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REPORT ON

FINAL (100%) DESIGN FOR PERMEABLE REACTIVE SUBSURFACE BARRIER (PRB) AND SURFACE IMPERMEABLE CAP SYSTEM FORMER ARROWHEAD PLATING FACILITY MONTROSS, VIRGINIA

VOLUME I of II

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April 2001

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GOLDER SIERRA

April 25, 2001

996-1100

Saltire Industrial, Inc.
12030 Sunrise Valley Dr.
Reston, VA 20191

Attn: Mr. Nicholas Bauer
Project Coordinator

RE: FINAL (100%) DESIGN FOR SUBSURFACE PERMEABLE REACTIVE BARRIER (PRB) AND SURFACE IMPERMEABLE CAP SYSTEM FORMER ARROWHEAD PLATING FACILITY MONTROSS, VIRGINIA

Dear Mr. Bauer:

Golder Sierra LLC (Golder) is pleased to submit this Final (100%) Design for a Subsurface Permeable Reactive Barrier (PRB) and Surface Impermeable Cap System to be installed at the Former Arrowhead Plating Facility in Montross, Virginia as part of the Remedial Action of Operable Unit 2 (OU-2). This Final (100%) Design submittal addresses comments provided by USEPA and VDEQ on the Pre-Final (90%) Design submittal for the PRB and Cap System.

Golder appreciates the opportunity of assisting Saltire Industrial, Inc. on this project. If you have any questions, please do not hesitate and contact Grant Hocking at (770) 496-1893 in our Atlanta office.

Very truly yours,

GOLDER SIERRA LLC

Grant Hocking, Ph.D.
President

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EXECUTIVE SUMMARY

The design, performance monitoring and remedial action work plan activities are detailed in this report for the construction of an iron Permeable Reactive Barrier (PRB) and an impermeable surface Cap System at the Former Arrowhead Plating Facility Superfund Site. The objective of the PRB and Cap System is to degrade VOC contaminants in the Site groundwater to non-toxic end products.

The PRB is proposed to be constructed by the azimuth controlled vertical hydrofracturing technology, be approximately 1200' in length, orientated approximately perpendicular to the groundwater flow regime, 3" to 4-1/2" in average iron-effective-thickness and extend from a depth of 15' down to a total depth of 42' to the underlying aquitard. The PRB is considered to have sufficient longevity and effectiveness at the Site for at least a minimum of ten (10) to fifteen (15) years. The Cap System is proposed to cover four and one half (4-1/2) acres and limit infiltration of rainfall into the subsurface and enhance the PRB performance by reducing the flux of groundwater VOC contaminants entering the PRB system. The iron PRB and Cap System is considered to be the most cost-effective remedy for the groundwater (OU-2).

The PRB and Cap System design methodology involved detailing functional design requirements and design criteria for the reactive barrier and impermeable surface cap. The Cap System design utilized a Site-wide groundwater model of the upper aquifer to predict Cap performance and in particular the reduction in groundwater hydraulic gradients across the proposed PRB alignment. The PRB design utilized a multi-specie VOC probabilistic model to quantify the overall reactive barrier system performance and the impact of system parameters on the barrier performance based on their expected variability. The system parameters consist of Site hydraulic conductivity, hydraulic gradients, barrier thickness and porosity, VOC compound degradation half lives, VOC daughter product generation and influent VOC concentrations. The probabilistic analyses quantified the sensitivity of the overall system performance to each system input parameter.

This design report details the Construction Drawings and Technical Specifications for the construction of the iron PRB and impermeable Cap System. The report also details the installation, instrumentation and monitoring requirements to ensure the reactive barrier and Cap System are constructed as planned and function as expected. Quality assurance functions and procedures are presented in the report for the installation and performance monitoring of the PRB and Cap System.

The design and remedial action work plan activities involved the development of various plans and procedures as outlined in the following plans included in this report.

