yellowish brown 14-24- Sandy CLAY, v. fn. sand, strong brown mottled w/ lt. greenish gray, moist, high plasticity, (B) at ~ 18", grading to CLAY, same coloring as above moist, high plasticity.	Split spoon 20-22' Composite MW-74C w/ 15-17' MW-74B sampled @ 1515		0	SC CL CH	2.5Y 6/4 7.5Y 5/4 Chart 2 7/5BG
			1715 - Sand at 10.5 pull auger up to 7' bgs 1720 - Sand at 9' pull auger up 1730 - 15 bags of sand pack up to 7' in hole. 1740 - 3 buckets (5 gal) bentonite up to 3'.	Start overreaming w/ 12¼" augers @ 1556 VOA'd 1619 - Finish overreaming to 20.5 Fill hole w/ #20 Center plug out / Tagged bottom at 20.5 10' screen / 10' riser in hole 1629.				
			11/10/95 0730 - Arrived to get augers out & decommed ~~and to grout well~~ (A) Top of hydrated bentonite 2.7' bgs. 11/10/95 0745 depth to water from TOC 6.36	Raise Auger 3' Sand @ 17' Took off 5' augers Sand at 14.5'				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

11/10/95 0905 - Depth to water fm TOC = 6.36'

WELL NO.: MW-74

DATE COMPLETED: ~~MW-74~~ 11/10/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

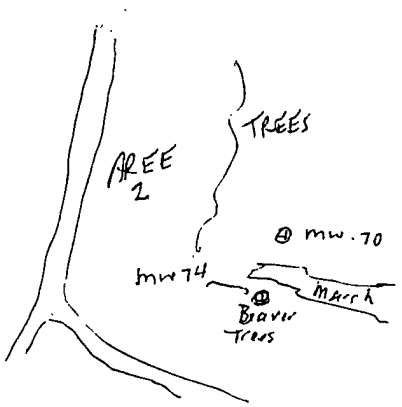
Project: WRF RI/FS	Boring: MW-74
Geologist: Jack Chojnowski/Dennis Batts	Signature: Jack Chojnowski
Driller & Company: Jay Corron/Hardin-Huber	Drilling Rig: Mobil B-80 (ATV)
Date Boring Started: 11/9/95	Completed: 11/09/95
First Encountered Water Level: 13 ft	Date: 11/09/95
Total Fluid Losses:	Date:
~~Total Fluid Losses:~~	
Casing Type: PVC 4" Diam w/ 0.1" Slot Screen	Screened Interval: 10-20'
Geophysical Logging: none	Date: —
Depth to Bedrock: not encountered	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/9/95	1435	1515	0	20'	4¼"	auger to 20'		split spoon	20-22'
11/09/95	1550	1619	0	20.5	8¼"	auger overburden			

Abbreviations:

Abbreviation	Meaning
~	Approximately
Trace	90/10
and	50/50
Some	70/30
OCS	Below ground surface
TIH	Trip into hole
TOH	Trip out of hole
&	and
MED	medium
lg	large
gr.	grain
@	at

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-74	Project Name: WRF RI/FS		
Driller/Company: Jay Corron/Hardin Hudson	Drilling Method: HSA 4¼"ID; Overream 8¼"ID	Date Started: 11/9/95	Date Completed: 11/09/95
Total Depth: 20'	Depth to Bedrock: not encountered	Water Table Depth: 13'	Ground Elevation:
Protection Level: Modified D	H&S Monitoring Equipment: OVM	Logged by: Jack Chaynowski	Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0-2	MW-74A 1445 0-2'	2-3-3-6 8"	0-2' SILT w/ trace fn. sand, light ~~olive~~ olive brown, dry, soft, crumbles.	4 Tilizing 4-2"OD X 2'/auger with split spoon sample inside 4¼" ID HSA Begin drilling Collect 1445 sample @ 2' Advance Auger 5'.		0	ML	2.5Y 5/4
5	MW-74B 2-4' 1450	4-3-6-5 17"	0-4" Silty CLAY, yellowish brown, slightly moist, low plasticity 4-12" ~~Silty~~ SAND, greenish gray w/ strong brown mottles, fn sand, moist, low plasticity 12-17" SAND w/ some Silt, lt. yellowish brown, fn. sand wet, loose.	Collect Sample @ 5-7' 1450 Split spoon 5-7'		0	CL SC SM	10YR 5/4 Grey 6/5G 2.5Y 6/4
10		5-3-7-6 ~~24~~ 2'	0-8" - CLAY w/ trace v. fn. sand, dry - slightly moist, yellowish brown, low-med plasticity, med. stiff.	Split spoon 10-12'		0	CL	10YR 5/4
12			~~8-24"~~ 8-18" - CLAY, moist, high plasticity, gray. 18-24" - Sandy CLAY, moist, fn. sand, high plasticity	Driller: water at 13'			CH CL	5Y 6/1 5Y 6/1
15	MW-74C Composite w/ 20-22' MW-74CD 1515	5-6-8-13 18"	0-4" - Clayey SAND, lt. olive gray, wet, loose, low to med plasticity, fn. sand 4-6" - Clayey SAND, lt. yellowish brown, wet, loose fn to med. grain 6-18" - SAND, lt. olive brown, little clay, wet, med. dense, fn. to med. grain	Split spoon 15-17' Sample: 1515 Composited 15-17' w/ 20-22' MW-74C and MW-74CD		0	SC SC ~~SC~~ SP	5Y 6/2 2.5Y 6/4 2.5Y 5/3
17								

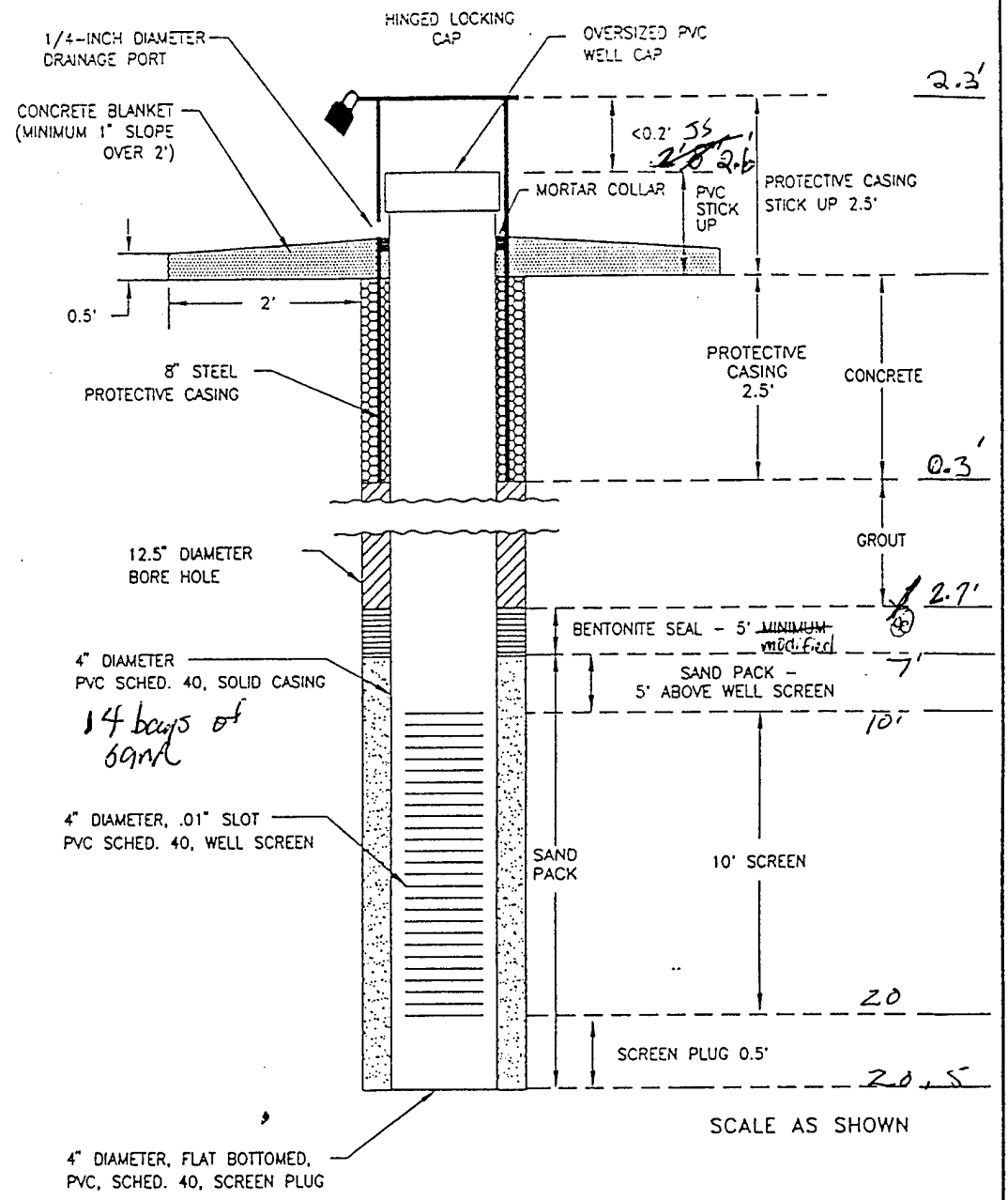
All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-74 | Project Name: WRF RI(FS)

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
22	MW-74C 15-17 & 20-22' 1515 and MW-74CD	5-7-6-7 2'	0-14" - SAND, v. fn. grain, trace clay, v. moist lt. yellowish brown 14-24 - sandy CLAY, v. fn. sand, strong brown mottled w/ gr lt. greenish gray, moist, high plasticity, @ at ~ 18", grading to CLAY, same coloring as above moist, high plasticity.	Splitspoon 20-22' Composite MW-74C w/ 15-17' MW-74D Sampled @ 1515		0	SC CL CH	2.5Y 6/4 7.5Y 5/4 Chart 2 7/5BG
			1715 - Sand at 10.5 pull auger up to 7' bgs 1720 - Sand at 9' pull auger up 1730 - 15 bags of sand back up to 7' in hole. 1740 - 3 buckets (5 gal) bentonite up to 3'.	Start over-reaming w/ 12¼" augers @ 1556 1619 - Finish over-reaming to 20.5 Fill hole w/ #20 sand plug out / Tagged bottom at 20.5 10' screen / 10' riser in hole 1629. Raise Auger 3' Sand @ 17' Took off 5' augers Sand at 14.5'				
			11/10/95 0730 - Arrived to get augers out & disconned ~~and to grout well~~ @ Top of hydrated bentonite 2.7' bgs. 11/10/95 0905 depth to water from TOC. 6.36					

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

11/10/95 0905 - Depth to water from TOC = 6.36'

WELL NO.: MW-74

DATE COMPLETED: ~~MW-74~~ 11/10/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

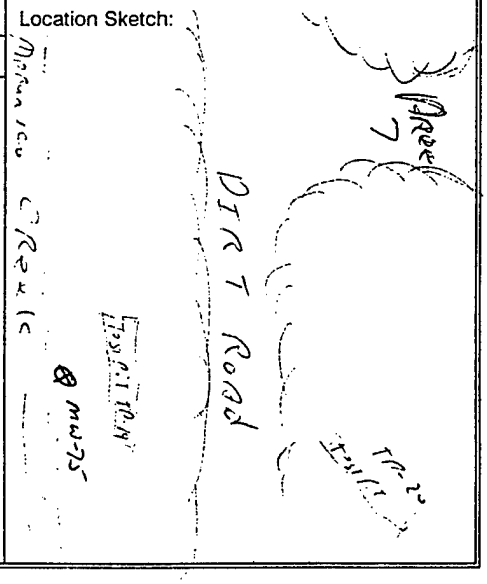
Project: WRF RI/FS	Boring: MW-75
Geologist: Jack Chaynowski & Dennis Batts	Signature: Jack Chaynowski
Driller & Company: Jay Corron / Hardin Huber	Drilling Rig: Mobil B-80 (ATV)
Date Boring Started: 11/8/95	Completed: 11/8/95
First Encountered Water Level: 15'	Date: 11/8/95
Total Fluid Losses:	Date:
~~Total Fluid Losses:~~	
Casing Type: PVC 4" Dia w/ Slot 0.1 Screen	Screened Interval: 12-22
Geophysical Logging: None	Date:
Depth to Bedrock: Not encountered	Ground Elev.:
Boring Completion Information: Completed as monitoring well	Date: 11/9/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/8/95	1600	1640	0	20'	— drilled mud rotary with 4¼" ID HSA				
11/9/95	0815	1015	0	22'	— overream with 8¼" Augers, Installed monitoring well				

Abbreviations:

Abbreviation	Meaning
~	Approximately
TRACE	30/70
AND	50/50
SOME	70/30
BGS	Below ground surface
TIH	Trip into hole
TOH	Trip out of hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-75	Project Name: WRF RI/FS		
Driller/Company: Jay Cocco - Hardin Explor	Drilling Method: HSA 4¼"ID; Overdrum 8¼"ID	Date Started: 11/8/95	Date Completed: 11/9/95
Total Depth: 22'	Depth to Bedrock: NOT Encountered	Water Table Depth: 15'	Ground Elevation:
Protection Level: Modified D	H&S Monitoring Equipment: OVM	Logged by: Jack Chojnacki	Checked by: T. Hamm

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
2	MW-75a 1612	1/3/3/3 12"rec	0-2' Dark yellowish Brown SILTy Clay, Orange, Low to moderate Plasticity	Will split spoon sample with 2"OD x 2'(2-5th) sampler inside 4¼"ID HSA. Sta Sample 0-2' @ 955 1612 advance auger 5' 14% collect sample 5-7'			ML	10YR 4/6
4	MW-75b MW-75b(A) 1616	7/9/8/8 20"rec	5-6 Same as above					10YR 4/6
6			6-7 Same as above except dark grayish Brown					2.5Y 4/2

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-75 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
8				Advance Auger 5'				
10		4/4/2/2 24" 10C	10-12': Dark gray Sandy clay, Damp, Low To moderate PLASTICITY	1618 Collect Sample 10-12'				10YR 4/1
12			Sand is F. gr Sub-angular grains	Advance Auger 5'				
14								
15	MW-75C 1626	2/5/7/2	15-17 Water @ 15' Sand poorly graded w/ some gravel Trace of clay grains are sub angular, saturated	1626 Collect Sample 15-17' Water @ 15' Advance Auger 5'				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-75 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
18				1632 Collect Physical sample 20-22' 1635 Will overream hole Tomorrow AM To Clean Pad. 11/9/95 0820 ONSITE SAFETY 8¼" ID HSA 0825-0840 Withdrew 4¼" HSA 0840 Begin Overreaming w/ 8¼" HSA 0850 Added 10' of Augers 0902 @ 15' Plug still intact Add 5' of Augers 0907 @ 20' Plug intact Fill Augers w/ ~~Water~~ Add 5' of Augers 0917 @ TD of 22' OSS Project To Check out Plug To Install well casing Screen set @ 12-22' BGS				
20	Physical Sample 1632	8/7/11/9	GRAVELLY SAND, poorly graded, saturated, 5YR 3/2 grab, dark gray					

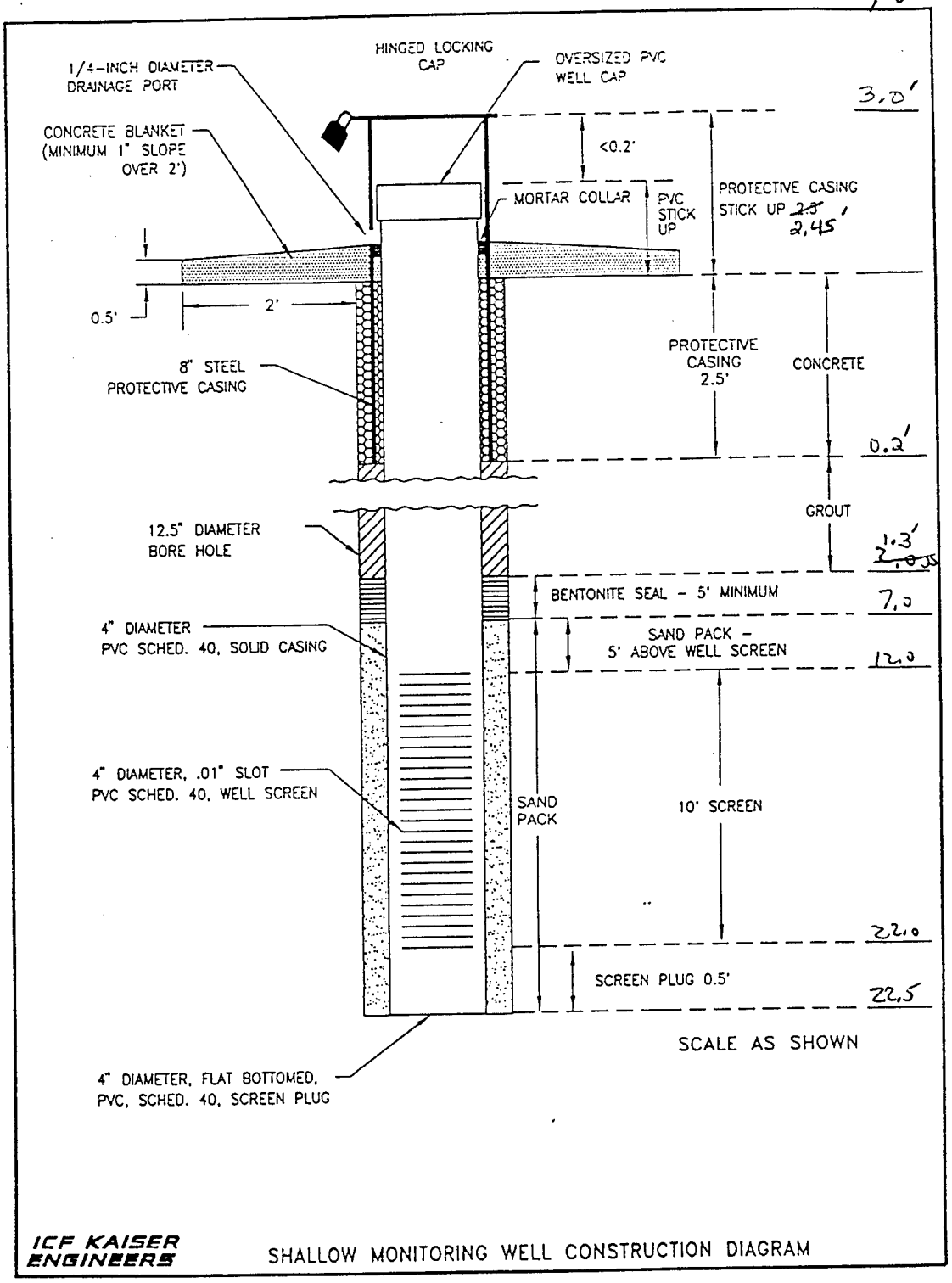
All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-75 | Project Name: WRK RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MmunSELL COLOR
			WELL CONSTR: 4" Diam PVC Well 14.5' Screen 1 X 10' Length 4" Diam Factory Slot 0.14 Bentonite Pellets SHUR-PEL By OSI Hickory, NC - 3/8" Used 84 Buckets Sand #1 50 LBS/Bag 14 Bags Used	Add Tremie Pipe for Tremie in Sand Bottom of Tremie @ 21' Begin Augur Rolling Filter Pack 0940 Sand @ 19' Withdrew 5' of Auger 0952 Sand @ 13' Pulled 5' of Auger Tremie @ 10'. 0959 Sand @ 9' Pulled 5' of Auger 10' of Auger STILL in Hole 1001 Sand @ 7' Augers 1003 Poured Two 2 Buckets Bentonite Pellets Pulled 5' of Auger Sand @ 5' 1007 Bentonite Added 1 Bucket of Bentonite 1011 Sand @ 2' BGS Pulled 5' of Auger 1015 Clean up site				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

11/10/95 0925 - MW-75 Depth to water = 7.10'

WELL NO.: MW-75

DATE COMPLETED: 11-10-95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

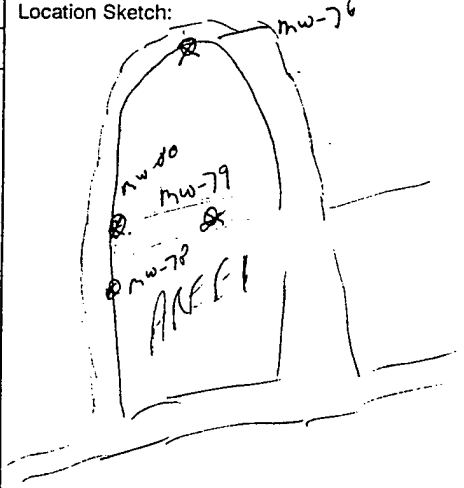
Project: WRF RI/FS	Boring: ~~MW-78~~ MW-76
Geologist: D. Romano / D. Batts	Signature: Deborah J. Romano
Driller & Company: HHI - Bruce, Alonzo	Drilling Rig: Mobile B-57 ATV
Date Boring Started: 11/17/95	Completed: 11/17/95
First Encountered Water Level: 2 ft.	Date: 11/17/95
Total Fluid Losses: —	Date: —
Total Fluid Losses: —	
Casing Type: PVC schedule 40	Screened Interval: 5-15 ft.
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/17/95	0830	0945	0	15.5'		4¼" ID auger.			
11/17/95	1020	1110	0	15.5'		8¼ ID auger overream & well installation to bentonite seal.			

Abbreviations:

Abbreviation	Meaning
med.	medium
fn.	fine
v.	very
gr.	grain
trace	90/10
little	80/20
some	70/30
and	50/50
&	and
dk.	dark
lt.	light

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-76 | Project Name: WRF RI/FS

Driller/Company: HHI - Bruce, Alonzo | Drilling Method: Hollow Stem Auger | Date Started: 11/17/95 | Date Completed: 11/17/95

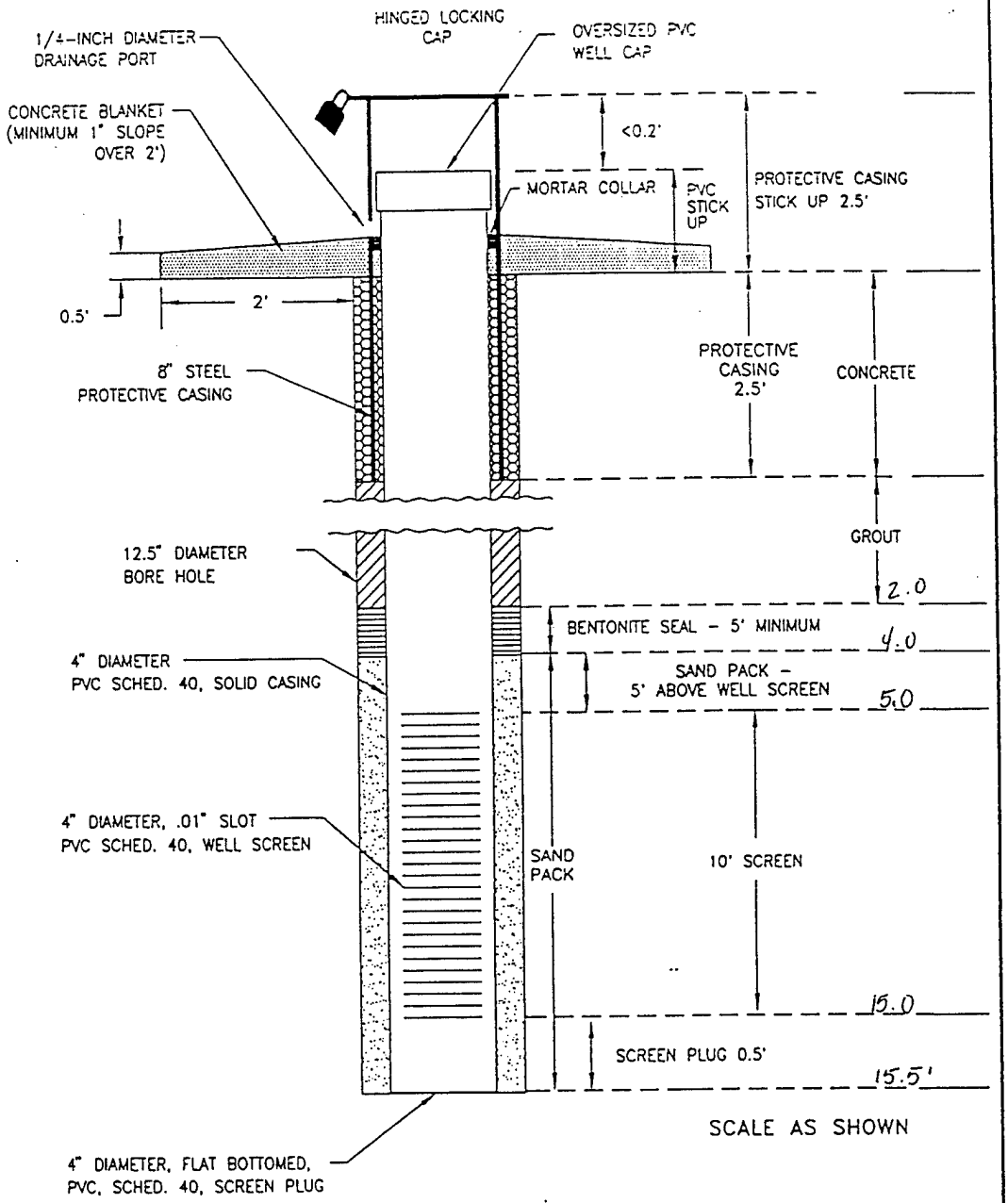
Total Depth: 15.5 ft | Depth to Bedrock: n/a | Water Table Depth: 2 ft. | Ground Elevation:

Protection Level: Modified Level D | H&S Monitoring Equipment: no OVM available | Logged by: Debbie Romano | Checked by: P. Thayer

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0	MW-76A 0857 0-2'	4-4-4-4 9"	SAND, dk. brown, w/ trace silt, v. moist, fine to med. gr. sand.	Split spoon 0-2' ESE sample collected @ 0857, MW-76		no OVM available	SW	10YR 3/3
2				Cuttings wet at 2'. auger to 5'				
5	MW-76B 0905 5-7'	1-1-1-4 20"	0-6" SAND, v. dk. grayish brown, mostly fn. to med. grain sand w/ little coarse & little silt. Wet, very loose.	split spoon 5-7' ESE sample, MW-76B @ 0905			SM	10YR 3/2
7	MW-76C 0922 7-9'	2-2-3-3 14"	6-19" - Clayey SILT, v. dk. grayish brown, wet, natural organics, mica flakes, low plasticity.	auger to 7' split spoon 7-9' ESE sample, MW-76C @ 0922			ML	2.5Y 3/2
9		1-1-2-1 12"	19-20" - Silty SAND, dk. gray, wet, fn. grain	auger to 9'			SM	2.5Y 4/1
10			Sandy SILT, v. dk. grayish brown, wet, sand is v. fn, little sand, organics				ML	2.5Y 3/2
11	Physical sample 11-13	1-1-2-1 20"	Same as above, w/ some v.fn. sand, wet.	Split spoon 9-11' auger to 11'			ML	2.5 Y 3/2
13			Bottom 3" - Clayey SILT, v. dk. grayish brown, wet	Split spoon 11-13' auger to 15.5'				
15			0-6" SAND, dk. grayish brown, trace silt, wet, med. grained				SW	2.5Y 4/2
20			6-15" Silty CLAY, v. dk. gray, med - high plasticity, wet, soft, organics				CL	5Y 3/1
			15-20' Silty SAND, dk. gray, wet, fn. to med. grained sand very loose sand.				SM	5Y 4/1

11/17/95
1020 - 8¼" ID auger overream to 15.5'
1035 - Installed PVC casing, screen & screen plug added 2 bags of sand immediately to prevent heaving sands.
1040 - 7 bags of sand in, 7' to top of sand.
~~1000~~ 11
1050 - 11 bags of sand in, sand to 4'
1100 - 1 bucket of bentonite pellets (3/8" Shur-Pel) bentonite seal at 2 ft.

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-76

DATE COMPLETED: 11-17-95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

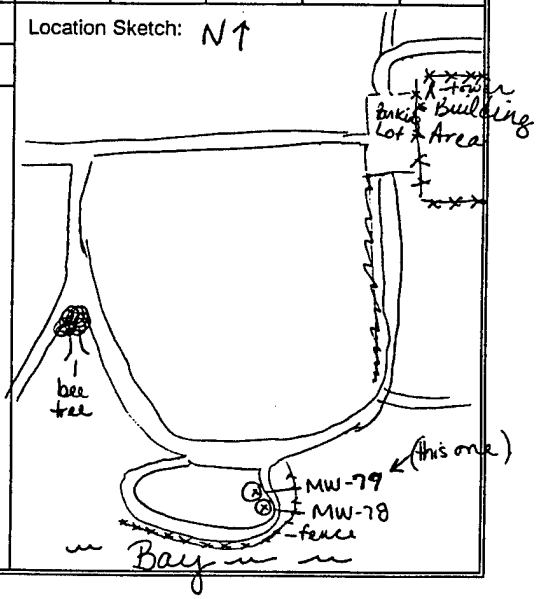
Project: WRF RI/FS	Boring: MW-77 (AREE 1)
Geologist: D. Romano / D. Batts	Signature: Deborah J. Romano
Driller & Company: Hardin-Huber: Rick, Alonzo	Drilling Rig: Mobile B-57 ATV
Date Boring Started: 11/20/95	Completed: 11/20/95
First Encountered Water Level: 5 ft.	Date: 11/20/95
Total Fluid Losses: n/a	Date: —
Total Fluid Losses: n/a	
Casing Type: PVC Schedule 40	Screened Interval: 6.0 - 16.0 ft
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/20/95	1110	1200	0'	9'	4¼" ID augers to 9', split spoon to 11'.				
	1200 - broke for lunch.								
11/20/95	1315	1545	0'	16.5'	Pull augers out, overream to 16.5' Well installed to bentonite seal.				

Abbreviations:

Abbreviation	Meaning
trace	90/10
little	80/20
Some	70/30
and	50/50
&	and
med.	medium
fn	fine
gr	grain
v.	very
lt.	light
dk.	dark.
w/	with
w/o	without

Location Sketch: N↑



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-77 AREE 2 | Project Name: WRF RI/FS

Driller/Company: Hardin Huber - Rick, Alonzo | Drilling Method: Hollow Stem Auger | Date Started: 11/20/95 | Date Completed: 11/20/95

Total Depth: 16.5 ft (well depth) | Depth to Bedrock: n/a | Water Table Depth: 5 ft | Ground Elevation:

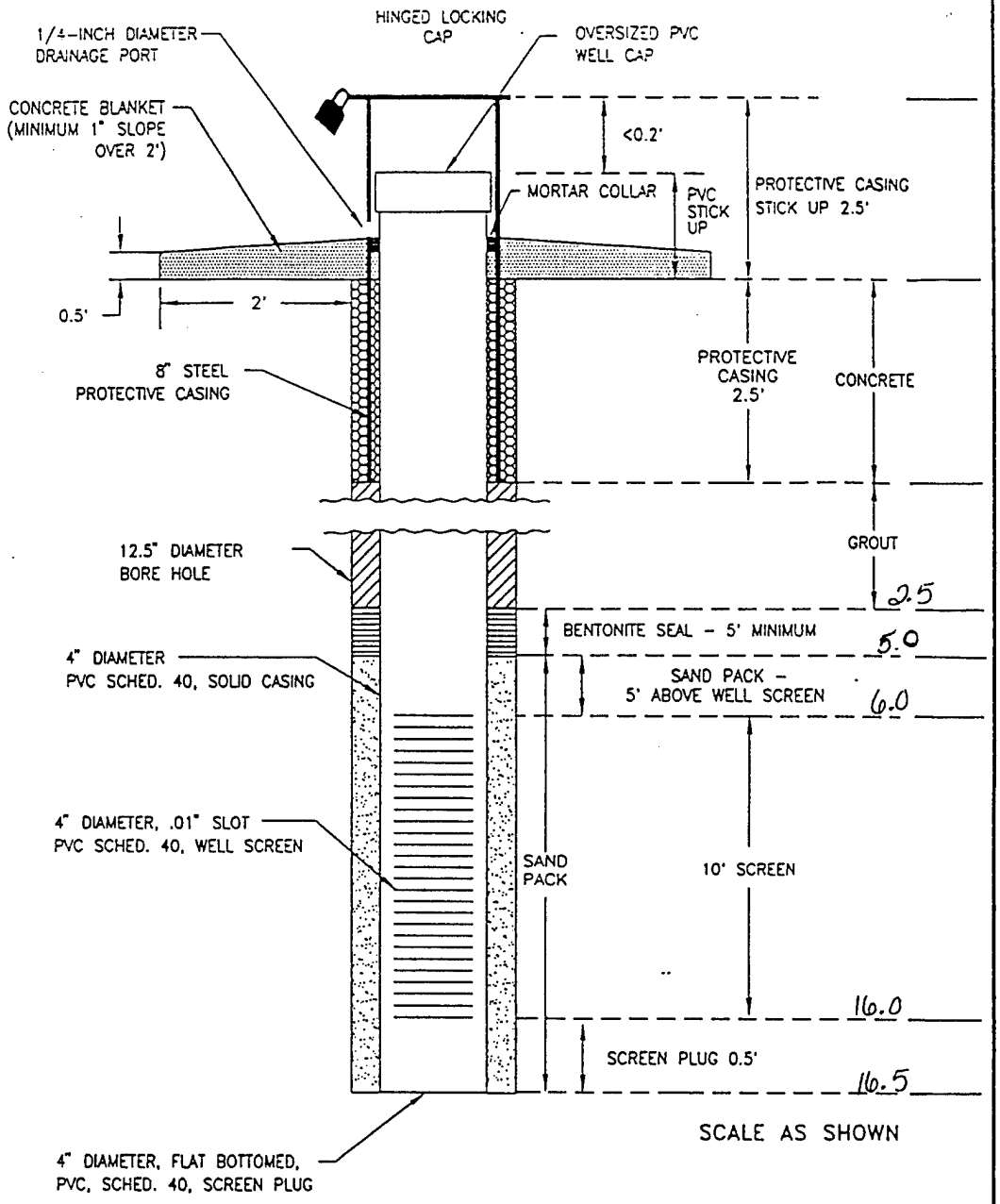
Protection Level: Modified Level D | H&S Monitoring Equipment: OVM | Logged by: Debbie Romano | Checked by: T. Thomas

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								
2	MW-77A MW-77AD 0-2'	4-6-9-13 20"	0-5" Silty CLAY, dk. yellowish brown, dry, med. stiff low-med. plasticity 5-9" - Silty CLAY, brown, dry, stiff, med. plasticity 9-20" - SILT, brown, dry, trace V. fn. gr. Sand	Split spoon 0-2' Collect ESE sample @1126, 0-2', MW-77A, MW-77AD auger to 5'		0	CL CL ML	10YR 3/4 7.5YR 4/4 7.5YR 4/4
5	MW-77B 1145 5-7'	6-6-11-13 10"	SAND, strong brown, med. grain w/ little silt, wet Grades downward to wet med. grain SAND w/ little silt and trace gravel, subangular grains.	Hit water at 5 ft. Split spoon 5-7', auger to 7' Collect ESE sample @1145, MW-77B, 5-7'		0	SM	7.5YR 4/6
7'	MW-77C 1157 7-9'	8-16-11-12 12"	0-10" SAND, fn. to coarse gr. w/ little to some gravel, and little silt, strong brown, wet, med. dense, subangular grains	Split spoon 7-9' Collect ESE sample @1157, 7-9', MW-77C auger to 9'.		0	SM	7.5YR 4/6 7.5YR 4/6
9	Physical sample 9-11'	4-29-24-30 14"	10-12" - SAND, strong brown, med. grain size, little silt, wet 0-14" Clayey SAND, strong brown, wet, fn. grain, some clay, dense sand.	Split spoon 9-11' Collect ~~ESE~~ sample 9-11' physical		0	SC	7.5YR 5/8
10								
11								
15								
20								

11/20/95
1315 - Pull augers out of hole
1330 - Begin overream w/ 8¼" ID
1345 - 1 auger in hole, add water to auger & continue overream.
1400 - 10' of auger in hole, more water added
1415 - 15' of auger in hole,
1420 - Overream to 16.5', add more water
1430 - PVC casing installed, 2 bag of sand poured in to prevent running sands.
1445 - Sand tremied in.
1500 - 3 augers in, sand to 13.5', 2½ bags used.
1510 - 10' of augers, sand to @ 8.8'
1525 - 9½ bags of sand, @ sand to 5'.
1533 - 1½ buckets of bentonite pellets, to 2.5'

1 x 10' PVC riser
1 x 10' PVC screen
1 x 0.5' PVC screen plug.

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-77

DATE COMPLETED: 11/20/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

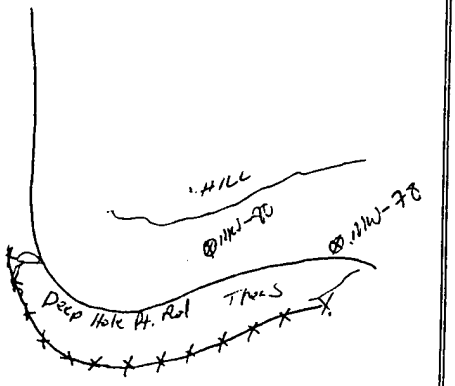
Project: WRF RI/FS	Boring: MW-78
Geologist: J. STOWERS	Signature:
Driller & Company: Hardin Huber	Drilling Rig: ATV 8-80
Date Boring Started: 11/17/95	Completed: 11/12/95
First Encountered Water Level: 7'	Date:
Total Fluid Losses: 0	Date:
Total Fluid Losses: 0	
Casing Type: 4" Sch 40 PVC	Screened Interval: 6-16'
Geophysical Logging: NA	Date:
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date: 11/17/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/17/95	1330	1415	0	16'					
	1415	1430	0	16.5'	Overdrilling w/ 8¼" ID Augers				
	1430	1450		6' of	Sand in Augers	— Drill off			
	1450	1530		Well	Installation				

Abbreviations:

Abbreviation	Meaning
sm	small
med	medium
lg	large
v.	very
fn	fine
gr	grain
w/	with
w/o	without
90/10	trace
80/20	little
70/30	some
50/50	and
TIH	Trip into Hole
TOH	Trip out of Hole
%	percent

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-78		Project Name: WRF RI/FS	
Driller/Company: Hardin Huber	Drilling Method: Hollow Stem Auger	Date Started: 11/17/95	Date Completed: 11/17/95
Total Depth: 16.5'	Depth to Bedrock: N/A	Water Table Depth:	Ground Elevation:
Protection Level: Modified D	H&S Monitoring Equipment: OVM	Logged by: J. Stowers	Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW78A	2-2-5-6 / 1.1'	CLAYEY SILT, very dark grayish brown, moist, stiff, plastic ~1.8' - Lithology change to SILTY SAND, V. moist to wet	1345 Begin drilling 1345 - Collect MW-78A		0.0ppm	ML	10yr 3/2
5	MW78B	4-4-5-6 / 1.4'	~4' Lith change to yellowish brown gravelly sand, wet. Gravelly SAND, wet to saturated, med to V. coarse gn. medium dense, yellowish brown w quartz gravel up to ¾" diameter (trace)	1350 - Collect MW-78B		0.0ppm	SP	10yr 5/8
			~9' Lithology change to gray Sand					
10	MW-78C	7-5-7-6 / 1.0'	SAND, light gray, saturated, coarse gn. to fn. gn. medium dense, poorly sorted, w/ little gravel (quartz) up to ¾" dia.	1400 - Collect MW-78C		0.0ppm	SP	10yr 7/1
	PHYSICAL	4-5-6-4 / 1.2'	- PHYSICAL / SAME AS ABOVE w/ increased coarse grains ~~until~~ TO 13.5' - finer grain Sands toward end of spoon.	1415 - Begin Overreaming w/ 8¼" ID Augers			SP	
15			TD = 16.5'	1430 - 6' of sand knocked plug up into Augers; Drillers get roller bit & clean out to knock plug & sand out.				
20								

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

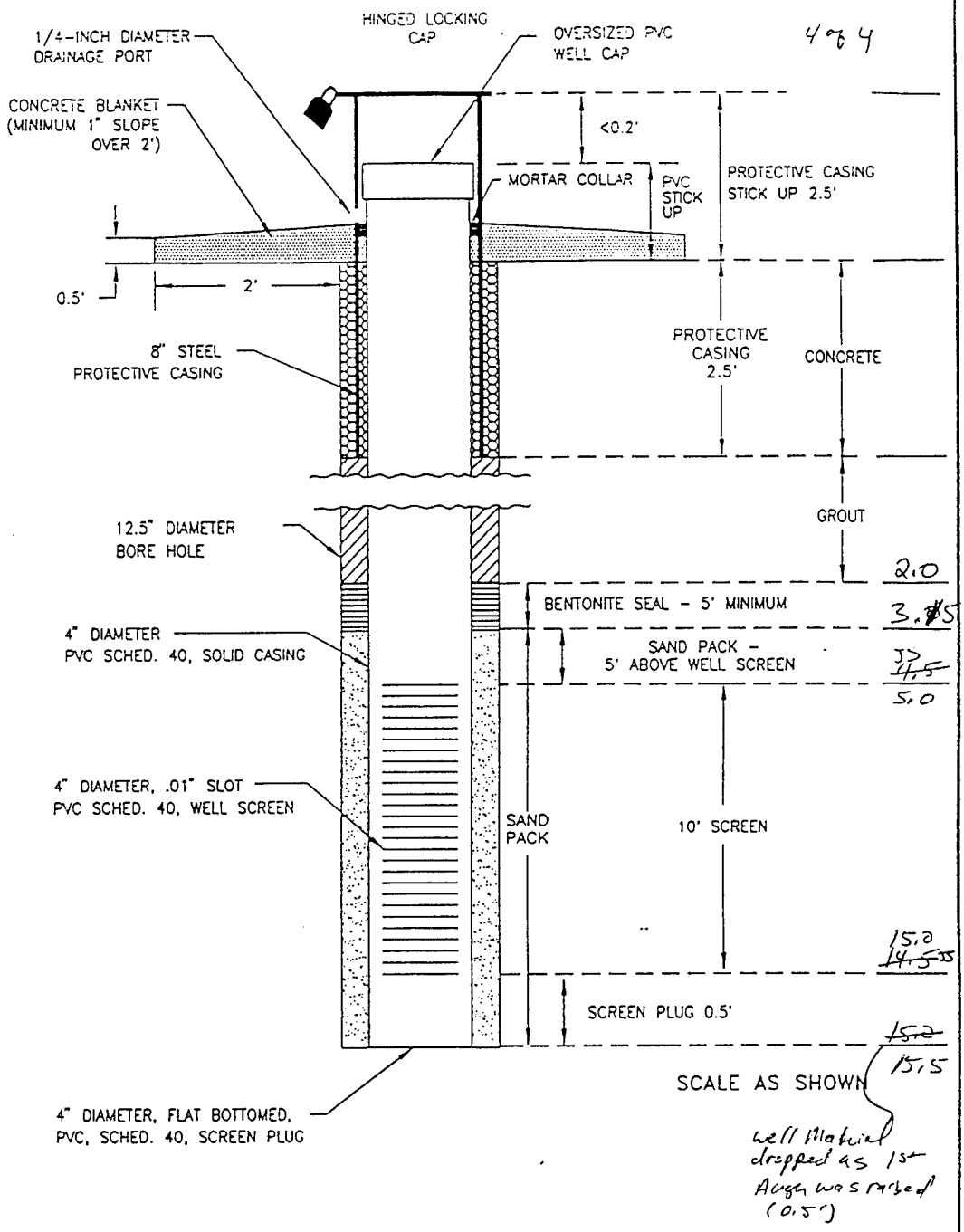
ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-78 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				Well Materials 1- 10' 4" PVC Sch 40 Riser 1- 10' 4" PVC Sch 40 0.01 slotted screen 1- 0.5' bottom cap. 9 50 lb bgs silica sand — 3/8" bentonite pellet buckets				

All measurements should be recorded in feet or tenths of feet.

‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-78

DATE COMPLETED: 11/17/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

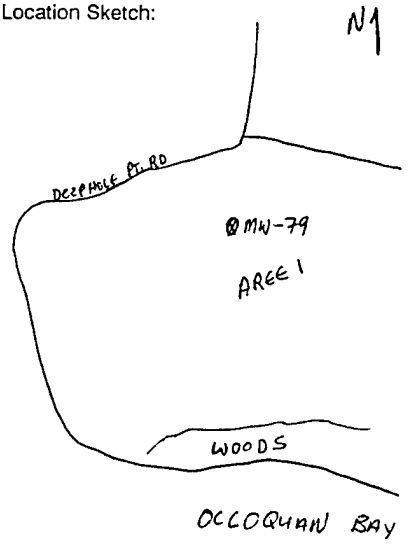
Project: WRF RI/FS	Boring: MW-79 AREE 1
Geologist: J. Stevens	Signature:
Driller & Company: Hardin Huber	Drilling Rig: ATV B-30
Date Boring Started: 11/16/95	Completed: 11/16/95
First Encountered Water Level: ~5'	Date: 11/16/95
Total Fluid Losses:	Date:
Total Fluid Losses:	
Casing Type: 4" PVC Sch 40	Screened Interval: 4-14'
Geophysical Logging: NA	Date:
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/16/95	1400	1450	0	14'	4¼" ID Auger				
	1450	1510	support truck stuck						
	1510	1535	Drilling go to decon pad for larger auger						

Abbreviations:

Abbreviation	Meaning
%	percent
v.	very
fn.	fine
gn.	grain
sm.	small
med.	medium
lg.	large
w/	with
w/o	without
TIH	Tripping H.
TOH	Tripping H.
90/10	trace
80/20	little
70/30	some

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-79	Project Name: WRF RI/FS		
Driller/Company: Hardin Huber	Drilling Method: Hollow-stem Auger	Date Started: 11/16/95	Date Completed: 11/16/95
Total Depth: 14.5'	Depth to Bedrock: N/A	Water Table Depth: 5'	Ground Elevation: NA
Protection Level: Modified D	H&S Monitoring Equipment: OVM	Logged by: J. Stevens	Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW-79A	1.2'	CLAY, stiff, brown, dry, mottled w light gray silt, low plasticity	(Auger to 5'		0.0	CL	7.5yr 5/6
				1440 Collect ESE MW-77A				
5	MW-79B	5-13-23-18 0.8'	SILT and SAND, light gray, wet; SAND - fn, to v. fn, gr., subrounded, well sorted w/ gravel toward bottom of spoon up to 1" diameter, saturated toward bottom of spoon	Water @ ~ 5' 1445 - Collect ESE MW-79B Note: Unable to collect 2nd 2.5D in. ESE jar due to low recovery		0.0	SM	10yr 7/1
				SAND ~ 7'				
10	MW-79C	2-7-9-9 2'	SAND, fn to med gr to 10.4, yellowish brown, saturated, subrounded, moderately well sorted, medium dense, trace silt	1450 - Collect GSE-79C		0.0	SW	10yr 5/6
	PHYSICAL	5-7-8-8 2'	10.4 - 13.1 - SAND, med to coarse gram, light yellowish brown, saturated, medium dense	SATURATED COARSE GR SANDS				2.5yr 6/4
15			13.1 - 14.0 color change to light gray, trace silt			0.0	SW	10yr 7/1
			TD of Boring = 14'					
			1445 - 1510 - Support Truck Stuck - wait for backhoe to pull truck to dry ground					
			1510 - 1535 Drillers go to get 8¼" Auger & Well materials.					

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

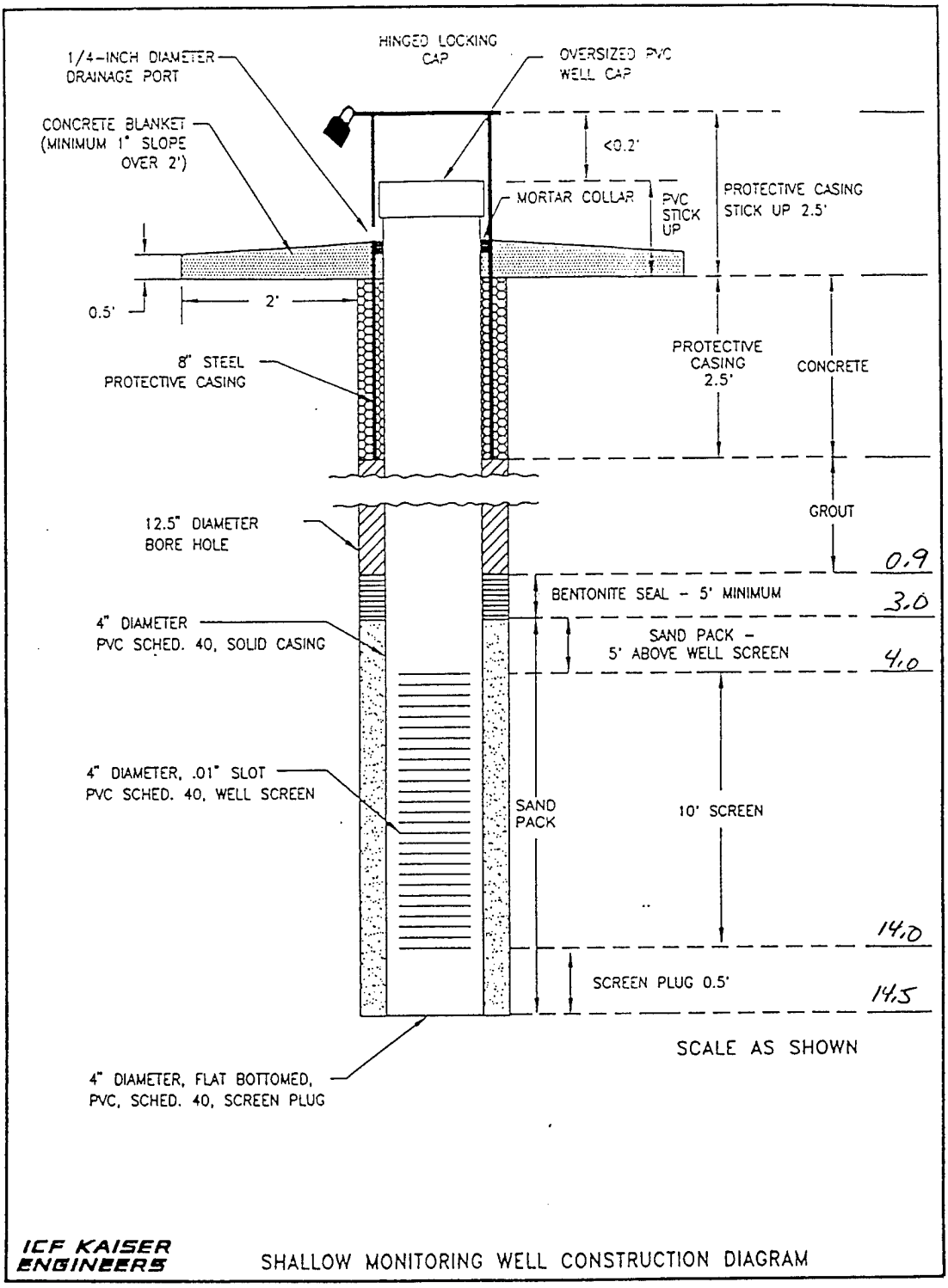
KEWRFSB #11 H
#12 B
#16 C

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-79 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
			1550 1555	Begin overreaming w/ 8¼" ID's End overreaming, prepare to install well 1600 Install PVC Sch 40 casing and knock Plug out of lead auger. WELL MATERIALS: 1 - 10' PVC Sch 40 0.01" slotted screen (4" DIA) 1 - 0.5' END CAP (PVC) 1 - 10' PVC Sch 40 riser (4" DIA) 10 50 lb bags eq #1 clean Silica Sand 1 buckets 3/8" bentonite pellets				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-79

DATE COMPLETED: 11/16/45

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

Project: WRF RI/FS	Boring: MW-80
Geologist: J. Stowers	Signature:
Driller & Company: Hardin Huber	Drilling Rig:
Date Boring Started: 11/17/95	Completed: 11/17/95
First Encountered Water Level: ~ 4'	Date: 11/17/95
Total Fluid Losses: 0	Date: 11/17/95
Total Fluid Losses: 0	
Casing Type: 4" Sch 40 PVC	Screened Interval: 6-16'
Geophysical Logging: NA	Date: NA
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: 4" Monitoring Well	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/17/95	0800	0840	0	14'					
	0840	0900	Move	8¼" ID Auger w/ backhoe to MW-80					
	0905	0920	0	16'	Overream w/ 18½" Auger				
	0925	1020	Well Installation						
	1020		Mob to Decon Pad						

Abbreviations:

Abbreviation	Meaning
sm	small
med	medium
lg	large
w/	with
w/o	without
%	percent
90/10	trace
80/20	little
70/30	some
50/50	and
TIH	Trip into Hole
TOH	Trip out of Hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-30 | Project Name: WRF RI/FS

Driller/Company: Hurdin Huber | Drilling Method: Hollow-stem Auger | Date Started: 11/17/95 | Date Completed: 11/17/95

Total Depth: 16.5 | Depth to Bedrock: NA | Water Table Depth: ~4' | Ground Elevation:

Protection Level: Modified D | H&S Monitoring Equipment: OVM | Logged by: J. Stowers | Checked by: T. Thrupp

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW-30A	2-3-7-9 / 1.1'	CLAY, dk. yellowish brown, stiff, slightly moist w/some silt; SILT increasing towards bottom of spoon; some organic staining	0825 - Collect ESE MW-30A		0.0	CL	10yr 4/6
			~4' hit silty zone - wet	Water ~ 4'				10yr 4/3
5	MW-30B	1-2-5-6 0.8'	SiCT, brown, wet, no plasticity, mottled slightly with CLAY (some clay as 0-2') - w/some V. fn. gr Sand - sand increasing toward bottom of spoon	0830 - Collect ESE MW-30 B		0.0	ML	10yr 4/3
				Sand ~ 8'				
10	MW-30C	4-7-10-5 2.0' JS	Sand, yellowish brown, saturated, med to coarse gr, subangular, med. dense, w/ trace gravel up to ¾" dia.	0840 - Collect ESE MW-30 C		0.0	SW	10yr 5/6
	Physical Sample	~~4-7-10-5~~ 7-10-4-4 2.0'	11.2 - Sand, fn. to coarse gr., saturated, dk yellowish brn.					10yr 4/6
			12 - 13.1 - Gravelly SAND, coarse to v. coarse gr w/ clay stringers @ 12.8, pale brn. saturated			0.0	SW	
15			13.1 - 13.3 - ~2" gravelly zone, w/ gravel (quartz) up to 0.1' diameter	0905 - Begin overreaming w/ 3¼" ID 0920 - End overreaming - prepared for well installation				10yr 6/3
			13.3 - 14.0 - Sand, gray, fn, to coarse gr, saturated 100se, grad decreasing - no gravel from 13.3 - 14.0'					10yr 6/1

All measurements should be recorded in feet or tenths of feet.

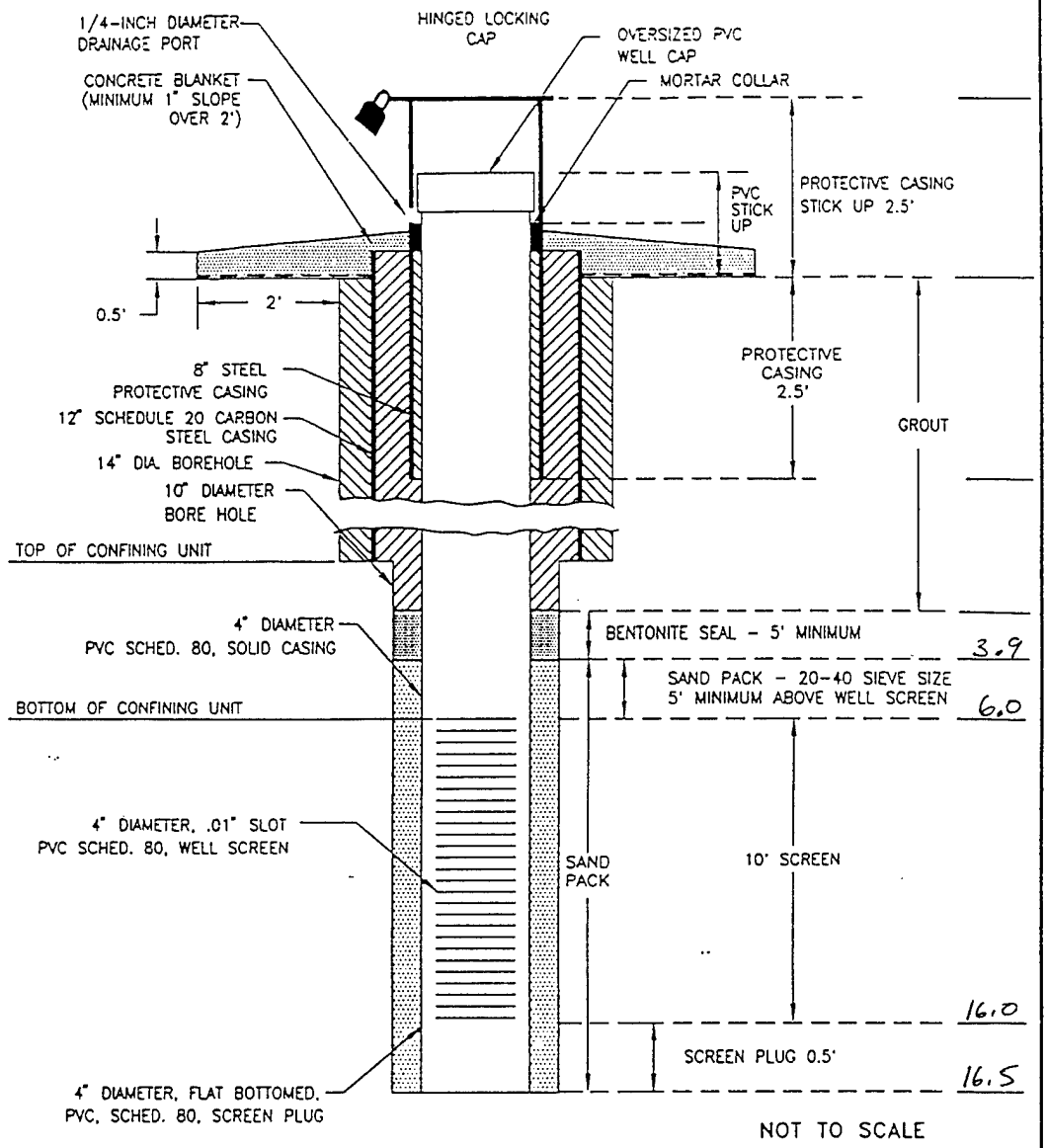
‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-80 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				0925 Begin Well Installation; Screen set from 6-16' 1/2 bga (50 lbs) silica sand 2 buckets 3/8" bentonite pellets 1-10' PVC 4" Riser 1-10' PVC 4" Sch 40 0.01 slotted screen, 1-0.5' screen plug Sand @ 12' upon taking off 1st auger Sand @ ' upon taking off 2nd auger				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

DEEP MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-80

DATE COMPLETED: 11/17/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

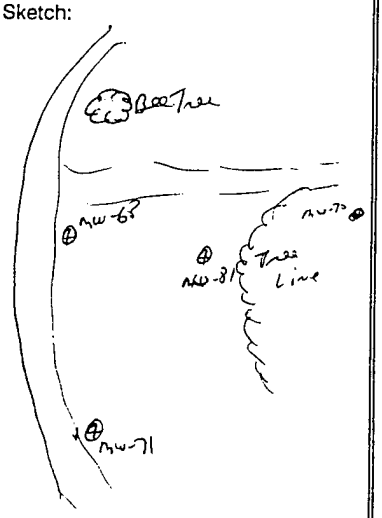
Project: WRF RI	Boring: MW-81
Geologist: P. Thompson / D. Batts	Signature: Jack Chyzowski
Driller & Company: Hawkins Hubber	Drilling Rig: B-61
Date Boring Started: 11/9/95	Completed: 11/10/95
First Encountered Water Level: 7'	Date: 11/10/95
Total Fluid Losses: 0	Date: —
Total Fluid Losses: 0	
Casing Type: Sch 40 PVC 4"	Screened Interval: 6'-16'
Geophysical Logging: NA	Date: —
Depth to Bedrock: NA	Ground Elev.: —
Boring Completion Information: 4" Sch 40 PVC 0.01 screen 16'	Date: 11/10/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/10/95	1304	1340	0	15'	11/10/95				
11/10/95	1405	1425	0	16.5	start over-reaming well				
	1425	1517							
	1517	1525			install sand pack - 13 bags				
					install bentonite pellets				

Abbreviations:

Abbreviation	Meaning
~	Approximately
10/90	Thick
50/50	and
70/30	Some
BGS	Below ground surface

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

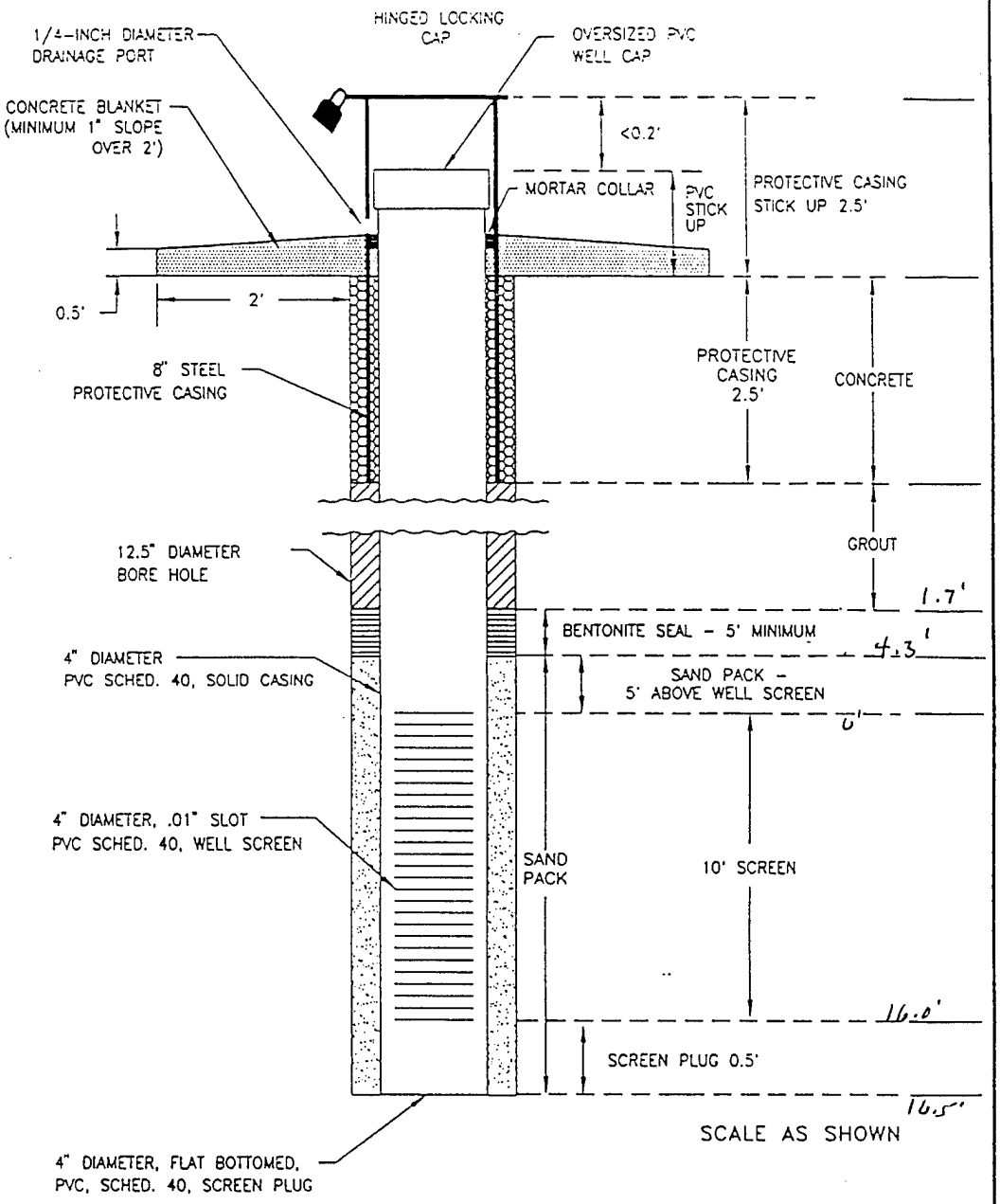
ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-81	Project Name: WCF RI		
Driller/Company: BV Hardin-Hunter	Drilling Method: Hollow Stem Auger	Date Started: 11/10/95	Date Completed: 11/10/95
Total Depth: 16.5	Depth to Bedrock: NA	Water Table Depth: 7'	Ground Elevation:
Protection Level: D	H&S Monitoring Equipment: OVM	Logged by: P. Thompson	Checked by: Jack Rynal

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0-2 Sample	MW-81 A	12 35	7.5YR 5/3 clk brown, silty clay damp m. plasticity recover 13"	*48 1308 took sample		0		7.5YR 5/3
2'								
5	MW-81 B	3,5,67	Top 4" same as above Silty clay w/ TR fn sand, damp, m. plasticity recover 18"	*49 1318 took sample		0		5YR 4/6
7			sndy silt, damp	Driller hit top of sand at 7'				
9								
10	MW81-C	5,8,10,10	10-10.8' fn STR Brn for red brn ~~silty~~ clay, some silt & mia clay, wet (water zone)	1322 - spoon for 10-12' interval *50 1325 - stopped driller to look at sand zone 1326 - took sample		0		7.5YR 4/6
12'			11-12' clay, damp, str. brown, hi plasticity Recover 24"					7.5YR 4/6
13	MW-81 C Geotech. sample	4,5,68	clay, with mina silt, damp, high plasticity w/ some yellow mottling, geotech. sample Recover 24"	Drove spoon from 13-15' @ 1328		0		10YR 5/2
15			1340 Stopped drilling at 15'. Will set well from 6-16' in same sand zone as MW-68.	Begin Over reaming @ 1405 will over-ream to 16.5', Finish over-reaming		1425		

All measurements should be recorded in feet or tenths of feet. ε Record cored intervals in this column if drilling bedrock.

Set Bentonite Seal @ 4.3-1.7' @ 1421' on 11/10/95
Sand pack to 4.3' bgs



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

well materials
10' - PVC Sch 40 0.01 screen
6' - PVC Sch 40 Riser
.5' end plug
13 bags silica sand

Bentonite seal set @ 1521

WELL NO.: MW-81

DATE COMPLETED: 11/10/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

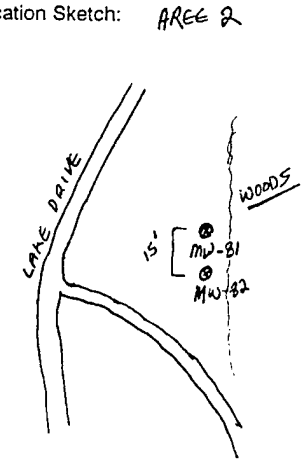
Project: WRF RI/FS	Boring: MW-82 AREA 2
Geologist: D. ROMANO / J. STOWERS	Signature:
Driller & Company: Hardin Huber	Drilling Rig: Mobil B-80 ATV
Date Boring Started: 11/29/95	Completed: 12/12/95
First Encountered Water Level: ~3'	Date: 12/12/95
Total Fluid Losses: 150 gal.	Date: —
Total Fluid Losses: —	
Casing Type: 4" Sch 80 PVC	Screened Interval: 23.5'-33.5'
Geophysical Logging: NA	Date: —
Depth to Bedrock: NA	Ground Elev.: —
Boring Completion Information: 10" steel outer casing / 4" PVC Monitoring Well C	Date: 12/12/95

Date	Time Start	Time End	Depth of Drilling Per Shift Start	Depth of Drilling Per Shift End	Date	Time Start	Time End	Depth of Drilling Per Shift Start	Depth of Drilling Per Shift End
11/27/95	1020	1040			Mob to MW-82				
11/28/95	1040				Begin setup for drilling; fill mud pan				
	0745				Begin Drilling MW-82 below steel casing.				

Abbreviations:

Abbreviation	Meaning
V.	very
fn.	fine
gr.	grain
w/	with
w/o	without
%	percent
90/10	trace
80/20	little
70/30	some
T I H	Trip into Hole
T o H	Trip out of Hole

Location Sketch: AREA 2



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-B2	Project Name: WRF RI/FS		
Driller/Company: Hardin Huber	Drilling Method: Mud Rotary	Date Started: 11/29/95	Date Completed: 12/1/95
Total Depth: 34'	Depth to Bedrock: N/A	Water Table Depth: 23'	Ground Elevation:
Protection Level: Modified D	H&S Monitoring Equipment: —	Logged by: J. STOWERS	Checked by: Jeff Chapman

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				1045 – Fill Mud pan 1100 – Begin drilling using wing bit	+ 1000 gals due to expected clay			
5			SICT, light yellowish brown, w/ some fn. to med. gn. sand, no plasticity (SAND is subrounded) - Lithology change to CLAY and SAND, fn. gn. with little gravel.				SM	10yr 6/4
				Bit grinding @ 10'				
10	①	7-12-10/5 1.0'	10 – 10.4 – Clayey SAND, strong brown, fn to med gn, subrounded	Mud rotary to 14' – Prepare to casing.	set steel			7.5yr 4/6
	②	6-6-6-7 2.0'	10.4 to end of spoon – CLAY, light gray, ~~dense~~, dry SAME AS 10.4 description (clay CLAY); clay-free very toward end of spoon.				CH	10yr 7/1
15				1245 – Begin setting 14' casing (carbon-steel) Used 450 gals of water 1400 – Unload drums to mix grout; Prepare to mix grout. Used bags Portland Cement and gals approximate water for grout.				
				1450 – Finish grating; Prepare mud pan.				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: [illegible] Project Name: LWRF 21 FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY x	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
22	(3)	5-6-6-6 / 2.0'	CLHY, greenish gray, slightly moist to moist, firm, medium dense (CLHY), w/ a scattered ~0.1' in length @ 20.5', Sandy clay, fn. gr., subrounded, and another sandy clay lense @ 21' (0.15' in length) fn to med gr., subrounded.	0745 - Drill rig ≈ 700 psi. Rig would not start, need to get other rig to thaw engine, hose connection frozen				
25	(4)	7-7-10-14 / 10.7'	SHVD (Top 0.4'), V. fn to fi. gr., Subrounded, Medium dense, wet, Grading to fn. gr., SHVD / CLHY (Bottom 0.3'), wet, dense to medium dense	0910 - Rig running / pump water into mud pan from the support truck.				10yr 5/1
	(5)	10-17-24-31	SHVD, fn. to coarse, gray, wet, w/ little clay, all stone gravel up to 1" diameter.	1115 - Hole open all the way to 35' / prepare to grout for water. Add 1 bag of Bentonite, lumpy flaky			SP	10yr 5/1
30			SHVD	Begin grouting bore hole @ 1415' Well Seal Grout / Pump out mixer and hose out				
35			- change in drilling	Lunch break				
35-37' →	(1)	27-32-41-50/4"	CLHY, very stiff, reddish brown, mottled w/ greenish gray clay, stiff, dry.	1415 Arrived / prepare to drill Drill collect 1st split - spoon sample	below surface casing	20-22'	CL	5yr 4/3 clay / silty
				1500 - Total depth @ 35'. Finish boring.				
				1630 Finish grouting / prepare to abandon well				

10/12/95 0730 - Finish set mudpan.

All measurements should be recorded in feet or tenths of feet.

x Record cored intervals in this column if drilling bedrock.

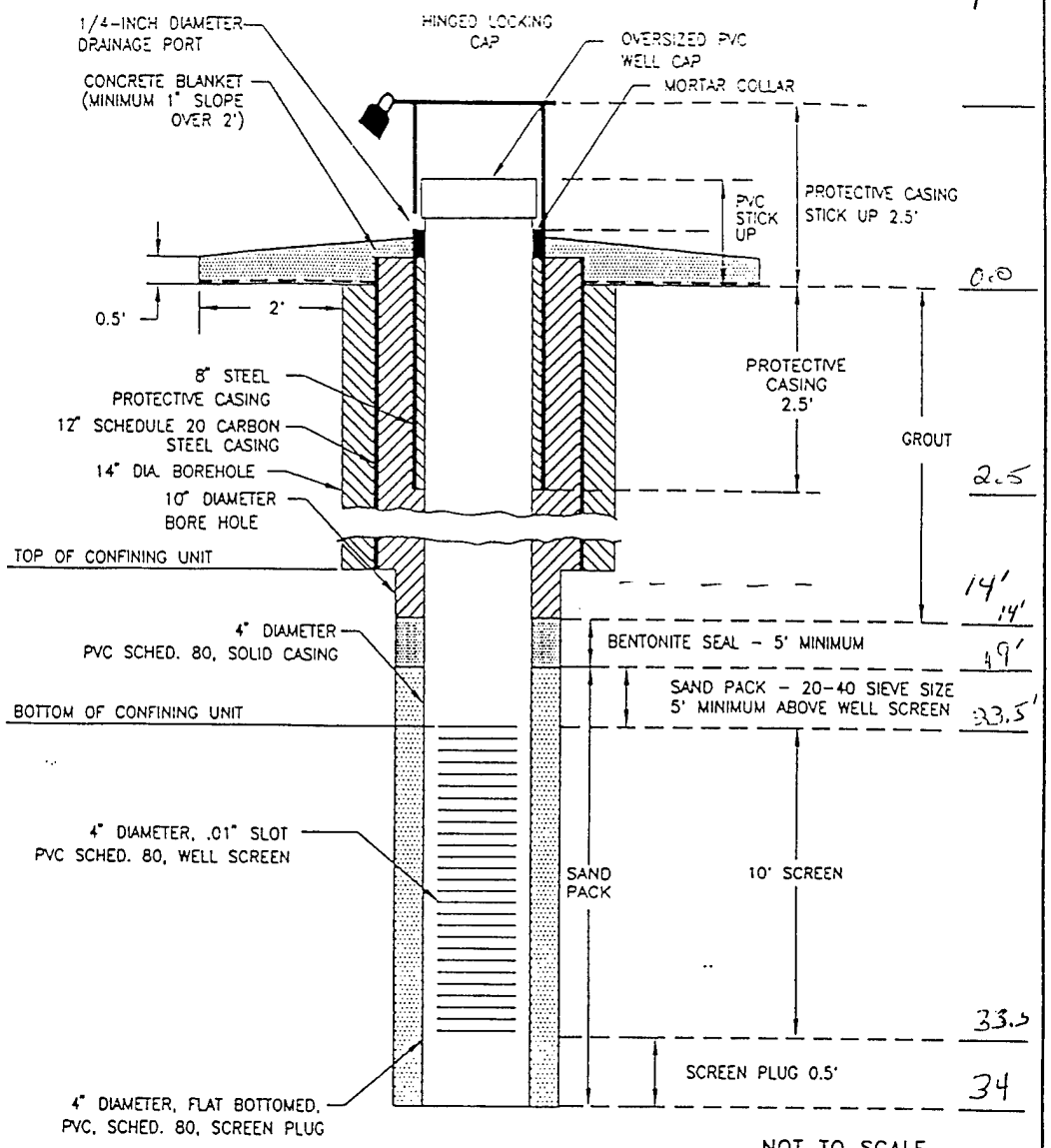
ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-32 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ¢	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				12/12/95 - Thaw out hoses; mix/pump 1 sx Tec- 12/11/95 Hole kept caving in to 32' Mixed thick bentonite slurry and pumped down hole to backfill open hole. 0930 - Rig running, Pump out mud pan with thinner drilling fluid. 0900 - Begin well installation. Well Materials: 21 bags #1, 20/40 silica sand 3 buckets of 3/8" pellets 1000 - Pump out mud pan				

All measurements should be recorded in feet or tenths of feet. ¢ Record cored intervals in this column if drilling bedrock.

5 of 5



ICF KAISER ENGINEERS

DEEP MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-82

DATE COMPLETED: 12-12-95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

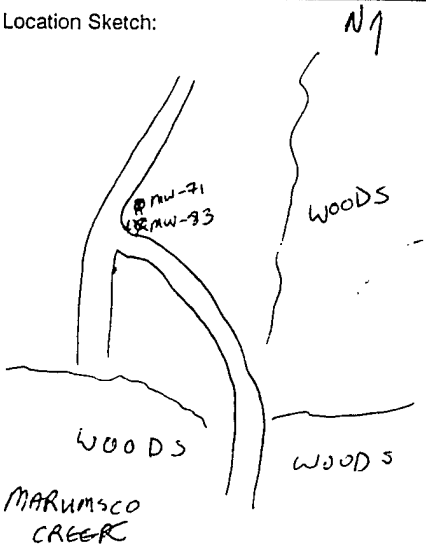
Project: WRF RI/FS	Boring: MW-83 Page 2
Geologist: J. STOWERS	Signature:
Driller & Company: Hardin Huber	Drilling Rig: ATV Mobil B-80
Date Boring Started: 11/29/95	Completed: 12/7/95
First Encountered Water Level: 24'	Date: 12/7/95
Total Fluid Losses: 125 gals.	Date: 12/7/95
Total Fluid Losses:	
Casing Type: 4" PVC w/10" carbon steel outercasing	Screened Interval: 24-34'
Geophysical Logging: NA	Date: —
Depth to Bedrock: NA	Ground Elev.: —
Boring Completion Information: 4" monitor well (double cased)	Date: 12/7/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/29/95	1630				Tower up; unload equipment,				
12/7/95	0900				Fill Mud pan 11/30/95				
					Begin flushing cased boring.				
	1055	12' (4 hot grout)			Begin flushing boring.				
	1600			35'	Begin drilling				
	1620				End drilling				
					Begin well installation				

Abbreviations:

Abbreviation	Meaning
lt.	light
dk.	dark
sm.	small
v.	very
fn.	fine
gr.	grain
%	percent
w/	with
w/o	without
TIH	Trip into Hole
TOH	Trip out of Hole
90/10	trace
70/30	some
50/50	and

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

62, 56- ~~35~~ 22.5'
84 39 or 35 21-23 split spoon

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-83	Project Name: WRF RI/FS		
Driller/Company: Hardin Huber	Drilling Method: Mud Rotary	Date Started: 11/30/85	Date Completed: 12/7/85
Total Depth: 34'	Depth to Bedrock: NA	Water Table Depth: 29'	Ground Elevation: NA
Protection Level: Modified D	H&S Monitoring Equipment:	Logged by: J. STOVERS	Checked by: Jack Chapman

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				0800 Hook up hoses and prepare to drill		11		
				0855 Begin drilling while mud pump is filling				+ 10YR gley
5			CLAY, yellowish brown w/ some fine gravel				CL	10YR 5/4
10			CLAY, slight color change - gravel @ 10'	Add 1-10' rod				
			CLAY, w/ little fine gravel, subrounded sand, color change to red brown	Driller sips CLAY w/ gravel @ 10' Clay @ 11'				
15	①	5-3-4-5 1.6'	clayey SAND, red brown, fine grained, wet	0905 Drive split-spoon from 15-17'			CH	10YR 7/4
	②	5-6-9-9 /24"	15.5 - CLAY, light gray, slightly moist to dry, soft, medium stiff					
			16.4 - SANDY CLAY, red brown					
			17.0 - SANDY CLAY to 18.4 gradually changing to CLAYEY SAND, gray	WILL SET STEEL CASING IN GRAY CLAY @ 16'				

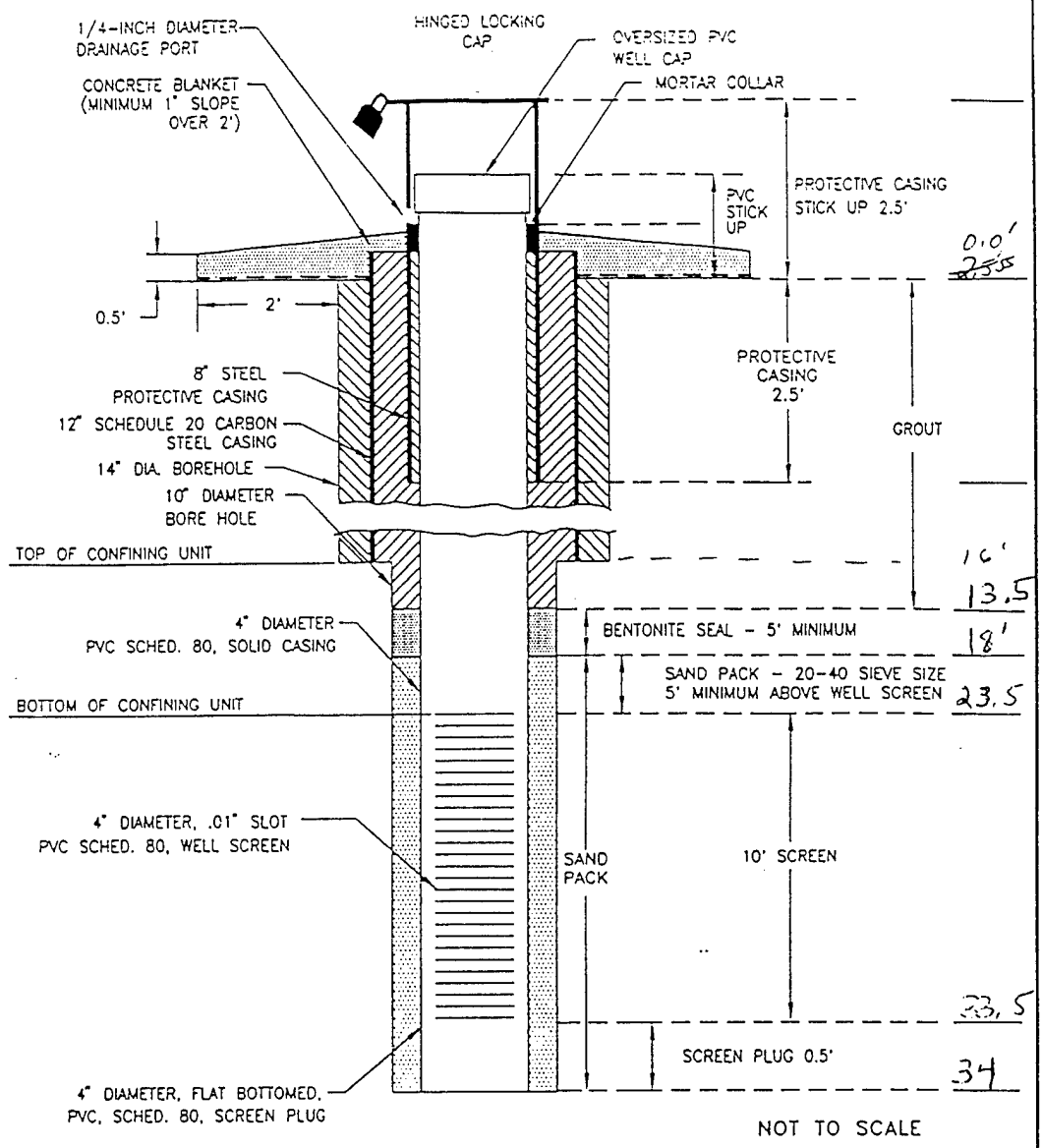
All measurements should be recorded in feet or tenths of feet. ε Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-33 | Project Name: WRP RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	③	5-3-4-4 / 10.7'	CLAY, gray, moist, medium stiff w/ little fine to med. gr. Sand, Subrounded, poorly graded (SAND is in lenses/veins of less than 0.5" per lense —) The 20-22' Sample was mostly CLAY	1010 Install steel casing to 16'		—	CH/SC	10YR 5/1
	④	3-4-8-5 / 12.0	CLAY, gray, fat, medium stiff, grading to CLAYEY SAND at the last 6" of spoon, v.fine, rounded gr., wet.	1020 Pump mudpan out into drums. Begin mixing grout. Used 100 gals of grout - tremie @ 15'.				
25	⑤	3-3-4-6 / 12.0	24'-26' - CLAY gray to 24.3, then mottling w/ grayish brown clay begins, medium stiff, moist.	12/7/95 0900 - @ MW-33 to Flush Boring in preparation for drilling				10YR 5/1 and 10YR 5/2
				0915 - Begin lowering rods into boring, Will Flush 0-16'. Note: Boring filled in to 10'				
				0945 - Clear water returns into mudpan. Pump mud pan water into drums.				
30	⑥	26-29-31-32 / 10.7	Gravel, up to 1" diameter, gravelly w some coarse gr. SAND, wet to saturated.	1010 - Move to decon pad				
				1010 - Finish deconing				
				1055 - Set up rig and mudpan. Close unit.		1 3/4"	rock bit	through concrete
				Will drill to 30' and collect a spoon				
35	⑦	29-36-32-42 /	CLAY, gray, dry, very stiff, w/ some silt	29' - Drilling in gravel, rough drilling.				
				30-32' - Gravel				5Y 5/2 olive gray to 5Y 5/1 gray with gravel
				1145 - Hydraulic fitting broke, Jay will go to purdue store during lunch to buy oil and see what fits.				
				1515 - Rig off until 1515; hydraulics fixed				
				33.5' - pit very dense clay				
				1520 - Begin well installation. Tremie mud down so sand will fall.				

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

DEEP MONITORING WELL CONSTRUCTION DIAGRAM

Well materials:
1 @ 50 lb bags 20/40 #1 Silica Sand

12/7/95 0935 @ MW-83, prepare to grout.
Batch #1
32 gals approx/ water
4 bags Lehigh Portland Cement Type I
16 lbs, powdered Bentonite
10 lbs/gal = wt of grout.

WELL NO.: MW-83

DATE COMPLETED: 12/7/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

Project: WRF RI/FS	Boring: MW-84
Geologist: J. STOWERS / P. THOMPSON	Signature:
Driller & Company: HARDIN HUBER	Drilling Rig: ATV Mobil B-80
Date Boring Started: 12/1/95	Completed: 12/5/95
First Encountered Water Level: ~ 30'	Date: 12/4/95
Total Fluid Losses: 200 gals	Date: 12/5/95
Total Fluid Losses: 200 gals	
Casing Type: 4" Sch 80 PVC	Screened Interval: 27-37'
Geophysical Logging: NA	Date: NA
Depth to Bedrock: NA	Ground Elev.: —
Boring Completion Information: 4" Double Cased Well	Date: 12/5/95

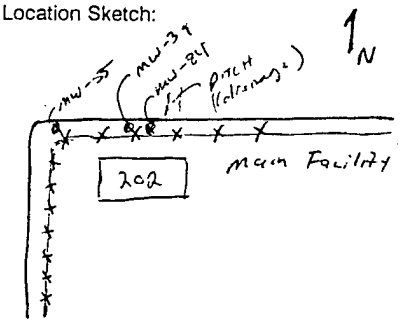
Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
12/1/95	1115	1700	0	25'					
12/4/95	0800	1000							
	1110	1400	25'	37'					
12/5/95	0800								

- Include collect of split spoons, reaching TD @ 25' w/ 10" bit, overream w/ 14" bit, install & grout 2" protective casing.
Flush boring using 100 gal approved water. Begin 10" drilling through Completion Casing. Include 1-hr lunch and Well Installation to Bentonite Seal.
Begin grouting 4" well to surface (4')

Abbreviations:

Abbreviation	Meaning
vf.	very
fn.	fine
gn.	grain
lt.	light
dk.	dark
w/	with
w/o	without
90	percent
90/10	trace
80/20	little
70/30	some
50/50	and
TIH	Trip into Hole
TOH	Trip out of Hole
bgs	below ground surface

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-84 | Project Name: WAF RI/FS

Driller/Company: Hardin Huber | Drilling Method: Mud Rotary | Date Started: 12/1/95 | Date Completed: 12/5/95

Total Depth: 37.5' | Depth to Bedrock: NA | Water Table Depth: 30' | Ground Elevation:

Protection Level: Modified D | H&S Monitoring Equipment: — | Logged by: J. Stowers | Checked by: Jack Chynoweth

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
			SILT, yellowish brown	1115 Arrive @ MW-84; Position rig over boring; Fill mud pan.	Install 6" dia steel casing to 25' bgs		ML	
5	①	5-6-7-7	SANDY CLAY, strong brown, low plasticity, slightly moist, fn. gn. sand, stiff				SC	7.5yr 4/6
	②	8-9-11-11	SAME AS ABOVE, but very moist w/ increased fn. gn. SAND toward bottom of spoon	1220 Collect Spt. Spoon # 2				
				Augers to 10'			SC	7.5yr 4/4
10	③	5-5-7-8	SAND w/ little CLAY; ½" zone of white sand @ ~11', fn. gr., medium dense w/ trace gravel (quartz) up to 1" dia at top of spoon				SW	7.5yr 5/6
				Augers to 20'				
15				Grout from 14-16' (DRILLER STATES)				
				Sand from ≈ 16-20'				
				~~1600~~ JB				
20								

All measurements should be recorded in feet or tenths of feet. ε Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-84 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	ESE MW-84A	2-2-5-4 / 2'	SILTY CLAY, v. dk. gray, stiff, moist to ~ 21' Dry from 21-22'; 20-21', some to little fn. gr. sand	Collect ESE MW-84A @ 1455	Install outer steel casing for 0.1-25.0	2.6 ppm	CL	10yr 3/1
	Physical Sample 24-25.5'	2-2-3-4 2'	Same as above, with sand (fn gr.) lenses, small thickness 23-24'. At 24' gray clay (blocky), medium stiff, moist, low plasticity.			0.0 ppm		
25		2-3-4 1.2'	24.0-24.3 SAND and CLAY, v. dk. gray, moist, loose, soft, low plasticity. 24.3 to end of spoon - CLAY, v. moist, approx very stiff, low plasticity.	Will set Steel Casing @ 25'		0.0 ppm		
				1520 Change out 10" Wing bit to 14" Will overream bring to 25'	14" Wing bit		CL	10yr 3/1
				1540 Finish overreaming to 25' Prepare to install steel outer casing				
				1600 Install Steel Casing 25.7', will cut .7' when constructing pad.				
				1605 Prepare to grout steel casing in place.				
				1620 Before grouting, mud pump was prepped out Used 12.5 gals grout				
				12 Bags Portland Type II Cement Used 0.75 bags powdered Bentonite				
				12/4/95 0700 - Fill support truck w/ water; Prepare to circulate boring prior to grouting. Shovel mud pan out.	Install outer steel casing for 0.1-25.0	Move to MW-84, finished 12/1/95		

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.