- ❑ Construction Quality Assurance Plan;
- ❑ Performance Standard Verification Plan;
- ❑ Groundwater Monitoring Plan;
- ❑ Contingency Plan;
- ❑ Health and Safety Plan;
- ❑ Operation and Maintenance Plan;
- ❑ Quality Assurance Project Plan; and
- ❑ Waste Management Plan.

1.0 INTRODUCTION

Golder Sierra LLC (Golder) was retained by Saltire Industrial, Inc. (Saltire) to design an in-situ iron permeable reactive barrier system (PRB) and surface impermeable Cap System to be constructed at the former Arrowhead Plating facility (the Site), located in Montross, Virginia, as shown on Figure 1. The design of the PRB is being performed in accordance with the April 11, 2000 PRB Remedial Design Work Plan (RDWP). The proposed full scale PRB is 1,165ft in length, installed from a depth of 15 ft below ground surface (bgs) to a total depth of 40-ft bgs and the proposed Cap System covers an area of approximately four and one half (4-1/2) acres. The proposed location of the PRB is along a portion of the property boundary of the Site and the Cap System covers the northeastern portion of the Site, as shown on Figure 2.

The objective of the final design is to develop a permeable reactive barrier and Cap System that will significantly reduce the levels of volatile organic compounds (VOCs) and metals encountered in the groundwater. In general, the design of the PRB and Cap System involved the following:

- ❑ Review of geotechnical, hydrogeological and groundwater chemistry data for the Site collected during previous investigation and the additional data collected during the PRB Pre-Design Field Investigation Program;
- ❑ Iron reactivity column testing for quantifying VOC degradation rates in the Site groundwater and also to address any precipitation or clogging issues of the iron filings proposed for the PRB;
- ❑ Geotechnical and specialized PRB testing of the Site soils and the proposed iron filings;
- ❑ Detailed site survey for topography and surface water drainage patterns;
- ❑ Identifying existing site features and structures;
- ❑ Review of climate data (precipitation, temperature, etc);
- ❑ Design of the Cap System utilizing the infiltration (HELP) model and a site wide regional groundwater model;
- ❑ Design of the PRB utilizing a probabilistic model for predicting effluent concentrations of VOCs in the groundwater emanating from the PRB;
- ❑ Evaluation of PRB construction methods suitable for the Site;

- Preparation of construction drawings and specifications for installation and construction of the PRB and Cap System; and

- Preparation of construction schedule and cost estimates for construction of the PRB and Cap System.

The following subcontractors were retained by Golder to provide services during PRB pre-design field investigation program, installation of the new monitoring well, shallow and deep soil borings, direct push groundwater sampling, site wide surface and groundwater sampling and investigation derived waste management activities:

- Drilling and groundwater monitoring well installation services were provided by Chesapeake Geosystems, Inc. of Baltimore, Maryland;

- Surveying services were provided by Baldwin and Gregg, Ltd. of Norfolk, Virginia;

- Groundwater and investigation derived waste (IDW) characterization analytical laboratory services were provided by Accutest Laboratories of Dayton, New Jersey;

- Groundwater analytical data validation services were provided by TechLaw, Inc. of Lakewood, Colorado;

- Investigation derived waste temporary storage services (roll-off containers) transportation and disposal were provided by Clean Harbors Environmental Services, Inc. of Colonial Heights, Virginia under agreement with Saltire Industrial, Inc.; and

- Iron column bench scale testing services were provided by EnviroMetal Technologies Inc. (ETI) of Waterloo, Ontario, Canada.