0930 - Mechanic @ MW-84 to fix Rig; intermittent start-up problem.
0940 - Flushed out ~ 600 gals. of clean water to clean out casing

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

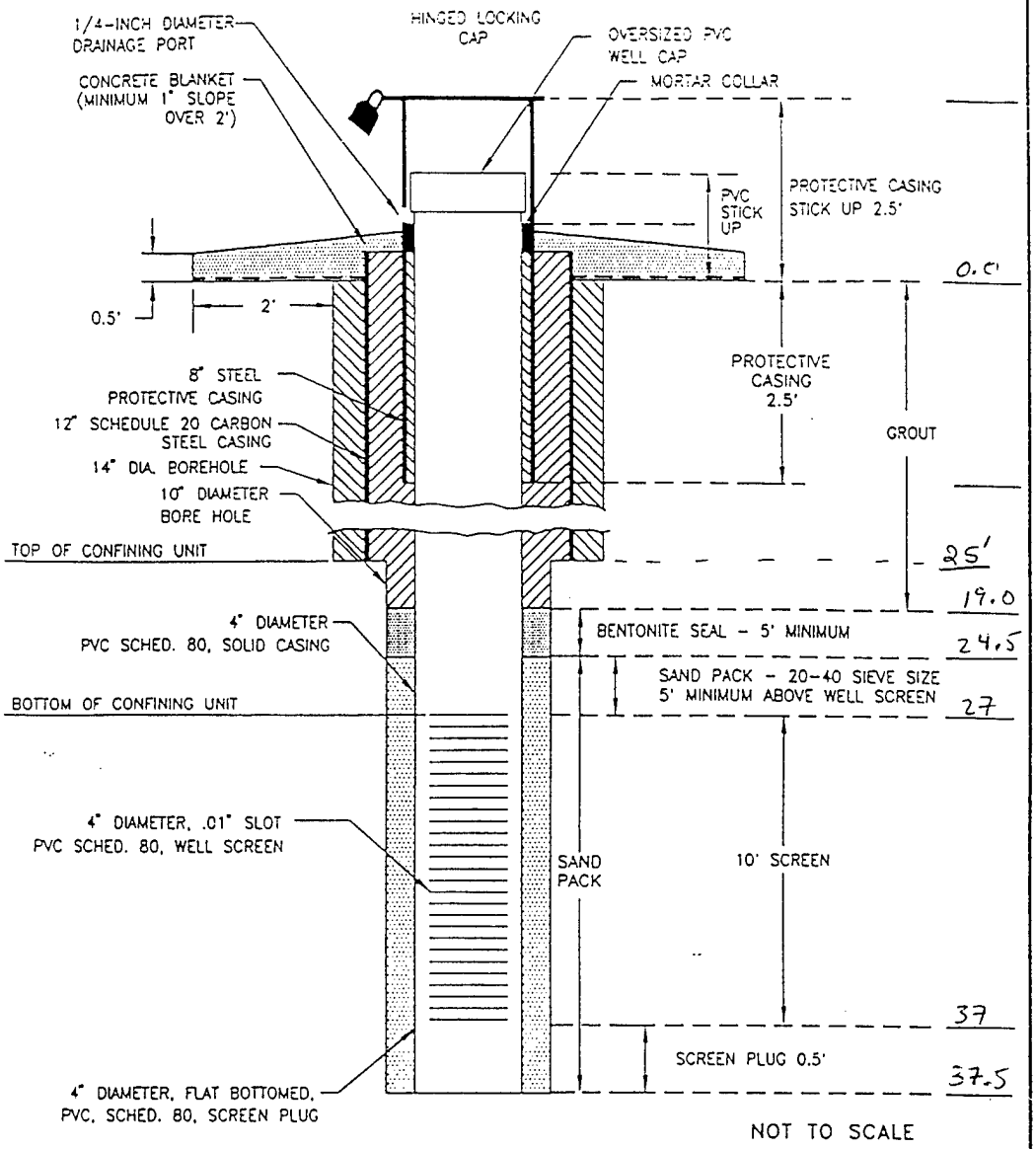
Boring No: MW-84 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
			25-30' - Cuttings in mudpan are v. fine gr. gray sand, no clay appearing in cuttings in mudpan.	12/4/95 1055 Began filling mudpan from steel casing (25').	for 10" dia. drilling below			
				1110 - Began attaching rods 4'-10'	rods + bit.			
30	30-32'	30-27-11-12 / 1.5'	SAND, gray, medium gr, dense, wet, grading to medium to coarse gr. SAND @ 31' w/some quartz gravel; stray fragm up to 1" diameter. Silt & yellow and quartzite (metamorphic)	1205 - Collect split spoon from 30-32' to confirm what clay is present. Cuttings return significantly clay w/ trace V. fn. gr. Unless sand is v. dense we don't know if we are in it.			SW	Sand, 10yr 5/1
				1215 Lunch; will drill to 35' and drive another split-spoon to confirm sand @ 35'			SW	10yr 5/1
35	35-37' dropped sample	25-28-32-31 / 11.8"	SAND, same as above, but v. coarse gr., with no metamorphics, however bottom 3" of spoon contained some little quartz gravel up to 3/4" dia., fairly well graded, subrounded	1400 (water stopped)				
				1500 - Well set screen from 27'-37'; end cap (J3) and approx with 10 feet of bentonite chips to stabilize hole, 35-37' - rough drilling				
				1410 (J3) 1500 Condition hole - Scoop of fluid and today				
40				1430 - Begin well installation				
				1500 Begin Filter Pack Installation w/tremie @ 34'				
				12/5/95 0730 Fill support truck w/ water & cover chips for grouting				
				0900 @ MW-84. Prepare to grout				
				Used 50 gals grout - 4 gal/16 bags Portland Type II (Cont) - 32 gals water, 0.5 bags powdered bentonite				
				Fluid Losses: 500 gals - 12 ($\frac{55}{2}$) = 230 => 510 - 230 (no) => 300 gals				

↓
Drums of Soil Cuttings Collected from 12/5/95, 25-37

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

DEEP MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-84

DATE COMPLETED: 12/5/85

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

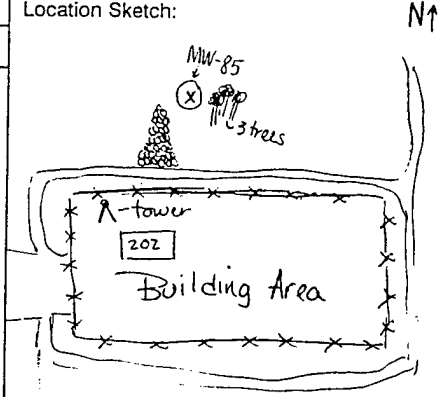
Project: WRF RI/FS	Boring: MW-85
Geologist: JACK CHOYNOWSKI / DENNIS BATTS	Signature: Jack Choynowski
Driller & Company: RICK RIDER / HARDIN HUBER, INC.	Drilling Rig: B-57 [redacted]
Date Boring Started: 11/28/95	Completed: 11/29/95
First Encountered Water Level: 22 ft.	Date: 11/28/95
Total Fluid Losses: N/A	Date: —
Total Fluid Losses: N/A	
Casing Type: PVC SCHEDULE 40	Screened Interval: 19.5 - 29.5'
Geophysical Logging: NONE	Date: —
Depth to Bedrock: NOT ENCOUNTERED	Ground Elev.: —
Boring Completion Information: Completed as monitoring well	Date: 11/29/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/28/95	1550	1803	0'	30' (SPLIT SPOON 30-32')		4.25" ID AUGER (HOLLOW STEM)			
11/29/95	0700	0807		30'		~~8.25" ID AUGER OVERREAM~~			
11/29/95	0834	1238	0'	30'		8.25" ID AUGER OVERREAM (HOLLOW STEM)			

Abbreviations:

Abbreviation	Meaning
v.	Very
Fn	Fine
w/	with
w/o	without
gr	grain
lt	light
dk	dark
~	Approximately

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-85 | Project Name: WRF RI/FS

Driller/Company: RICK RIDER/HARDIN HUGER, INC. | Drilling Method: HOLLOW STEM AUGER | Date Started: 11/28/95 | Date Completed: 11/29/95

Total Depth: 30' | Depth to Bedrock: not encountered | Water Table Depth: 22' | Ground Elevation: —

Protection Level: MODIFIED LEVEL D | H&S Monitoring Equipment: MICROTIP PID | Logged by: ~~JACK CHOYNOWSKI~~ DB DENNIS BATTS | Checked by: Jack Chapman

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0'				2" OD x 2' LENGTH SPLIT SPOON				
0-2'	MW-85A 1606	2-4-5-8 16"	0-3" SILTY CLAY, DRY, LOW PLASTICITY, BROWN, SOME ORGANICS 3-16" CLAY WITH ~~SOME~~ SILT (DECREASING SILT TOWARDS BOTTOM) LOW PLASTICITY, DRY, GRAY WITH BROWN MOTTLING	COLLECTED SPLIT SPOON SAMPLE 0-2' MW-85A 1606 AUGER TO 5'		0.0	CL/ML CH	10YR4/3 5YG/1
2'								
5'		4-8-15-17 23"	CLAY WITH SOME SILT, DRY, LOW PLASTICITY, GRAY WITH BROWN MOTTLING	SPLIT SPOONED 5-7' AUGER TO 10'		0.0	CH	5YG/1
5-7'								
7'								
10'			WITH SOME SAND					
10-12'	MW-85B 1632	3-8-10-6 12"	0-3" ~~SANDY~~ CLAY, WET, HIGH PLASTICITY, DARK GRAY 3-7" SAND LENS, WET, FINE TO MEDIUM GRAIN SAND, DARK GRAY 7-12" SANDY CLAY, WET, LOW PLASTICITY, DARK GRAY	SPLIT SPOONED 10-12' COLLECTED MW-85B 1632 HIT WATER AUGER TO 12' SATURATED AT 11' (PERCHED ZONE)		0.0		2.5Y4/1
12-14'		4-3-4-4 24"	0-5" SLOUGH 5-16" CLAY, WET, HIGH PLASTICITY, DARK GRAY 16-24" ~~SILTY~~ CLAY WITH LITTLE SILT, TRACE SAND, MEDIUM PLASTICITY, MOIST, DARK GRAY	SPLIT SPOONED 12-14' AUGER TO 14'		0.0	CH	2.5Y4/1
15'		4-9-8-8	0-3" SLOUGH 3-12" SILTY CLAY, DRY, MEDIUM PLASTICITY, DARK GRAY 12-17" SAND LENS, MEDIUM GRAIN SAND, DARK GRAY 17-24" CLAY WITH LITTLE SILT, DRY, MEDIUM PLASTICITY, DARK GRAY	SPLIT SPOONED 14-16' AUGER TO 20'				2.5Y4/1
14-16'								

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-95 | Project Name: WRF RI/FS

DEPTH (ft.)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20'								
20-22'		3-5-8-10 24"	0-19" CLAY, HIGH PLASTICITY, MOIST, DARK GRAY 19-24" SANDY CLAY, MEDIUM PLASTICITY, WET, DARK GRAY	SPLIT SPOONED 20-22' AUGER TO 25'		0.0	CH	2.5Y4/1
22'								
25'								
25 27'		10-8-8-10 24"	0-12" CLAY WITH SOME SAND, LITTLE SILT, MEDIUM PLASTICITY, DARK GRAY, MOIST 12-18" SANDY CLAY, LOW PLASTICITY, MOIST TO DRY, DARK GRAY 18-24" CLAY WITH SOME SAND, LITTLE SILT, MEDIUM PLASTICITY, DARK GRAY, MOIST	SPLIT SPOONED 25-27' AUGER TO 30'		0.0	CH	2.5Y4/1
27								
30								
30-32'	~~MW-95-C~~ ~~1753~~ DB	WEIGHT OF HAMMER/6-6-4-6	CLAY WITH LITTLE SILT, DRY, MEDIUM TO HIGH PLASTICITY, DARK GRAY TO SLIGHTLY MOIST	SPLIT SPOONED 30-32' ~~SAMPLE COLLECTED MW-95C 1753~~ DB 11/29/95 0705 — WATER TO WITHIN 6" OF TOP OF AUGERS (INSIDE AUGERS) DRILLERS BEGIN PULLING AUGERS 0807 — DRILLERS PULL LAST OF 4.25" AUGERS FROM HOLE 0834 — BEGIN 8.25" ID AUGER OVERREAM 0955 — 4 AUGERS IN HOLE. WATER ADDED INSIDE AUGERS. 5½ AUGER ADDED.				2.5Y4/1
32								

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

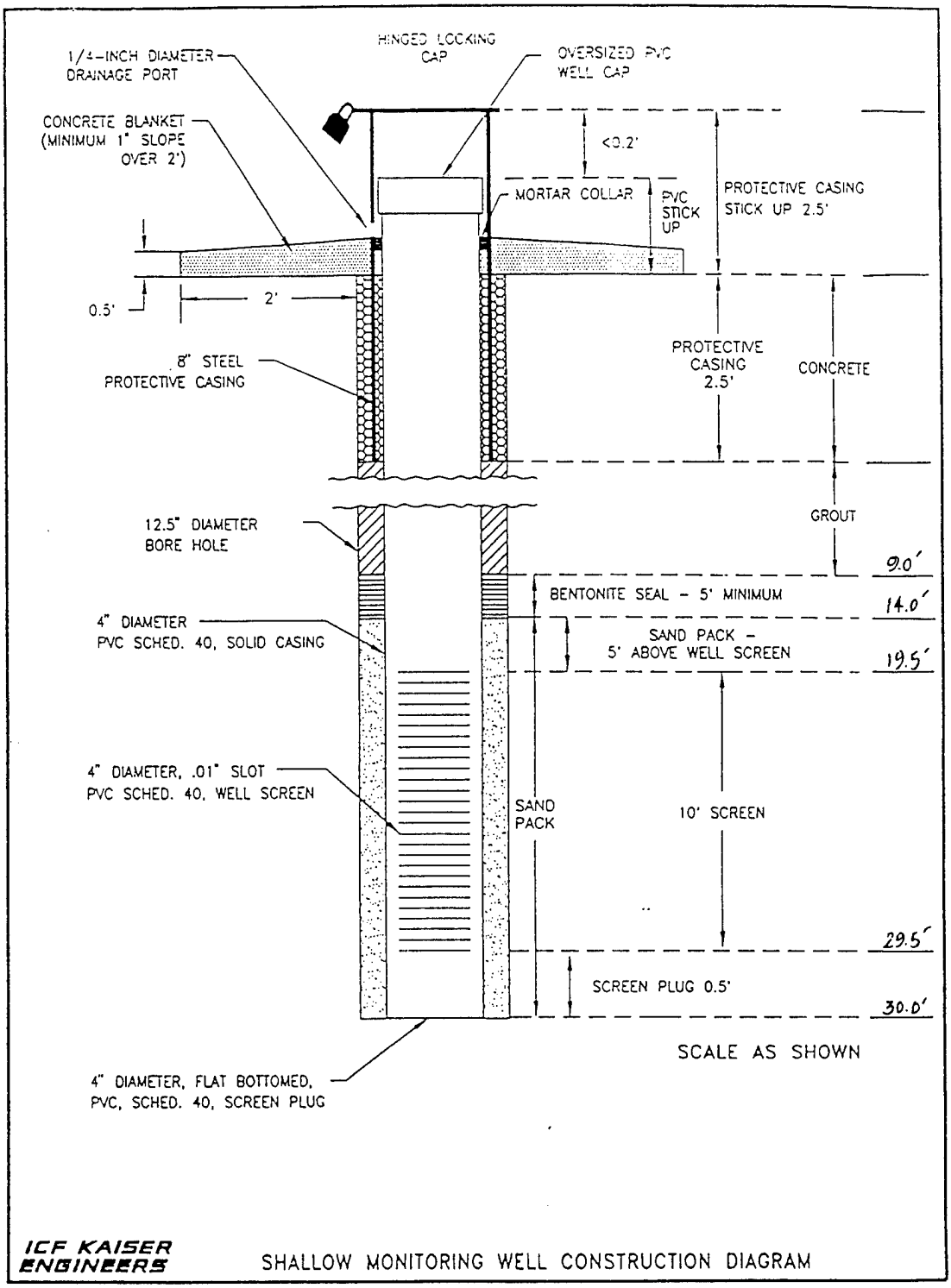
56
58
57

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-85 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				11/29/95 CONT'D. 1021 - WATER ADDED INSIDE AUGERS. 6th AUGER ADDED. 1046 - BEGIN INSTALLING WELL CASING TD OF BOREHOLE = 30' BGS TREMIE PIPE LOWERED TO 28.5' BEGIN INSTALLING SAND FILTER PACK 1107 - PULLED 1st 5' OF AUGER. SAND IS TO 24.5' 1130 - PULLED 2nd 5' OF AUGER. SAND IS TO 19.2' 1154 - PULLED 3rd 5' OF AUGER. SAND IS TO 14' 1159 - BEGIN INSTALLING BENTONITE SEAL 1220 - PULLED 4th 5' OF AUGER. BENTONITE IS TO 11' 1238 - BENTONITE SEAL TO 9'. 16 50LB BAGS #1 FILTER PACK SAND [redacted]DB 5 GAL. BUCKETS DSI BRAND SHUR-PEL				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

SHALLOW MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-05

DATE COMPLETED: 11/29/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

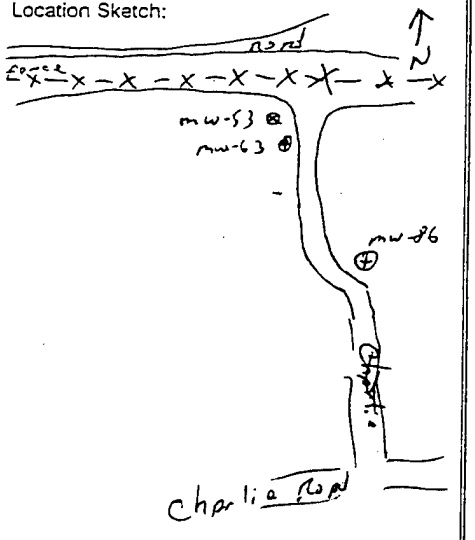
Project: WRF Phase II RI	Boring: MW-86
Geologist: Jack Chaynewski.	Signature: Jack Chaynewski
Driller & Company: Chad Chism / Hurlin-Hall	Drilling Rig: Mobile B-80
Date Boring Started: 8/13/96	Completed: 8/15/96
First Encountered Water Level: 15'	Date: 8/13/96
Total Fluid Losses: 125 gallon	Date:
Total Fluid Losses:	
Casing Type: Sch 40 4" ID PVC w/.01 screen	Screened Interval: 40 - 50'
Geophysical Logging: None	Date: —
Depth to Bedrock: not encountered	Ground Elev.:
Boring Completion Information: Completed as monitoring well	Date: 8/15/96

Date	Time Start	Time End	Depth of Drilling Per Shift Start	Depth of Drilling Per Shift End	Date	Time Start	Time End	Depth of Drilling Per Shift Start	Depth of Drilling Per Shift End
8/13	0	36'	0715	1530	Drilled & Sampled TO 37' w/ 10" OD overreamed w/ 14" OD & Installed 10" ID Carbon Steel Casing TO 37' → Installed monitoring well.				
8/15	36'	50'	0815	1600					

Abbreviations:

Abbreviation	Meaning
TRACE	10/90 %
some	30/70 %
and	50/50 %
BGS	Below ground surface
TIH	Trip Into Hole
TOH	Trip Out of Hole
%	Percent
V.	very
f.	fine
gr	grain
w/	with

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-86	Project Name: WRF Phase II RI/FS		
Driller/Company: Chad Chism/Hart-Hansen	Drilling Method: mud rotary w/ 4" Bit	Date Started: 8/13/96	Date Completed: 8/15/96
Total Depth: 52'	Depth to Bedrock: NOT encountered	Water Table Depth:	Ground Elevation: —
Protection Level: Modified D	H&S Monitoring Equipment: PID	Logged by: Jodi Chaynowski	Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	~~mw-86A~~	5/6/8/9 6" rec	0-2' silty clay, Brown, ~~trace~~ low plasticity, moist	10" Bit w/ 3" rods. (500 gal drum of soil support rig) 0732 Drive spoon 0-2'		+1000 -0-	CL	10YR 4/3
7'	mw-86A	8/9/7/14	7-9' clay & silt, Brown, slightly moist low plasticity	0742 collect mw-86A 7-9'		0	CL	7.5YR 5/4
15	mw-86B mw-86Dup 15-19' Interval Sampled	10/12/14/10 12" 9/14/10/8 18"	15-17' Sand, yellowish red, poorly graded, saturated, medium to coarse 17-19 Same as above except w/ some gravel gravel is fine to medium, sub-angular to sub rounded	0927 collect mw-86B + Dup From 15-19' BGS		0	SP	5YR 5/6

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-86 | Project Name: WRF Sheet Ext

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
		8/7/8/15 18"	20-22' Sand, lt gray/yellowish Brown, coarse to med gr, SAturated, SUBANGular to SUBrounded Poorly graded	0850 drove spoon 20-22' 0855 drove spoon 25-27'		0	SP	10YR 5/4
25'		10/11/17/20 11"	Sand & Gravel, yellowish Brown, coarse & med gr Sand & gravel mod & coarse SAturated, SUBAngular grains	@900 @30' Driller notes drilling Ingravelly will continue Drilling Till diff Forever to drilling is noted. BET Jumping.	Sand	0	SP/GP	
30'			Same as above (Through Drilling)	0911 @36' Driller notes change will drive spoon from 36-38' CIRculating Borehole for STABILIZATION	→ @35' Clay?			
36'	MW-86C 0930	13/8/6/7 no rec. 12/10/15/8 14"	36-38' GRavel @ Bottom of Borehole will drive spoon again. 11" Clay, gray, w/some SILT, low to medium PLASTICITY, moist to dry. (3" gravel, Slough)	0 RAN! Falling To Bottom of Borehole will RECEIVE spoon. 0930 reaching spoon 36-38' will set Camp @ 36'. TOH Rods. changed BIT to 14" wing BIT	Bentonite		CL	7.5YR 5/1

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-86 | Project Name: WRF Phase II RI

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY †	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				Overburden Drilled w/14" Wing Bit 0940 @ 10' add 10' of rod 0950 @ 20' add 10' of rod 1005 @ 30' add 10' of rod 1015 @ ~~36~~ 36' Drilled ~~Rotary Chop~~ 1020–1035 TO 14 Rods 1035–1205 Installed 41' of 10" Diameter Carbon Steel Casing Casing Seated @ ~~36~~ 36' BGS Welded Casing Together. 1205–1300 Break for Lunch. 1300–1400 Set up To grout Casing +/- plug. Cut Casing ~~Flush~~ To To 1' Above ground surface. Covered Trench Spoil To 36' BGS Batch #1 4 Bags 94# Portland Type II Cement. 3 ½ gal of water 15 Lbs of Bentonite				
			Batch #2 Same as Batch #1 1430 Casing grouted In place. 1430-1525 Clean up Site.					

All measurements should be recorded in feet or tenths of feet. † Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-86 | Project Name: WRF RI/FS II

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
35			36-38 Clay (See page 3	8/15/96 0815 — 0935				
			38-40'	Set up rig over Borehole.	+500	Water from	CL	7.5YR 5/1
38'		3/2/4/4	Clay, Strong Brown, w/some f. gr.	0935 Tih w/3" rods w/8" wings & 7.	+500	RI2		
		6"	Sand, Damp, Low Plasticity, SOFT.	0943 @ 35' Circulating water				
40'			40-42 10"	Through Borehole. Flushed out mud			CL—	7.5YR
		10/7/9/22	Sand SILT w/Some clay, Dry to slightly damp	To ensure no grout enters Lower Aquifer.			SC	4/6
42'		14"	Sand is F-gr.	0958 @ 38' Drive Spoon.				
			4" Sand mix f/Coarse gr w/some silt, Subrounded	1015 @ 40' Drive Spoon			SM	5YR 4/2
			Subangular to Subrounded, Loose, Brown	1042 @ 42' Drive spoon			SP	7.5YR
		37/32/24	42-44' Sand & Gravel, light Brownish	1040 @ 45' Come sand				5/4
		13	gray, SAT'urated, Loose. Sand is	coming up from mud pan.			SP—	4.5Y
		12" Rec	med to Coarse gr. Gravel is fine to	will drill to 50' & collect			GW	6/2
			Coarse. Subangular to Subrounded.	add'l spoon,				
				1040 — 1055 Send Batch of				
50'			50-52'	mixed (Bentonite) mud down Borehole				
		11/16/16/19	Sandy SILT, Brown, Friable, slightly Damp to	to Dry gr Coarse Sand & gravel.				
			Dry.	1052 @ 49' Add gravel to well Suppli & Borehole				
				1135 Driller sent down new batch of mud to clean borehole				
				of gravel.				
				1140 @ 50' Circulating & Borehole				
				1145 Drive spoon for 50-52' Interval				7.5YR
				1202 @ 50' will set 2" PVC Flush 40 → 50' OBS				5/3

All measurements should be recorded in feet or tenths of feet.

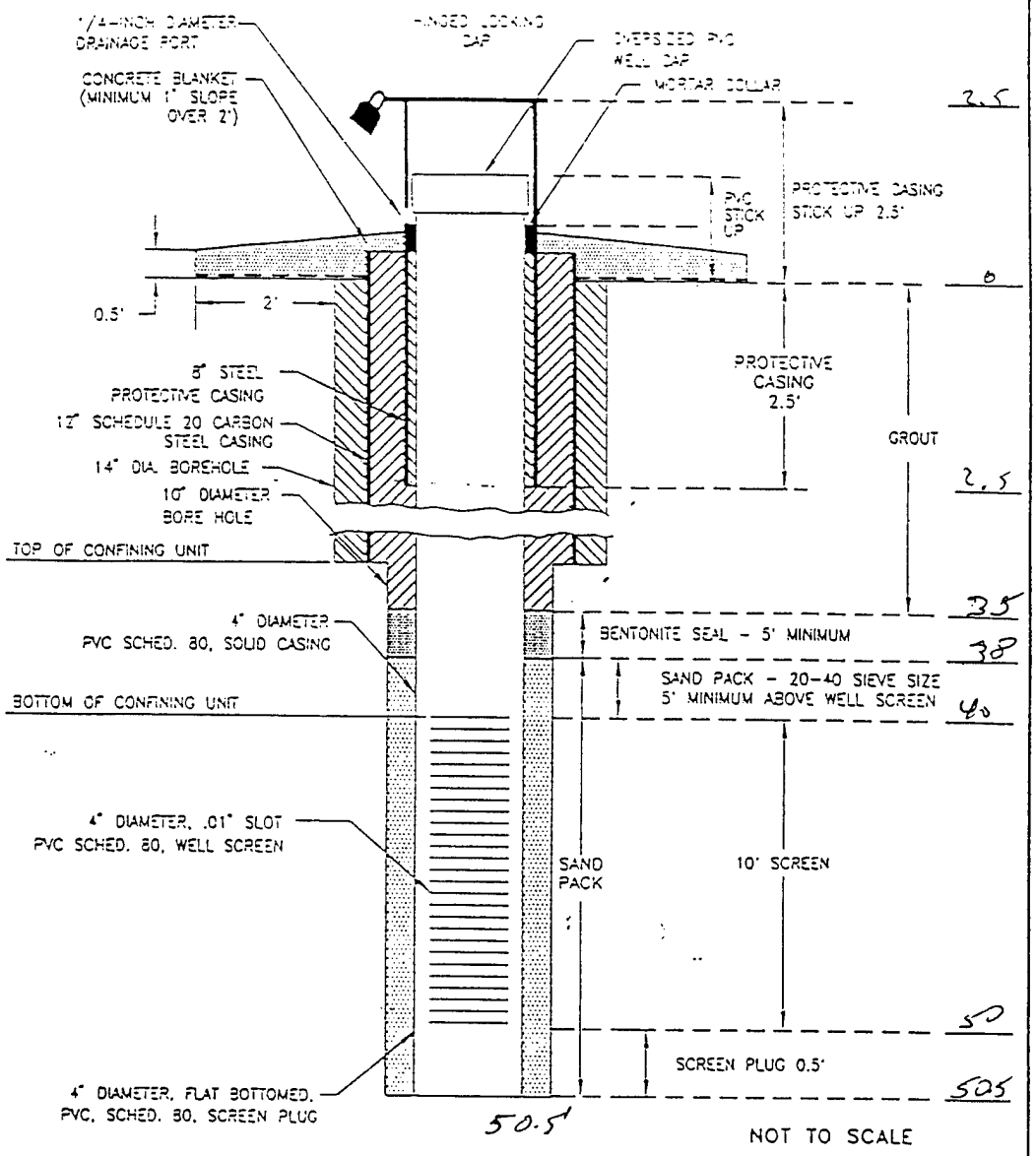
‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-86 | Project Name: WRF Phase II RI

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ¢	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				1203 Thin out mud by pumping thickener mud into drums. 1220 TOH rods 1220–1235 Install screen & casing Screen 40–50' BGS Lowered Tremie to 48' BGS Begin to Tremie in filter pack 1320 Sand @ 38' BGS Used 18 Bags 1325 Bentonite installed to 35' BGS Bullseye Tremie Lunch! 1410 Begin to mix Grout. 1430 Begin to grout annulus Tremie @ 33' BGS Batch #1 4-94lb Bags of Portland type II cement 32 gal of water 12 LBS of Bentonite. Batch #2 same as #1 Batch #3 2-94lb Bags of Portland Cement 16 gal of water 8 LBS of Bentonite 1500 Grouted Hole To Surface				

All measurements should be recorded in feet or tenths of feet. ¢ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

DEEP MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: MW-86

DATE COMPLETED: 2/15/86

Well: MW-87 Date Started: 8/19/96 Date Completed: 8/19/96

Location:

Well diameter (in) 4

Borehole diameter (in) 8

Filter pack length (ft) 15

Total Depth (ft) 50.5

Est. depth to water (ft) 20

Est. water column height (ft) 30.5

Est. extraction volume (gal) —

FLUID LOSSES DURING DRILLING (gal) 150

ESTIMATED RECOVERY RATE

Height of stickup (ft) 2.12

Actual total depth (ft)(TOC) 52.5

Actual depth to water (ft) 29.5

Actual water column height (ft) 23.0

Actual extraction volume (gal) 120 230

EXTRACTION VOLUME FACTORS

Extraction Volume Factors (A,B)	Borehole Diam.= 8 inches	Borehole Diam.= 10 inches	Borehole Diam.= 12 inches
Well Diameter = 2 in	0.82, 3.7	0.82, 6.1	0.82, 8.6
Well Diameter = 4 in	3.3, 2.9	3.3, 5.1	3.3, 7.8

5 TIMES WELL VOLUME (GAL) = A × (water column height) + B × (filter pack length)[1]

(3.3) (23) + (2.9) (15).

76 + 43.5 = 119.2

+ 150 estimated

269.2

23

3.3

69

690

75.9

76

+44

120

5 TIMES WELL VOLUME (gal) 120

5 TIMES FLUID LOSSES (gal) + 150

REQUIRED EXTRACTION VOLUME = 270

[1]extraction volume (gal) = $5\times[\pi r_w^2 H_{WL} + 0.3\pi(r_b^2 - r_w^2)H_{FP}]\times 7.48$ gal/ft^3

STABILIZATION DATA

Time	Flow Rate	Water Level	Volume Extracted	Turbidity	Cond.	D.O.	Redox	pH	Temp.	Description
0821	—	29.50	Initial	Tint	Water	Level	—	—		
0905	1GPM	~~42.52~~ 42.52	Initial	—	440	3.68	339	6.12	15.87	TURBED
0911	5GPM	39.86	40.0	—	242	7.84	349	6.31	16.42	TURBED
0926	3GPM	39.54	70.0		184	7.85	366	6.21	16.41	Cloudy
0936	4GPM	39.57	110.0		124	6.48	361	6.14	16.40	cloudy
0941	3 GPM	39.64	140.0		115	7.02	361	6.08	16.34	Slightly cloudy
0951	~~3~~ 2.5 GPM	38.54	165		46	7.01	337	6.05	16.32	Slightly cloudy
1001	2.5	38.20	190	96.6	41	7.01	314	6.06	16.32	slightly cloudy
1011	2.5	38.51	215	90.4	48	7.06	311	6.05	16.30	slightly Cloudy
1021	2.5	38.44	240	87.5	47	7.06	301	6.05	16.29	slightly cloudy
1031	2.5	38.51	265	60.2	49	7.02	291	6.03	16.27	slightly cloudy to clear
1035	2.5	38.47	275	55.5	47	7.01	285	6.02	16.28	clear

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

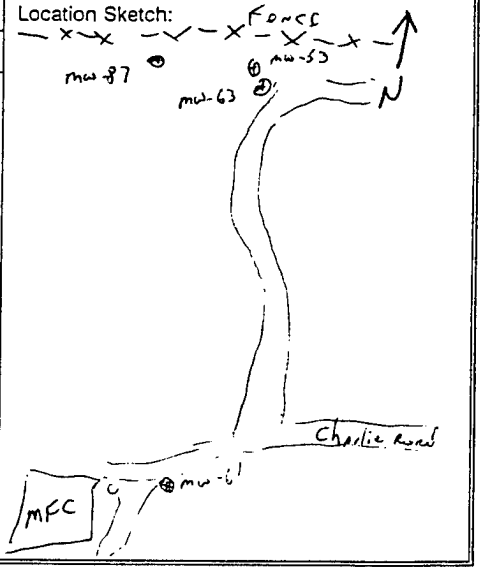
Project: WRF Phase II RI		Boring: MW-87	
Geologist: Jack Choyncwski		Signature: Jack Choynowski	
Driller & Company: Chad Chism / Hardin Hubbard		Drilling Rig: B-53 M.A.	
Date Boring Started: 8/14/96		Completed: 8/16/96	
First Encountered Water Level: ~15'		Date: 8/14/96	
Total Fluid Losses: 150		Date: 8/16/96	
Total Fluid Losses:			
Casing Type: Sch 40 PVC Slot 0.01" 4" Dia.		Screened Interval: 40-50	
Geophysical Logging: none		Date: —	
Depth to Bedrock: not encountered		Ground Elev.:	
Boring Completion Information: Completed as monitoring well		Date: 8/16/96	

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
8/14/96	0720	1520	0	21'	Drilled & Sampled w/ 8" BIT. Overcased w/ 14" BIT. Set grouted casing to 21' Installed monitoring well.				
8/16/96	0820	1610	21'	50'					

Abbreviations:

Abbreviation	Meaning
~	Approximately
TRACE	1 to 9%
Some	30 to 45%
and	50 to 50%
BGS	Below ground surface
V.	Very
f.	Fine
gr.	grain
w/	With

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: MW-87		Project Name: PHASE II RI - WRF	
Driller/Company: Chad Chism/Hardin-Huber	Drilling Method: Mud rotary	Date Started: 8/14/96	Date Completed:
Total Depth:	Depth to Bedrock: not encountered	Water Table Depth:	Ground Elevation:
Protection Level: modified D	H&S Monitoring Equipment: PID	Logged by: Jack Choynowski	Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW-87A 0830	2/1/3/4 18"/rec	0-2' Clay & SILT, Reddish Brown, Low Plasticity, Slightly Damp, Very Soft.	Drilling initially w/ 8" Wash Bit Spl'd w/ 2" OD S.S. split spoon-Sample 140 LB Hammer & 30 inch Drop. 0825 Drive Spoon 0-2' BGS 0830 Collect MW-87A Start drilling	+500 +500	Trace NRS / 0	CL	5YR 4/3
7'	MW-87-B 0855	7/7/4/4 17"/rec	7-9' 8" Sand and SILT, dark yellowish Reddish Brown Sand is fine to med. gr, Loose, Damp to Very moist 9" Sand w/ little SILT, yellowish red, Very moist, med. to fine gr, Loose Subangular to Subround	0852 @ 7' Drive Spoon 0855 Collect MW-87B		0	SM SP	5YR 3/4 5YR 4/6
15'		6/5/4/5	15-17' Gravelly Sand, Sand is coarse to medium gr, gravel is fine gr. Angular to subangular, Loose & Saturated Strong Brown	0905 @ 15' drive spoon 15-17'		0	SP-GP	7.5YR 4/6

All measurements should be recorded in feet or tenths of feet. ¹ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-27 | Project Name: Phase II RI WRE

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	MW-27C 0920	3/2/2/3 24"/Rec.	20-22' Clay, gray, SOFT, slightly Dry, Low Plasticity	0910 @ 20' Drive spoon 20-22' 0920 collect MW-27C @ last 2' of clay @ 20-22' Will set casing @ 21' BGS TOH rods 0945 Start Overcem Hole w/ 14" BIT. 0958 @ 10' add 10' of rod. 1010 @ 21' BGS Thinned out mud in Borehole 1050 TOH Drill Rods 1100 Rods out of Hole, Begin to Install Casing. 20' of Casing in Borehole held on 4' Section OF Additional Casing		0	CL	5Y 5/1
			1145 Casing Installed to 21' BGS 1200-1300 Lunch Break 1300 Lower Tremie Into Borehole to 20' BSS BATCH #1 10 LBS of Bentonite, 32 gal of water, 4 Bags (94 LB/Bag) Portland Type I Cement 1345-1520 Clean mud pad clean up site.					

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-87 | Project Name: WRF Phase II RI

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20			20-22' See description on Page 3.	8/16/96 0820-0900 SETUP ON Borehole.	+500 +500	N.T. Taken		
				0921 TFH 8" w/ Bit & 3" Drill Rods			CL	5Y 5/1
24		2/3/1/3 24"	24-26' Clay, gray, SOFT, Slightly damp, Low Plasticity, Little SILT.	0925 Start drilling (Circulating water Through Borehole)				
				0930 @ 24' Drive spoon to collect sample for Lithological alteration 24-26' Bgs				
29		1/2/1/2 24"	29-31' Clay, Brown, SOFT, Damp, Low Plasticity	0939 @ 29' Drive spoon for 29-31' Bgs			CL	10YR 4/3
				0955 @ 34' Drill rods change @ 34' Drive SPOON (Drilling IS SOFT)				
34'		5/4/3/3 18" pr	34-36' Sand, STrong Brown, Poorly graded F. To med gr. / Very moist to saturated / Loose some Trace SILT, Trace of clay,	1005 @ 37' Drive spoon for 37-39' Bgs			SP	7.5YR 4/6
37'		16/8/7/7 18"	37-39' 8" — Sand & gravel Same to moist, Poorly graded, SUBROUNDED to SUBROUNDED med TO COARSE gr.				SP-GP	2.5Y 4/4
			10" Sand - Fine TO med gr, Damp, Poorly Graded				SP	10YR 5/4

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-87 | Project Name: WRF Phase II RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
42		9/7/8/9 15"	5" Slough of ground. 10" Clay, dark yellowish brown, dry to slightly moist, low to medium plasticity. Trace of f. sand	1018 @ 42' Drive Spoon		0	CL	10YR 4/4
49		35/22/24/22 12"	49-51 10" Gravel, yellowish brown w/some sand, saturated, poorly graded. Gravel is medium to coarse gr, sand is coarse gr. w/ little med. gr., dense. 8" Sand, pale brown, well graded f. → coarse gr, saturated, loose to dense, subangular → subrounded	1033 @ 49' Drive Spoon Mix new batch of drilling mud 1105 @ 53' Drive Spoon 1115 Drilling rough B-E Jetting in gravel			GP SP	10YR 5/4 10YR 6/3
53		50/4 no rec	53' refusal. Driller notes in ground.	1130 @ 53' will set well for 49' → 53' BGS This was cut mud by pumping fresh Borehole keeps caving in to 49' BGS. Drive & hoist rods are rusty				
57								

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

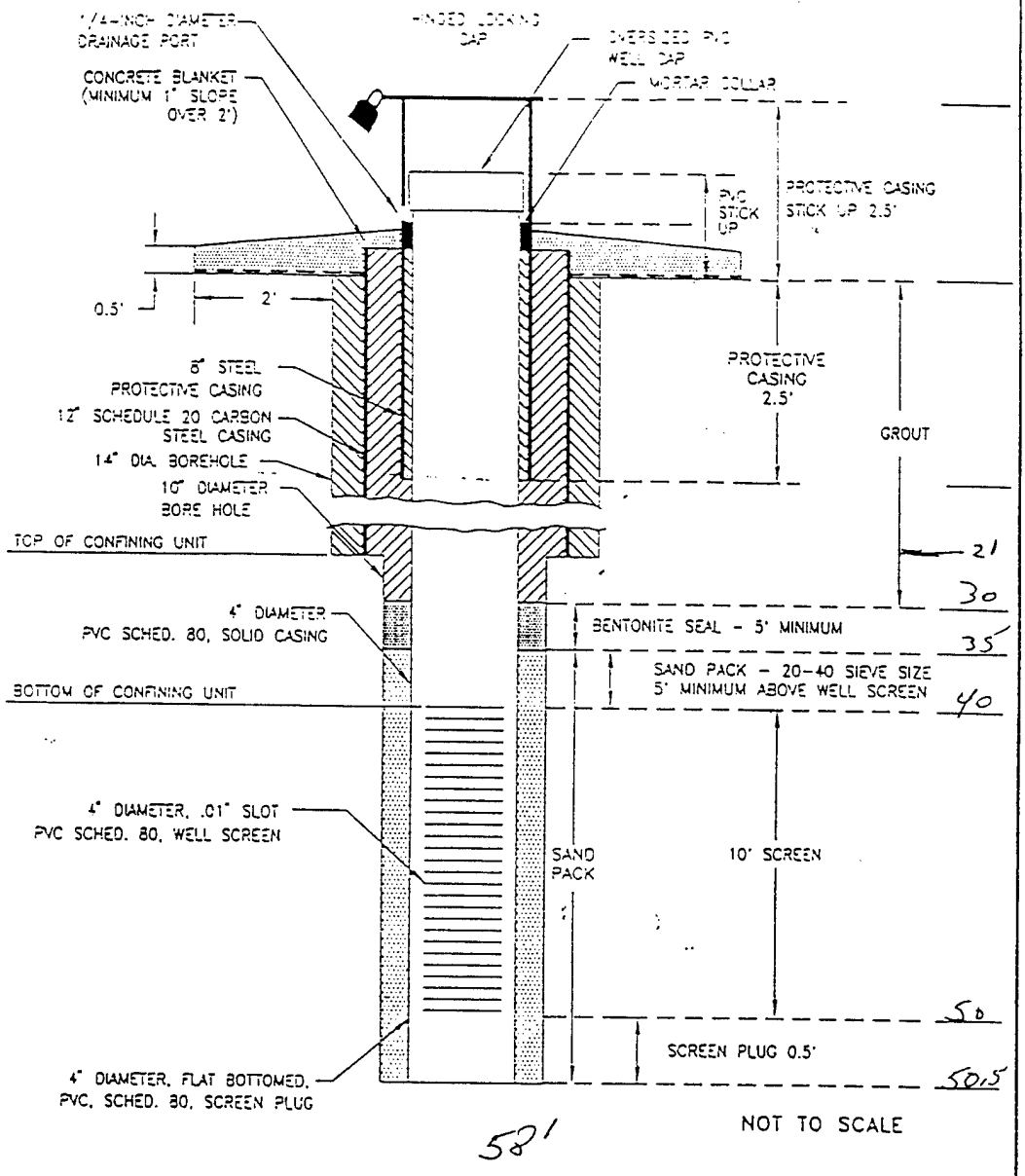
ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: MW-87 | Project Name: WRF Phase II RI

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY †	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				1145 To H Drill Rods. ~~Grease~~ @				
				1152 Installed Casing to a depth of 50.5' 7.5' of Casing SW. Lowered Tremie Pipe to depth of 42'. Begin Installing filter pack.				
				1315 Sand @ 35'				
				1320 Installed Bentonite seal to 30' BGS. Cleaned out mudspot. Tube Lunch.				
				1530 Begin Tremie grout Annulus. Tremie Pipe @ 28' BGS. Batch #1 11 LBS of Bentonite 32 gal of water 4 Bags of 94LB/Bag Portland Type II Cement.				
				Batch #2 Same as #1 Tremied to backside grouted to surface.				
				1610 will clean up Muddy Water off Site.				

All measurements should be recorded in feet or tenths of feet.

† Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

DEEP MONITORING WELL CONSTRUCTION DIAGRAM

WELL NO.: _____

DATE COMPLETED: _____

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

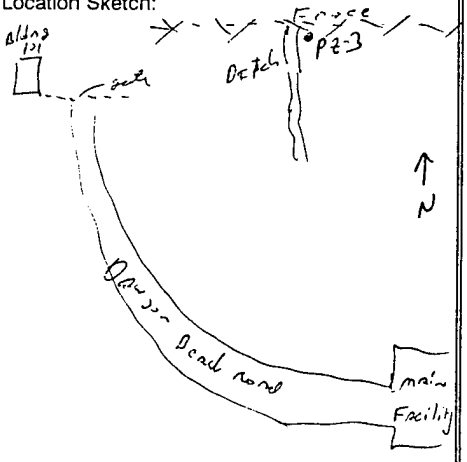
Project: WRF RI/FS	Boring: PZ-3
Geologist: J. CHOYNOWSKI / D. BATTS	Signature: Dennis Batts
Driller & Company: RICK RIDER / HARDIN-HUBER, INC.	Drilling Rig: B-57 MOBILE
Date Boring Started: 12/1/95	Completed: 12/1/95
First Encountered Water Level: 12'	Date: 12/1/95
Total Fluid Losses: N/A	Date: —
Total Fluid Losses: N/A	
Casing Type: PVC SCHEDULE 40 2"	Screened Interval: 22-12'
Geophysical Logging: NONE	Date: —
Depth to Bedrock: NOT ENCOUNTERED	Ground Elev.: —
Boring Completion Information: Capped and pierometer	Date: 12/1/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
12/1/95	0935	1345	0'	22.5'		4.25" HSA			

Abbreviations:

Abbreviation	Meaning
TRACE	90/10
LITTLE	80/20
SOME	70/30
AND	50/50
V.	VERY
FN.	FINE
MED.	MEDIUM
DK.	DARK
LT.	LIGHT
W/	WITH
W/O	WITHOUT
GR.	GRAIN
H.	HIGH
BGS	BELOW GROUND SURFACE

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-3	Project Name: WRF RI/FS		
Driller/Company: RICK RIDER/HKI	Drilling Method: HSA 4.25" ID	Date Started: 12/1/95	Date Completed: 12/1/95
Total Depth: 22.5'	Depth to Bedrock: not encountered	Water Table Depth: 13'	Ground Elevation:
Protection Level: MODIFIED LEVEL D	H&S Monitoring Equipment: MICROTIP PID	Logged by: D. BATTS	Checked by: Jack Chumley

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0'								
0-2'	PZ-3A 0943	2-2-1-3 16"	6-8" CLAY W/ LITTLE SILT, HIGH PLASTICITY, SLIGHTLY MOIST, LIGHT YELLOWISH BROWN	SPLIT SPOONED 0-2'. COLLECT SAMPLE PZ-3A 0943		0.0		2.5Y 6/3
2			8-16" SILTY CLAY, LOW PLASTICITY, DRY, LIGHT GRAY W/ SOME LIGHT BROWN MOTTLING	AUGER TO 5'				2.5Y 7/2
5'								
5-7'	PZ-3B 0958	2-2-3-2 22"	0-3" SLOUGH	SPLIT SPOONED 5-7' COLLECTED SAMPLE PZ-3B 0958		0.0		
7			3-13" CLAYEY SAND, MED. GR. SAND, LOW PLASTICITY, MOIST, LT. GRAY					2.5Y 7/1
			13-22" CLAY W/ SOME SAND (DECREASING FROM 13-22") MOIST TO SLIGHTLY MOIST, LIGHT GRAY W/ BROWN MOTTLING, MED. PLASTICITY	AUGER TO 10'				2.5Y 7/1
10'								
10-12'		6-12-11-7 24"	SAND, MOIST TO WET, MED. GR SAND, MOD. LOOSE, GRAYISH-BROWN	SPLIT SPOONED 10-12' AUGER TO 12' HIT WATER AT ~12'		0.0		10YR 5/2
12'								
12-14'	PZ-3C 1019	5-7-12-6 :1"	GRAVELLY SAND, SATURATED, MED. GR SAND, LOOSE, GRAYISH BROWN, GRAVEL 1/16" TO 3/4" IN SIZE, SUBROUNDED	SPLIT SPOONED 12-14' COLLECTED SAMPLE PZ-3C 1019 AUGER TO 14'		0.0		10YR/5/2
14'								
15'		2-4-7-11 14"	0-3" SLOUGH	SPLIT SPOONED 14-16'		0.0		
			3-14" CLAY W/ TRACE SAND, MED. PLASTICITY, DRY, GREENISH GRAY	AUGER TO 20'				5GY 5/1
				HEAVING SANDS IN AUGER				

All measurements should be recorded in feet or tenths of feet.

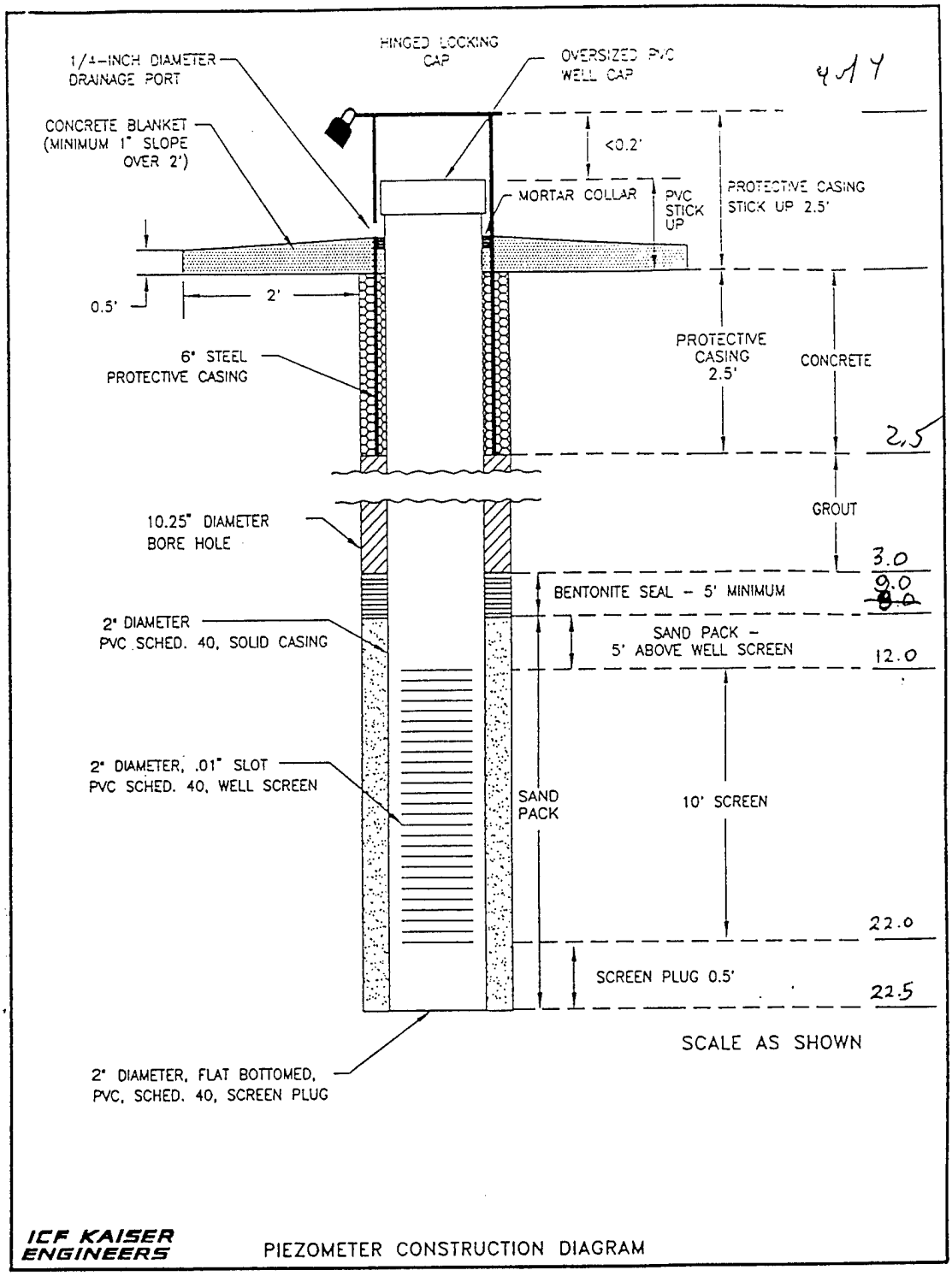
* Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: PZ-3 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20' 20-22 22' 25'		13-15-13-13	GRAVELLY SAND, SATURATED, LIGHT GRAY, MED. GR. SAND. GRAVEL 1/16" TO 1/2" SUBANGULAR TO SUBROUNDED	SPLIT SPOONED 20-22' COLLECTED PHYSICAL SAMPLE 1108 - AUGER TO 22.5' TO SET WELL CASING (111) - BEGIN INSTALLING 2" OD PVC CASING SCREEN FROM 22 TO 12' BGS. ~~LOWER TREMIE PIPE TO 20.5' TO INSTALL FILTER PACK.~~ J.C. INSTALL FILTER PACK TO 8' BGS 1250 - PULLED 1st 5' OF AUGER. SAND IS AT 19' BGS. 1302 - PULLED 2nd 5' OF AUGER. SAND IS AT 14' BGS. 1331 - PULLED 3rd 5' OF AUGER. SAND IS AT 9' BGS. 1340 - BEGIN INSTALLING BENTONITE SEAL PULLED 4th 5' OF AUGER 1345 - PULLED LAST 5' OF AUGER. BENTONITE IS AT 3' BGS. ~~1350 DRILLING CLEAN UP WATER SAMPLING~~ DB 6 - 50 LB BAGS #1 FILTER PACK SAND 2 - 5 GAL BUCKETS DSI BRAND SHUR-PEL 3/8" BENTONITE PELLETS		0.0		2.5Y7/1

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

PIEZOMETER CONSTRUCTION DIAGRAM

WELL NO.: PZ-3

DATE COMPLETED: 12/1/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

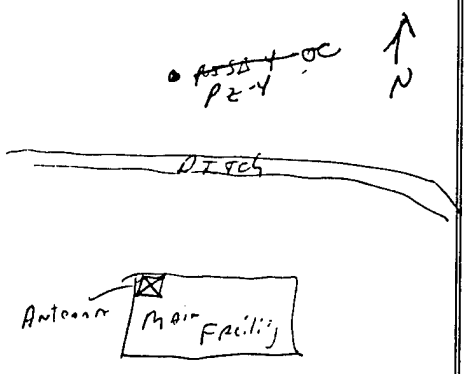
Project: WRF RI/FS	Boring: PZ-4
Geologist: J. CHOYNOWSKI / D. BATTS	Signature: Dennis Batts
Driller & Company: DAVE TAYLOR / HARDIN - HUBER, INC	Drilling Rig: B-57 MOBILE
Date Boring Started: 12/4/95	Completed: 12/4/95
First Encountered Water Level: 3'	Date: 12/4/95
Total Fluid Losses: N/A	Date: —
Total Fluid Losses: N/A	
Casing Type: PVC SCHEDULE 40'	Screened Interval: 15'-5'
Geophysical Logging: NONE	Date: —
Depth to Bedrock: NOT ENCOUNTERED	Ground Elev.: —
Boring Completion Information: Completed as Piezometer	Date: 12/4/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
12/4/95	1450	1545	0'	15.5'		4.25" HSA			

Abbreviations:

Abbreviation	Meaning
TRACE	90/10
LITTLE	80/20
SOME	70/30
V.	VERY
FN.	FINE
MED.	MEDIUM
W/	WITH
W/O	WITHOUT
GR.	GRAIN
H.	HIGH
LT.	LIGHT
DK.	DARK
BGS	BELOW GROUND SURFACE

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-4 | Project Name: WRF RI/FS

Driller/Company: DAVE TAYLOR / HHI | Drilling Method: 4.25" HSA | Date Started: 12/4/95 | Date Completed: 12/4/95

Total Depth: 15.5' | Depth to Bedrock: not encountered | Water Table Depth: 3' | Ground Elevation:

Protection Level: MODIFIED LEVEL D | H&S Monitoring Equipment: MICROTIP PID | Logged by: D. BATTS | Checked by: Jack Clymer

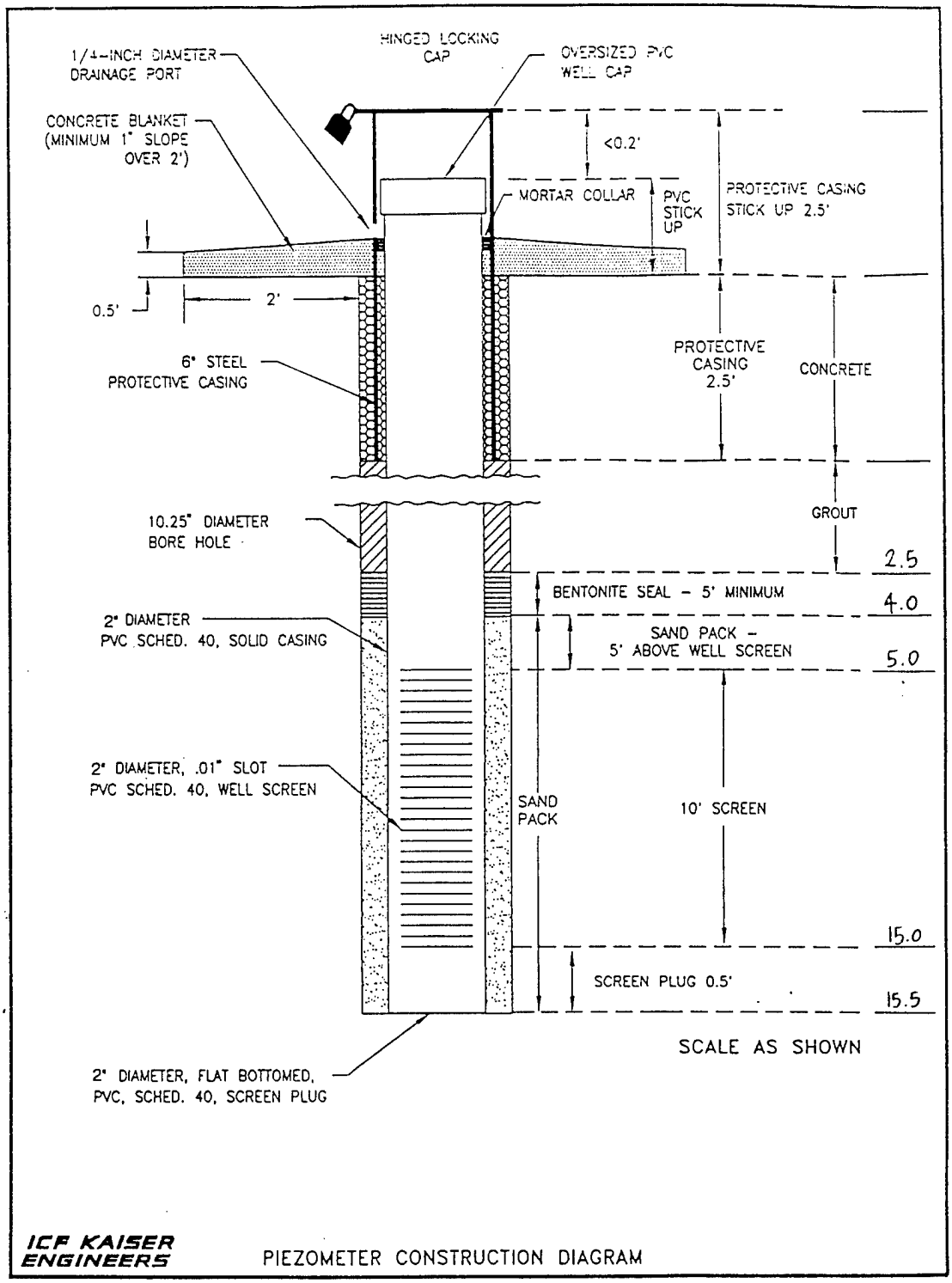
DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0 0-2' 2	PZ-4A 1500	3-3-3-4 18"	SANDY CLAY, DRY, SAND MED. GRAIN, LOW PLASTICITY, STRONG BROWN	SPLIT SPOONED 0-2' COLLECTED SAMPLE PZ-4A 1500 AUGER TO 5'		0.0		7.5YR4/6
5 5-7' 7	PZ-4B 1505	6-6-7-9 16"	GRAVELLY SAND, SAND MED. GRAIN, SATURATED, GRAVEL 1/8" TO 1" SUBROUNDED, STRONG BROWN	SPLIT SPOONED 5-7' COLLECTED SAMPLE PZ-4B 1505 AUGER TO 7'		0.0		7.5YR4/6
7-9' 9	PZ-4C PZ-4 DUP 1510	2-2-3-2 22"	0-8" GRAVELLY SAND SAND MED. GR., SATURATED, 1/8 TO 1/4" SUBROUNDED, STRONG BROWN 8-22" CLAY W/TRACE SAND, H. PLASTICITY, SATURATED, STRONG BROWN	SPLIT SPOONED 7-9' COLLECTED SAMPLE PZ-4C & PZ-4 DUP 1510 AUGER TO 10'		0.0		7.5YR4/6
10 10-12' 12		~~2-2-3-DB~~ 3-4-10-6 14"	0-3" ~~CLAY W/TRACE~~ CLAYEY SAND, SATURATED, SAND MED. GRAIN, STRONG BROWN 3-6" CLAY STRINGER (SANDY CLAY) SATURATED, MED. PLASTICITY, DARK GRAY 6-14" ~~CLAYEY~~ SAND W/TRACE CLAY, MED. GRAIN SAND, SATURATED, DARK GRAY	SPLIT SPOONED 10-12' COLLECTED PHYSICAL SAMPLE 10-12'		0.0		7.5YR4/6 10YR4/1 10YR4/1
15								

12/4/95
1518 – AUGER TO 15.5' BGS TO SET CASING
1521 – INSTALLED CASING TO TD = @ 15.5' BGS.
SCREEN FROM 15 TO 5' BGS - BEGIN INSTALLING FILTER PACK.
1532 – REMOVED 1ST 5' OF AUGER. SAND IS TO 10'.
1539 – REMOVED 2nd 5' OF AUGER. SAND IS TO 5'.
1542 – SAND IS TO 4' BGS. BEGIN INSTALLING BENTONITE SEAL.
1547 – PULLED LAST 5' OF AUGER. BENTONITE IS TO 2.5' BGS.

5 – 50 LB BAGS #1 FILTER PACK SAND.
.5 – 5 GAL BUCKETS DSI BRAND SHUR-PEL 3/8" BENTONITE PELLETS

All measurements should be recorded in feet or tenths of feet.

‡ Record cored intervals in this column if drilling bedrock.



WELL NO.: PZ-4

DATE COMPLETED: 1/4/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

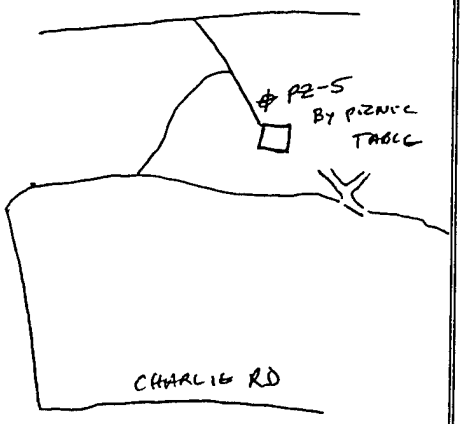
Project: WRF RI/FS	Boring: PZ-5
Geologist: Debbie Romano/JoAnn Stowers	Signature: Deborah J. Romano
Driller & Company: Hardin Huber - Terry, Tom	Drilling Rig: Mobile B-61
Date Boring Started: 11/08/95	Completed: 11/08/95
First Encountered Water Level: 6'	Date: 11/08/95
Total Fluid Losses: ——	Date: ——
Total Fluid Losses: ⟶	
Casing Type: PVC Schedule 40	Screened Interval: 5.4 - 15.4'
Geophysical Logging: n/a	Date: ——
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: 2" Piezometer	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/08/95	1545	1650	0	15.7	4¼" auger & seal.	well installed to bentonite			

Abbreviations:

Abbreviation	Meaning
v	very
fn	fine
med	medium
lg	large
w/	with
w/out	without
gr.	grain

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-5 | Project Name: WRF RI/FS

Driller/Company: Hardin Huber - Terry, Tom | Drilling Method: Hollow Stem Auger | Date Started: 11/08/95 | Date Completed: 11/08/95

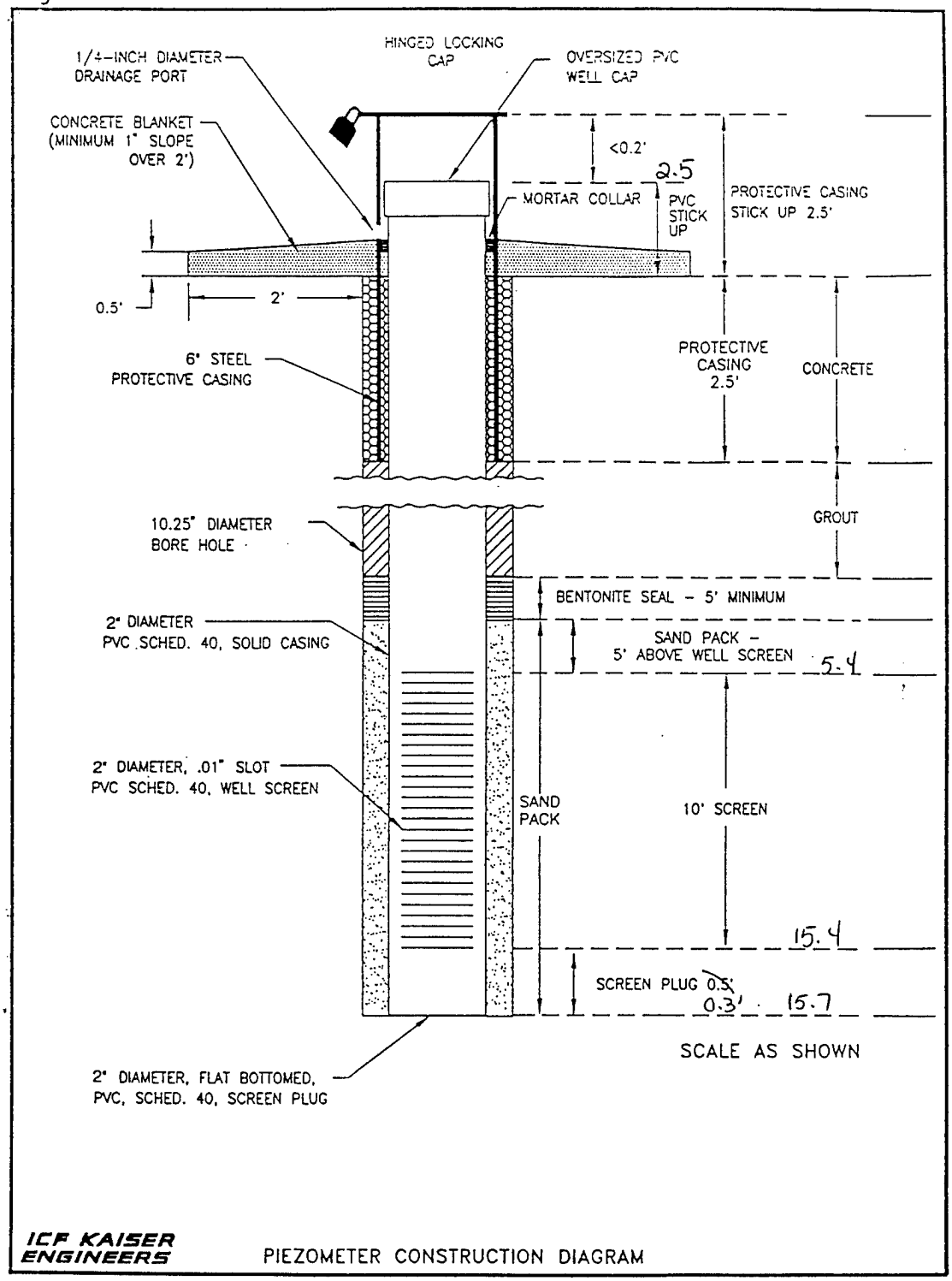
Total Depth: 15.7' | Depth to Bedrock: n/a | Water Table Depth: 6 ft | Ground Elevation:

Protection Level: Modified Level D | H&S Monitoring Equipment: OVM | Logged by: Debbie Romano | Checked by: P. Thmn

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0'	PZ-5A 0-2' 1600	3-3-6-6 15"	SILT, brown, soft, no plasticity, dry			0	ML	7.5YR 4/4
2'		7-8-13-16 22"	0-2" - Silty CLAY, dark yellowish brown, low to med. plasticity, dry, med. stiff. 2-22" - SILT, dark yellowish brown, no plasticity, dry, med. stiff to stiff; has small areas of black organic materials at ~ 4", bored through ~ 0.2" thick ~~stc~~ rock, gray w/ platy structure.	Split spoon 0-2' Split spoon 2-4'		0	CL ML	10YR 4/4 10YR 4/4
4'								
5'				Split spoon 5-7' 6' - soil cuttings wet. ~ 6' - soil in boring wet				
7'	PZ-5B 5-7' 1610	~~9-8-13-16~~ 4-6-5-9 21"	0-11" Clayey SILT, dry, dark yellowish brown, dry, soft to med. stiff grading to silty CLAY, yellowish brown, Soft to med. stiff, ~~med plas~~ low to med. plasticity, dry 11-17" Silty CLAY, grayish brown, soft, wet, med. plasticity 17-21" Silty SAND, light brownish gray, soft, little silt, fn. grain sand, wet.			0	ML CL CL SM	10YR 4/4 10YR 5/3 10YR 5/2 10YR 6/2
10'	PZ-5C 10-12' 1615	10-12-10-6 10"	Silty SAND, brown, fn. to coarse grain sand, little silt, 1" length white stones (quartz?), wet, med. dense little coarse gravel	Split spoon 10-12'		0	SP →	10YR ~~5/4~~ 5/3 (bc)
12'	Physical Sample	5-6-6-7 2'	0-8" Silty SAND, brown, fn. to coarse grain sand, some silt, little gravel, wet, med. dense, grading to Silty SAND, ~~fn~~ v. fn. grain sand, wet, med. dense, brown, some silt	Split spoon 12-14'			SP SM SM	10YR 5/3
14'								
15'		~~5-8-6-~~ (bc)	8-24" - Silty CLAY, yellowish brown mottled with greenish gray, stiff, slightly moist, high plasticity grading down to silty CLAY, all greenish gray, low plasticity, stiff, dry			0	ML ML	10YR 5/6 Chart 1 Gley 6/5G
20'								

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

PIEZOMETER CONSTRUCTION DIAGRAM

11/08/95

1 screen plug PVC sched. 40
1 x 10' PVC sched. 40 screen
1 x 10' PVC sched. 40 riser

5 bags #1 sand (20/40)
½ 5 gal. bucket Shur-Pel 3/8" bentonite pellets

WELL NO.: PZ-5

DATE COMPLETED: 11/8/95

Water level to top of PVC - 7.33'
Water level bgs - 4.83'

8.33
-1.5
2.83

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

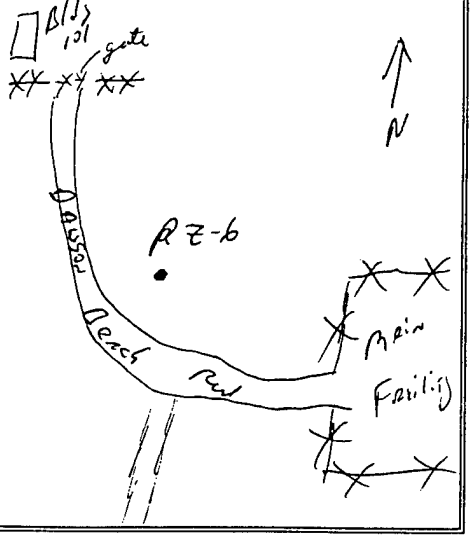
Project: WRF RI/FS	Boring: PZ-6
Geologist: D. ROMANO/D. BATTS	Signature: Dennis Batts
Driller & Company: RICK RIDER/HARDIN-HUBER, INC.	Drilling Rig: B-57
Date Boring Started: 11/30/95	Completed: 11/30/95
First Encountered Water Level: 25'	Date: 11/30/95
Total Fluid Losses: N/A	Date: —
Total Fluid Losses: N/A	
Casing Type: PVC SCHEDULE 40	Screened Interval: 32-22'
Geophysical Logging: NONE	Date: —
Depth to Bedrock: NOT ENCOUNTERED	Ground Elev.: —
Boring Completion Information: Completed as Piezometer	Date: 12/1/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/30/95	1515	1650	0	32.5'		4.25" ID HSA			

Abbreviations:

Abbreviation	Meaning
TRACE	90/10
LITTLE	80/20
SOME	70/30
AND	50/50
V.	VERY
FN.	FINE
MED.	MEDIUM
DK.	DARK
LT.	LIGHT
W/	WITH
W/O	WITHOUT
GR.	GRAIN
H.	HIGH
BGS	BELOW GROUND SURFACE

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-6		Project Name: WRF RI/FS	
Driller/Company: RICK RIDER/HHI	Drilling Method: HSA 4.25" ID	Date Started: 11/30/95	Date Completed: 11/30/95
Total Depth: 32.5'	Depth to Bedrock: not encountered	Water Table Depth: 25'	Ground Elevation:
Protection Level: MODIFIED LEVEL D	H&S Monitoring Equipment: MICROTIP PID	Logged by: DENNIS BATT	Checked by: Jack Chrysler

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0	PZ-6A 0-2' 1520	1-3-5-5 8"	SILTY CLAY, DRY, HIGH PLASTICITY, YELLOWISH BROWN	SPLIT SPOONED 0-2' COLLECTED SAMPLE PZ-6A 1520 AUGER TO 5'		0.0		10YR5/4
5		4-7-11-12 16"	CLAY WITH LITTLE SILT, DRY, MED. PLASTICITY, GRAY WITH BROWN MOTTLING	SPLIT SPOONED 5-7' AUGER TO 10'		0.0		2.5Y5/1
10		3-6-9-11 20"	CLAY, DRY, HIGH PLASTICITY, TRACE SILT, GRAY WITH BROWN MOTTLING, DENSE TOP 2" SLOUGH	SPLIT SPOONED 10-12' AUGER TO 15'		0.0	CH	2.5Y6/1
15		6-9-13-15	CLAY, DRY, HIGH PLASTICITY, LIGHT BROWNISH GRAY WITH BROWN MOTTLING, DENSE	SPLIT SPOONED 15-17' AUGER TO 20'		0.0	CH	10YR 6/2

All measurements should be recorded in feet or tenths of feet.

‡ Record cored intervals in this column if drilling bedrock.

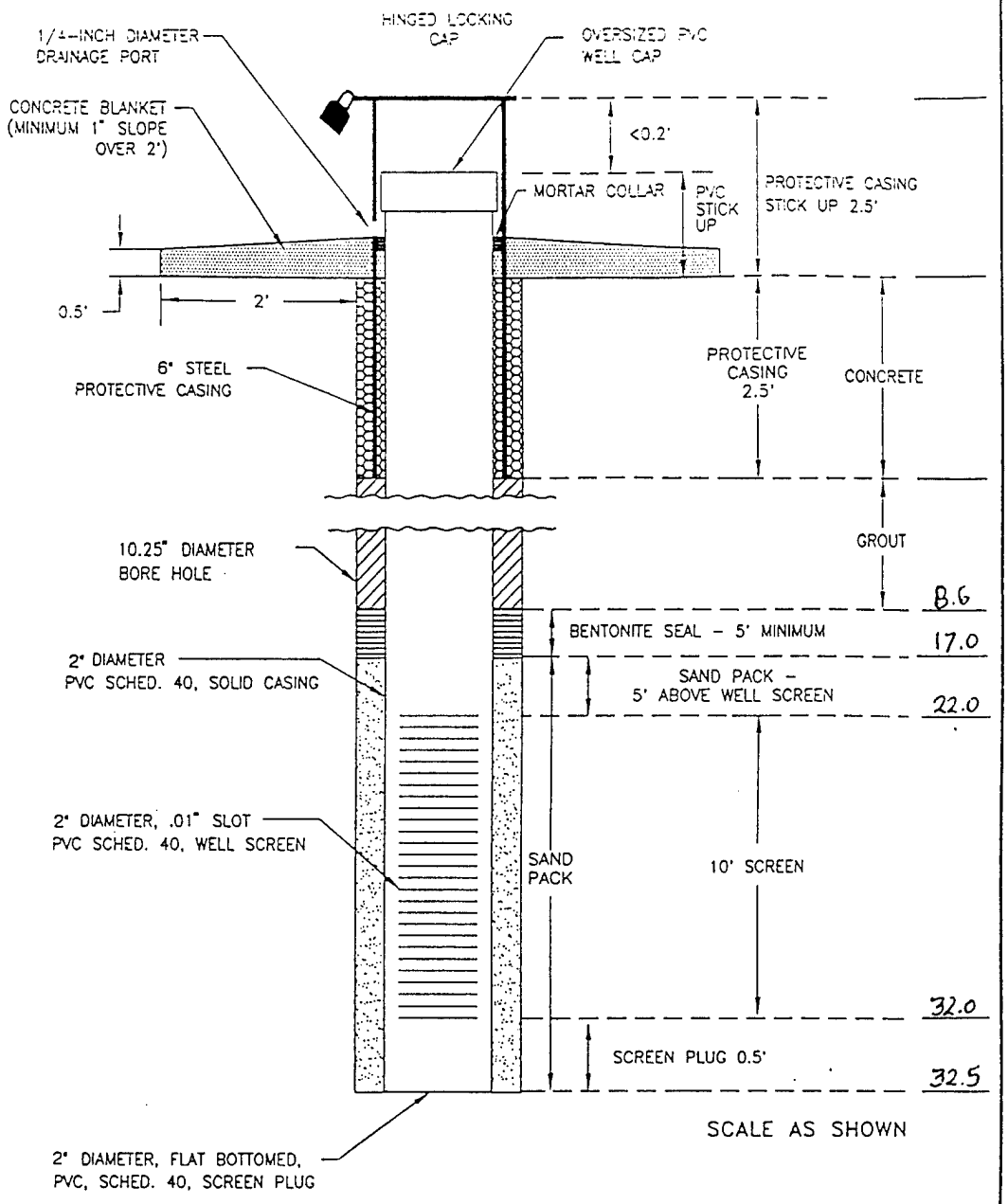
ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: PZ-6 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20'	PZ-6B 1610	4-4-5-6 18"	0-4" SLOUGH 4-10" CLAY W/SOME SAND, SLIGHTLY MOIST, H. PLASTICITY, GRAY 10-18" SANDY CLAY, MED. [redacted] PLASTICITY, MOIST, GRAY	SPLIT SPOONED 20-22' COLLECTED SAMPLE PZ-6B 1610		0.0	CL	10YR5/1
20-22'								
22		3-4-5-6 22"	0-15" FAT CLAY, MOIST, H. PLASTICITY, GRAY 15-22" SILTY CLAY, MED. PLASTICITY, DRY, DARK GRAY, SILT PERCENTAGE INCREASING FROM 15-22"	SPLIT SPOONED 22-24'		0.0	CH	10YR5/1 10YR4/1
22-24'								
24				AUGER TO 25' WATER AT 25' BGS				
25								
25-27'	PZ-6C 1626	6-10-15-17 16"	0-8" SANDY CLAY, MED. PLASTICITY, MOIST, DARK GRAY, WITH [redacted] GRAVEL (TRACE) 8-16" GRAVELLY SAND, WET, MED. GR. SAND, GRAVEL 1/8" TO 1/2" IN SIZE, SUBROUNDED, GRAY	SPLIT SPOONED 25-27' COLLECTED SAMPLE PZ-6C 1626		0.0		10YR4/1 10YR5/1
27		13-10-10-15 15"	GRAVELLY SAND, WET, GRAY, MED. GR. SAND, GRAVEL 1/8" TO 1" IN SIZE, SUB-ANGULAR TO SUB-ROUNDED, LITTLE CLAY IN BOTTOM 8".	SPLIT SPOONED 27-29' COLLECTED PHYSICAL SAMPLE AUGER TO 32.5' TO SET CASING		0.0		10YR5/1
27								
29'								
			7- 50LB BAGS #1 FILTER PACK SAND - 5 GAL BUCKETS	11/30/95 1650 - BEGIN INSTALLING CASING. SCREEN SET FROM 32-22' BGS. 1655 - ~~LOWERED TREMIE PIPE TO 30.5' DB~~ BEGIN INSTALLING FILTER PACK. 1709 - PULLED 1st 5' OF AUGER. SAND IS TO 27' BGS. 1730 - PULLED 2nd 5' OF AUGER. SAND IS TO 22.8' BGS. 1745 - PULLED 3rd 5' OF AUGER. SAND IS TO 19.5' BGS. 1810 - SAND IS TO 17' BGS. BEGIN INSTALLING BENTONITE SEAL. 1818 - PULLED 4th 5' OF AUGER. 1842 - BENTONITE TO 14' BGS [redacted] DB				

All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

*130 - 138



ICF KAISER ENGINEERS

PIEZOMETER CONSTRUCTION DIAGRAM

WELL NO.: P2-6

DATE COMPLETED: 12/1/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

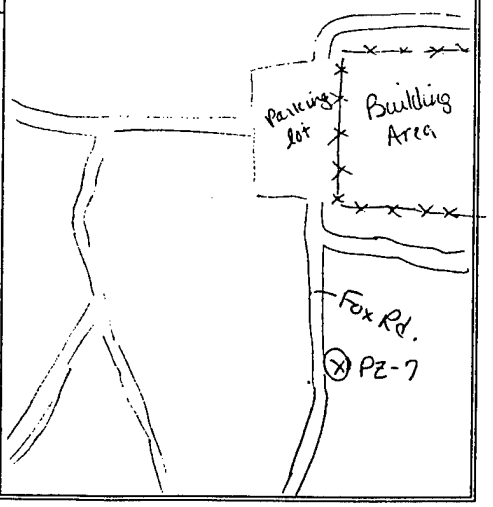
Project: WRF RI/FS	Boring: PZ-7
Geologist: Debbie Romano/JoAnn Stowers	Signature: Debbie J. Romano
Driller & Company: Hardin Huber - Terry & Tom	Drilling Rig: Mobile B-61
Date Boring Started: 11/08/95	Completed: 11/08/95
First Encountered Water Level: 10.5 ft	Date: 11/08/95
Total Fluid Losses: n/a	Date: —
Total Fluid Losses: n/a	
Casing Type: Schedule 40 PVC	Screened Interval: 8 - 18 ft
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: 2" Piezometer completed	Date: 11/09/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/08/95	0840	1020	0	18'	4¼" auger & ~~well~~ installation to bentonite seal piezometer				
11/09/95	Grouted piezometer								

Abbreviations:

Abbreviation	Meaning
v.	very
fn	fine
gn	grain
med	medium
lg	large
sm	small
w/	with
w/out	without
trace	90/10
little	80/20
some	70/30

Location Sketch: N ↑



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-7 | Project Name: WRF RI/FS

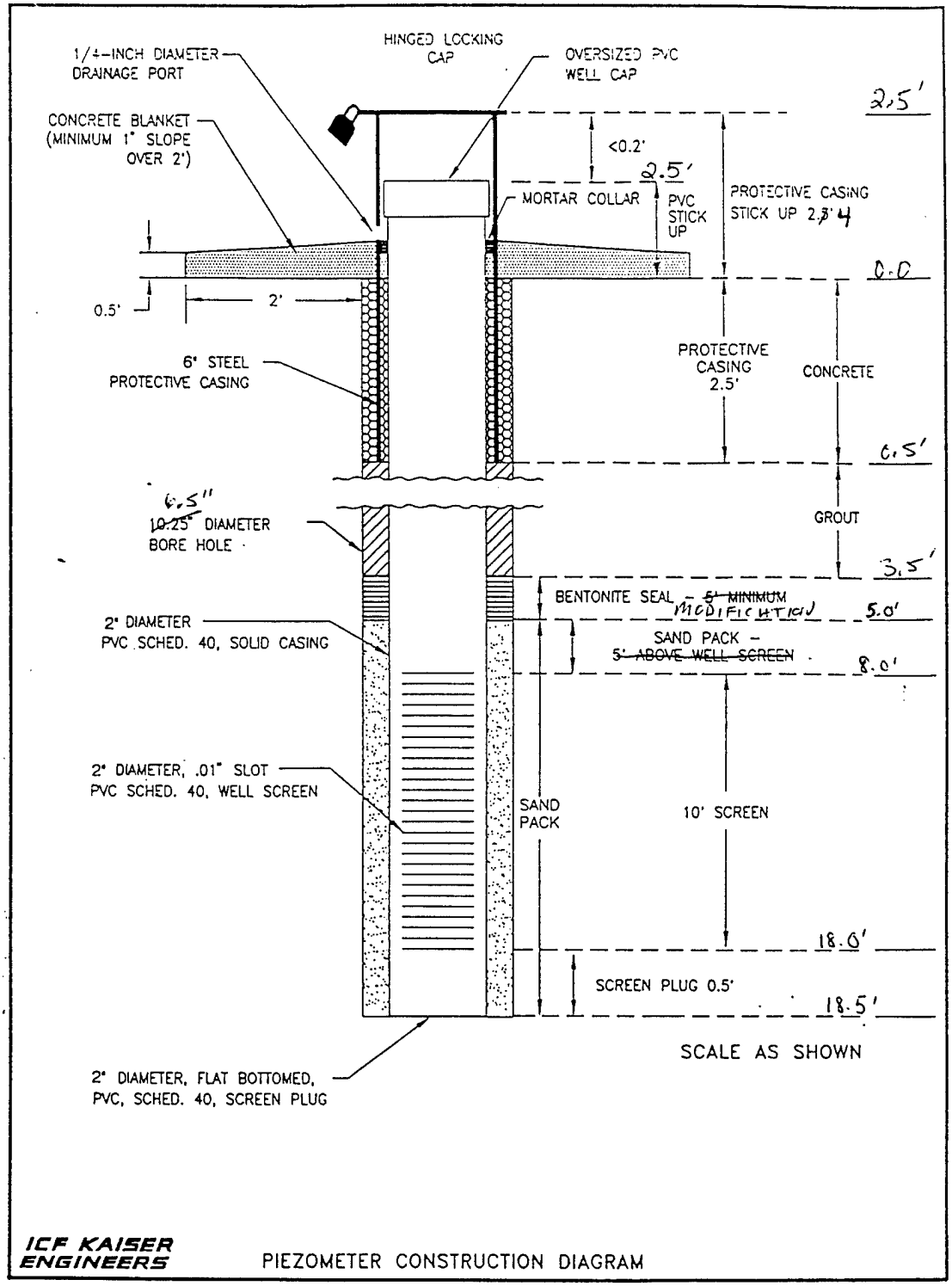
Driller/Company: Hardin Huber - Terry, Tom | Drilling Method: Hollow Stem Auger | Date Started: 11/08/95 | Date Completed: 11/08/95

Total Depth: ~~18~~ ~~18.5~~ 18' | Depth to Bedrock: n/a | Water Table Depth: 10.5' | Ground Elevation:

Protection Level: Modified Level D | H&S Monitoring Equipment: OVM | Logged by: Debbie Romano | Checked by: P Thomas

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								
2'	PZ-7A 0-2' 0855	1-4-2-3 9" 15"	SILT, brown, soft, dry, no plasticity, crumbles easily, trace sand at ~ 9-15". (fn. grain sand) very	Split spoon 0-2'		0ppm	ML	7.5YR 4/4
5'								
7'	PZ-7B ~~5-7'~~ 5-7' 0910	3-11-4-6 9"	SILT, brown, soft to med. stiff, dry, no plasticity crumbles easily.	split spoon 5-7' Driller says: Soil cuttings wet at 8'		0ppm	ML	7.5YR 4/4
10'								
12'	PZ-7C 10-12' 0920	5-7-43 20"	0-4" Silty CLAY, dark yellowish brown, med. stiff, med. plasticity, slightly moist 4-20" Clayey SAND, strong brown, loose, wet, sand is fine to coarse grained, poorly sorted, trace fine gravel; little clay.	split spoon 10-12' Wet soil in boring at ~10.5'		0	CL SC	10YR 4/4 7.5YR 5/6
15'								
17'	Physical Sample	1-2-1-1 2'	0-4" Clayey SILT, brown, very soft, slightly moist, v. little plasticity 4-7" CLAY, strong brown, very soft, moist, high plasticity. Trace amount of black natural organics. 7-24" CLAY, dark grayish brown, very soft, moist, high plasticity.	Split spoon 15-17'		0	ML CH CH	7.5YR 4/3 7.5YR 5/6 10YR 4/2
20'								

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

PIEZOMETER CONSTRUCTION DIAGRAM

11/08/95

Pg. 3 of 3

0.5' screen plug - PVC sched. 40
1 x 10' screen section - PVC sched. 40
1 x 10' PVC sched. 40 riser

#1 Sand (20/40) - 5 bags

Shur-Pel 3/8" bentonite pellets - 1/2 5 gal. bucket + water for hydration

WELL NO.: ~~PZ-8~~ PZ-7

DATE COMPLETED: 11-9-95

water level - 8.6' to top of PVC casing.