This report is divided into the following sections:

- Section 1 provides an introduction to the report, objectives and background information;

- Section 2 provides a brief description of the Site;

- Section 3 provides a summary of the selected remedy including a background of the iron PRB systems technology, reactivity of zero valent iron, iron emplacement methods, and the design requirements and criteria for the system;

- Section 4 discusses the PRB pre-design field investigation including groundwater and surface water sampling, deep boring investigation, and direct push sampling;

- Section 5 presents the results of the iron column bench scale treatability study conducted to quantify VOC degradation in the Site groundwater in the presence of iron;

- Section 6 presents the geotechnical and specialized PRB laboratory tests conducted on the Site soils and various grades of iron filings and gels. This section provides the methodology used for the laboratory testing and interpretation of the test results;

- Section 7 presents the Cap System design. This section describes the design components, the design approach, and the expected Cap System performance and impact on the PRB Design;

- Section 8 presents the iron PRB design. This section describes the design components, the design approach, and the expected PRB performance;

- Section 9 describes the proposed PRB installation method;

- Section 10 details the construction of the Cap System including site preparation, construction drawings, technical specifications, construction quality assurance, construction sequence schedule, construction quantities and cost and surface water management, Cap System maintenance and cost;

- Section 11 details the construction of the PRB including site preparation, construction drawings and technical specifications, performance monitoring system installation, construction quality assurance and monitoring, construction sequence schedule, construction quantities and cost; and

- Section 12 presents the summary and conclusions of the final PRB and Cap System design.

These sections are supported by tables and figures, which summarize laboratory data from analytical and geotechnical tests, illustrate geologic and hydrogeologic interpretations from earlier field investigations, and depict the PRB and Cap System design. Supporting geotechnical, contaminant degradation and analytical information is included in the appendices and the following plans and construction details are included in the following appendices.

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2.0 BRIEF DESCRIPTION OF SITE

2.1 Site Background

The Site is located on a 30-acre parcel in a rural area, two miles southeast of Montross, Westmoreland County, Virginia, as shown on Figure 1 and the Site plan is presented on Figure 2. Industrial activities at the Site have been carried out since 1966. These activities included electroplating cosmetic cases, filling cases with cosmetics, and fabrication of automobile wire harnesses. Electroplating wastes were treated at the Site in a settling pond system and discharged to Scates Branch in accordance with a National Pollutant Discharge Elimination System (NPDES) permit. In general, the topography at the Site is relatively flat. The Site is located on a topographic high with a maximum elevation of 150 feet mean sea level (msl).

Studies conducted at the Site indicated groundwater contaminated with volatile organic constituents (VOCs) and limited soil contamination with VOCs, metals, and cyanide. Remedial actions were initiated in 1986 and included several phases of drum, soil, and sludge removal and backfilling, grading, and revegetation of the former ponds.

In 1989, the United States Environmental Protection Agency (USEPA) entered into an Administrative Order on Consent that required Saltire (formerly Scovill, Inc.) to conduct Remedial Investigation (RI) and Feasibility Studies (FS) at the Site. Following the completion of the RI/FS by ICF Kaiser, a Record of Decision (ROD) was issued by the USEPA on September 30, 1991. The ROD required the implementation of an in-situ vacuum extraction of VOC contaminated soils, and implementation of a groundwater pump-and-treat system. Based on additional work conducted at the Site, Saltire demonstrated that the pump-and-treat system could be replaced by a PRB with an equal or better effectiveness in treating contaminated groundwater. In September 1998, the USEPA issued an Explanation of Significant Differences (ESD) approving the PRB as the select remedy for the Operable Unit 2 (OU2) – Groundwater. Based on the ESD, a RDWP for the PRB was submitted to the USEPA by ICF Kaiser on December 18, 1998. The December 18, 1998 RDWP for the PRB was revised by Golder and submitted final to USEPA and VDEQ on April 11, 2000.

2.2 Surface Site Characterization

The Site is located within the northern neck of the Coastal Plain Physiographic Province of Virginia. The surface topography of the Coastal Plain is characterized by gently rolling to relatively flat relief. Natural surface drainage is conducted through radial and trellis drainage networks, which in turn discharge to the southeast flowing tidal rivers of the Chesapeake Bay.