1- 94 lb bg of Lehigh Portland Type II cement,

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

Project: WRF RI/FS	Boring: ~~MW~~ PZ-8
Geologist: Debbie Romano/JoAnn Stowers	Signature: Deborah J Romano
Driller & Company: Hardin-Huber / Terry & Tom	Drilling Rig: Mobile B-61
Date Boring Started: 11/07/95	Completed: 11/07/95
First Encountered Water Level: 4'	Date: 11/07/95
Total Fluid Losses: n/a	Date: —
Total Fluid Losses: n/a	
Casing Type: Sched. 40 PVC	Screened Interval: 2-12'
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: 2" Piezometer completed	Date: 11/08/95

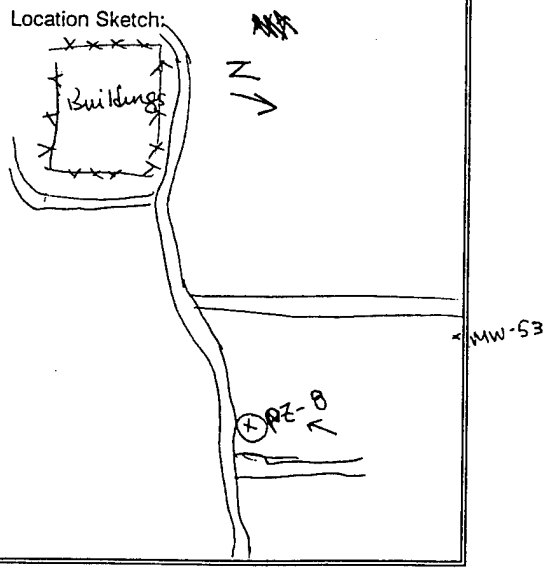
Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/07/95	1520	1725	0	15					
11/08/95	Piezometer grouted								

4¼" auger, piezometer installed (hearing sands to 12')

Abbreviations:

Abbreviation	Meaning
v.	very
sm.	small
fn.	fine
med.	medium
lg.	large
w/	with
w/out	without
trace	90/10
some	70/30
little	80/20

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-8 | Project Name: WRF RI/FS

Driller/Company: Hardin Hubber / Terry-Tom | Drilling Method: Hollow Stem Auger | Date Started: 11/07/95 | Date Completed: 11/07/95

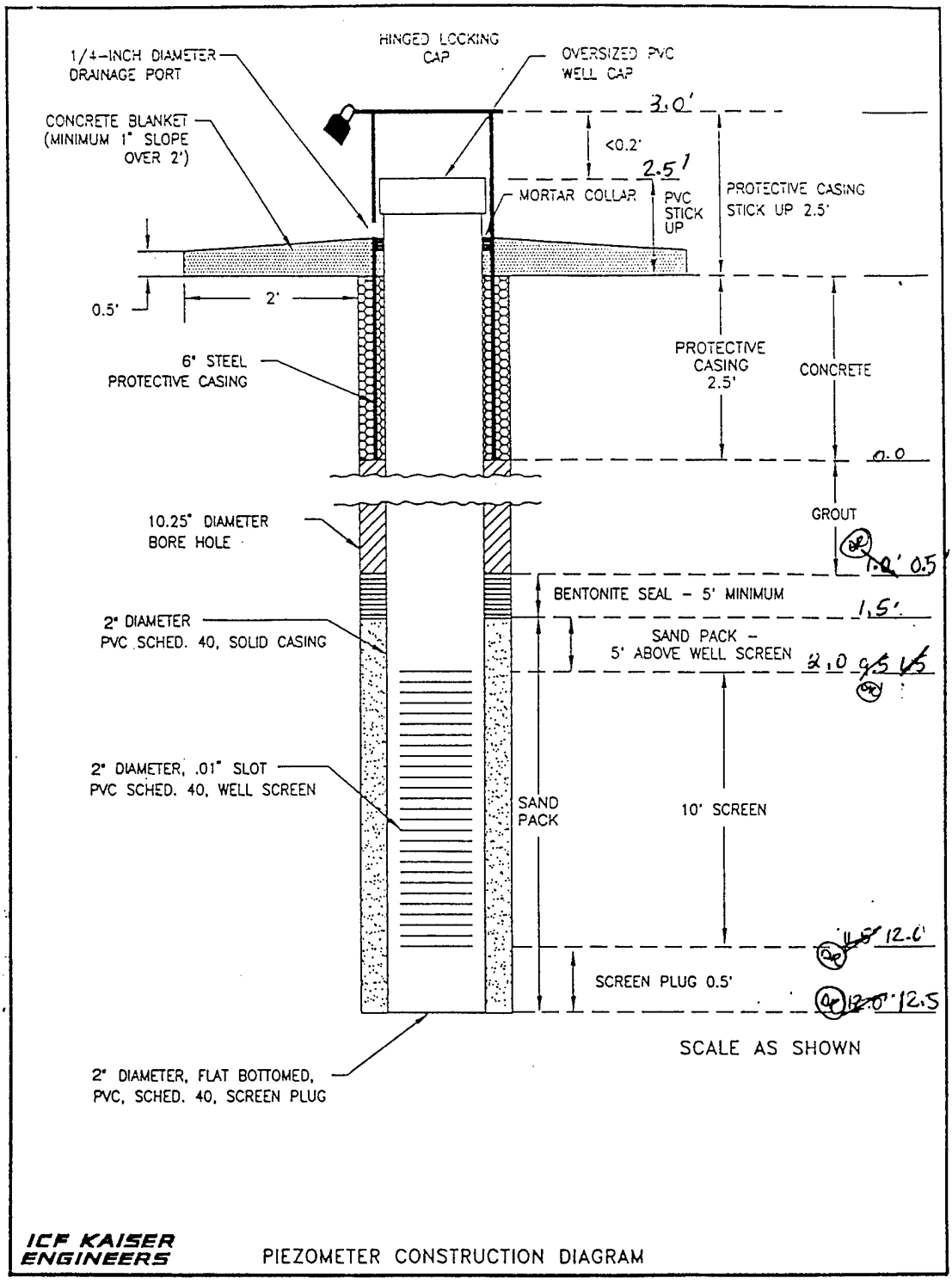
Total Depth: 12 ft | Depth to Bedrock: n/a | Water Table Depth: 4 ft | Ground Elevation:

Protection Level: Modified D. | H&S Monitoring Equipment: — (OVM broken) | Logged by: Debbie Romano | Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0	PZ-8A PZ-8AD 0-4' 2'	2-4-7-6 13"	Clayey SILT, dark yellowish brown, soft to med. stiff, med. plasticity, dry				ML	10YR 4/6
4'		13-21-13-14 16"	Silty ~~SAND~~, brown, poorly graded fn. gn. to coarse gn. sand. Little fine gravel, white, pink, orange/yellow colors. Top of spoon moist going to wet at bottom of spoon. medium dense	Water at 4' in spoon. Driller says he hit it at 2'.			SM	7.5 YR 4/4
5	PZ-8B 5-7	6-12-11-12 2'	Silty SAND, brown, poorly graded, fn. to coarse grained sand, little silt, loose, wet.				SM	7.5 YR 4/4
7'	~~PZ-8~~ (12)							
10	PZ-8C 10-12'	8-11-10-12 19"	0-4" - SAND, brown, fn-coarse grained, loose, mostly coarse grain. Wet, ~~trace silt~~ little silt			10	SP	7.5 YR 4/3
12'	~~PZ-8C~~ Physical sample	4-1-1-2 ~~Duplicate Sample~~ 2'	4-13" - SAND, brown, fn.-med. grained, trace coarse grain; ~~loose~~ med. dense, wet, little silt	Heaving sands in 4¼" auger at 15'. Sand rose up to 12'. Well will be set w/ screen 2-12'.			↓	↓ except black org.
14'	→ 12-13'		13-19" - SAND, ~~brown~~, black natural organics (no odor) color for top 2", bottom 4" brown; fn - med. grained well sorted med. dense, wet, trace silt.				SW	
15			0-1' - SAND, brown, fn-coarse grained, trace silt, loose, wet			12	SP	7.5YR 4/3 ~~PZ-8C~~ 12-13'
			1-2' - Silty CLAY, brown, very soft, wet, little plasticity			14	CL	7.5YR 5/4 12-14'
20								

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

PIEZOMETER CONSTRUCTION DIAGRAM

11/07/95
#1 Sand (20/40) – 4 bags

Bentonite Pellets – 1/3 of 5 gal bucket
Shur-Pel 3/8"

Sched. 40 PVC Screen – 10' section
Sched. 40 PVC riser – 20' section
Sched. 40 PVC screen-plug – 0.5' section

11/08/95
Grout added: 1/4 94 lb. bag Lehigh Portland Cement mixed with 2 gal. water.

WELL NO.: PZ-8

DATE COMPLETED: 11/08/95

Water level: 3.14' to top of PVC casing.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

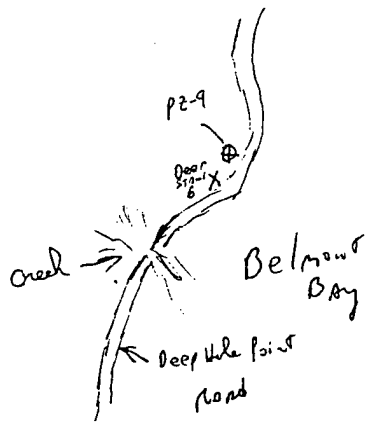
Project: WRF RI/FS	Boring: PZ-9
Geologist: Jack Chojnowski / DENNIS BATTS	Signature: Jack Chojnowski
Driller & Company: Hardin & Huber	Drilling Rig: (MOBIL B-80 CATV)
Date Boring Started: 11/2/95	Completed: 11/8/95
First Encountered Water Level: 6.0 BGS	Date: 11/8/95
Total Fluid Losses: —	Date: —
Total Fluid Losses: —	
Casing Type: 2" Dia Sch 40 PVC w/ 0.1" Screen	Screened Interval: 6-16'
Geophysical Logging: NONE	Date: —
Depth to Bedrock: NOT ENCOUNTERED	Ground Elev.:
Boring Completion Information: COMPLETED AS Monitoring Well	Date: 11/9/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/2/95	1330	1445	0	16.0					

Abbreviations:

Abbreviation	Meaning
~	APPROXIMATELY
Trace	30/70
and	50/50
Some	70/30
%	PERCENT
TFH	TRIP FULL HOLE
TOH	TRIP OUT OF HOLE
HSA	HOLLOW STEM AUGERS
BGS	BELOW GROUND SURFACE

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-9	Project Name: WRF RE/FI		
Driller/Company: Hardin Hubon	Drilling Method: Hollow Stem Auger	Date Started: 11/8/95	Date Completed: 11/8/95
Total Depth: 16'	Depth to Bedrock: Not encountered	Water Table Depth: 6' BGS	Ground Elevation:
Protection Level: modified D	H&S Monitoring Equipment: OVM	Logged by: Frank Chyrek	Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0-2	~~PZ-9A~~	2-2-2-4 / 8 11	TOPSOIL Dark Brown SILTY clay w/some sand and SILTY Sand with some gravel, SUBangular to SUBrounded, Damp	1341 - Collect Split spoon 0-2'			ML	7.5YR 3/3
5-7	PZ-9A (1347)	2-9-11-13 / 16"	Brown Sandy clay, w/some Sand and gravel Sand IS SUBangular, Damp, Low-To Plasticity. [12"]	0347 - Sampled 5-7' Collect PZ-9A Water @ 6' Augered TO 10' BGS			SC/SW	7.5YR 4/2
10-12	PZ-9B (1352)	4/4/7/8 2011	(6") Sand Well graded, WET, w/Some gravel SUB angular, Brown.	1352 - Sampled 10-12' Collect PZ-9B Augered TO 14' BGS Added Water To Auger To keep Sand.				
			10-11' Brown Sandy clay SATURATED, w/ Some Sand And gravel, SUBangular 11-12' Brown Sand, Well graded, SATURATED, SUBangular grain					
14-16	1359	~~6~~ 6/6/5/4	14-16 Sand, W.G. Same as above.	1359 Sampled 14-16' BGS Collect PZ-9C Augered TO 16' will SET well Screen @ 6-16' Interval. UNABLE To collect Physical Sample			SC/SW	7.5YR 4/4
							SW	7.5YR 4/4

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

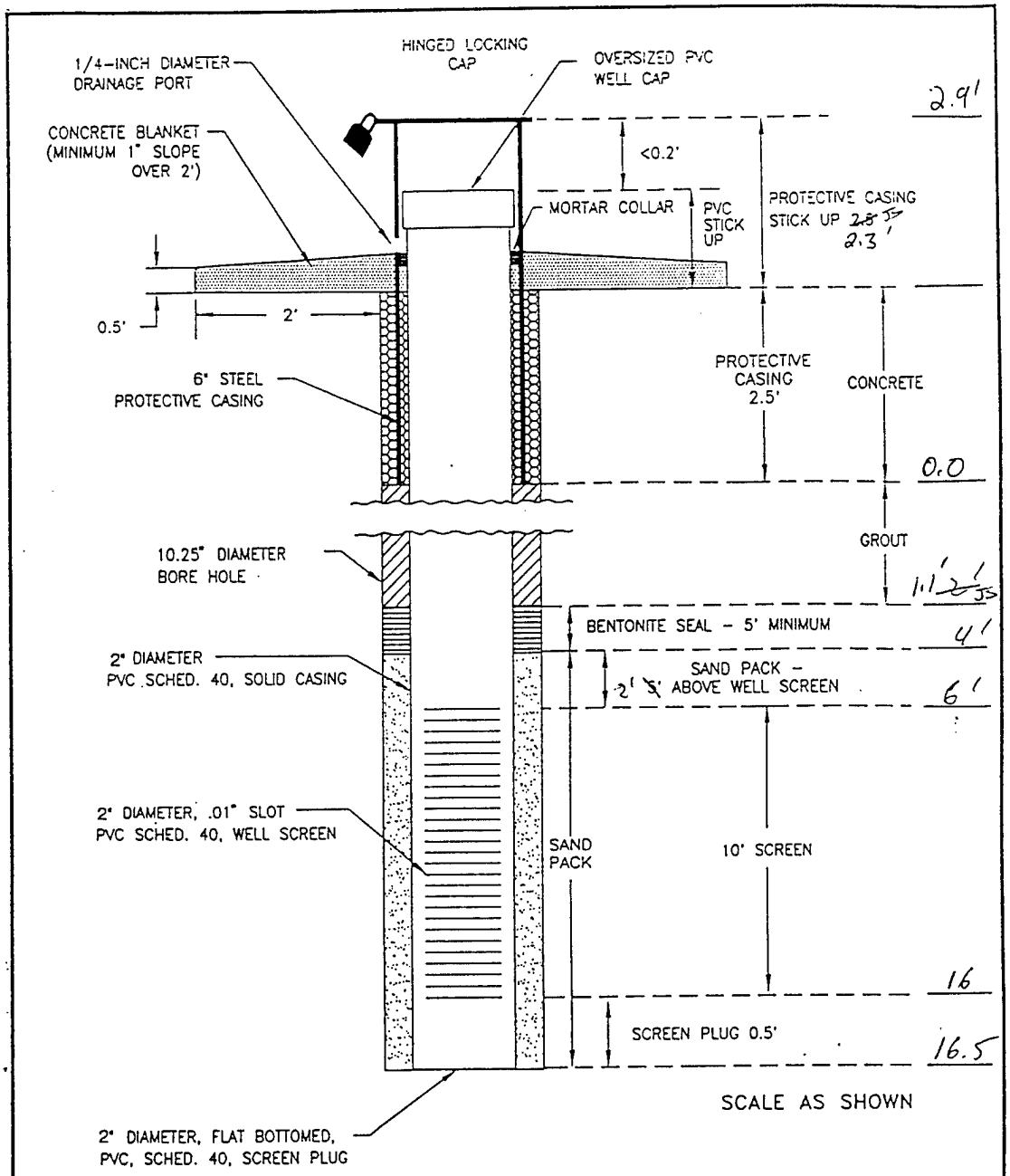
Boring No: P2-9 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
				1403 TD of Borehole 16' Begin to install well Bottom of screen will be 16' Well Casing installed. 1407 Begin to install filter pack w/bottom 5' of auger 1411 w/bottom 5' of Auger 1419 w/bottom 5' of Auger 1440 filter pack installed to 14' BGS 148 Bentonite seal installed to 2' 145 clean up site				

All measurements should be recorded in feet or tenths of feet.

‡ Record cored intervals in this column if drilling bedrock.

Depth to Water = 3.66'



ICF KAISER ENGINEERS

PIEZOMETER CONSTRUCTION DIAGRAM

WELL NO.: PZ-9

DATE COMPLETED: 11/10/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

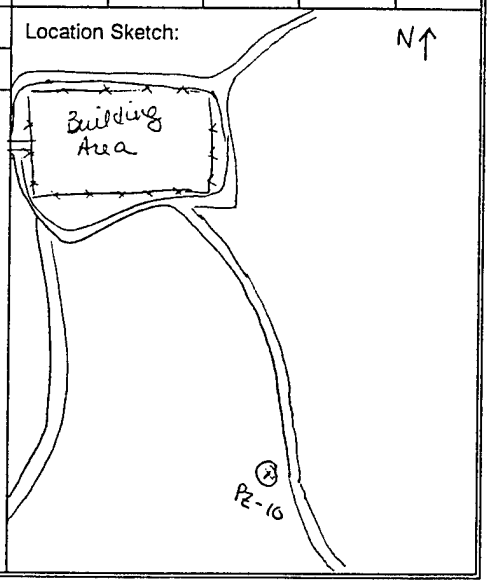
Project: WRF RI/FS	Boring: PZ-10
Geologist: Debbie Romano/JoAnn Stowers	Signature: Deborah J. Romano
Driller & Company: Hardin Huber - Terry, Tom	Drilling Rig: Mobile B-61
Date Boring Started: 11/08/95	Completed: 11/08/95
First Encountered Water Level: 2.5	Date: 11/08/95
Total Fluid Losses: n/a	Date: —
Total Fluid Losses: n/a	
Casing Type: PVC Schedule 40	Screened Interval: 4.7 - 14.7'
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information: 2" Piezometer completed	Date: 11/09/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/08/95	~~1050~~ (DC)								
	1110	1200	0	15	4¼" auger, soil borings				
↓	1315	1420	—	—	Piezometer installation to bentonite seal				
11/09/95	Grouted piezometer								

Abbreviations:

Abbreviation	Meaning
v.	very
fn	fine
gn	grain
lg	large
med	medium
sm.	small
w/	with
w/out	without
little	(80/20)
trace	(90/10)
some	(70/30)

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-10 | Project Name: WRF RI/FS

Driller/Company: Hardin Huber - Terry, Tom | Drilling Method: Hollow Stem Auger | Date Started: 11/08/95 | Date Completed: 11/08/95

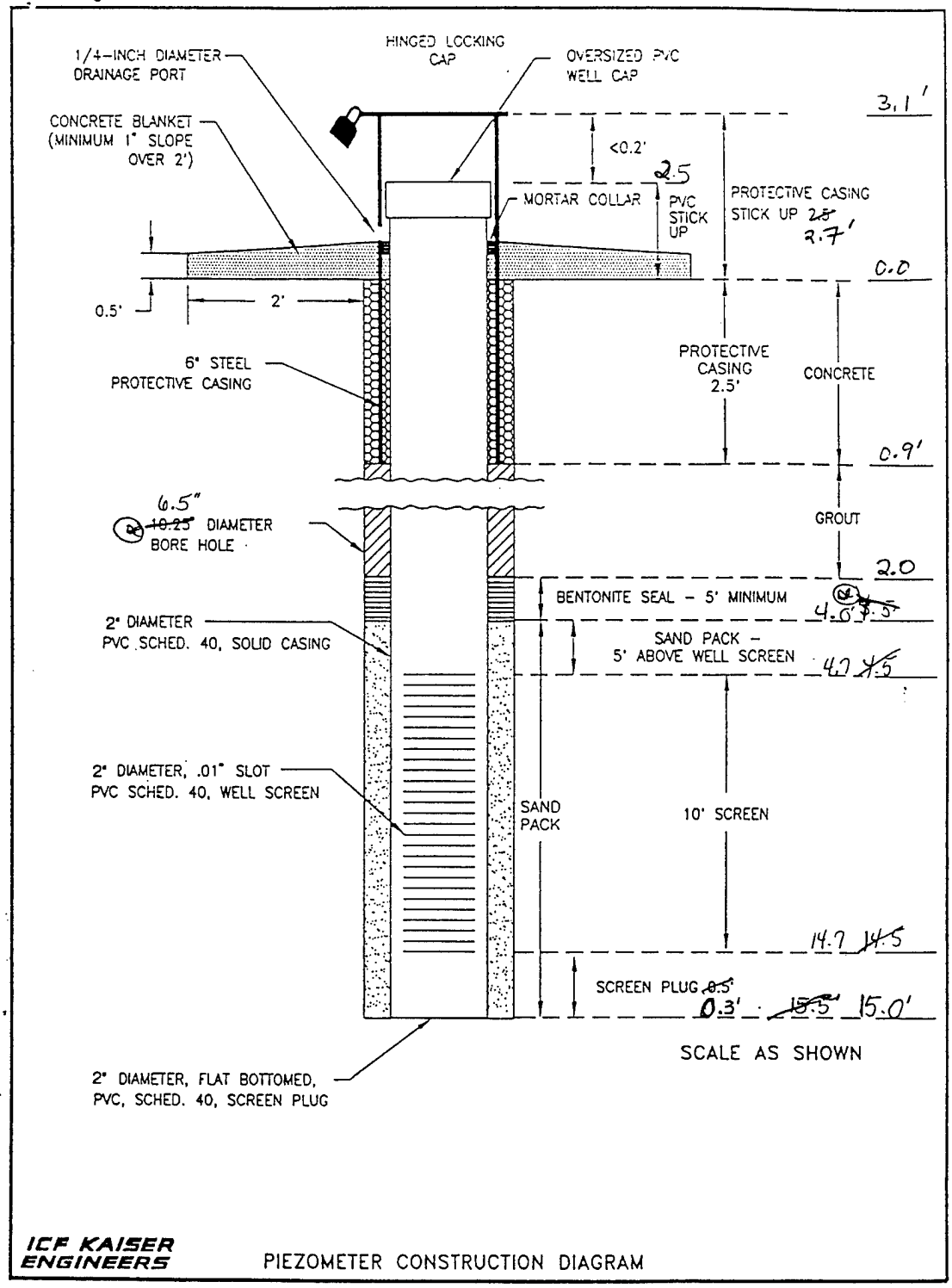
Total Depth: 15.0 ft | Depth to Bedrock: n/a | Water Table Depth: 2.5' | Ground Elevation:

Protection Level: Modified Level D | H&S Monitoring Equipment: OVM | Logged by: Debbie Romano | Checked by: P. Thrun

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0'	PZ-10A 0-2' 1120	2-5-6-6 15½"	0-2" ~~Sandy SILT~~, dark yellowish brown, V. fn. gn. sand ~~little silt~~ trace sand, very soft, no plasticity, dry	Split spoon 0-2'		0	ML	10YR 4/4
2'			2-15½" - SILT, brown, dry, crumbles easily, med. stiff	Driller: Hit water at 2.5'			ML	10YR 4/3
5'	PZ-10B 5-7' 1130	5-4-6-8 13"	0-11" SAND, strong brown, fine - ~~med~~ coarse gn. sand little ~~clay~~ silt, wet, loose, 1½" long stone present.	Split spoon 5-7'		0	SP	7.5 YR 4/6
7'			11-13" SAND, dark brown, fn - coarse grain sand, trace silt., wet; more fn - med. grained than 0-11" interval; loose				SP	7.5 YR 3/4
10'	PZ-10C 10-12' 1135	1-1-1-2 14"	0-6" SAND, fn. grain, wet, very loose, dark brown	Split spoon 10-12'		0	SW	10YR 3/3
12'			6-14" SAND, dark yellowish brown, med. grained at 6"-8" grading down to coarse grained at ~ 8-14", wet, very loose				SW	10YR 4/4
14'	Physical sample 12-14'	5-3-2-2 21"	0-3" - SAND, fn. grain, wet, loose, dark yellowish brown little med. grain sand, trace silt.	Split spoon 12-14'		0	SW	10YR 4/4
15'			3-4" - SAND, dark yellowish brown, wet, med. to coarse grained, very loose				SP	↓
17'			4-13" - SAND, dark yellowish brown, little silt, fn. grain sand, loose, wet				SW	
			13-14" - sandy CLAY, dark yellowish brown, fn. sand, very soft, wet, little plasticity				CL	
20'			14-21' SAND, dark yellowish brown, fn. to ~~coarse~~ med. grain, little clay, trace coarse grain sand, wet, very loose				SP	

All measurements should be recorded in feet or tenths of feet.

ε Record cored intervals in this column if drilling bedrock.



11/08/95

1315 - Added water to the borehole to try and wash out the heaving sands. Want to set well at 5'-15', but there ~~is~~ is 6' of sand at the bottom of the borehole (is

1335 - Set well in place, screen ~~5'-15'~~ (OK) 4.7 - 14.7

#1 Sand (20/40) - 4 bags

Shur-Pel 3/8" bentonite pellets - ½ 5 gal. bucket

WELL NO.: PZ-10

DATE COMPLETED: 11/09/95

1 x 10' section of Screen, PVC sched. 40

1 x 10' section of riser, PVC sched. 40

1 x 0.3' screen plug, PVC sched. 40

0.5 (½) bag Lehigh Portland Type II Cement

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

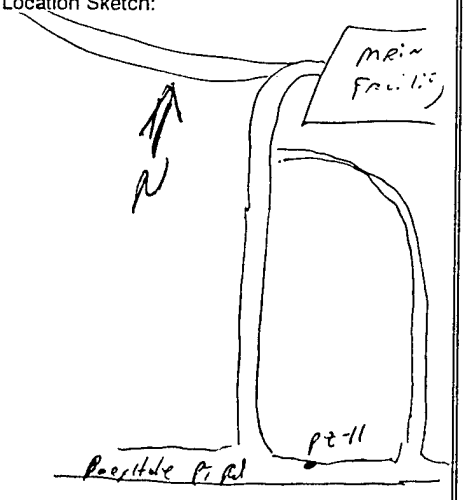
Project: WRF R1/F5	Boring: PZ-11
Geologist: J. CHOYNOWSKI / D. BATTS	Signature: Dennis Batts
Driller & Company: RICK RIDER/HARDIN-HUBER, INC.	Drilling Rig: B-57 MOBILE
Date Boring Started: 12-1-95	Completed: 12/1/95
First Encountered Water Level: 10'	Date: 12/1/95
Total Fluid Losses: N/A	Date: —
Total Fluid Losses: N/A	
Casing Type: PVC SCHEDULE 40	Screened Interval: 20-10'
Geophysical Logging: NONE	Date: —
Depth to Bedrock: NOT ENCOUNTERED	Ground Elev.: —
Boring Completion Information: Completed as piezometer	Date: 12/1/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
12/1/95	1530	1703	0'	20.5'		4.25"	HSA		

Abbreviations:

Abbreviation	Meaning
TRACE	90/10
LITTLE	80/20
SOME	70/30
AND	50/50
V.	VERY
FN.	FINE
MED.	MEDIUM
DK.	DARK
LT.	LIGHT
W/	WITH
W/O	WITHOUT
GR.	GRAIN
H.	HIGH
BGS	BELOW GROUND SURFACE

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-11 | Project Name: WRF RI/FS

Driller/Company: RICK RIDER/HHI | Drilling Method: HSA 4.25" | Date Started: 12/1/95 | Date Completed: 12/1/95

Total Depth: 20.5' | Depth to Bedrock: not encountered | Water Table Depth: 10' | Ground Elevation:

Protection Level: MODIFIED LEVEL D | H&S Monitoring Equipment: NONE | Logged by: D. BATTS | Checked by: Jack Chyall

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								
0-2'	PZ-11A 1544	1-3-4-8 12"	SANDY CLAY, LOW PLASTICITY, TRACE GRAVEL, GRAVEL SUBROUNDED, DRY, DARK YELLOWISH BROWN	SPLIT SPOONED 0-2' COLLECTED SAMPLE PZ-11A 1544 AUGER TO 5'				10YR4/4
2								
5								
5-7'		1-2-1-3 9"	0-2" SLOUGH 2-9" CLAY W/TRACE SAND, HIGH PLASTICITY, SLIGHTLY MOIST, DARK GRAY	SPLIT SPOONED 5-7' AUGER TO 10' HIT WATER AT ~10' BGS				10YR4/1
7								
10								
	PZ-11B PZ-11DUP 1556	2-1-2-4 20"	GRAVELLY SAND, MED. GR. SAND, FINE GRAVEL < 1/8", SUBROUNDED, SATURATED, TRACE CLAY, VERY DARK GRAY	SPLIT SPOONED 10-12' COLLECTED PZ-11B PZ-11DUP 1556 AUGER TO 18'				10YR/3/1
12'								
15								
				HEAVING SANDS AT 18'. BANGED OUT BOTTOM W/ROLLER BIT AND HAMMER				
18								
18-20'		-2-2 22"	SAND, MED. GR., SATURATED, VERY DARK GRAY	SPLIT SPOONED 18-20' COLLECTED PHYSICAL SAMPLE				10YR 3/1

All measurements should be recorded in feet or tenths of feet.

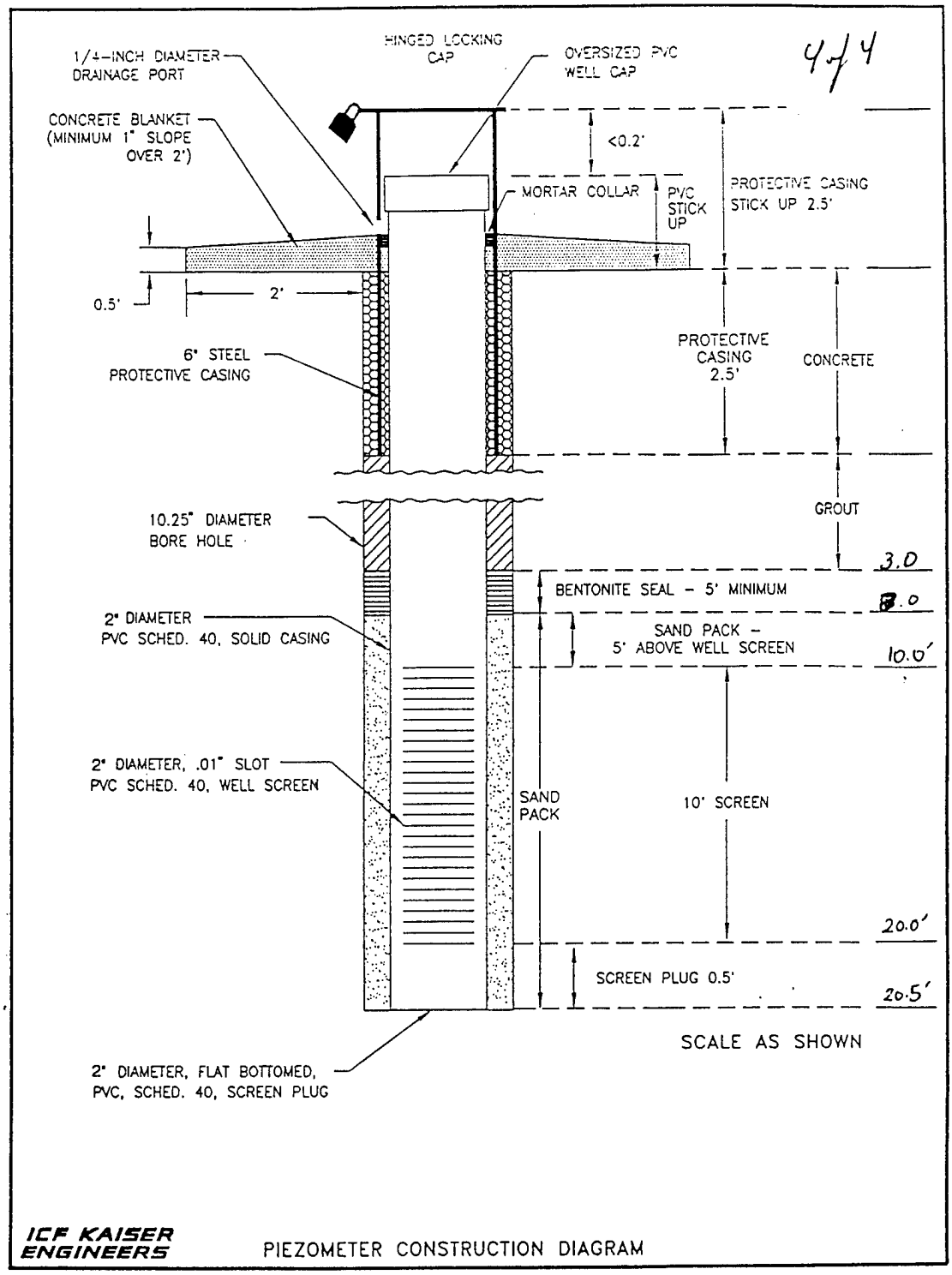
‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: PZ-11 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MmunSELL COLOR
20				1625 - AUGER TO ~~20.5'~~ 21.0' BGS TO SET CASING. OVERDRILLING TO 21' TO COMPENSATE FOR SAND IN AUGERS. TD = 20.5' BGS				
				1632 - BEGIN INSTALLING CASING, SCREEN FROM 20-10'				
				1635 - BEGIN INSTALLING FILTER PACK				
				1640 - 1st 5' AUGER PULLED, SAND IS TO 13' BGS.				
				1647 - 2nd 5' AUGER PULLED. SAND IS TO 8' BGS.				
				1652 - SAND IS TO 7' BGS. PULLED 3rd 5' AUGER.				
				1658 - BEGIN INSTALLING BENTONITE SEAL. PULLED 4th 5' AUGER.				
				1703 - PULLED LAST 5' AUGER. BENTONITE IS TO 3' BGS				
			6 - 50 LB BAGS #1 FILTER PACK SAND					
			1 - 5 GAL BUCKET DSI BRAND SHUR-PEL 3/8" BENTONITE PELLETS					

All measurements should be recorded in feet or tenths of feet. ε Record cored intervals in this column if drilling bedrock.



WELL NO.: PZ-11

DATE COMPLETED: 12/11/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

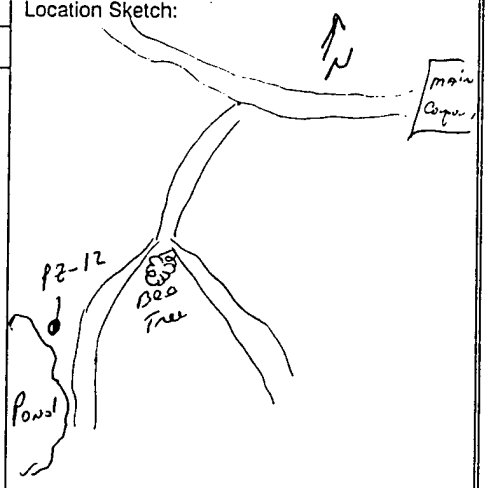
Project: WRF RI/FS	Boring: PZ-12
Geologist: J. CHOYNOWSKI / D. BATTS	Signature: Dennis Batts
Driller & Company: DAVE TAYLOR / HARDIN-HUBER, INC.	Drilling Rig: B-57 MOBILE
Date Boring Started: ~~12/4/95~~ DB 12/4/95	Completed: 12/4/95
First Encountered Water Level: 10'	Date: 12/4/95
Total Fluid Losses: N/A	Date: ———
Total Fluid Losses: N/A	
Casing Type: PVC SCHEDULE 40 2"	Screened Interval: 20-10'
Geophysical Logging: NONE	Date: ———
Depth to Bedrock: NOT ENCOUNTERED	Ground Elev.: —
Boring Completion Information: Completed as Piezometer	Date: 12/4/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
12/4/95	0850	1000	0'	20.5'		4.25" HSA			

Abbreviations:

Abbreviation	Meaning
TRACE	90/10
LITTLE	80/20
SOME	70/30
V.	VERY
FN.	FINE
MED.	MEDIUM
GR.	GR.
W/	WITH
W/O	WITHOUT
H.	HIGH
LT.	LIGHT
DK.	DARK
BGS	BELOW GROUND SURFACE

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-12 | Project Name: WRF RI/FS

Driller/Company: DAVE TAYLOR / HHI | Drilling Method: HSA 4.25" | Date Started: 12/4/95 | Date Completed: 12/4/95

Total Depth: 20.5' | Depth to Bedrock: Not encountered | Water Table Depth: 10' | Ground Elevation:

Protection Level: MODIFIED LEVEL D | H&S Monitoring Equipment: MICROTIP PID | Logged by: D.BATTS | Checked by: Joel Chrysl

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0"	PZ-12A	2-2-4-7	SILTY CLAY W/TRACE SAND, DRY, HIGH PLASTICITY, LT. BROWNISH GRAY	SPLIT SPOONED 0-2'		0.0		10YR6/2
0-2	0858	12"		COLLECTED SAMPLE PZ-12A 0858				
2				AUGER TO 5'				
5								
5-7	PZ-12B	2-6-6-7	FAT CLAY W/< TRACE SAND, DRY, HIGH PLASTICITY, PALE BROWN	SPLIT SPOONED 5-7'		0.0		10YR6/3
7	PZ-12DUP	18"		COLLECTED SAMPLES PZ-12B/PZ-12 DUP				
	0906			AUGER TO 10' 0906				
10								
10-12	PZ-12C	3-5-11-11	GRAVELLY SAND, SAND MED. GR., SATURATED, GRAVEL 1/8" TO 1/2", SUBROUNDED TO SUBANGULAR, 3-8" LIGHT BROWNISH GRAY	SPLIT SPOONED 10-12		0.0		10YR5/8
12	0911	16"	8-16" YELLOWISH BROWN	COLLECTED SAMPLE PZ-12C 0911				10YR6/2
			0-3" SLOUGH	HIT WATER ~11' BGS				
15								
15-17'		3-3-3-5	0-4" SLOUGH	SPLIT SPOONED 15-17'		0.0		7.5YR4/6
17		24"	4-12" ~~FAT CLAY~~ SILTY CLAY, SLIGHTLY MOIST, H. PLASTICITY ~~COLLECT~~ DB STRONG BROWN					10YR5/2
18			12-24" FAT CLAY, MOIST, HIGH PLASTICITY, GRAYISH BROWN					
18-20'		1-5-5-6	0-3" SLOUGH	SPLIT SPOONED 18-20'		0.0		2.5Y4/1
20		24	3-24" FAT CLAY W/< TRACE SILT AND SAND, WET, DARK GRAY, H. PLASTICITY	COLLECTED PHYSICAL SAMPLE 18-20'				

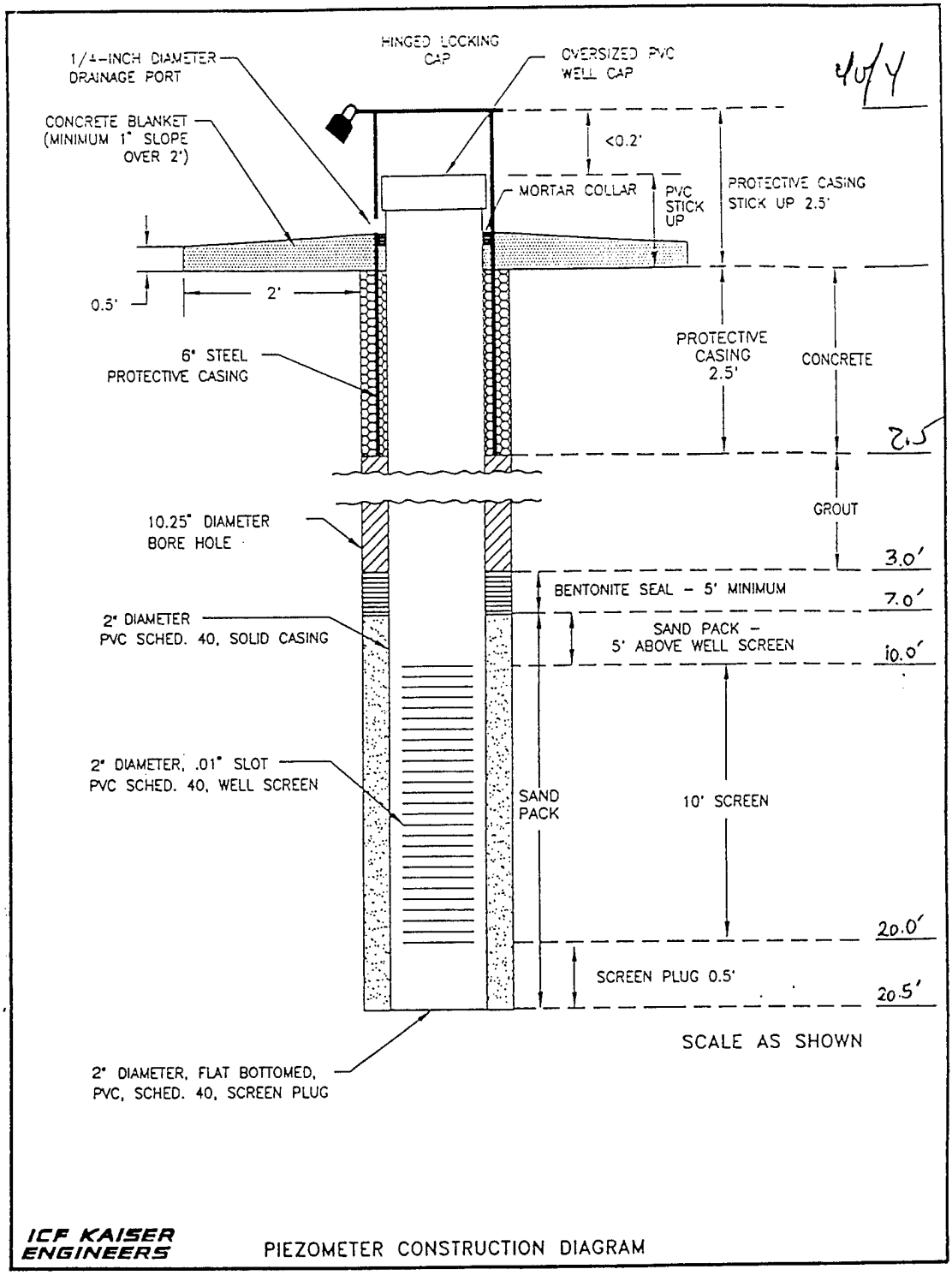
All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: PZ-12 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20'			6 – 50 LB BAGS #1 FILTER SAND. 1.5 – 5 GAL. BUCKETS DSI BRAND SHUR-DEL 3/8" BENTONITE PELLETS	0927 - AUGER TO 20.5' BGS 0932 - BEGIN SETTING CASING. SCREEN FROM 20-10'. BEGIN INSTALLING FILTER PACK. 0941 - PULLED 1st 5' OF AUGER. SAND IS TO 17' BGS. 0950 - PULLED 2nd 5' OF AUGER. SAND IS TO 12' BGS. 0954 - SAND IS TO 7' BGS. BEGIN INSTALLING BENTONITE SEAL. PULLED 3rd 5' OF AUGER. 0959 - PULLED LAST 5' OF AUGER. BENTONITE IS TO 3' BGS.				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



WELL NO.: PZ-12

DATE COMPLETED: 12/4/95

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

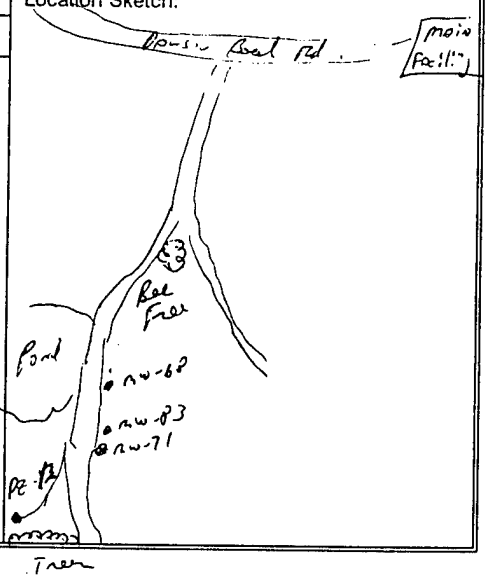
Project: WRF RI/FS	Boring: PZ-13
Geologist: J. CHOYNOWSKI / D. BATTS	Signature: Dennis Batts
Driller & Company: DAVE TAYLOR / HARDIN-HUBER, INC.	Drilling Rig: B-57 MOBILE
Date Boring Started: 12/4/95	Completed: 12/4/95
First Encountered Water Level: ~15'	Date: 12/4/95
Total Fluid Losses: N/A	Date: ———
Total Fluid Losses: N/A	
Casing Type: PVC SCHEDULE 40 2"	Screened Interval: 25-15'
Geophysical Logging: NONE	Date: ———
Depth to Bedrock: NOT ENCOUNTERED	Ground Elev.:
Boring Completion Information: Completed as Piezometer	Date: 12/4/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
12/4/95	1105	1242	0'	25.5'		4.25" HSA			

Abbreviations:

Abbreviation	Meaning		
TRACE	90/10		
LITTLE	80/20		
SOME	70/30		
V.	VERY		
FN.	FINE		
GR.	GRAIN		
W/	WITH		
W/O	WITHOUT		
MED.	MEDIUM		
H.	HIGH		
LT.	LIGHT		
DK.	DARK		
BGS	BELOW	GROUND	SURFACE

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: PZ-13		Project Name: WRF RI/FS	
Driller/Company: DAVE TAYLOR / HHI	Drilling Method: 4.25" HSA	Date Started: 12/4/95	Date Completed: 12/4/95
Total Depth: 25.5'	Depth to Bedrock: not encountered	Water Table Depth: 15'	Ground Elevation:
Protection Level: MODIFIED LEVEL D	H&S Monitoring Equipment: MICROTIP TIP	Logged by: D. BATTS	Checked by: Jack Chym

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0'	PZ-13A 1119	~~3-5-5-7~~ DB 3-3-5-5 12"	SILTY ~~CLAY~~ DB W/LITTLE CLAY, SOME ORGANICS, DRY, FRIABLE, VERY DK. GRAYISH BROWN	SPLIT SPOONED 0-2' COLLECTED SAMPLE PZ-13A 1119 AUGER TO 5'		0.0		2.5Y3/3
5		3-5-5-7 18"	SANDY CLAY, DRY, MED. PLASTICITY, GRAY W/SOME BROWN MOTTLING, SAND FN. TO MED. GRAIN	SPLIT SPOONED 5-7' AUGER TO 10'		0.0		5Y6/1
10	PZ-13B 1129	3-5-6-7 18"	SANDY CLAY, VERY MOIST, MED. PLASTICITY, SAND FN. TO MED. GRAIN, GRAY W/ SOME BROWN MOTTLING.	SPLIT SPOONED 10-12' COLLECTED SAMPLE PZ-13B 1129 AUGER TO 15'		0.0		5Y6/1
15		4-5-5-7 22"	0-12 SANDY CLAY, VERY MOIST, MED. PLASTICITY, LT. YELLOWISH BROWN 12-22" CLAYEY SAND, VERY MOIST, LOW PLASTICITY, LT. YELLOWISH BROWN W/YELLOWISH BROWN SAND	SPLIT SPOONED 15-17' ~~COLLECTED SAMPLE PZ-13C [redacted]~~ DB COLLECTED SAMPLE PZ-13C 1138 AUGER TO 20'				2.5Y6/3 2.5Y6/3 10YR5/8

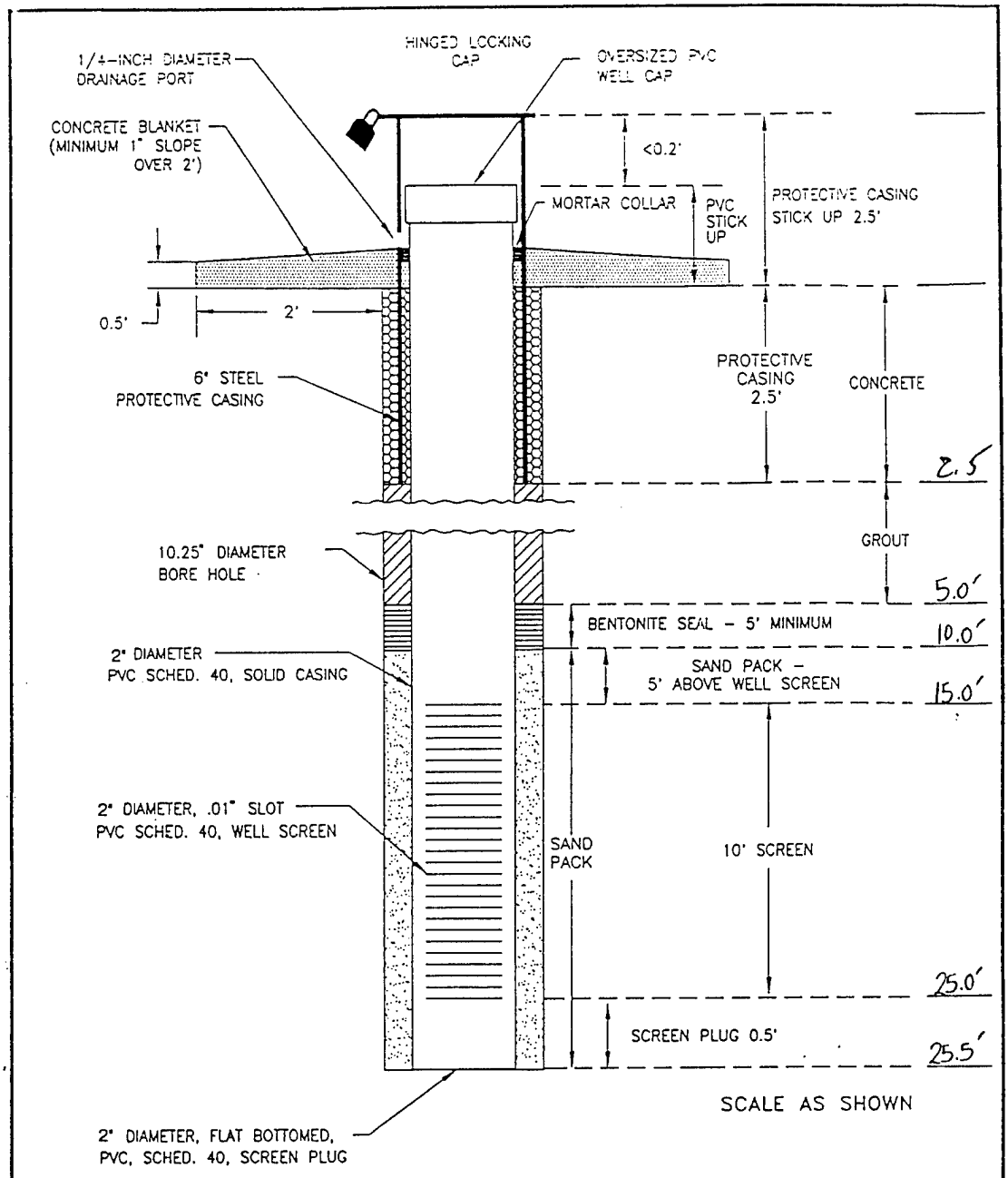
All measurements should be recorded in feet or tenths of feet. * Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: P2-13 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20 20-22' 22		4-6-6-7 24"	FAT CLAY, MOIST, H. PLASTICITY, TRACE SAND, LIGHT GRAY	SPLIT SPOONED 20-22' AUGER TO 25'		0.0	CH	2.5Y7/1
25 25-27' 27		5-6-7-6 16"	0-6" SLOUGH 6-16" SAND W/ TRACE TO LITTLE CLAY, SATURATED, MED. GR. SAND, YELLOWISH BROWN	SPLIT SPOONED 25-27' COLLECTED PHYSICAL SAMPLE		0.0		10YR5/4
				12/4/95 1207 - SAND COMING UP AUGERS, USED HAMMER TO BANG OUT SAND PLUG; ADDED WATER TO AUGERS. 1210 - INSTALLED PVC CASING. SCREEN FROM 25-15'. TD = 25.5' BGS.				
			7 - 50 LB. BAGS OF #1 FILTER PACK SAND 1.5 - 5 GAL. BUCKETS DSI BRAND SHUR-PEL 3/8" BENTONITE PELLETS	1217 - PULLED 1st 5' OF AUGER. SAND IS TO 22' BGS. 1222 - PULLED 2nd 5' OF AUGER. SAND IS TO 17' BGS. 1230 - PULLED 3rd 5' OF AUGER. SAND IS TO 13' BGS. 1238 - PULLED 4th 5' OF AUGER. SAND IS TO 10' BGS. BEGIN INSTALLING BENTONITE SEAL. 1242 - PULLED LAST 5' OF AUGER. BENTONITE IS TO 5' BGS.				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.