In general, the topography over much of the Site is relatively flat but steepens considerably near surface water drainage features. The Site is located on a topographic high with a maximum elevation of 150 feet mean sea level (msl). The surface water drainage pattern is radial from the Site area, however, the main drainage occurs to the northeast to Scates Branch, which, in turn, discharges into Weavers Millpond. Groundwater flow directions generally parallel that of surface water, with recharge generated in the higher elevations, and discharge along streams at lower elevations. In turn, drainage divides often coincide with groundwater divides.

2.3 Subsurface Site Characterization

Groundwater flow directions generally parallel that of surface water, with recharge generated in the higher elevations, and discharge along streams at lower elevations. In turn, drainage divides often coincide with groundwater divides. Public and private wells within the area tap groundwater for potable and industrial use.

Regionally, the subsurface geology is comprised of gently eastward-dipping interbedded sands, silts and clays. These sediments form a seaward dipping wedge that was deposited on more competent basement rocks. The sands, silts and clays were deposited in a gradually retreating shallow marine to open marine environment. These sediments have been classified into three main stratigraphic regional groups (in increasing depth and age): Chesapeake, Pamunkey and Potomac. Within each group, interbedded sand, silt and clay formations have been recognized and have been regionally correlated. These sediments comprise regional aquifers and confining units, and have been further subdivided into hydrostratigraphic units.

The sediments of the Chesapeake Group directly underlie the Site, and the uppermost unconfined aquifer is contained within these sediments. The interbedded upper sands, silts and clays that comprise the Yorktown/Eastover unconfined aquifer unit reach a maximum thickness of 40 feet beneath the Site. Underlying the upper aquifer, clays and silts that comprise the St. Mary's confining unit have an approximate thickness of at least 70 feet. This confining unit is regional in extent and separates the upper aquifer from the underlying confined aquifers contained within the lower (and much deeper) Pamunkey and Potomac Groups. Regional hydrogeologic studies have shown that a downward vertical gradient exists between the upper aquifer and the next lower confined aquifer (Chickahominy-Piney Point aquifer of the Pamunkey Group). The silt and clay of the St. Mary's create a relatively impermeable hydrogeologic barrier, preventing the downward vertical flow of groundwater.

The Site lies just to the northeast of a local topographic high, running northwest-southeast, which acts as a surface water divide, as well as an upper aquifer groundwater divide. Locally, both groundwater and surface water flow to the northeast and southwest of this divide. Horizontal groundwater flow within the upper aquifer immediately beneath the Site is generally to the northeast, where it discharges to tributaries of the northeast-flowing Scates Branch. This stream discharges into Weavers Millpond, which discharges to the east-flowing Pierce Creek, which discharges into Nomini Bay, a tidal estuary of the southeast-flowing Potomac River.

Geologic cross sections have been constructed to illustrate the general geology of the Site. Figure 2 presents the lines of geologic sections and Figures 3, 4 and 5 provide geological cross sections of the Site. Local drainage channels define the lateral extent of the water table aquifer. A rough approximation of the extent of this unit can be drawn on a topographic map where the 100-ft msl contour represents the approximation of the extent of the shallow aquifer. Figure 6 illustrates this relationship between elevation and water table aquifer extent. This figure also depicts the highest areas (above 150 ft msl) of the Site and also illustrates the implied radial groundwater flow from these higher areas toward surface water drainage channels.

The saturated interbedded sands and silts of the upper aquifer have measured hydraulic conductivities, ranging from approximately 1.0×10^{-3} centimeters per second (cm/sec) to 1.0×10^{-5} cm/sec. This variability in hydraulic conductivity is due to the heterogeneous nature of the thin interbedded fine sands, silts and clays comprising the upper aquifer. The measured vertical hydraulic conductivity of the confining unit beneath the upper aquifer was less than 1.0×10^{-5} cm/sec, as measured in laboratory permeameter tests conducted on Shelby tube samples. The vertical hydraulic conductivity of the confining unit as measured from these two (2) laboratory tests was 1.7 x 10^{-6} cm/sec and 0.9 x 10^{-6} cm/sec, ICF Kaiser (1997). Horizontal hydraulic gradients within the upper aquifer are variable ranging from approximately 0.05 feet/foot to 0.003 feet/foot and are primarily controlled by surface topography.