ICF KAISER ENGINEERS

PIEZOMETER CONSTRUCTION DIAGRAM

WELL NO.: PZ-13

DATE COMPLETED: 12/4/90

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

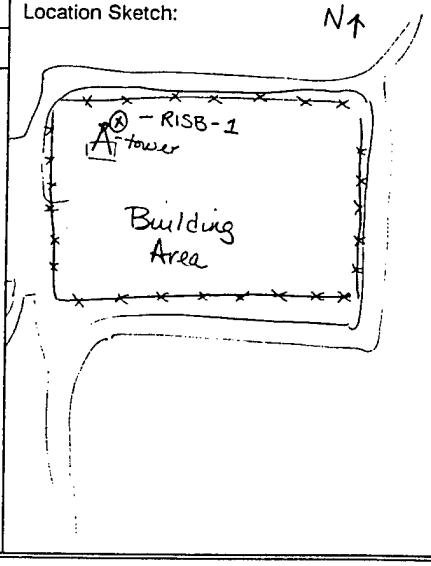
Project: WRF RI/FS	Boring: RISB-1 (Main Compound)
Geologist: D. Romano / J. Stowers	Signature: Deborah S. Romano
Driller & Company: Hardin Huber - Rick & Alonzo	Drilling Rig: Mobile B-57 ATV
Date Boring Started: 11/21/95	Completed: 11/21/95
First Encountered Water Level: 10 ft	Date: ~~11~~ 11/21/95
Total Fluid Losses: n/a	Date: —
Total Fluid Losses: n/a	
Casing Type: n/a	Screened Interval: —
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information:	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/21/95	1225	1300	0	10					
11/21/95	1300		—	—	Augers out of hole & grout up.				

Abbreviations:

Abbreviation	Meaning
v.	very
w/	with
med.	medium
fn	fine
gr	grain
lg.	large
lt.	light
dk.	dark
trace	90/10
little	80/20
some	70/30
and	50/50
&	and
~	approximately

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: RISB-1 Main Compound | Project Name: WRF RI/FS

Driller/Company: Hardin Huber-Rick, Nuno | Drilling Method: Hollow Stem Auger | Date Started: 11/21/95 | Date Completed: 11/21/95

Total Depth: 10 ft (Split spoon to 12 ft) | Depth to Bedrock: n/a | Water Table Depth: 10 ft | Ground Elevation:

Protection Level: Modified Level D | H&S Monitoring Equipment: PID | Logged by: Debbie Romano | Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								
2	RISB-1A 1240 0-2	2-12-6-8 1.5'	0-6" - Concrete 6-12" - GRAVEL w/ some clay and sand, strong brown, ~~fill~~, dry, ½" - 1½" size range of gravel. 12-18" - SILT, dk. grayish brown, dry, stiff	auger to ½ ft. Split spoon 0-2 ft auger to 5' Collect ESE sample @1240 RISB-1		0	GC ~~SM~~ ML	7.5 YR 4/6 2.5 Y 4/2
5	RISB-1B RISB-1BD 1250 5-7'	3-5-6-9 1.5'	0-2" - Sandy SILT w/ trace fn. gravel, dk. yellowish brown, sand is fn., v. low plasticity, dry. 2-18" - Clayey SILT, strong brown, dry, low plasticity, stiff. little clay at top of section, & increasing ~~to~~ content of clay towards bottom.	Split spoon 5-7 ft Collect ESE sample, @1250, RISB-1B RISB-1BD auger to 10 ft		0	ML ML	10 YR 3/4 7.5 YR 4/6
10	RISB-1C 1300	3-5-5-7 20"	0-5". - SAND w/ little silt, wet, ~~reddish yellow~~ brown, fn. to ~~med~~ coarse grain size, loose 5-14" - SAND w/ little silt, brown, wet, fn to coarse gr, loose 14-20" - SAND w/ some silt, reddish yellow, wet, fn. to coarse gr, loose	Split spoon 10-12 ft Hit water at 10 ft.		0	SM SM SM	7.5 YR ~~4/6~~ 5/4 7.5 YR 4/4 7.5 YR 6/6
15			1300 - 1345 - Grout up borehole. 2 x 94 lb. Lehigh Portland Cement bags 16 gal. water 9.0 lbs. bentonite powder					
20								

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

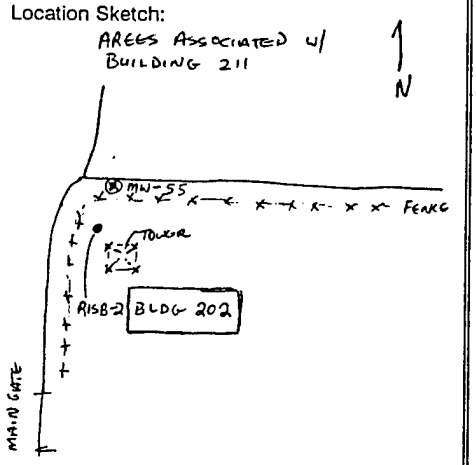
Project: WRF RI/FS	Boring: RISB-2
Geologist: J. STOWERS	Signature:
Driller & Company: Hardin Hukm	Drilling Rig: ATV Mobil B-57
Date Boring Started: 11/21/95	Completed: 11/21/95
First Encountered Water Level:	Date:
Total Fluid Losses: 0	Date:
Total Fluid Losses: 0	
Casing Type: NA	Screened Interval: NA
Geophysical Logging: NA	Date:
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: Grouted to Surface	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/21/95	1355		0						
11/21/95		1445	12'						

Abbreviations:

Abbreviation	Meaning
V.	very
fn.	fine
gn.	grain
sm.	small
med.	medium
lg	large
w/	with
w/o	without
%	percent
tr	trace
90/10	little
80/20	and
50/50	
TIH	Trip into Hole
TOH	Trip out of Hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: RISB-2 | Project Name: WRF RI/FS

Driller/Company: Hardin Hukan | Drilling Method: Hollow-Stem Auger | Date Started: 11/21/95 | Date Completed: 11/21/95

Total Depth: | Depth to Bedrock: NA | Water Table Depth: 12' | Ground Elevation: NA

Protection Level: Modified D | H&S Monitoring Equipment: OVM/MICROTIP | Logged by: JI STOWERS | Checked by:

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY *	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	RISB-2A	2-8-10-10 / 1.1'	0.0 - 0.5' - Asphalt 0.5 - 0.8 - Fill material; gravel mixed w/ silt, asphalt frags. 0.8 - 2.0 - CLAYEY SILT, dark grayish brown, dry, very stiff w/ little fine grain sand, slt. plast. Note: 1.7' color change to brown	1355 - Begin drilling 1400 - Collect RISB-2A Auger to 5'		0.0 ppm	SM	10yr 4/2
5	RISB-2B	3-5-6-7 / 1.6'	CLAYEY SILT, dark grayish brown, dry, medium stiff, natural slight plasticity w/ little very fine grain sand, organic staining. 5.8' - grading gradually to SILTY CLAY, brown; stiff, low to medium plasticity, dry, w trace v. fn. gr. Sand.	1420 - Collect RISB-2B - Hit water @ 8.5'		0.0 ppm	SM / CL	7.5yr 4/3
10	RISB-2C	4-6-7-6	SAND w/ little SILT, reddish yellow, wet, fn. to med. gr; moderately well sorted, medium dense. Grain size of sand increasing in last 0.3' of spoon.	1432 - Collect RISB-2C		0.0 ppm	SM	7.5yr 6/6
15				1445 - Grout up RISB-2 2 bgs 94 lbs of Portland Cement Type II 15 gals approved water 8. lbs powdered bentonite.				
20								

All measurements should be recorded in feet or tenths of feet.

* Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

Project: WRF RI/FS	Boring: RISB-3 AREE near bldg. 202
Geologist: D. Romano/J. Stowers	Signature: Deborah J. Romano
Driller & Company: Hardin Huber, Rick, Alonzo	Drilling Rig: Mobile B-57 ATV
Date Boring Started: 11/21/95	Completed: 11/21/95
First Encountered Water Level: 8.5 ft	Date: 11/21/95
Total Fluid Losses: —	Date: —
Total Fluid Losses: —	
Casing Type: —	Screened Interval: —
Geophysical Logging: —	Date: —
Depth to Bedrock: —	Ground Elev.:
Boring Completion Information:	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/21/95	1700	1740	0	10	4¼" auger	to 10 ft			

Abbreviations:

Abbreviation	Meaning
v.	very
fn	fine.
med	medium
gr.	grain
trace	90/10
little	80/20
some	70/30
and &	50/50
& ~~and~~	and
w/	with
~	approximately
lt.	light
dk.	dark.

Location Sketch:

* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: RISB-3 AREE near Bldg. 202 | Project Name: WRF RI/FS

Driller/Company: Hardin Huber - Rick, Alonzo | Drilling Method: Hollow Stem Auger | Date Started: 11/21/95 | Date Completed: 11/21/95

Total Depth: 10 ft (12 ft. for split spoon) | Depth to Bedrock: n/a | Water Table Depth: 8.5 ft | Ground Elevation:

Protection Level: Modified Level D. | H&S Monitoring Equipment: PID | Logged by: Debbie Romano | Checked by: P. Thompson

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								7.5YR
2	RISB-3A 0-2' 1705	4-5-6-8 1'	0-4"- SILT, brown, dry, friable, stiff 4-12"- Clayey SILT, dry, low plasticity, dk. brown, stiff	Split spoon 0-2' ESE sample @ 1705 - RISB-3A, 0-2' auger to 5'		0 ↓	ML ML	~~10YR 4/3~~ ~~10YR 3/4~~
5	RISB-3B 5-7' 1715	3-6-7-6 19"	0-14"- Clayey SILT, brown, slightly moist, low to med. plasticity, stiff. 14-19"- Clayey SILT w/ little v. fn. sand, slightly moist, low to med. plasticity, stiff, strong brown	split spoon 5-7' ESE sample @ 1715 5-7', RISB-3B auger to 10'		0 ↓	ML ML	7.5YR 4/4 7.5YR 4/6
10	RISB-3C 10-12' 1730	4-4-3-5 22"	0-2" gilty SAND, dk. yellowish brown, wet, fn-med. gr. 2-4" CLAY, strong brown, wet, high plasticity 4-22" Silty SAND, fn-med gr. sand, some silt, wet	water at 8.5-9.0 ft. Split spoon 10-12' ESE sample, @ 1730, RISB-3C, 10-12'		0 ↓	SM CH SM	10YR 4/6 7.5YR 4/6 10YR 4/6
15								
20								

All measurements should be recorded in feet or tenths of feet.

‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

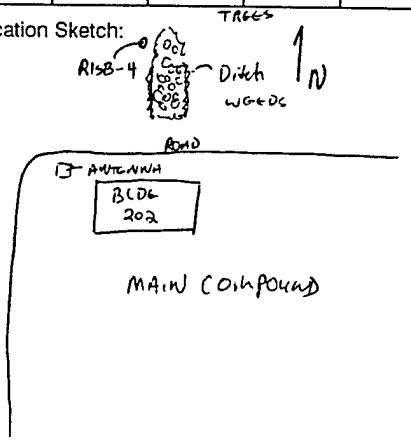
Project: WRF RI/FS	Boring: RISB-4
Geologist: J. STOWERS	Signature:
Driller & Company: Hardin Heben	Drilling Rig: ATV Mobil B-53
Date Boring Started: 11/21/95	Completed: 11/21/95
First Encountered Water Level: 3.5'	Date: 11/21/95
Total Fluid Losses: 0	Date:
Total Fluid Losses: 0	
Casing Type: —	Screened Interval:
Geophysical Logging: NA	Date:
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information: Grouted to Surface	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/21/95	1610	1645	0	5.7	Drove spoon from 5-7' incrementally grouting to surface.				

Abbreviations:

Abbreviation	Meaning
V.	very
fn	fine
gr.	grain
sm.	small
med	medium
lg	large
w/	with
w/o	without
%	percent
90/10	trace
80/20	little
60/40	some
TIH	Trip into Hole
TOH	Trip out of Hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: RISB-4 | Project Name: IWRF RI/FS

Driller/Company: Hardin Huban | Drilling Method: Hollow-stem Auger | Date Started: 11/21/95 | Date Completed: 11/21/95

Total Depth: 7' | Depth to Bedrock: NA | Water Table Depth: | Ground Elevation:

Protection Level: Modified D | H&S Monitoring Equipment: Photovac | Logged by: J. Stowers | Checked by: P. Thompson

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	RISB-4A	5-6-5-7 /0.3'	SILT, dark yellowish brown, dry, trace sand.	1610 - Collect RISB-4A/corrective. Not enough recovery / move over 1' to re-drive spoon		0.0 ppm	ML	10YR 4/6
5				Water @ 3.5'				
	RISB-4B	2-5-5-7	SAND, fn to coarse gn, light yellowish brown, wet, medium dense, poorly sorted. 6.6'-7.0' - grains becoming coarser toward bottom of spoon			0.0 ppm	SP	10YR 6/4
				TD = 7.0'				
				NOTE: Collect RISB4-1AC 1620 for 0-2 & 2' offset for Migrant Bldg.				

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

Project: WRF RI/FS	Boring: RISB-5 AREE assoc. w/ Bldg. 202
Geologist: D. Romano/ J. Stowers	Signature: Deborah J. Romano
Driller & Company: Hardin Huber: Rick, Alonzo	Drilling Rig: Mobile B57 ATV
Date Boring Started: 11/21/95	Completed: 11/21/95
First Encountered Water Level: 4.5 ft	Date:
Total Fluid Losses: n/a	Date: —
Total Fluid Losses: n/a	
Casing Type: n/a	Screened Interval: —
Geophysical Logging: n/a	Date: —
Depth to Bedrock: n/a	Ground Elev.:
Boring Completion Information:	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/21/95	1515	1555	0	5	- Setup at RISB-6. 4¼" auger & splitspoon.				

Abbreviations:

Abbreviation	Meaning
v.	very
fn	fine
med.	medium
gr.	grain
lt.	light
dk	dark
w/	with
trace	90/10
little	80/20
some	70/30
&	and
and	50/50
~	approximately

Location Sketch:

* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: RISB-5 AREEs assoc. w/ Bldg. 202 | Project Name: WRF RI/FS

Driller/Company: Hardin Huber - Rick, Alonzo | Drilling Method: Hollow Stem Auger | Date Started: 11/21/95 | Date Completed: 11/21/95

Total Depth: 5 ft (split spoon to 7 ft) | Depth to Bedrock: n/a | Water Table Depth: 4.5 ft | Ground Elevation:

Protection Level: Modified Level D | H&S Monitoring Equipment: PID | Logged by: Debbie Romano | Checked by: Putam Thompson

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0								
2	RISB-6A 0-2 ft 1530	1-2-2-3 16"	0-6" - Silty CLAY, brown, moist, high plasticity, soft 6-12" - Silty CLAY w/ trace sand, med. plasticity, soft, brown w/ lt. brownish gray mottles; sand is fn. gr, dry 12-16" - Silty CLAY, gray w/ brownish yellow mottles, trace fn. sand, med plasticity, dry, med. stiff.	Split spoon 0-2' auger to 5' Collect ESE sample 0-2', RISB-6A, 15:30		0 ↓	CL CL CL	10 YR 4/3 10 YR 4/3, 6/2 10YR 6/1, 6/8
5				water at 4.5'				
7	RISB-6B 5-7 ft 1545	2-2-3-4 14"	0-6" CLAY w/ trace fn. sand, lt. greenish gray & strong brown mottles; wet, high plasticity, soft. 6-14" - same as above, no sand.	Split spoon 5-7' ~~DSGD~~ Collect ESE sample, 5-7', RISB-6B @1545		0	CH	Grey Chart 2 7/10BG w/ 10YR 5/8
10								
15								
20								

All measurements should be recorded in feet or tenths of feet.

‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

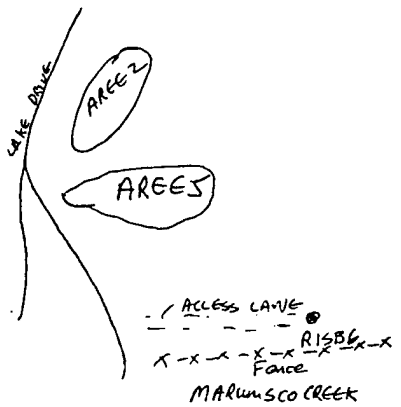
Project: WAF RI/FS	Boring: RISB-6 Area 5
Geologist: J. STOWERS	Signature:
Driller & Company: Hardin Huber	Drilling Rig: ATV Mobil B-57
Date Boring Started: 11/21/95	Completed: 11/21/95
First Encountered Water Level:	Date: 11/21/95
Total Fluid Losses:	Date:
Total Fluid Losses:	
Casing Type: ~~4" PVC~~ (JS)	Screened Interval:
Geophysical Logging: NA	Date:
Depth to Bedrock: NA	Ground Elev.:
Boring Completion Information:	Date:

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
11/21/95	0950	1115	0	17'	0930 - Arrive @ location, Hardin Huber needs ATV support Truck to haul equipment to location.				
		1120 mob to RISB-1							

Abbreviations:

Abbreviation	Meaning
V.	very
fn.	fine
gr.	grain
sm.	small
med.	medium
lg.	large
w/	with
w/o	without
%	percent
10/10	trace
80/20	little
70/30	some
50/50	and
TIH	Trip into Hole
TOH	Trip out of Hole

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: RISB6 AREE5 | Project Name: WRF R1/FS

Driller/Company: Hardin Huber | Drilling Method: Hollow Stem Auger | Date Started: 11/21/95 | Date Completed: 11/21/95

Total Depth: 15' (split spoon to 17') | Depth to Bedrock: N/A | Water Table Depth: | Ground Elevation:

Protection Level: Modified D | H&S Monitoring Equipment: OVM | Logged by: J. Stowers | Checked by: T. Hompson

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
	RISB-6A 0-2'	4-6-8-9 / 1.0'	0.0 - 0.3 - Topsoil, very dark grayish brown, dry, very stiff, no plasticity, hi % organic 0.3 - 2.0 - Silty CLAY, dry, brownish yellow, very stiff, low to medium plasticity	1005 - Team up / Prepare to begin 1015 - Collect RISB-6A Augr to 5'	drilling	exhaust 5.0 ppm	ML CL	10yr 3/6 10yr 6/8
5	RISB-6B 5-7'	1-2-3-5 / 0.7'	SILTY CLAY, moist, brownish yellow, medium stiff, slight to low plasticity, mottled w/ gray silt, soft, no plasticity.	1025 - Collect RISB-6B Cuttings wet @ ~ 6' to 7' Augr to 10'		exhaust 4.0 ppm	ML	10yr 6/1
10	~~RISB-6C~~ RISB-6	4-5-6-10 / 1.7'	10.0 - 10.4 - CLAY, lt gray, med to high plasticity, med stiff w/ SAND, v. fine to med gr, subrounded, moderately well sorted, v. moist to wet mottled w/ little clay, Fe staining 10.4 - 12.0 - SILTY CLAY, light gray, stiff, med. plasticity (strong brown, no plasticity mottled w/ silt,	Hit water @ 14' Augr to 15'		0.0 ppm	SC	10yr 7/1 7.5yr 5/6
15	RISB-6C 15-17'	3-5-5-7 / 1.5'	CLAYEY SAND, very pale brown, wet, v. fine gr. to coarse gr, poorly sorted, medium dense, subrounded, grading to CLAY, light gray @ 15.2', stiff, med to high plasticity, moist w/ strong brown SILTY CLAY nodules dominant gray clay.	1040 - Collect RISB-6C		0.0 ppm	SC CL	10yr 7/1
20								

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET*

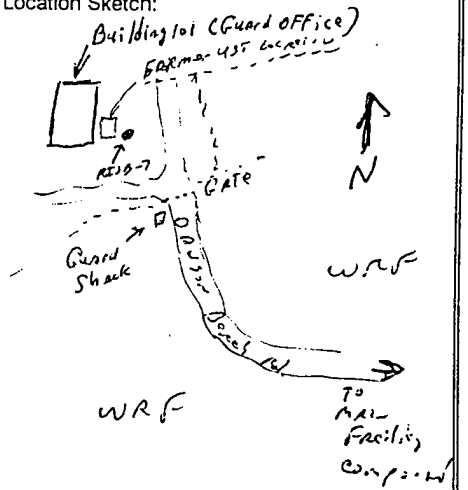
Project: WRF RI/FS	Boring: RSB-7
Geologist: J. CHOYNOWSKI / D. BATTS	Signature: Dennis Batts
Driller & Company: DAVE TAYLOR / HARDIN-HUBER, INC.	Drilling Rig: B-57 MOBILE
Date Boring Started: 12/4/95	Completed: 12/4/95
First Encountered Water Level: 25'	Date: 12/4/95
Total Fluid Losses: N/A	Date: —
Total Fluid Losses: N/A	
Casing Type: PVC SCHEDULE 40	Screened Interval: —
Geophysical Logging: NONE	Date: —
Depth to Bedrock: NOT ENCOUNTERED	Ground Elev.: —
Boring Completion Information: Borehole Grouted To Surface	Date: 12/5/95

Date	Time		Depth of Drilling Per Shift		Date	Time		Depth of Drilling Per Shift	
	Start	End	Start	End		Start	End	Start	End
12/4/95	1645	1805	0'	25.0'		~~AVG~~ 4.25" HSA SPLIT SPOON TO 27'			
12/4/95	0720	0930	Grouted Borehole To Surface						

Abbreviations:

Abbreviation	Meaning
TRACE	90/10
LITTLE	80/20
SOME	70/30
V.	VERY
FN.	FINE
MED.	MEDIUM
GR.	GRAIN
LT.	LIGHT
DK.	DARK
H.	HIGH
BGS	BELOW GROUND SURFACE
W/	WITH
W/O	WITHOUT

Location Sketch:



* All depth measurements should be in feet or tenths of feet.

ICF KAISER ENGINEERS
BORING GENERAL DATA SHEET

Boring No: ~~SB-7 DB~~ RISB-7	Project Name: WRF RI/FS		
Driller/Company: DAVE TAYLOR / HHI	Drilling Method: 4.25" HSA	Date Started: 12/4/95	Date Completed: 12/5/95
Total Depth: 27.0' BGS	Depth to Bedrock: NOT ENCOUNTERED	Water Table Depth: 2.5' BGS	Ground Elevation:
Protection Level: MODIFIED LEVEL D	H&S Monitoring Equipment: MICROTIP PID	Logged by: D. BATTS	Checked by: Jack Chaymowski

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ε	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
0	~~SB-7A~~	5-5-6-7	FILL	SPLIT SPOONED 0.5-2.5'		0.0		
0.5-2.5'		8"		AUGER TO 5'				
2								
5								
5-7'	RISB-7A 1652	3-7-20-12	0-3" SLOUGH	SPLIT SPOONED 5-7		0.6		
7		18"	3-13" SANDY CLAY, MED. PLASTICITY, SLIGHTLY MOIST, LT. GRAY, SAND MED. GRAIN	COLLECTED SAMPLE ~~RISB-7A DB~~ RISB-7A 1652				2.5Y7/1
8			13-18" SAND W/TRACE CLAY, SLIGHTLY MOIST, LT. YELLOWISH BROWN	AUGER TO 8'				10YR 6/4
8-10'	~~RISB-7B DB~~	3-3-6-6	CLAY W/ TRACE SAND, LITTLE SILT, MED TO H. PLASTICITY SLIGHTLY MOIST, LT. BROWNISH GRAY	SPLIT SPOON 8-10'		0.0		10YR 6/2
10		18"		AUGER TO 10'				
		5-7-12-10	CLAY W/TRACE SAND, H. PLASTICITY, DRY, LT. BROWNISH GRAY W/SOME BROWN MOTTLING	SPLIT SPOON 10-12'		0.0		10YR 6/2
12'		18"		AUGER TO 15'				
15								
15-17'	RISB-7B 1727	5-8-17-13	0-3" SLOUGH	SPLIT SPOONED 15-17'		0.0		10YR 6/1
17		20"	3-15" SANDY CLAY, SLIGHTLY MOIST, LOW TO MED. PLASTICITY, GRAY	COLLECTED SAMPLE RISB-7B 1727				
			~~15-20" DB~~ 12-15" SAND LENS, MED. GR. SAND, SLIGHTLY MOIST, GRAY	AUGER TO 20'				
			15-20" SANDY CLAY, DRY, LOW PLASTICITY, STRONG BROWN					7.5YR 5/6

All measurements should be recorded in feet or tenths of feet. ε Record cored intervals in this column if drilling bedrock.

ICF KAISER ENGINEERS (Continued)
BORING GENERAL DATA SHEET

Boring No: RISB-7 | Project Name: WRF RI/FS

DEPTH (ft)	SAMPLE NO.	BLOW COUNTS/ RECOVERY ‡	SOIL/ROCK DESCRIPTION	DRILLING DATA/REMARKS	CASING	PID HEADSPACE READING (ppm)	USCS CLASS	MUNSELL COLOR
20 20-22' 22		3-7-7-9	SANDY CLAY DRY TO SLIGHTLY MOIST, ~~MED.~~ LOW PLASTICITY, SAND IS MED GRAIN, GRAYISH BROWN	SPLIT SPOONED 20-22' AUGER TO 25'		0.0		10YR5/2
25 25-27' 27	RISB-7C 1756	10-23-25-28 10"	GRAVELLY SAND, SATURATED, SAND MED. GRAIN, GRAVEL 1/8" TO 1.5" SUBROUNDED, GRAY	SPLIT SPOONED 25-27' COLLECTED SAMPLE RISB-7C 1756 12/5/91 0715 - ARRIVE @ SITE TO GROUT GET WATER, + MOB EQUIPMENT TO GROUT BOREHOLE. 0804 GROUT MIXTURE #1 94-94LB Bags Portland Type II Cement 35-gallon Water 15-LBS Bentonite Pumped TC Tremied grout with auger Pulled of auger.		0.0		10YR5/1

All measurements should be recorded in feet or tenths of feet. ‡ Record cored intervals in this column if drilling bedrock.

A-3

Table 1 - Water Elevation Data

Table 1
Summary of Water Level Elevation Data at WRF

Well ID	Top of Casing Elevation (ft-msl)	PVC Stickup (ft)	Surface Elevation (ft-msl)	Depth to Water (FT-TOC)		Groundwater Elevation (FT-MSL)		Screen Elevation (ft-msl)
				January 5, 1996	September 13, 1996	January 5, 1996	September 13, 1996	
MW-52	19.75	2.09	17.53	16.51	15.96	3.11	3.79	3.53 to -6.47
MW-53	36.34	2.33	33.91	31.36	29.78	4.88	6.56	8,91 to -1.09
MW-54	17.06	2.53	14.44	12.32	12.12	4.65	4.74	7.14 to -2.86
MW-55	8.08	2.52	5.27	2.57	2.46	5.21	5.62	.27 to -9.73
MW-56	6.44	2.17	3.99	0.65	0.40	6.10	6.04	-9.01 to -19.01
MW-57	6.49	2.34	4.04	1.91	1.64	4.47	4.85	-7.96 to 17.96
MW-58	8.95	2.62	5.84	3.83	3.66	4.63	5.29	1.84 to -8.16
MW-59	25.09	2.39	22.61	23.15	22.46	1.66	2.63	.61 to -9.39
MW-60	26.34	2.71	23.48	24.42	23.76	1.81	2.58	-10.52 to -20.52
MW-61	19.96	2.71	17.16	15.45	15.66	4.42	4.30	6.16 to -3.84
MW-62	6.71	2.51	4.14	1.21	1.11	5.44	5.60	-25.86 to -35.86
MW-63	36.67	2.41	34.12	31.74	30.25	4.79	6.42	-5.88 to -15.88
MW-64	24.79	2.18	22.46	22.30	21.60	2.34	3.19	3.96 to -6.04
MW-65	6.56	1.98	3.90	3.36	2.70	2.52	3.86	-10.1 to -20.1
MW-66	8.68	2.13	6.02	5.80	5.18	2.35	3.50	.02 to -9.98
MW-67	9.84	2.10	7.43	7.38	6.72	2.15	3.12	.93 to -9.07
MW-68	15.09	2.50	12.16	10.49	9.64	4.23	5.45	5.16 to -4.84
MW-69	6.27	2.14	3.81	3.00	2.40	2.95	3.87	-16.19 to -26.19
MW-70	10.51	2.34	7.78	7.18	6.88	3.02	3.63	2.78 to -7.22
MW-71	12.09	2.66	8.92	6.68	5.55	4.90	6.54	3.42 to -6.58

Table 1
Summary of Water Level Elevation Data at WRF

Well ID	Top of Casing Elevation (ft-msl)	PVC Stickup (ft)	Surface Elevation (ft-msl)	Depth to Water (FT-TOC)		Groundwater Elevation (FT-MSL)		Screen Elevation (ft-msl)
				January 5, 1996	September 13, 1996	January 5, 1996	September 13, 1996	
MW-72	9.79	2.37	6.77	5.18	4.32	3.95	5.47	-1.23 to -11.23
MW-73	8.24	1.81	5.84	3.94	3.16	3.71	5.08	-7.66 to -17.66
MW-74	7.75	2.15	5.44	5.53	5.02	2.06	2.73	-4.56 to -14.56
MW-75	8.98	2.19	6.14	6.57	5.92	1.76	3.06	-5.86 to -15.86
MW-76	5.94	2.39	2.80	3.62	3.38	1.57	2.56	-2.2 to -12.2
MW-77	9.34	2.32	6.49	7.04	6.42	1.78	2.92	.49 to -9.51
MW-78	6.46	2.27	3.35	3.87	3.16	1.75	3.30	-2.65 to -12.65
MW-79	8.09	2.10	5.56	5.90	5.24	1.76	2.85	1.56 to -8.44
MW-80	7.64	2.23	4.85	5.30	4.62	1.78	3.02	-1.15 to -11.15
MW-81	11.11	2.46	8.22	6.72	5.94	3.96	5.17	2.22 to -7.78
MW-82	10.9	2.39	8.39	7.83	7.40	2.95	3.50	-15.11 to -25.11
MW-83	11.37	2.31	8.89	8.23	7.68	2.97	3.69	-15.11 tp -25.11
MW-84	14.17	2.40	11.61	9.71	9.46	4.30	4.71	-15.39 to -25.39
MW-85	6.90	1.87	4.63	1.90	1.67	5.60	5.23	-14.87 to -24.87
PZ-12	19.49	1.95	16.58	11.53	10.84	6.99	8.65	6.58 to -3.42
MW-1	15.17	2.16	12.74	10.66	10.00	4.24	5.17	2.44 to -2.66
MW-2	10.17	2.38	7.68	6.47	5.73	3.59	4.44	0.08 to -5.12
MW-3	9.87	2.46	7.31	5.98	5.16	3.79	4.71	-0.19 to -5.29
MW-4	10.05	2.35	7.58	6.01	---	3.92	---	-2.82 to -7.92
MW-5	10.33	2.80	7.41	6.74	6.16	3.47	4.17	-12.89 to -18.09

Table 1
Summary of Water Level Elevation Data at WRF

Well ID	Top of Casing Elevation (ft-msl)	PVC Stickup (ft)	Surface Elevation (ft-msl)	Depth to Water (FT-TOC)		Groundwater Elevation (FT-MSL)		Screen Elevation (ft-msl)
				January 5, 1996	September 13, 1996	January 5, 1996	September 13, 1996	
MW-7	27.89	1.84	25.94	26.02	25.42	1.76	2.47	-4.11 to -9.11
MW-8	10.06	1.54	8.45	8.12	25.00	1.87	1.15	2.06 to -2.94
MW-9	6.31	3.49	2.82	4.54	7.46	1.77	2.43	2.31 to -2.69
MW-10	5.19	1.36	3.83	3.30	2.76	1.89	2.02	-0.41 to -5.41
MW-11	5.33	1.35	3.98	3.59	---	1.74	---	2.13 to -2.87
MW-12	6.76	1.34	5.42	4.94	---	1.82	---	3.76 to -1.24

--- Not measured

Table 2 - Well Construction Data for AREE 1 Monitoring Wells

Table 2
AREE 1 Monitoring Well Construction Summary

Well I.D.	Screen and Casing Material	Well Diameter	Borehole Diameter	Total Depth
MW-7	Stainless steel Sch. 40 (0.02 slot screen)	2-inch	12-inch	39.5
MW-8		2-inch	12-inch	15.5
MW-9		2-inch	12-inch	10.5
MW-10		2-inch	12-inch	13.1
MW-11		2-inch	12-inch	10.5
MW-12		2-inch	12-inch	15.5
MW-77	PVC Sch. 40 (0.01 slot screen)	4-inch	10-inch	16.5
MW-78		4-inch	10-inch	15.5
MW-79		4-inch	10-inch	14.5
MW-80		4-inch	10-inch	16.5

APPENDIX B

ECOLOGICAL RISK ASSESSMENT

B.1 Graphical Presentation of Selected Surface Soil and Sediment TRV Exceedences

B.1.1 Surface Soil
B.1.2 Sediment

APPENDIX B.1

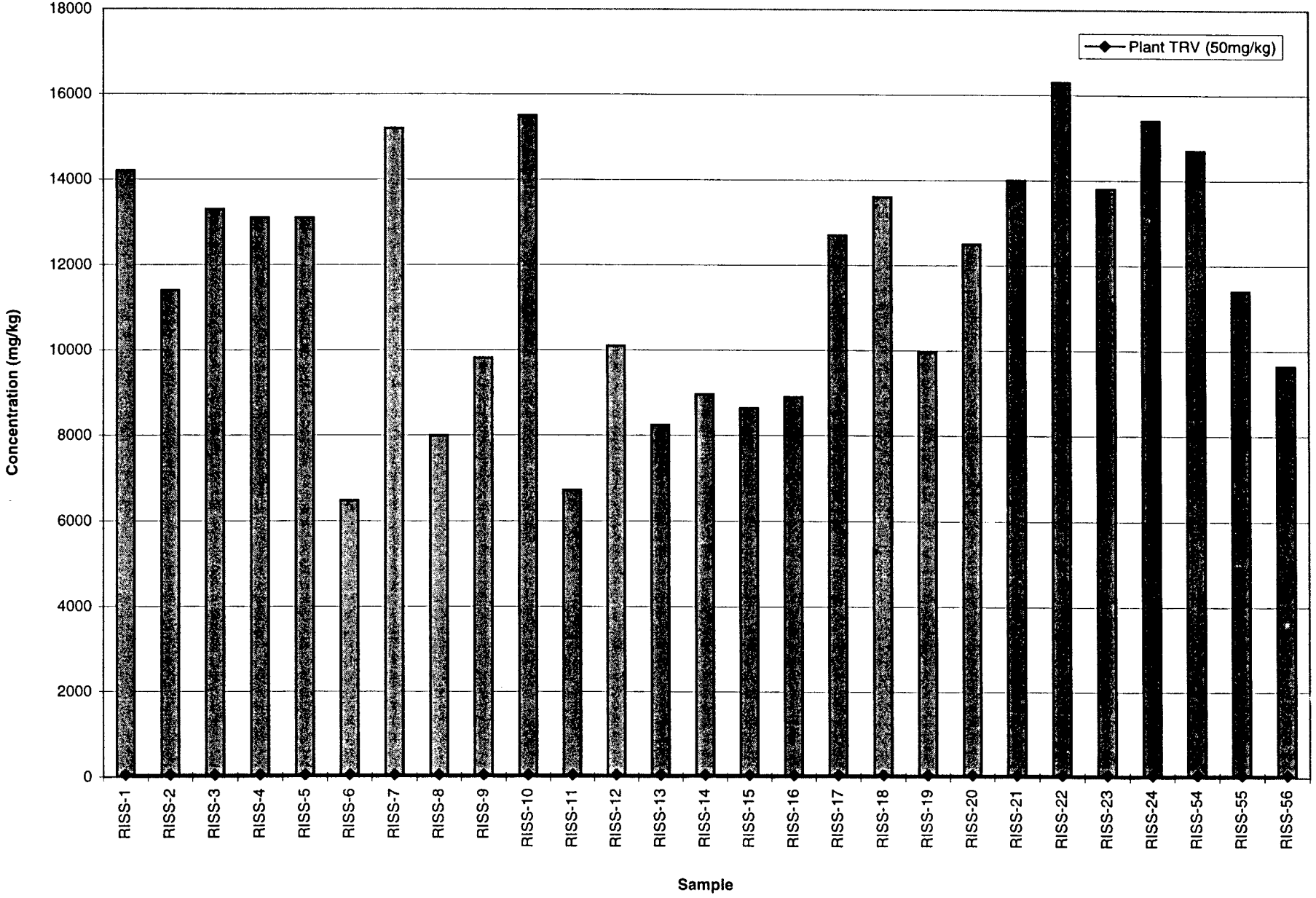
GRAPHICAL PRESENTATION OF SELECTED SURFACE SOIL AND SEDIMENT TRV EXCEEDENCES

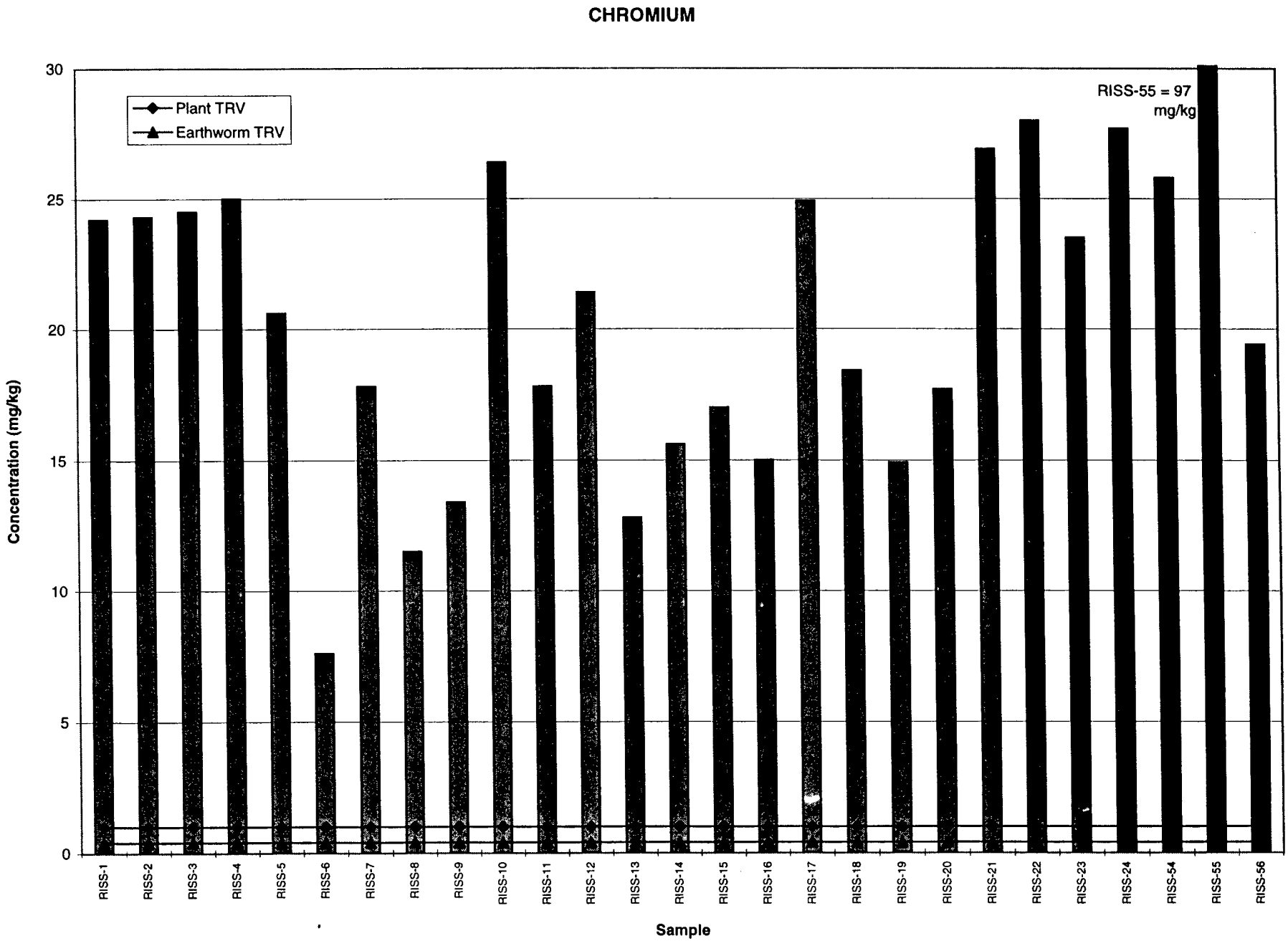
Figures were constructed for surface soil and sediment data to allow the reader to view the exact sample locations where certain compounds exceeded TRVs. For surface soil, compounds with an EEQ greater than one for either the terrestrial plant TRV or the earthworm TRV (see Tables 4-7 and 4-8) were graphed. These compounds are aluminum, chromium, manganese, selenium, vanadium, and zinc. A figure for mercury is not presented because it was detected at only one sample location.