The prime compounds of concern at the Site include VOCs, metals and cyanide.[1] The primary VOCs include: benzene, tetrachloroethene (PCE), trichloroethene (TCE), toluene and total xylenes. Other VOCs of concern include: 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethene, 1,2-dichloroethene (total), 1,1-dichloroethane, acetone, 2-butanone, methylene chloride, carbon disulfide, chloroform (TCM), chloroethane, 1,2-dichloroethane, 1,1,2-trichloroethane, ethylbenzene, vinyl chloride (VC) and 4-methyl-2-pentanone. Groundwater concentration maps indicate that the main VOC migration pathway is to the northeast from the on-site potential source area towards the headwaters of Scates Branch and the Middle Fork of Scates Branch.

[1] Cyanide and metals are also present at similar concentrations in background samples.

3.0 SUMMARY OF SELECTED REMEDY

Saltire and the USEPA have agreed to implement an alternative remedy for groundwater at the Arrowhead Plating Site. The major components of the newly selected groundwater remedy are described in the ESD and consist of:

- ❑ A PRB to transform dissolved VOCs into non-toxic products before groundwater discharges into the tributaries of Scates Branch;
- ❑ A surface impermeable Cap System to limit the surface water infiltration into the sub-surface immediately up gradient of the PRB;
- ❑ Implementation of an environmental monitoring plan to evaluate the effectiveness of the RA and to ensure the protection of environmental receptors in Scates Branch; and
- ❑ Implementation of appropriate institutional control measures, if needed, prohibiting the use of contaminated surficial groundwater to ensure protection of human health and the environment.

This section summarizes the selected remedy, process description of the zero valent iron technology and the design requirements and criteria for the system.

3.1 Iron Reactive Permeable Barriers

3.1.1 Background

In situ passive iron reactive permeable barriers have been placed at a number of sites, dating back to the first constructed at CFB Borden in 1991 by the University of Waterloo. The early iron reactive barriers had been designed on the funnel and gate concept, Starr and Cherry (1994). Recently continuous permeable barriers have been installed by backhoe, continuous trenchers and azimuth controlled vertical hydrofracturing. The continuous permeable barriers do not modify the natural groundwater flow; whereas funnel and gate systems do impact the natural groundwater flow.

Iron reactive permeable barriers have significant advantages over conventional technologies for remediation of chlorinated solvent contaminated groundwater, with the prime advantage being that the system is passive. It is a simple process that has been proven both in the laboratory and the field. Site characterization and laboratory bench scale studies are sufficient to design and construct an iron reactive barrier. The number of iron reactive permeable barriers installed to date is detailed in Table 1. The first reactive barrier was constructed in 1991 as a field trial, followed by two in early '95, and during the past five years a significant number of full scale and pilot systems have been installed. The rapid increase in the number of reactive barriers installed reflects the increasing maturity and acceptance of the zero valent iron technology.

3.1.2 Zero Valent Iron

Zero valent metals have been known to abiotic degrade certain compounds; such as, pesticides as described by Sweeny and Fisher (1972), and halogenated compounds such as TCE, tetrachloroethene (PCE), vinyl chloride (VC) and isomers of dichloroethene (DCE) as detailed in Gillham and O'Hannesin (1994). In the case of zero valent iron, a first order reduction process can approximate the abiotic degradation of halogenated aliphatics. The compounds are progressively degraded and eventually broken down into ethanes and ethenes, as described by Orth and Gillham (1996) and shown as reductive dehalogenation pathways on Figures 7 and 8. In the presence of iron, the chlorinated compound, TCE, is predominantly degraded through the chloroacetylene pathway with only a minor generation of daughter product c-DCE. Therefore the reductive process in the presence of iron generates significantly less daughter products than those generated due to natural degradation. In column experiments, the mol fraction of TCE degraded into chlorinated daughter products such as c-DCE and VC is typically less than 5 - 10%, Gillham and O'Hannesin (1994). Five (5) year performance data of the Borden iron reactive barrier has indicated no decline in degradation performance over time, minimal precipitation, and expectations that the reactive barrier will continue performing satisfactory for at least another five years, Gillham and O'Hannesin (1998).