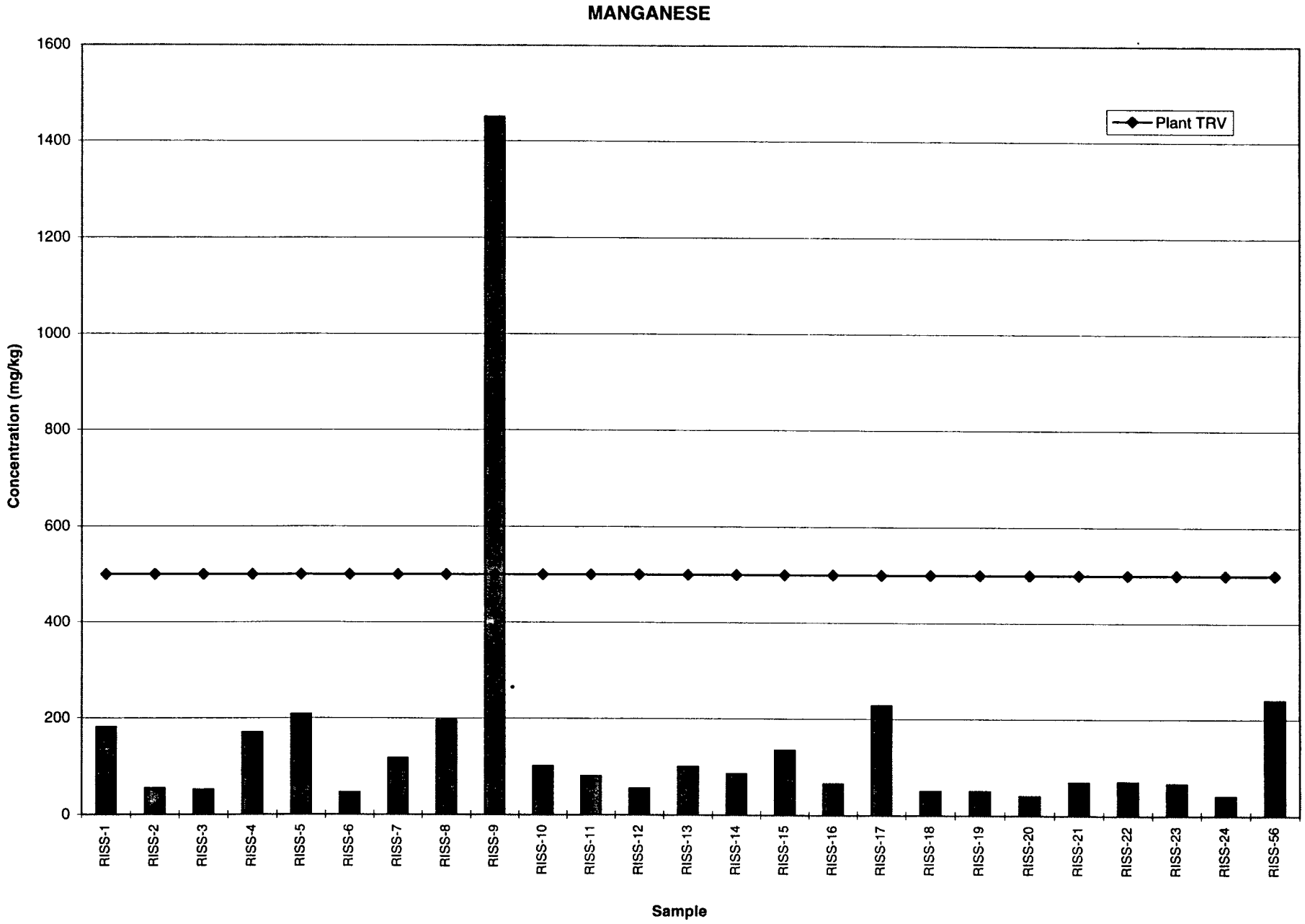
For sediment, chemical concentrations are graphed only for the wetland (RISD-11 and 12) and open water areas (RISD-13 to 21) because no risks were associated with the pond area (all EEQs < 1). Both wetland and open water sample locations are included on the same figures. For PCB-1260, two additional samples, 02SE02 and 02SE04, are included in the wetland area, reflecting the results of samples collected by Earth Tech, Inc. as part of the Phase 1 Site Investigation. Figures were constructed for all organic compounds exceeding TRVs (acenaphthene, anthracene, 1-methylnaphthalene, naphthalene, and PCB-1260), with the exception of chemicals that were detected at only one sample location (indeno(1,2,3-c,d)pyrene, fluorene, 2-methylnapththalene, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT). No figures were constructed for inorganics because the associated risks were relatively low (all EEQs < 3.6). For 1-methylnaphthalene, and naphthalene, figures include wetland sampling locations because these compounds were not detected in the open water area.

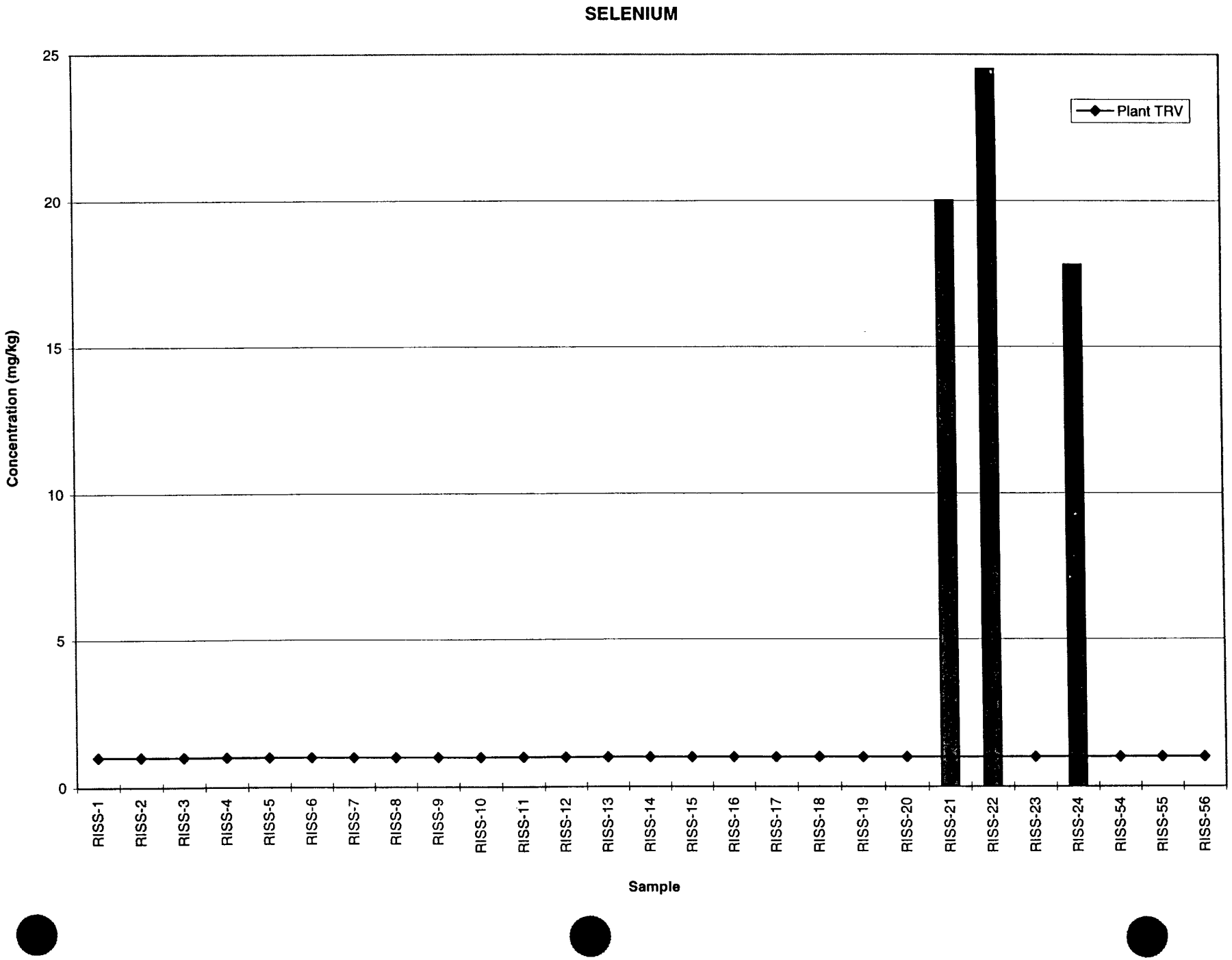
B.1.1 Surface Soil

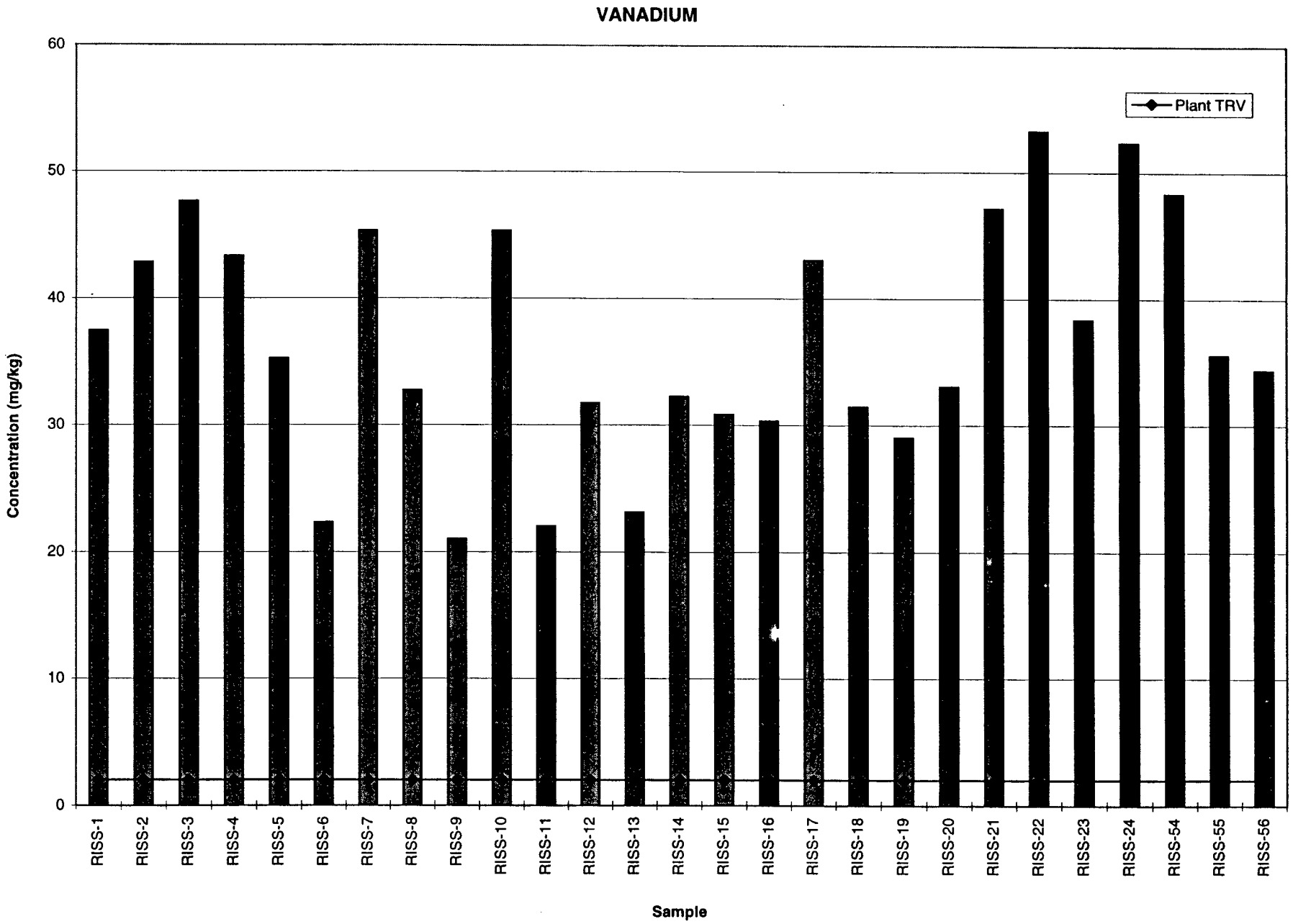
ALUMINUM

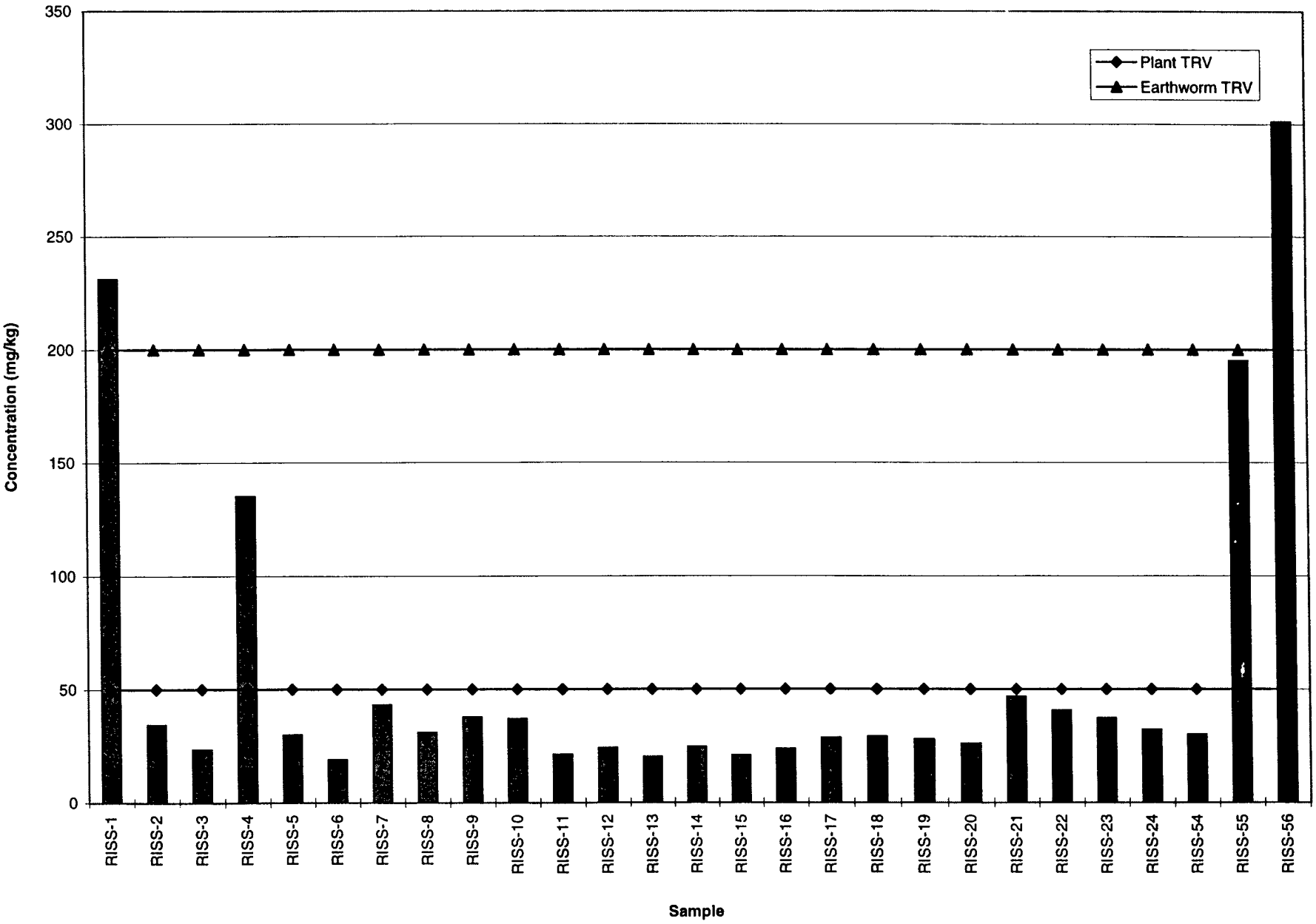

Plant TRV (50mg/kg)
Concentration (mg/kg)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
RISS-1
RISS-2
RISS-3
RISS-4
RISS-5
RISS-6
RISS-7
RISS-8
RISS-9
RISS-10
RISS-11
RISS-12
RISS-13
RISS-14
RISS-15
RISS-16
RISS-17
RISS-18
RISS-19
RISS-20
RISS-21
RISS-22
RISS-23
RISS-24
RISS-54
RISS-55
RISS-56
Sample


CHROMIUM
Plant TRV
Earthworm TRV
RISS-55 = 97 mg/kg
Concentration (mg/kg)
0
5
10
15
20
25
30
RISS-1
RISS-2
RISS-3
RISS-4
RISS-5
RISS-6
RISS-7
RISS-8
RISS-9
RISS-10
RISS-11
RISS-12
RISS-13
RISS-14
RISS-15
RISS-16
RISS-17
RISS-18
RISS-19
RISS-20
RISS-21
RISS-22
RISS-23
RISS-24
RISS-54
RISS-55
RISS-56
Sample


MANGANESE
Plant TRV
Concentration (mg/kg)
1600
1400
1200
1000
800
600
400
200
0
RISS-1
RISS-2
RISS-3
RISS-4
RISS-5
RISS-6
RISS-7
RISS-8
RISS-9
RISS-10
RISS-11
RISS-12
RISS-13
RISS-14
RISS-15
RISS-16
RISS-17
RISS-18
RISS-19
RISS-20
RISS-21
RISS-22
RISS-23
RISS-24
RISS-56
Sample

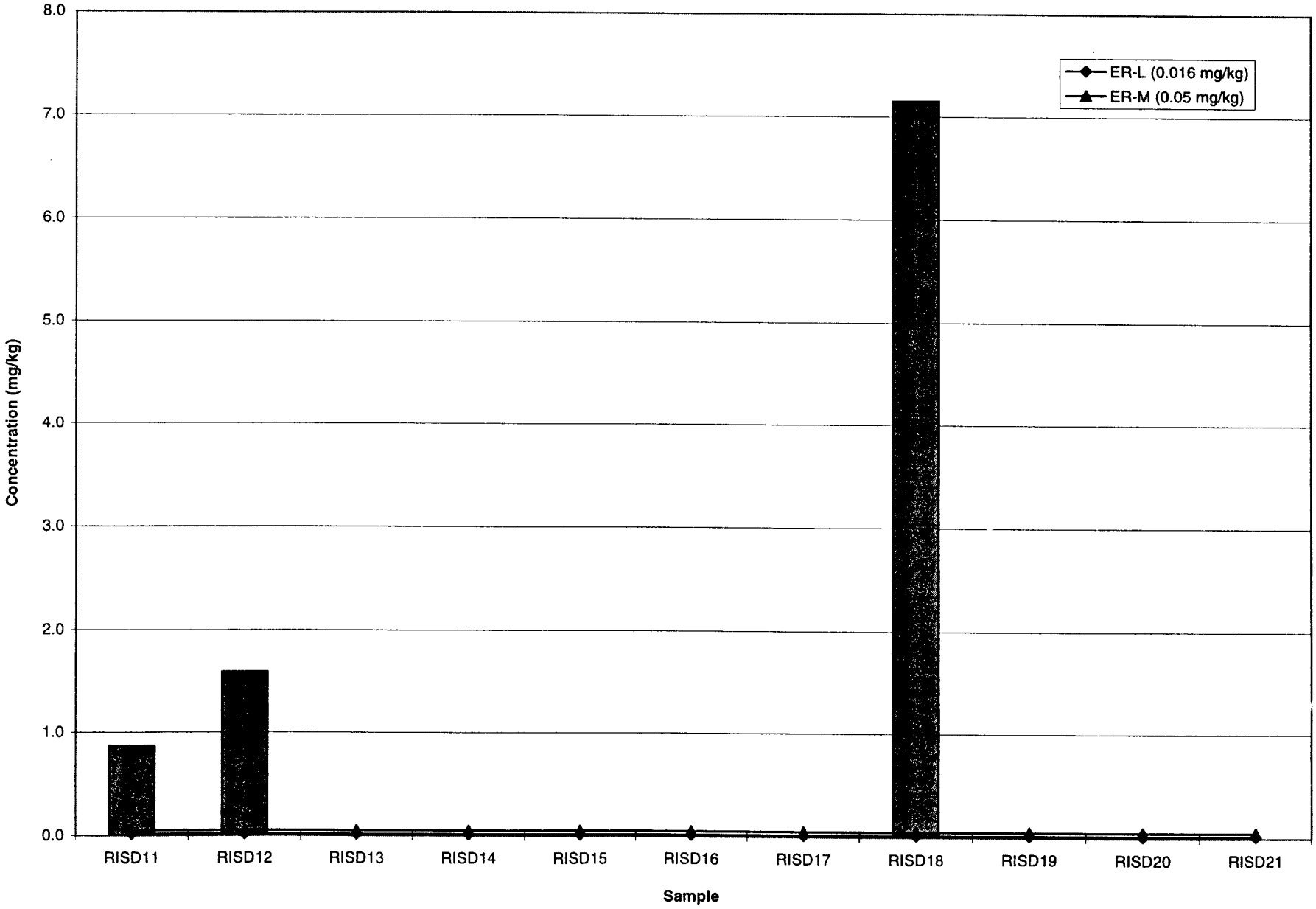

SELENIUM
Concentration (mg/kg)
25
20
15
10
5
0
Plant TRV
RISS-1
RISS-2
RISS-3
RISS-4
RISS-5
RISS-6
RISS-7
RISS-8
RISS-9
RISS-10
RISS-11
RISS-12
RISS-13
RISS-14
RISS-15
RISS-16
RISS-17
RISS-18
RISS-19
RISS-20
RISS-21
RISS-22
RISS-23
RISS-24
RISS-54
RISS-55
RISS-56
Sample

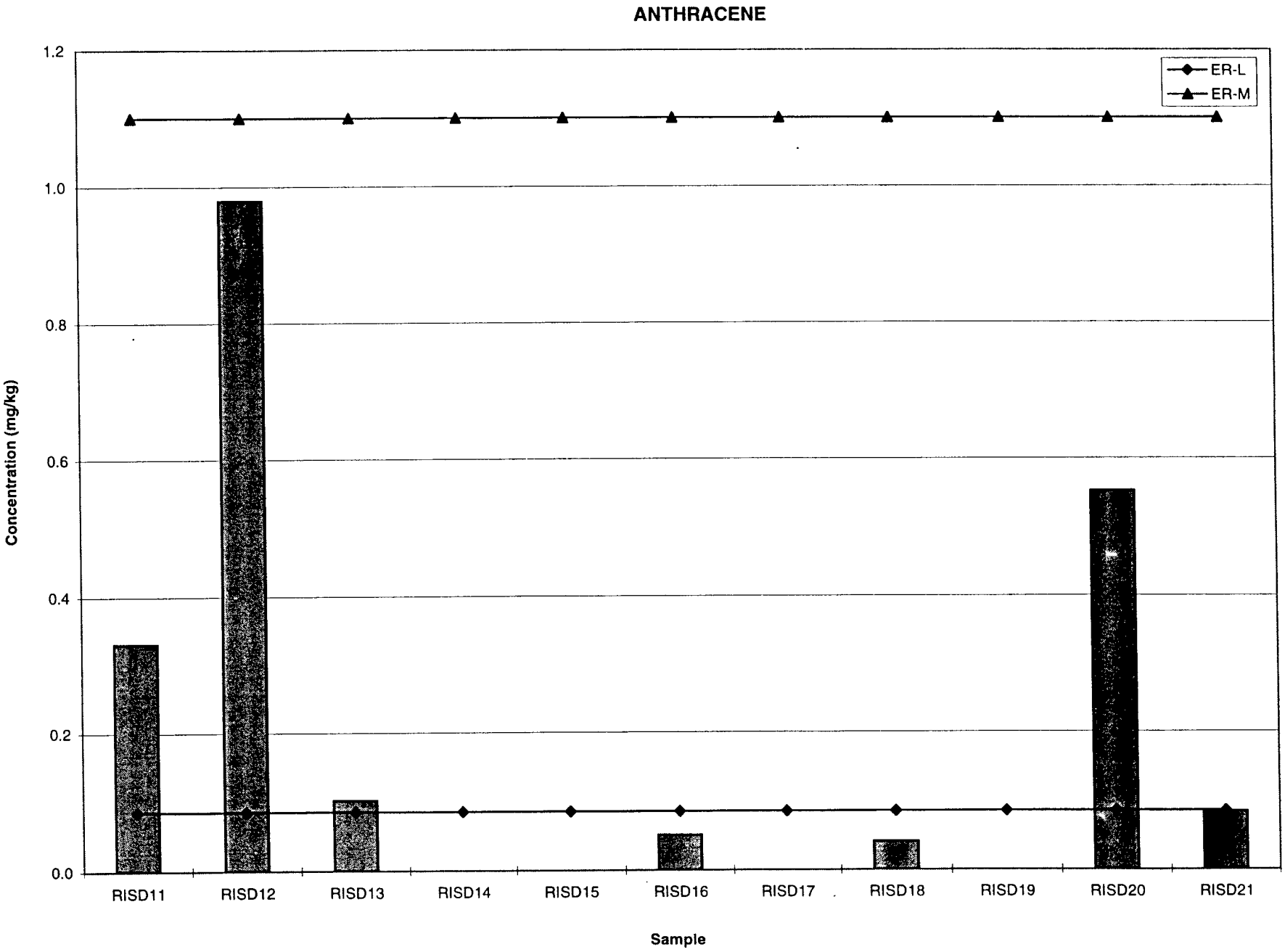

VANADIUM
Plant TRV
Concentration (mg/kg)
0
10
20
30
40
50
60
RISS-1
RISS-2
RISS-3
RISS-4
RISS-5
RISS-6
RISS-7
RISS-8
RISS-9
RISS-10
RISS-11
RISS-12
RISS-13
RISS-14
RISS-15
RISS-16
RISS-17
RISS-18
RISS-19
RISS-20
RISS-21
RISS-22
RISS-23
RISS-24
RISS-54
RISS-55
RISS-56
Sample


ZINC
Plant TRV
Earthworm TRV
Concentration (mg/kg)
350
300
250
200
150
100
50
0
RISS-1
RISS-2
RISS-3
RISS-4
RISS-5
RISS-6
RISS-7
RISS-8
RISS-9
RISS-10
RISS-11
RISS-12
RISS-13
RISS-14
RISS-15
RISS-16
RISS-17
RISS-18
RISS-19
RISS-20
RISS-21
RISS-22
RISS-23
RISS-24
RISS-54
RISS-55
RISS-56
Sample

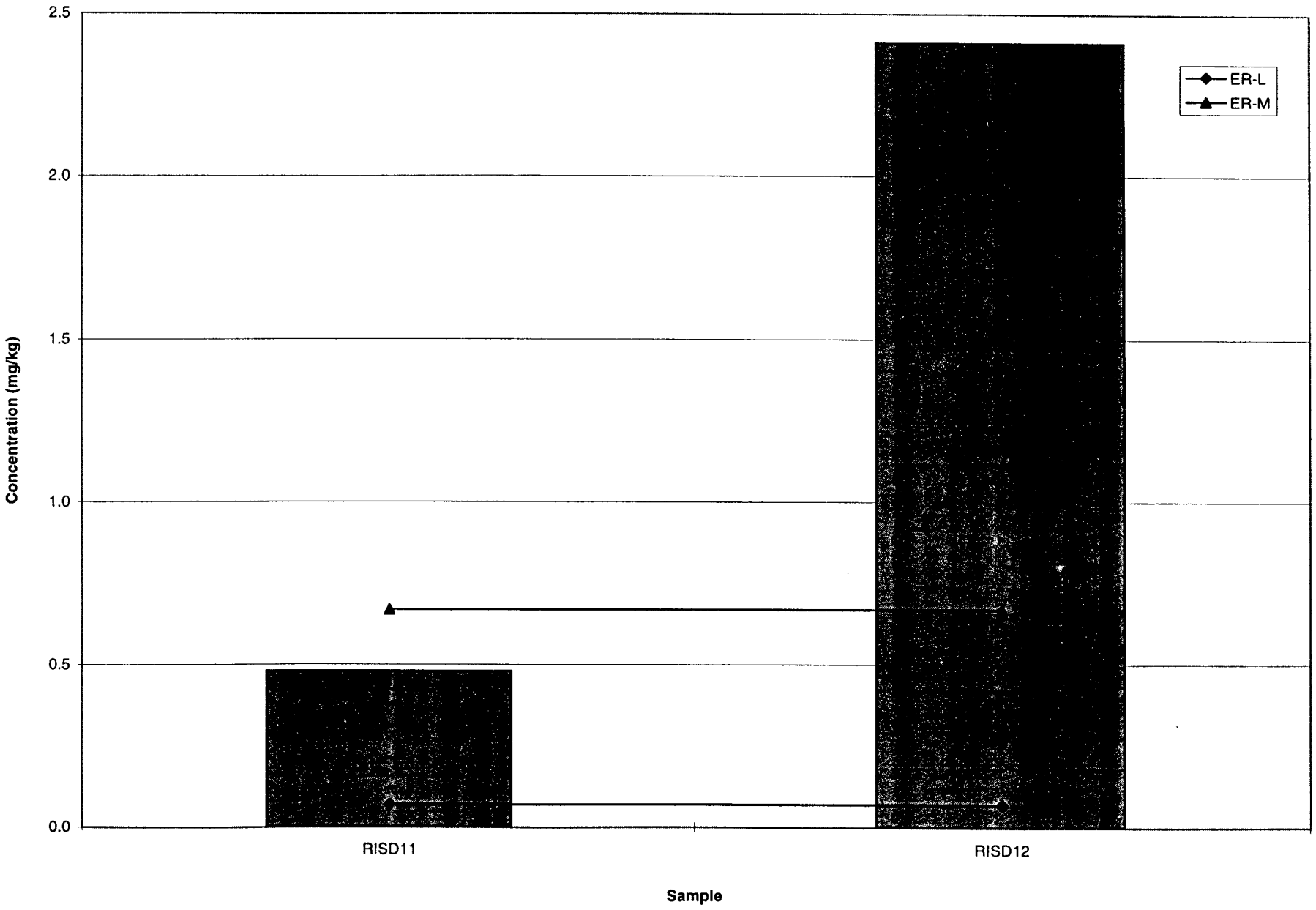
B.1.2 Sediment

ACENAPHTHENE

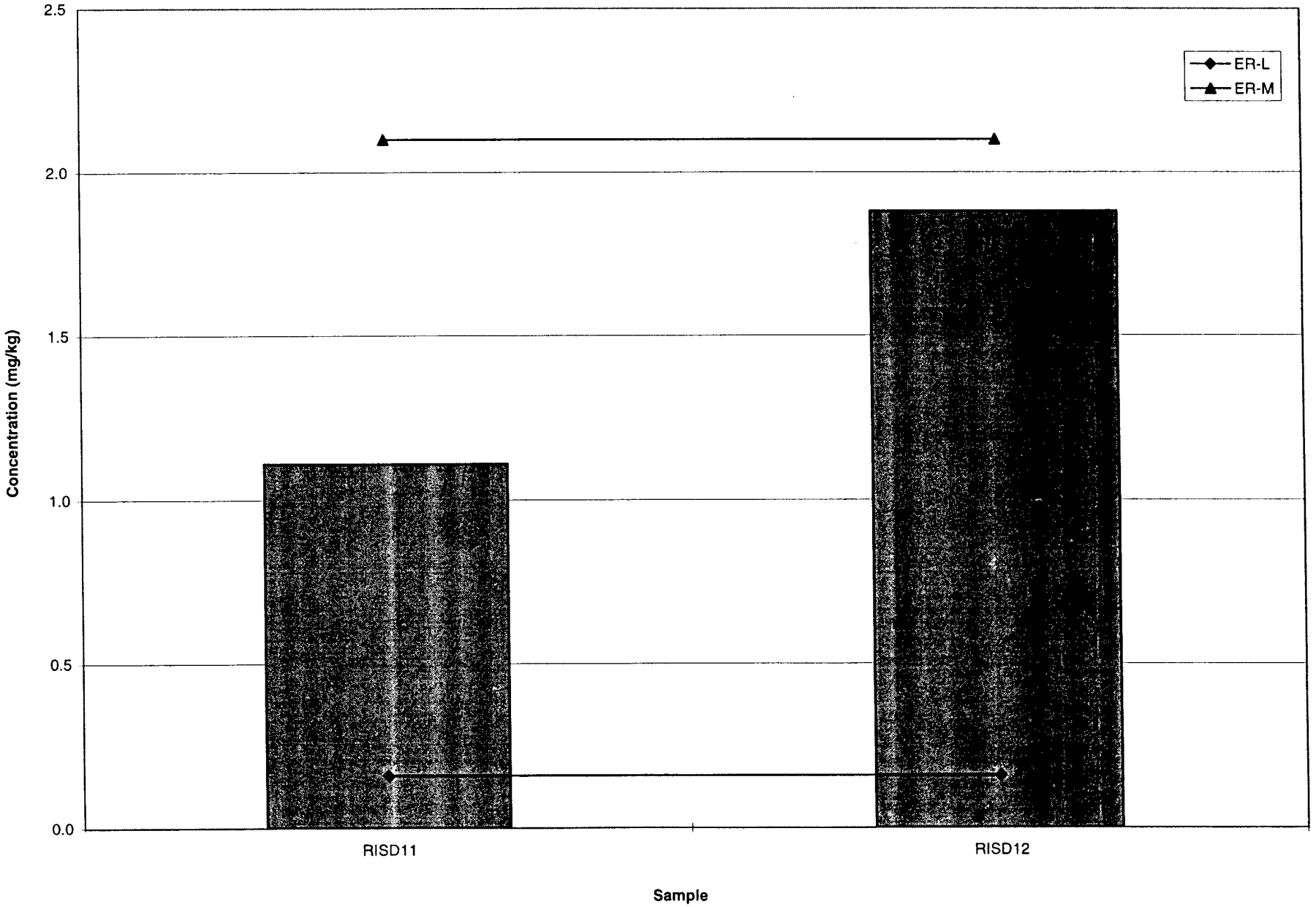


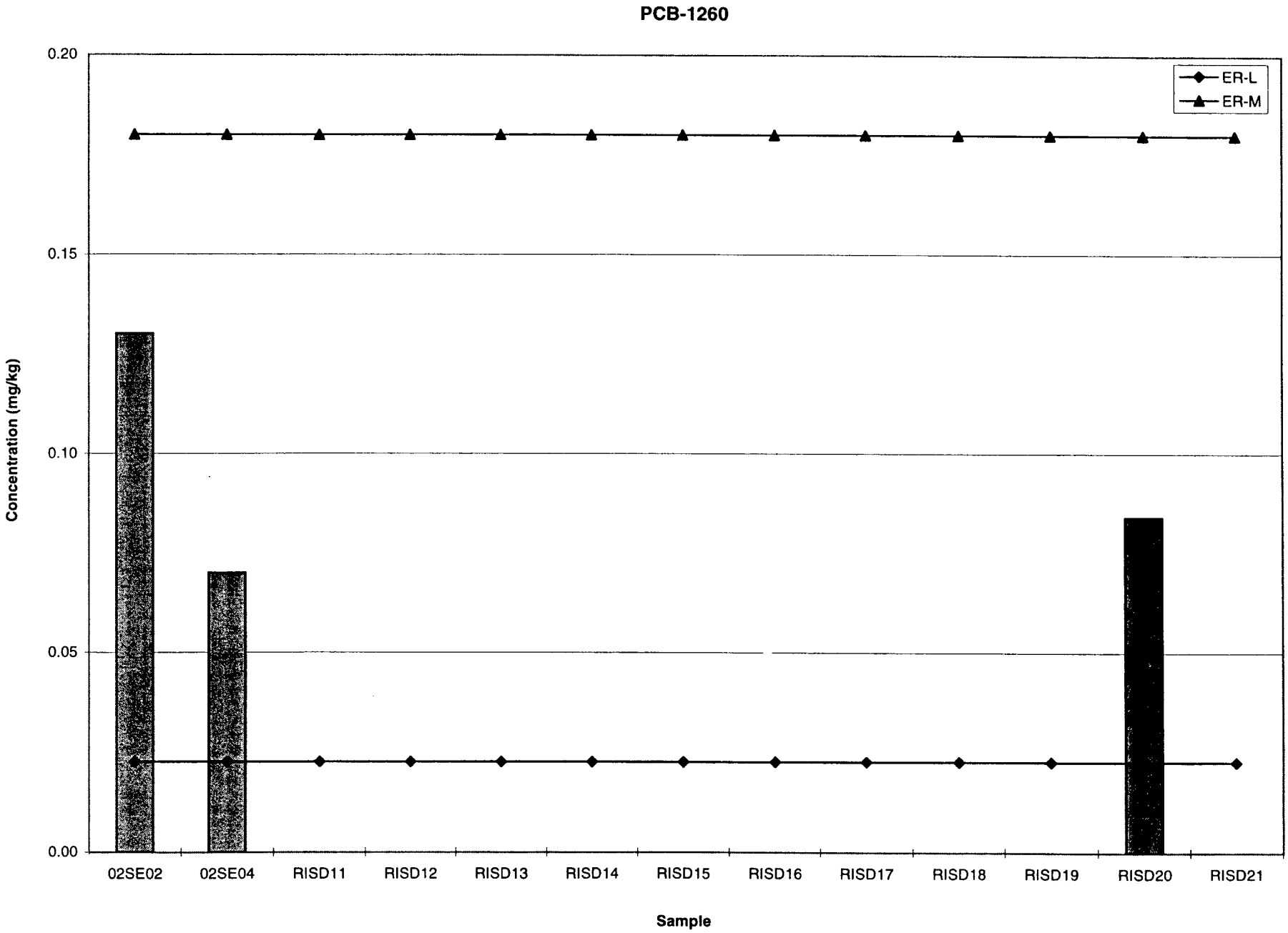

ANTHRACENE
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Concentration (mg/kg)
ER-L
ER-M
RISD11
RISD12
RISD13
RISD14
RISD15
RISD16
RISD17
RISD18
RISD19
RISD20
RISD21
Sample

1-METHYLNAPHTHALENE



NAPHTHALENE




PCB-1260
0.20
0.15
0.10
0.05
0.00
Concentration (mg/kg)
ER-L
ER-M
02SE02
02SE04
RISD11
RISD12
RISD13
RISD14
RISD15
RISD16
RISD17
RISD18
RISD19
RISD20
RISD21
Sample

APPENDIX C

REMEDIAL ALTERNATIVE COST CALCULATIONS

C-1 Cost Calculation Tables
C-2 Cost Estimate Rationale
C-3 Pre-Design Studies for the Development of the Long-Term Groundwater Monitoring Program for Operable Unit One

C-1
Cost Calculation Tables

Table C-1
Estimated O&M Cost for Alternative 1: No Action

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
1	5-year evaluation required by USEPA, 1/5 of report charged each year.	0.2	lump sum	30,000	6,000	Engineer's Estimate
2	Scope contingency	20%			1,200	
	Total annual O&M cost				**7,200**	

Table C-2
Estimated Capital Cost for Alternative 2: Institutional Controls

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
1	4-inch dia. PVC groundwater monitoring wells, 30 ft. deep	9	1 well	9,000	81,000	Recent ICF Kaiser experience at WRF
2	Mobilization/demobilization	1	lump sum	2,000	2,000	Contractor's estimate
3	Groundwater/Land Use Restrictions	1	lump sum	2,000	2,000	Engineer's estimate
4	Posting of signs	1	lump sum	1,000	1,000	Engineer's estimate
	Subtotal estimated construction cost				**86,000**	
6	Bid contingency	10%			8,600	
7	Scope contingency	10%			8,600	
	Total capital cost				**103,200**	
8	Permitting and legal	5%			5,160	
9	Servicing during construction	5%			5,160	
10	Design cost	8%			8,256	
	Total estimated capital cost				**121,776**	

Table C-3
Estimated Annual O&M Cost for Alternative 2: Institutional Controls

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
1	Sampling and analysis of 24 groundwater wells, twice/year	48	each	1,635	78,480	See Table C-4
	Sampling and Analysis in Occoquan and Marumsco every 5th year					
2	surface water	4	each	1,026	4,104	See Table C-4
3	sediment	4	each	1,129	4,516	See Table C-4
4	storm water runoff	4	each	1,447	5,788	See Table C-4
5	Annual cost	0.2	lump sum	14,408	2,882	Add rows 2,3,4
6	**Subtotal estimated annual sampling and analysis cost**				**81,362**	Add rows 1 and 5
7	QC samples	20%	lump sum	81,362	16,272	Use row 6
8	Maintenance on monitoring wells	12	each	1,300	15,600	Engineer's estimate
9	5 year performance demonstration report (charge 1/5 annually)	0.2	lump sum	30,000	6,000	Engineer's estimate
	Subtotal estimated O&M cost				**119,234**	
10	Scope contingency	20%			23,847	
	Total estimated annual O&M cost				**143,081**	

Table C-4
Analytical Cost Table

	Groundwater	Surface Water	Sediment	Storm Water Runoff
Labor	800	200	400	600
PAHs	222	222	240	360
TAL inorganics *	292	292	258	140
water quality param.	100	100	0	0
pest/PCBs	221	212	231	347
Total Cost per Sample	1,635	1,026	1,129	1,447

Table C-5

Estimated Capital Cost for Alternative 3: Containment through Surface Cover and Hot Spot Removal

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
1	Institutional controls	1	lump sum	86,000	86,000	See Table C-2
2	Mobilization and demobilization	1	lump sum	12,000	12,000	Engineer's estimate
3	Site monitoring air, soil, water	12	month	1,500	18,000	Engineer's estimate
4	PCB contaminated soils in AREE 1, excavate, remove, dispose	75	cubic yards	437	32,738	Volume estimated. Vendor quote.
	Subtotal				**148,738**	
	Site Preparation					
5	Grade Existing Roads	6,000	square yard	0.5	3,000	Means
6	Add Gravel to Roads	6,000	square yard	2	12,000	Means
7	AREE 1 site clearing, heavy	1.00	acre	6,000	6,000	Oversized clearing. Cost from Means.
8	AREE 2 site clearing, moderate	0.28	acre	5,000	1,400	Size from ASC figure. Cost from Means.
9	AREE 3 site clearing, light	0.39	acre	4,000	1,560	Size from ASC figure. Cost from Means.
10	AREE 4 site clearing, light	1.60	acre	4,000	6,400	Size from ASC figure. Cost from Means.
11	AREE 5 site clearing, heavy	0.34	acre	6,000	2,040	Size from ASC figure. Cost from Means.
12	AREE 6A site clearing, moderate	3.00	acre	5,000	15,000	Oversized clearing. Cost from Means.
13	AREE 6B site clearing, heavy	0.63	acre	6,000	3,780	Size from ASC figure. Cost from Means.
14	AREE 7 site clearing, heavy	0.00	acre	6,000	0	No activities
	Subtotal for site preparation				**51,180**	
	Containment, Capping and Rip Rap					
15	Total acreage of all AREEs	7.24	acre			
16	Construction of Covers	35,042	square yard	25	876,040	USDOD, 1994
17	Revegetation	35,042	square yard	15	525,624	USDOD, 1994
18	Rip rap along AREE1	1	lump sum	179,100	179,100	Table C-9, Item 3
	Subtotal				**1,580,764**	
	Subtotal estimated construction cost				**1,780,682**	
19	Bid contingency	15%			12,900	
20	Scope contingency	20%			17,200	
	Total capital cost				**1,810,782**	
21	Permitting and legal	5%			90,539	
22	Servicing during construction	5%			90,539	
23	Design cost	5%			90,539	
	Total estimated capital cost				**2,082,399**	

Table C-6
Estimated Annual O&M Cost for Alternative 3: Containment through Surface Cover and Hot Spot Removal

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
1	O&M of institutional controls	1	lump sum	119,234	119,234	Table C-3
2	Annual inspection	1	each	750	750	USDOD, 1994
3	Revegetation	7.24	acre	800	5,792	USDOD, 1994
4	Erosion control	7.24	acre	300	2,172	USDOD, 1994
5	Repairs	1.00	lump sum	300	300	USDOD, 1994
	Subtotal estimated O&M cost				**127,948**	
6	Scope contingency	20%			25,590	
	Total estimated annual O&M cost				**153,538**	

Table C-7
Estimated Capital Cost for Alternative 4: Removal and Disposal

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
1	Institutional controls capital costs	1	lump sum	86,000	86,000	See Table C-2
2	Mobilization and demobilization	1	lump sum	12,000	12,000	Engineer's estimate
3	Site monitoring air, soil, water	12	month	1,500	18,000	Engineer's estimate
4	Sampling and analysis of 24 wells, quarterly for one year	96	each	1,635	156,960	See Table C-4 for analytical costs
	Subtotal				**272,960**	
	Subtotal for site preparation				**51,180**	See Table C-5
	Subtotal for revegetation				**525,624**	See Table C-5
	Volumes for Excavation, Removal and RCRA Disposal					
5	AREE 1 dig 10 feet (Hazardous Waste Disposal)	5,556	cubic yard	437	2,425,000	Vendor Quote
6	AREE 2 dig 10 feet (Non-hazardous Waste Disposal)	2,889	cubic yard	37	105,444	Vendor Quote
7	AREE 3 dig 5 feet (Non-hazardous Waste Disposal)	944	cubic yard	37	34,472	Vendor Quote
8	AREE 4 dig 5 feet (Non-hazardous Waste Disposal)	5,556	cubic yard	37	202,778	Vendor Quote
9	AREE 5 dig 10 feet (Non-hazardous Waste Disposal)	2,889	cubic yard	37	105,444	Vendor Quote
10	AREE 6A dig 5 feet (Non-hazardous Waste Disposal)	3,704	cubic yard	37	135,185	Vendor Quote
11	AREE 6B dig 10 feet (Non-hazardous Waste Disposal)	1,556	cubic yard	37	56,778	Vendor Quote
12	AREE 7	0	cubic yard	37	0	
	Subtotal for excavation and disposal				**3,065,102**	
	Subtotal estimated capital cost				**3,914,866**	
13	Bid contingency	20%			782,973	
14	Scope contingency	20%			782,973	
	Total capital cost				**5,480,812**	
15	Permitting and legal	8%			438,465	
16	Servicing during construction	10%			548,081	
17	Design cost	5%			274,041	
	Total estimated capital cost				**6,741,399**	

Table C-8
Estimated O&M Cost for Alternative 4: Removal and Disposal

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
1	O&M of institutional controls	1	lump sum	119,234	119,234	See Table C-3
	Subtotal estimated O&M cost				**119,234**	
	Scope contingency	20%			23,847	
	Total estimated sampling and analysis cost				**143,081**	

Table C-9
Estimated Capital Costs for Alternative 5: AREE-Specific Remedial Action

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
	General Activities					
1	Institutional controls capital costs	1	lump sum	86,000	**$86,000**	See Table C-2
2	**Clean Up Visible Debris**				**$18,900**	
	Pick up Debris, Transport, and Dispose at Landfill	28	30 cubic yard boxes	275	$7,700	Vendor Quote
	Along Shoreline	4				
	OU1	2				
	AREE 1	2				
	On Land	15				
	OU1	2				
	AREE 1	3				
	AREE 2/5	4				
	AREE 3	2				
	AREE 4	1				
	AREE 6A	2				
	AREE 6B	1				
	AREE 7					
	In Wetland	9				
	AREE 1	2				
	AREE 2/5	3				
	AREE 6A	4				
	Labor	14	days	800	$11,200	
3	**Rip Rap AREE 1 Shoreline**				**$179,100**	
	Rip Rap	6,000	tons	14.35	$86,100	Vendor Quote
	Spread Rip Rap	30	day	2,900	$87,000	Vendor Quote
	Labor	30	days	200	$6,000	

Table C-9 (Continued)

Estimated Capital Costs for Alternative 5: AREE-Specific Remedial Action

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
	Sites for Clean Closure					
					$21,600	
4	**Geophysical Survey**	16	acres	1,000	$16,000	Vendor Quote
	AREE 2/5	4				
	AREE 3	4				
	AREE 4	4				
	AREE 6B	4				
	Labor	14	days	400	$5,600	
5	**Dig Test Pits**				**$37,842**	
	Assume 28 pits					
	Backhoe	112	hours	156	$17,472	Means
	Labor (3 operators)	112	hours	100	$11,200	Means
	Field Engineer	112	hours	50	$5,600	Means
	Debris Disposal	420	cubic yards	8.50	$3,570	Potomac Landfill
6	**Expanded Digging**				**$9,461**	
	Assume 25% Expansion					
	Backhoe	28	hours	156	$4,368	Means
	Labor (3 operators)	28	hours	100	$2,800	Means
	Field Engineer	28	hours	50	$1,400	Means
	Debris Disposal	105	cubic yards	8.50	$893	Potomac Landfill
7	**Confirmatory Sampling**				**$16,564**	
	Field Screening Tests	30	sample	150	$4,500	Vendor Quote
	AREE2/5	10				
	AREE3	5				
	AREE4	10				
	AREE6B	5				
	Laboratory Analysis	16	sample	754	$12,064	Vendor Quote
	AREE2/5	4				
	AREE3	4				
	AREE4	4				
	AREE6B	4				
	Labor					Included in Task 8
8	**Soil and sediment with PCBs:**				**$48,250**	
	Excavate Soil	500	cubic yds	6.50	$3,250	Vendor quote
	Transport/Dispose (>50 ppm)					
	AREE1	75	cubic yds	430	$32,250	Vendor quote
	Transport/Dispose (>1 &< 50 ppm)	425	cubic yds	30	$12,750	Vendor quote
	AREE1	370				
	AREE 2/5	20				
	AREE 3	9				
	AREE 4	12				
	AREE 6B	14				

Table C-9 (Continued)
Estimated Capital Costs for Alternative 5: AREE-Specific Remedial Action

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
	Sites for Clean Closure (cont.)					
9	**Restore Wetlands**				**$1,233**	
	Soil Replacement	1.8	tons	560	$1,008	
	AREE1	0.5				
	AREE 2/5	0.2				
	AREE 3	0.3				
	AREE 4	0.4				
	AREE 6B	0.4				
	Revegetate	15	square yards	15	$225	USDOD, 1994
	AREE1	5				
	AREE 2/5	4				
	AREE 3	3				
	AREE 4	2				
	AREE 6B	1				
10	**Groundwater Monitoring** (Quarterly for 1 Year)	64	samples	1,962	**$125,568**	
	AREE 2/5	16				AREE1 and 6A will be subject to long-term monitoring.
	AREE 3	16				
	AREE 4	16				
	AREE 6B	16				
	Sites for Engineered Covers					
11	**Geophysical Survey**	6	acres	1,000	**$6,000**	Vendor Quote
	AREE 1	2				
	AREE 6A	4				
12	**Clear and Grub**				**$17,750**	
	Clear/Grub	2.5	acres	6,000	$15,000	
	AREE 1	1.00				
	AREE 6A	1.50				
	Transport and Landfill	10	30 cy boxes	275	$2,750	Vendor quote
	AREE 1	4				
	AREE 6A	6				
13	**Slope Stabilization/Excavation**				**$15,066**	
	Trackhoe	64	hours	120	$7,680	
	AREE 1	40				
	AREE 6A	24				
	Labor					
	Equipment Operator	64	hours	65	$4,186	
	Field Engineer	64	hours	50	$3,200	

Table C-9 (Continued)
Estimated Capital Costs for Alternative 5: AREE-Specific Remedial Action

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
	Sites for Engineered Covers (cont.)					
14	**Construct Covers**				**$130,297**	
	Low Permeability Soil	9,680	cubic yards	11	$106,480	purchase and delivery
	AREE 1(Total area is one acre)	2,420				
	AREE 6A (Total area is three acres)	7,260				
	Spread Soil & Compact					
	AREE 1					
	Equipment Costs (F.E. Loader)	24	hours	86	$2,064	Means
	Labor Costs (One Operator)	24	hours	35	$850	Means
	Field Engineer	24	hours	50	$1,200	Means
	AREE 6A					
	Equipment Costs (F.E. Loader)	48	hours	86	$4,128	Means
	Labor Costs (One Operator)	48	hours	35	$1,699	Means
	Field Engineer	48	hours	50	$2,400	Means
	Top Soil/Purchase & Delivery	308	cubic yards	15	$4,620	Vendor Quote
	AREE 1(Total area is one acre)	66				
	AREE 6A (Total area is three acres)	242				
	Top Soil Spread					
	AREE 1					
	Equipment Costs (F.E. Loader)	16	hours	86	$1,376	Means
	Labor Costs (One Operator)	16	hours	35	$566	Means
	Field Engineer	16	hours	50	$800	Means
	AREE 6A					
	Equipment Costs (F.E. Loader)	24	hours	86	$2,064	Means
	Labor Costs (One Operator)	24	hours	35	$850	Means
	Field Engineer	24	hours	50	$1,200	Means
	Subtotal, general activities				**284,000**	
	Subtotal, clean closure				**260,518**	
	Subtotal, engineered covers				**169,112**	
	Subtotal estimated capital cost				**713,630**	
15	Bid contingency	15%			107,044	
16	Scope contingency	10%			71,363	
	Total capital cost				**892,037**	
17	Permitting and legal	5%			44,602	
18	Servicing during construction	10%			89,204	
19	Design cost	10%			89,204	
	Total estimated capital cost				**1,115,047**	

Table C-10

Estimated Annual O&M Costs for Alternative 5: AREE-Specific Remedial Action

Item	Description	Quantity	Unit of Measure	Unit Cost $	Item Cost $	Reference or Comment
1	Long-Term Monitoring 15 years				**$30,468**	
	Cover Maintenance	5	acres	600	$3,000	
	AREE 1	2				
	AREE 6A	3				
	Groundwater Monitoring	14	samples	1,962	$27,468	
	AREE 1	5				
	AREE2/5	5				
	AREE6A	4				
2	**Five Year Review**				**$146,730**	Divide this Number by Five to add to the Annual Cost
	Surface Water	25	samples	1231	$30,775	
	Sediment	25		1355	$33,875	
	Biota	30		1736	$52,080	
3	Report	1	lump sum	30,000	$30,000	
	Total Estimated O&M Costs				**$59,814**	

Table C-11

Capital, O&M, and Present Worth Costs

Alt.	Description	Capital	O&M	Present Worth
1	No Action	0	7,200	74,734
2	Institutional Controls	121,776	143,081	1,606,911
3	Containment through Surface Cover and Hot Spot Removal	2,082,399	153,538	3,676,072
4	Removal and Disposal	6,741,399	143,081	8,226,534
5	AREE-Specific Remedial Actions	1,115,047	59,814	1,735,898

Present worth assumes an interest rate of 5%, over an O&M period of 15 years.

C-2

Cost Estimate Rationale

COST ESTIMATE RATIONALE

Cost estimates for WRF OU1 were prepared using information available at the time of the estimate. Tables C-1 through C-11 identify the costs that were developed for remedial Alternatives 1, 2, 4, 5 and 6. Other alternatives were screened out. Cost information for equipment, construction, and operation and maintenance (O&M) for the tables presented here was derived from vendor's estimates, cost guides and other literature, cost estimates from contractors, and professional judgment, based on previous engineering experience.

The FS costs were derived to provide an accuracy of +50% to -30% of the actual final costs, which is the target range for CERCLA feasibility studies (USEPA 1988). Cost tables and considerations utilize USEPA guidance (USEPA 1987a, b), other engineering references (Peurifoy 1989; Perry 1973) and professional judgment gained from other similar studies.

In addition to estimated capital and O&M costs, two contingency costs and three indirect costs were added, as described below:

Scope Contingency

The scope contingency is intended to cover changes during final design and implementation. It may be 10 to 25 percent of the construction subtotal for known technologies and sites with minimum elements of risk, or much more for state-of-the-art technologies at sites with higher elements of risk. Factors that determine the magnitude of the scope contingency include:

- At the FS stage, the design concept is not developed fully enough to identify all of the project components and ancillary costs.
- A reserve for change orders. On conventional projects with a completed design, owners historically allow a 6- to 8-percent change order contingency for scope change.
- Scope changes that can occur during design and/or that are needed to meet performance-based criteria. For example, at WRF OU1, quantifying the volume of debris or contaminated soil is possible only after the implementation of intrusive activities. Feasibility study cost estimates are completed prior to excavation activities, and allowance must be made that these estimates do not accurately predict exact site conditions.
- The special nature of hazardous waste construction eliminates many contractors from competition and, therefore, reduces the bidding competitiveness, which, in turn, increases the bids.

Bid Contingency

The bid contingency is intended to cover unforeseen circumstances which result in additional costs, such as: adverse weather conditions, strikes by material suppliers, unfavorable market conditions, and inadequate site characterization. A bid contingency may vary between 10 and 20 percent (average is 15 percent.), and is applied against the construction subtotal.

Permitting and Legal

Project expenses may include legal fees and fees for technical personnel necessary to obtain licenses and permits. Non-environmental construction permits and temporary or long-term operating permits may be required from federal, state, and local jurisdictions to complete a remedial action. Similarly, legal advice may be necessary to obtain licenses or negotiate construction and operating contracts. Legal and license/permit costs are typically in the range of 2 to 5 percent of total capital cost.

Servicing During Construction

The cost of services during construction are typically in the range of 7 to 10 percent of the total capital cost, and are necessary for the following activities:

- Supervision and Administration
  - Bidding and contract administration
  - Construction management and on-site observation
  - Change order negotiations
  - Pre-purchase of equipment and expediting deliveries
  - Submittal review and office services
  - Record drawings
- Engineering and Design During Construction
  - Additional design work
  - O&M manuals.

Engineering Design

Engineering design costs are typically in the range of 6 to 10 percent of the total capital cost and normally account for:

- Design and process development
- Preparation specifications and bid documents
- Drafting
- Monitoring and testing, if additionally required.

C-3

Pre-design Studies for the Development of the Long-Term Groundwater Monitoring Program for OU1

PRE-DESIGN STUDIES FOR THE DEVELOPMENT OF THE LONG-TERM GROUNDWATER MONITORING PROGRAM FOR OU1

Groundwater at WRF is most likely influenced by tides in the Occoquan Bay which would cause fluctuations in water levels measured in monitoring wells and could possibly cause variations in concentrations of chemical compounds detected in groundwater. To effectively design a long-term monitoring plan, pre-design studies are proposed to evaluate the tidal range observed in wells so that monitoring wells can be selected for long-term monitoring or additional monitoring wells can be installed, if necessary. In addition to water-level monitoring, groundwater sampling is proposed to evaluate the range of chemical concentrations detected over a tidal cycle so that a statistical data set can be established for the long-term monitoring plan. The proposed elements of the pre-design studies are discussed below and include: (1) continuous water-level monitoring in selected monitoring wells, (2) continuous (and concurrent) monitoring in selected surface water locations, and (3) groundwater sampling at high and low tide intervals at selected locations to establish a range in concentrations due to tides.

Continuous Water Level Readings

To evaluate the fluctuations of water levels due to tides, data loggers will be placed in selected monitoring wells at OU1. The table below lists the wells for which continuous monitoring is proposed and includes both near shore wells and wells farther away from the shoreline at OU1.

AREE	Monitoring Well	Depth of Monitoring Well	Near Shore
1	MW-76	Shallow	Yes
	MW-79	Shallow	Yes
	MW-80	Shallow	Yes
	MW-7	Shallow	No
2/5	MW-68	Shallow	No
	MW-81	Shallow	No
	MW-82	Deep	No
	MW-74	Shallow	No
3	MW-69	Shallow	No
4	MW-64	Deep	No
	MW-66	Shallow	Yes
6B	MW-60	Deep	No
Site Wide	PZ-7	Shallow	No
	PZ-12	Shallow	No

NOTE: No deep monitoring wells are currently installed close to the shoreline at OU1 and therefore have not been included for the pre-design study.

Data loggers should be placed in the wells and continuous water level readings collected for a minimum of one month. In conjunction with the continuous monitoring, tidal information, e.g, tide tables and seasonal ranges, will be obtained from the local tidal station (High Point, Occoquan Bay). This information can be compared to fluctuations in water levels measured in the wells to evaluate possible response times in the wells due to tides.

Tidal Monitoring in Surface Waters

Tidal monitoring in surface water will be done in conjunction with water level monitoring in wells. This can be accomplished by installing data loggers in selected streams/wetland areas, Marumsco Creek, and the Occoquan Bay. The duration and measurement frequency of the monitoring will be the same as that in the monitoring wells. The areas proposed are as follows: 1) the marsh/wetland area west/southwest of AREEs 2 and 5, the mouth of Marumsco Creek, and the Occoquan Bay just south of AREE 1. The data collected from the tidal monitors can be compared to the water level data collected from the monitoring wells to evaluate the tidal effects on water level changes.

Groundwater Sampling

Fluctuations in water levels and tidal influences may affect concentrations of compounds detected during long-term monitoring. It is important to know chemical concentration variations related to tides so that these data can be incorporated into the statistical data base which is used for comparison purposes as part of a long-term monitoring program. Unexplainable variations in concentrations of compounds detected may cause uncertainties that could result in the initiation of a detection monitoring program that may be unwarranted.

Groundwater monitoring has been proposed for Alternatives 2, 4, 5, and 6 to provide effectiveness demonstrations for AREEs that will be closed per the VSWMR and/or long-term monitoring for AREEs 1 and 6B. Quarterly groundwater samples will be collected for one year from selected wells within OU1. The groundwater samples will be collected after the tidal data has been evaluated. Two rounds of sampling (one collected at high tide and one at low tide) should be collected during each quarterly sampling event from selected wells where data loggers were installed. The sample collection time would be based on the lag time response for high and low tide based on the results of the water level/tidal cycle studies. For example, if the highest water level in a monitoring well occurred 2 hours after the high tide measured at the tidal station, then the sample would be collected two hours after a known high tide. These data would be statistically analyzed to develop the data base from which to compare the chemical data that will be obtained during the long-term monitoring program.

Item 1 : Institutional Controls

See budgetary cost details for Alternative 2

Item 2: Cleanup Visible Debris

- Quantities of debris estimated from visual investigation of the site by ICF KE employees and its sub-contractors.
- Visible debris will be collected by hand and placed in 30 yd^3 rolloff containers.
- BFI was contacted for an estimate for collection of visible debris by hand, and disposal of the collected solid waste in a permitted landfill.

  Cost per 30 yd^3 container transported and disposed of was $275.

- Estimated Quantities for budgetary costs were as follows

- Along Shoreline

Location	# of containers
OU 1	2
AREE 1	2

- On Land

Location	# of containers
OU 1	2
AREE 1	3
AREE 2/5	4
AREE 3	2
AREE 4	1
AREE 6a	2

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Item 2: Cleanup Visible Debris (continued)

- On Land

Location	# of containers
AREE 6b	1

- In Wetland

Location	# of containers
AREE 1	2
AREE 2/5	3
AREE 6a	4

Labor was estimated to cost $800 / day
Assumed time of 14 days for completion of Item 2.

Totals

Total # of containers was estimated to be 28.

28 * $275 = $7,700

Labor cost

14 * $800 = 11,200

Total Estimated Cost for Item 2 is $18,900.

Item 3: Installation of Rip Rap

A quote for installation of Rip rap along the shore line in the vicinity of AREE 1 was obtained from Vulcan Material of Occoquan, VA.

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Item 3: Installation of Rip. Rap (cont.)

Tasks included in the quote were:

- preparation of shoreline to receive rip rap
- haul rip rap to the site
- placement of rip rap along shore line

Total Cost of Vulcan Materials Quote

$179,100.

Item 4: Geophysical Survey

Item 4 is the geophysical survey cost for AREES which will qualify for clean closure. Subsurface Detection Investigations Incorporated was contacted for a cost of conducting a geophysical survey at this site. They confirmed a price of $1000/Acre. Also required is a field engineer or field geologist to record the geophysical survey results.

Location	Area	Time to complete
AREE 2/5	4 acres	3.5 days
AREE 3	4 acres	3.5 days
AREE 4	4 acres	3.5 days
AREE 66	4 acres	3.5 days

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Item 4: Geophysical Survey (cont.)

Total for conducting survey

16 acres * $1,000 = 16,000

Total for field supervision

14 days * $400/day = 5,600

Total for Item 4 $ 21,600

Item 5: Dig Test Pits

Assume 28 Test Pits will be constructed through out OU 1.

Equipment Required

Track mounted Hydraulic Excavator w/ 2 yd^3 buck

$121.99/hour from Means Site Work & Landscape Cost Data 15th Annual Addition (Means) pg. 498

12 yd^3 Dump Truck

$40.73 from Means pg. 495

Assume 112 hours are required. Then Equipment total is:

112 * 121.99 + 112 * 40.73 = $18,224.64

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Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Labor-Hour	
Crew B-11L	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.55
1 Laborer	19.80	158.40	31.60	252.80		
1 Grader, 30,000 Lbs.		537.35		591.10	33.58	36.94
16 L.H., Daily Totals		$901.35		$1159.90	$56.33	$72.49
Crew B-11M	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.55
1 Laborer	19.80	158.40	31.60	252.80		
1 Backhoe Loader, 80 H.P.		285.85		314.45	17.87	19.65
16 L.H., Daily Totals		$649.85		$883.25	$40.62	$55.20
Crew B-12	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
16 L.H., Daily Totals		$389.20		$598.00	$24.33	$37.38
Crew B-12A	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 1 C.Y.		551.40		606.55	34.46	37.91
16 L.H., Daily Totals		$940.60		$1204.55	$58.79	$75.29
Crew B-12B	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 1.5 C.Y.		710.50		781.55	44.41	48.85
16 L.H., Daily Totals		$1099.70		$1379.55	$68.74	$86.23
Crew B-12C	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 2 C.Y.		975.90		1073.50	60.99	67.09
16 L.H., Daily Totals		$1365.10		$1671.50	$85.32	$104.47
Crew B-12D	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 3.5 C.Y.		2184.00		2402.40	136.50	150.15
16 L.H., Daily Totals		$2573.20		$3000.40	$160.83	$187.53
Crew B-12E	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, .5 C.Y.		332.05		365.25	20.75	22.83
16 L.H., Daily Totals		$721.25		$963.25	$45.08	$60.21
Crew B-12F	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, .75 C.Y.		450.65		495.70	28.17	30.98
16 L.H., Daily Totals		$839.85		$1093.70	$52.50	$68.36
Crew B-12G	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .5 C.Y.		427.35		470.10		
1 Clamshell Bucket, .5 C.Y		43.00		47.30	29.40	32.34
16 L.H., Daily Totals		$859.55		$1115.40	$53.73	$69.72

Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Labor-Hour	
Crew B-12H	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, 1 C.Y.		492.30		541.55		
1 Clamshell Bucket, 1 C.Y.		63.80		70.20	34.76	38.23
16 L.H., Daily Totals		$945.30		$1209.75	$59.09	$75.61
Crew B-12I	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .75 C.Y.		454.80		500.30		
1 Dragline Bucket, .75 C.Y.		32.00		35.20	30.43	33.47
16 L.H., Daily Totals		$876.00		$1133.50	$54.76	$70.85
Crew B-12J	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Gradall, 3 Ton, .5 C.Y.		630.50		693.55	39.41	43.35
16 L.H., Daily Totals		$1019.70		$1291.55	$63.74	$80.73
Crew B-12K	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Gradall, 3 Ton, 1 C.Y.		866.55		953.20	54.16	59.58
16 L.H., Daily Totals		$1255.75		$1551.20	$78.49	$96.96
Crew B-12L	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .5 C.Y.		427.35		470.10		
1 F.E. Attachment, .5 C.Y.		50.60		55.65	29.87	32.86
16 L.H., Daily Totals		$867.15		$1123.75	$54.20	$70.24
Crew B-12M	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .75 C.Y		454.80		500.30		
1 F.E. Attachment, .75 C.Y.		96.20		105.80	34.44	37.88
16 L.H., Daily Totals		$940.20		$1204.10	$58.77	$75.26
Crew B-12N	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, 1 C.Y.		492.30		541.55		
1 F.E. Attachment, 1 C.Y.		134.20		147.60	39.16	43.07
16 L.H., Daily Totals		$1015.70		$1287.15	$63.49	$80.45
Crew B-12O	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, 1.5 C.Y.		743.60		817.95		
1 F.E. Attachment, 1.5 C.Y.		153.50		168.85	56.07	61.68
16 L.H., Daily Totals		$1286.30		$1584.80	$80.40	$99.06
Crew B-12P	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Crawler Crane, 40 Ton		743.60		817.95		
1 Dragline Bucket, 1.5 C.Y.		45.60		50.15	49.33	54.26
16 L.H., Daily Totals		$1178.40		$1466.10	$73.66	$91.64

Item 5: Dig Test Pits (cont.)

Labor Required

1	Trackhoe operator	$39.50 / hour
1	Heavy Truck Driver	$32.05 / hour
1	Laborer	$ 19.80 / hour

Total for Labor is

112 * 91.35 = 10,231.20

Field Supervision

Field Engineer @ 51.93 / hour

112 * $51.93 = 5816.16

Debris Disposal

A quote for debris disposal was obtained from Potomac Landfill. They stated that excavated solid waste could be disposed of at that facility for $8.50 / yd³

Assume 420 yd³ of Solid Wask will be excavated during Test Pit Construction

Total Debris Disposal will be 420 * $8.50 = $3570.00

WEBB MASON REV (5-96)

Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Labor-Hour	
Crew B-11L	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.55
1 Laborer	19.80	158.40	31.60	252.80		
1 Grader, 30,000 Lbs.		537.35		591.10	33.58	36.94
16 L.H., Daily Totals		$901.35		$1159.90	$56.33	$72.49
Crew B-11M	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.55
1 Laborer	19.80	158.40	31.60	252.80		
1 Backhoe Loader, 80 H.P.		285.85		314.45	17.87	19.65
16 L.H., Daily Totals		$649.85		$883.25	$40.62	$55.20
Crew B-12	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
16 L.H., Daily Totals		$389.20		$598.00	$24.33	$37.38
Crew B-12A	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 1 C.Y.		551.40		606.55	34.46	37.91
16 L.H., Daily Totals		$940.60		$1204.55	$58.79	$75.29
Crew B-12B	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 1.5 C.Y.		710.50		781.55	44.41	48.85
16 L.H., Daily Totals		$1099.70		$1379.55	$68.74	$86.23
Crew B-12C	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 2 C.Y.		975.90		1073.50	60.99	67.09
16 L.H., Daily Totals		$1365.10		$1671.50	$85.32	$104.47
Crew B-12D	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 3.5 C.Y.		2184.00		2402.40	136.50	150.15
16 L.H., Daily Totals		$2573.20		$3000.40	$160.83	$187.53
Crew B-12E	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, .5 C.Y.		332.05		365.25	20.75	22.83
16 L.H., Daily Totals		$721.25		$963.25	$45.08	$60.21
Crew B-12F	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, .75 C.Y.		450.65		495.70	28.17	30.98
16 L.H., Daily Totals		$839.85		$1093.70	$52.50	$68.36
Crew B-12G	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .5 C.Y.		427.35		470.10		
1 Clamshell Bucket, .5 C.Y		43.00		47.30	29.40	32.34
16 L.H., Daily Totals		$859.55		$1115.40	$53.73	$69.72

Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Labor-Hour	
Crew B-12H	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, 1 C.Y.		492.30		541.55		
1 Clamshell Bucket, 1 C.Y.		63.80		70.20	34.76	38.23
16 L.H., Daily Totals		$945.30		$1209.75	$59.09	$75.61
Crew B-12I	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .75 C.Y.		454.80		500.30		
1 Dragline Bucket, .75 C.Y.		32.00		35.20	30.43	33.47
16 L.H., Daily Totals		$876.00		$1133.50	$54.76	$70.85
Crew B-12J	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Gradall, 3 Ton, .5 C.Y.		630.50		693.55	39.41	43.35
16 L.H., Daily Totals		$1019.70		$1291.55	$63.74	$80.73
Crew B-12K	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Gradall, 3 Ton, 1 C.Y.		866.55		953.20	54.16	59.58
16 L.H., Daily Totals		$1255.75		$1551.20	$78.49	$96.96
Crew B-12L	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .5 C.Y.		427.35		470.10		
1 F.E. Attachment, .5 C.Y.		50.60		55.65	29.87	32.86
16 L.H., Daily Totals		$867.15		$1123.75	$54.20	$70.24
Crew B-12M	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .75 C.Y		454.80		500.30		
1 F.E. Attachment, .75 C.Y.		96.20		105.80	34.44	37.88
16 L.H., Daily Totals		$940.20		$1204.10	$58.77	$75.26
Crew B-12N	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, 1 C.Y.		492.30		541.55		
1 F.E. Attachment, 1 C.Y.		134.20		147.60	39.16	43.07
16 L.H., Daily Totals		$1015.70		$1287.15	$63.49	$80.45
Crew B-12O	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, 1.5 C.Y.		743.60		817.95		
1 F.E. Attachment, 1.5 C.Y.		153.50		168.85	56.07	61.68
16 L.H., Daily Totals		$1286.30		$1584.80	$80.40	$99.06
Crew B-12P	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Crawler Crane, 40 Ton		743.60		817.95		
1 Dragline Bucket, 1.5 C.Y.		45.60		50.15	49.33	54.26
16 L.H., Daily Totals		$1178.40		$1466.10	$73.66	$91.64

Item 5: Dig Test Pits (cont.)

Total Cost for Item 5 is

Equipment:	18,224.64
Labor:	10,231.20
Supervision:	5816.16
Disposal:	3570.00

Total $37,842

Item 6: Expand Test Pits

It is assumed that during Test Pit constructed over digging by 25% will be required therefore the following additional costs are expected

Equipment

Trackhoe	$121.99/hour	for 28 hours
Dump Truck	$40.73/hour	for 28 hours

Equipment Sub total $4556.16

Item 6: Expand Test Pits (cont.)

Labor

Trackhoe Operator	$39.50/hour	for 28 hours
Dump Truck Driver	$32.05/hour	for 28 hours
Laborer	$19.80/hour	for 28 hours

Subtotal for labor $2557.80

Field Supervision

Field Engineer @ 51.93/hour for 28 hours

Subtotal for supervision 1454.04

Debris Disposal

Assumed 105 yd³ of debris is removed during expansion of Test Pit excavation. Potomac Landfill has quoted a disposal cost of $8.50/yd³ to dispose of solid waste.

Subtotal for Debris Disposal $892.50

Total for Item Six is

Equipment	4556.16
Labor	2557.80
Supervision	1454.04
Disposal	892.50
Total	$9461.00

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Item 7: Confirmatory Sampling

This sampling program will be conducted in two phase. The first phase will consist of Field Screening Tests. These tests will be conducted by the persons responsible for field supervision of the construction of test pits during the time that the test pits are being excavated.

The second phase of this sampling program will be analysis of split samples of a representative part of the samples which were screened in the field. ES & E Laboratories provided a Quote for the cost of purchasing the Field Screening Test at $150/Test and a quote of $754/sample to analyze the representative soil samples collected for Lab analysis.

The following number of field screening and samples requiring lab analysis are anticipated.

Location	Field Screens	Lab Samples	Cost
AREE 2/5	10	4	$ 4516
AREE 3	5	4	$ 3766
AREE 4	10	4	$ 4516
AREE 6	5	4	$ 3766

Total Cost of Item 7 $16,564

Item 8: Disposal of Soil and Sediment with PCBs

Clean Harbours, Inc. was contacted to provide a cost estimate for excavation and disposal of soils and sediments which contain PCBs.

Their costs are as follows:

Excavation of soils $6.50 / yd^3

Transport and Dispose of Soils/Sediment w/ PCB concentration $\geq$ 50 ppm $430 / yd^3

Transport and Dispose of Soils/Sediment w/ PCB concentration $<$ 50 ppm 30/yd^3

The following quantities of soils/sediment containing PCBs are assumed for this Budgetary Cost Estimate.

Soils $\geq$ 50 ppm PCB

Location	Quantity	Cost
AREE 1	75 yd^3	32,737.50

Soils $<$ 50 ppm PCBs

AREE 1	370	13,505
AREE 2/5	20	730
AREE 3	9	328.50
AREE 4	12	438
AREE 6S	14	511
Total Cost for Item 8		$48,250

Item 9: Restore wetlands

Virginia Solid Waste Management Regulation require all debris be removed from wetlands. Also Representatives from the VDEQ have given a TBC for PCBs in sediment limit of 1ppm. Therefore it is anticipated that restoration of wetlands will be required in OU1.

Restoration of the wetlands will require Soil Replacement and Revegetation.

The following amounts and costs are assumed.

Soil Replacement

Location	Quantity (tons)	Cost ($560/ton)
AREE 1	0.5	$ 230
AREE 2/5	0.2	$112
AREE 3	0.3	$168
AREE 4	0.4	$ 224
AREE 66	0.4	$ 225
	Subtotal	1008

Revegetation

Location	Quantity (yd²)	Cost ($15 yd²)
AREE 1	5	$ 75
AREE 2/5	4	$ 60
AREE 3	3	$ 45
AREE 4	2	$ 30
AREE 66	1	$ 15
		$ 225

Total for Item 9 $1233

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Item 10: Groundwater Monitoring

Groundwater samples will be collected and analyzed for one year on a quarterly basis in AREEs 2/5, 3, 4 and 6b to demonstrate the requirements for clean closure have been met. ES&E Laboratories was contacted to obtain a quote for the cost of analyzing these samples.

The follow costs were stated

PAHs	222
TAL inorganics	292
Water Quality Parameters	100
PCBs	221

Labor and shipping costs bring the cost of one sample to $1,962 / sample

A total of 4 samples per AREE for one year on a quarterly basis mean 64 samples will be collected and analyzed.

Therefore Total cost for Item 10 will be

64 * $ 1,962 = $125,568

Item 11: Geophysical Survey

Geophysical surveys will be conducted in the areas of AREE 1 & AREE 6a to delineate the extent of buried debris. Sub surface Detection Investigations Inc. was contacted and confirmed a price of $1,000/acre for conducting Geophysical Surveying activities.

The following Acerages are anticipated

Location	Acerage	Cost
AREE 1	2	$2,000
AREE 6a	4	$4,000

Total Cost for Item 11 is $6,000.

Item 12: Clear and Grub

Clear & Grub w/ Trees up to 12" in Diameter from Means Page 32. is $6,000/Acre, (Value in means is $5450 but greater travel distances are anticipated for this site)

	Quantity	Cost
AREE 1	1 Acre	$6,000
AREE 6a	1.5 Acres	$9000

020 | Subsurface Investigation & Demolition

020 750 | Concrete Removal

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	1996 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
758	4100	Stone, soft old mortar	A-1	1.50	5.333	Ea.		106	40	146	213	758
	4120	Hard mortar	↓	1	8	↓		158	60	218	320	
880	0010	REMOVAL OF UNDERGROUND STORAGE TANKS R020-880										880
	0011	Petroleum storage tanks, non-leaking										
	0100	Excavate & load onto trailer										
	0110	3000 gal. to 5000 gal. tank	B-14	5	9.600	Ea.		201	41.50	242.50	365	
	0120	6000 gal to 8000 gal tank	↓	4	12	↓		251	52	303	455	
	0130	9000 gal to 12000 tank	↓	3	16	↓		335	69.50	404.50	605	
	0190	Known leaking tank add				%				100%	100%	
	0200	Remove sludge, water and remaining product from bottom										
	0201	of tank with vacuum truck										
	0300	3000 gal to 5000 gal tank	A-13	10	.800	Ea.		19.75	49.50	69.25	85	
	0310	6000 gal to 8000 gal tank	↓	8	1	↓		24.50	62	86.50	106	
	0320	9000 gal to 12000 gal tank	↓	6	1.333	↓		33	82.50	115.50	142	
	0390	Dispose of sludge off-site, average				Gal.					2.45	
	0400	Insert solid carbon dioxide "dry ice" to produce inert gas										
	0401	For cleaning & transporting tanks (1.5 lbs./100 gal. capacity)	1 Clab	500	.016	Lb.	1	.32		1.32	1.61	
	1020	Haul tank to certified salvage dump, 100 miles round trip										
	1023	3000 gal. to 5000 gal. tank				Ea.				525	600	
	1026	6000 gal. to 8000 gal. tank				↓				625	690	
	1029	9,000 gal. to 12,000 gal. tank				↓				850	935	
	1100	Disposal of contaminated soil to landfill										
	1110	Minimum				C.Y.					150	
	1111	Maximum				"					310	
	1120	Disposal of contaminated soil to										
	1121	bituminous concrete batch plant										
	1130	Minimum				C.Y.					49	
	1131	Maximum				"					100	
	2010	Decontamination of soil on site including poly tarp on top & bottom										
	2011	Soil containment berm, and chemical treatment										
	2020	Minimum	B-11C	100	.160	C.Y.	5.30	3.64	2.08	11.02	13.85	
	2021	Maximum	"	100	.160	↓	6.55	3.64	2.08	12.27	15.20	
	2050	Disposal of decontaminated soil, minimum									58	
	2055	Maximum				↓					100	

021 | Site Preparation & Excavation Support

021 100 | Site Clearing

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	1996 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
104	0010	CLEAR AND GRUB, Cut & chip light, trees to 6" diam.	B-7	1	48	Acre		1,025	1,125	2,150	2,850	104
	0150	Grub stumps and remove	B-30	2	12			268	785	1,053	1,275	
	0160	Clear & grub brush including stumps	"	.58	41.379			925	2,700	3,625	4,400	
	0200	Cut & chip medium, trees to 12" diam.	B-7	.70	68.571			1,450	1,600	3,050	4,075	
	0250	Grub stumps and remove	B-30	1	24			535	1,575	2,110	2,550	
	0260	Clear & grub dense brush including stumps	"	.47	51.064			1,150	3,350	4,500	5,450	
	0300	Cut & chip heavy, trees to 24" diam.	B-7	.30	160			3,375	3,750	7,125	9,475	
	0350	Grub stumps and remove	B-30	.50	48			1,075	3,150	4,225	5,100	
	0400	If burning is allowed, reduce cut & chip				↓					40%	
	3000	Chipping stumps, to 18" deep, 12" diam.	B-86	20	.400	Ea.		10.30	8	18.30	24.50	
	3040	18" diameter	↓	16	.500	↓		12.85	10	22.85	31	
	3080	24" diameter	↓	14	.571	↓		14.70	11.40	26.10	35	

Item 12: Clear and Grub (cont.)

Transport and Dispose of Clear and Grub material
Cost Estimate received from BFI, Inc.
was $275/yd³ container.

Location	Quantity (30yd³ boxes)	Cost
AREE 1	4	1100
AREE 6a	6	1650
		2750

Total Cost for Item 12: $17,750

Item 13: Slope Stabilization

Trackhoe at 121.99 /hour for 64 hours

Time Estimates are

AREE 1 → 40 hours
AREE 6a → 24 hours

Trackhoe Operator and Spotter @ $65/hour for 64 hours

Field Engineer at $48.01/hour for 64 hours

Total for Item 13 is $15,066

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Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Labor-Hour	
Crew B-11L	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.55
1 Laborer	19.80	158.40	31.60	252.80		
1 Grader, 30,000 Lbs.		537.35		591.10	33.58	36.94
16 L.H., Daily Totals		$901.35		$1159.90	$56.33	$72.49
Crew B-11M	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.55
1 Laborer	19.80	158.40	31.60	252.80		
1 Backhoe Loader, 80 H.P.		285.85		314.45	17.87	19.65
16 L.H., Daily Totals		$649.85		$883.25	$40.62	$55.20
Crew B-12	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
16 L.H., Daily Totals		$389.20		$598.00	$24.33	$37.38
Crew B-12A	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 1 C.Y.		551.40		606.55	34.46	37.91
16 L.H., Daily Totals		$940.60		$1204.55	$58.79	$75.29
Crew B-12B	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 1.5 C.Y.		710.50		781.55	44.41	48.85
16 L.H., Daily Totals		$1099.70		$1379.55	$68.74	$86.23
Crew B-12C	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 2 C.Y.		975.90		1073.50	60.99	67.09
16 L.H., Daily Totals		$1365.10		$1671.50	$85.32	$104.47
Crew B-12D	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, 3.5 C.Y.		2184.00		2402.40	136.50	150.15
16 L.H., Daily Totals		$2573.20		$3000.40	$160.83	$187.53
Crew B-12E	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, .5 C.Y.		332.05		365.25	20.75	22.83
16 L.H., Daily Totals		$721.25		$963.25	$45.08	$60.21
Crew B-12F	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Hyd. Excavator, .75 C.Y.		450.65		495.70	28.17	30.98
16 L.H., Daily Totals		$839.85		$1093.70	$52.50	$68.36
Crew B-12G	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .5 C.Y.		427.35		470.10		
1 Clamshell Bucket, .5 C.Y		43.00		47.30	29.40	32.34
16 L.H., Daily Totals		$859.55		$1115.40	$53.73	$69.72

Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Labor-Hour	
Crew B-12H	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, 1 C.Y.		492.30		541.55		
1 Clamshell Bucket, 1 C.Y.		63.80		70.20	34.76	38.23
16 L.H., Daily Totals		$945.30		$1209.75	$59.09	$75.61
Crew B-12I	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .75 C.Y.		454.80		500.30		
1 Dragline Bucket, .75 C.Y.		32.00		35.20	30.43	33.47
16 L.H., Daily Totals		$876.00		$1133.50	$54.76	$70.85
Crew B-12J	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Gradall, 3 Ton, .5 C.Y.		630.50		693.55	39.41	43.35
16 L.H., Daily Totals		$1019.70		$1291.55	$63.74	$80.73
Crew B-12K	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Gradall, 3 Ton, 1 C.Y.		866.55		953.20	54.16	59.58
16 L.H., Daily Totals		$1255.75		$1551.20	$78.49	$96.96
Crew B-12L	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .5 C.Y.		427.35		470.10		
1 F.E. Attachment, .5 C.Y.		50.60		55.65	29.87	32.86
16 L.H., Daily Totals		$867.15		$1123.75	$54.20	$70.24
Crew B-12M	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, .75 C.Y		454.80		500.30		
1 F.E. Attachment, .75 C.Y.		96.20		105.80	34.44	37.88
16 L.H., Daily Totals		$940.20		$1204.10	$58.77	$75.26
Crew B-12N	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, 1 C.Y.		492.30		541.55		
1 F.E. Attachment, 1 C.Y.		134.20		147.60	39.16	43.07
16 L.H., Daily Totals		$1015.70		$1287.15	$63.49	$80.45
Crew B-12O	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Power Shovel, 1.5 C.Y.		743.60		817.95		
1 F.E. Attachment, 1.5 C.Y.		153.50		168.85	56.07	61.68
16 L.H., Daily Totals		$1286.30		$1584.80	$80.40	$99.06
Crew B-12P	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Equip. Oper. (crane)	$26.75	$214.00	$41.10	$328.80	$24.33	$37.38
1 Equip. Oper. Oiler	21.90	175.20	33.65	269.20		
1 Crawler Crane, 40 Ton		743.60		817.95		
1 Dragline Bucket, 1.5 C.Y.		45.60		50.15	49.33	54.26
16 L.H., Daily Totals		$1178.40		$1466.10	$73.66	$91.64

Item 1f: Construct Covers

Purchase and Delivery of Fill. Fill must meet requirements of a low permeability soil, as measured by its vertical permeability. Engineer's estimate of cost per yd3 is $11/yd3.

Required Amounts

Location	Quantity (yd3)	Cost
AREE1	2420	$26,620
AREE6a	7260	$79,860

Subtotal for purchase & delivery of Low Permeability Soil $106,480

Local Vendors of Topsoil was contacted and an average price for Topsoil was estimated to be $15/yd3

Required Amounts

Location	Quantity (yd3)	Cost
AREE1	66	990
AREE6a	242	3630

Sub Total Cost for purchase & delivery of Top soil is $4620

Low permeability soil and Top soil will be spread and compacted in 6" lifts.

Woodbridge Research Facility
Focused Feasibility Study for OU 1
Budgetary Costs for Alternative Six

DESIGNED BY KSM DATE 4.4.
CHECKED BY DATE

Estimated Times for the two AREEs are

Location	Total Hours to spread & Compact Covers
AREE 1	40
AREE 6a	72

Required Equipment

Front End Loader cost of $86/hour (from Means)

Labor Requirements

One Operator @ a cost of $35/hour (from Means)

Supervision

Field Engineer @ a cost of $50/hour (from Means)

Labor & Equipment Subtotal for

AREE 1 $16840

AREE 6a $12,312

Total Cost for Item 14 $130,252

WEBB MASON REV (5-96)

Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Labor-Hour	
Crew B-10K	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 Centr. Water Pump, 6"		167.85		184.65		
1-20 Ft. Suction Hose, 6"		20.40		22.45		
2-50 Ft. Disch. Hoses, 6"		32.80		36.10	18.42	20.26
12 L.H., Daily Totals		$505.85		$685.60	$42.15	$57.13
Crew B-10L	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 Dozer, 75 H.P.		282.90		311.20	23.58	25.93
12 L.H., Daily Totals		$567.70		$753.60	$47.31	$62.80
Crew B-10M	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 Dozer, 300 H.P.		1111.00		1222.10	92.58	101.84
12 L.H., Daily Totals		$1395.80		$1664.50	$116.31	$138.71
Crew B-10N	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 F.E. Loader, T.M., 1.5 C.Y		363.30		399.65	30.28	33.30
12 L.H., Daily Totals		$648.10		$842.05	$54.01	$70.17
Crew B-10O	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 F.E. Loader, T.M., 2.25 C.Y.		492.35		541.60	41.03	45.13
12 L.H., Daily Totals		$777.15		$984.00	$64.76	$82.00
Crew B-10P	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 F.E. Loader, T.M., 2.5 C.Y.		817.40		899.15	68.12	74.93
12 L.H., Daily Totals		$1102.20		$1341.55	$91.85	$111.80
Crew B-10Q	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 F.E. Loader, T.M., 5 C.Y.		1136.00		1249.60	94.67	104.13
12 L.H., Daily Totals		$1420.80		$1692.00	$118.40	$141.00
Crew B-10R	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 F.E. Loader, W.M., 1 C.Y.		233.00		256.30	19.42	21.36
12 L.H., Daily Totals		$517.80		$698.70	$43.15	$58.23
Crew B-10S	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 F.E. Loader, W.M., 1.5 C.Y.		309.70		340.65	25.81	28.39
12 L.H., Daily Totals		$594.50		$783.05	$49.54	$65.26
Crew B-10T	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 F.E. Loader, W.M., 2.5 C.Y.		426.75		469.45	35.56	39.12
12 L.H., Daily Totals		$711.55		$911.85	$59.29	$75.99

Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Labor-Hour	
Crew B-10U	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$3
.5 Laborer	19.80	79.20	31.60	126.40		
1 F.E. Loader, W.M., 5.5 C.Y.		896.10		985.70	74.68	82.14
12 L.H., Daily Totals		$1180.90		$1428.10	$98.41	$119.01
Crew B-10V	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 Dozer, 700 H.P.		2873.00		3160.30	239.42	263.36
12 L.H., Daily Totals		$3157.80		$3602.70	$263.15	$300.23
Crew B-10W	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 Dozer, 105 H.P.		419.50		461.45	34.96	38.45
12 L.H., Daily Totals		$704.30		$903.85	$58.69	$75.32
Crew B-10X	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 Dozer, 410 H.P.		1309.00		1439.90	109.08	119.99
12 L.H., Daily Totals		$1593.80		$1882.30	$132.81	$156.86
Crew B-10Y	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equip. Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$23.73	$36.87
.5 Laborer	19.80	79.20	31.60	126.40		
1 Vibratory Drum Roller		338.45		372.30	28.20	31.02
12 L.H., Daily Totals		$623.25		$814.70	$51.93	$67.9
Crew B-11	Hr.	Daily	Hr.	Daily	Bare Costs	In. O&P
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.55
1 Laborer	19.80	158.40	31.60	252.80		
16 L.H., Daily Totals		$364.00		$568.80	$22.75	$35.55
Crew B-11A	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.55
1 Laborer	19.80	158.40	31.60	252.80		
1 Dozer, 200 H.P.		852.90		938.20	53.31	58.64
16 L.H., Daily Totals		$1216.90		$1507.00	$76.06	$94.19
Crew B-11B	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.55
1 Laborer	19.80	158.40	31.60	252.80		
1 Dozer, 200 H.P.		852.90		938.20		
1 Air Powered Tamper		13.80		15.20		
1 Air Compr. 365 C.F.M.		191.45		210.60		
2-50 Ft. Air Hoses, 1.5" Dia.		12.80		14.10	66.93	73.63
16 L.H., Daily Totals		$1434.95		$1746.90	$89.68	$109.18
Crew B-11C	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.55
1 Laborer	19.80	158.40	31.60	252.80		
1 Backhoe Loader, 48 H.P.		207.90		228.70	12.99	14.29
16 L.H., Daily Totals		$571.90		$797.50	$35.74	$49.84
Crew B-11K	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Equipment Oper. (med.)	$25.70	$205.60	$39.50	$316.00	$22.75	$35.5
1 Laborer	19.80	158.40	31.60	252.80		
1 Trencher, 8' D., 16" W.		510.90		562.00	31.93	35.12
16 L.H., Daily Totals		$874.90		$1130.80	$54.68	$70.67