3.1.3 Emplacement Methods

The placement of iron filings in the subsurface for passive in situ treatment of contaminated groundwater was first discussed by Gillham (1993). The mode of placing the iron filings has been by conventional technologies such as shoring and excavation, trenching and during the past five (5) years by azimuth controlled vertical hydrofracturing. Seven alternate emplacement techniques were considered for the construction of the PRB at the Site including a) slurry wall, b) trenching, c) braced excavation, d) jet grouting, e) hydrofracturing technology, f) driven/vibrated beam and g) soil mixing.

The selection of the most appropriate emplacement technology at the Site is to be based on the following: 1) minimal impact to the natural groundwater flow regimes, 2) proven technology (maturity of the technology and previous installation of iron reactive systems), 3) minimal impact on the lower confining layers, 4) minimal excavation and disturbance (aerial extent of the impact, noise, volumes of excavated materials, etc.), and finally 5) cost.

3.2 Applicable or Relevant and Appropriate Requirements (ARARs)

This section lists the ARARs that are required during implementation of the Remedial Action. The system must be designed to ensure compliance with these and all other applicable ARARs.

3.2.1 Compliance with ARARs

The PRB and Cap System must comply with all pertinent chemical and action-specific ARARs. The chemical and action-specific ARARs applicable to the PRB and Cap System include the following rules and regulations:

- OSHA - All field activities will be performed in accordance with health and safety regulations governing construction and other activities and activities at hazardous waste sites;
- RCRA - The remedial activities will be performed in compliance with all applicable provisions of RCRA, which include RCRA *Generator Standards and Transportation* Standards for transportation and off-site disposal of hazardous wastes; RCRA Treatment Standards for on-site disposal of hazardous wastes, including treatment to meet land disposal restrictions; and RCRA landfill Standards for design and construction of landfills;
- Clean Air Act - The remedial activities will be performed in compliance with all applicable provisions of the Clean Air Act, and its amendments;
- Virginia Environmental Quality Act - The Virginia Environmental Quality Act empowers the VADEQ to establish regulations and programs similar to the federal Resource Conservation and Recovery Act and Clean Air Act. The remedial activities will be performed in compliance with all applicable provisions of the Virginia Environmental Quality Act; and
- City of Montross Ordinances - The fencing and any temporary buildings will comply with applicable building and fire codes.

The PRB and Cap System will comply with the following specific ARARs:

- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA);
- Hazardous Waste Regulations, 9 VAC 20-60-12 to 1505;
- Regulations Governing the Transportation of Hazardous Materials, 9 VAC 20-110-10 to 130;
- Virginia Waste Management Regulations, Va. Code Ann. §§ 10.1-1400 to 1457 (1998);
- Solid Waste Management Regulations, 9 VAC 20-80-10 to 790;
- Ambient Air Quality Standards, 9 VAC 5-30-10 to 80;
- Standards of Performance for Visible Emissions and Fugitive Dust/Emissions [Rule 5-1] 9 VAC 5-50-60 to 120;
- Standards of Performance for Toxic Pollutants [Rule 5-3], 9 VAC 5-50-160 to 230;
- Environmental Protection Agency National Emission Standards for Hazardous Air Pollutants (Rule 6-1), 9 VAC 5-60-60 to 80;
- Erosion and Sediment Control Law, Va. Code Ann. §§ 10.1-560 to 571 (1998); and
- Erosion and Sediment Control Regulations, 4 VAC 50-30-10 to 110.

The PRB and Cap System will also comply with the following location specific ARARs:

- Chesapeake Bay Preservation Act, Va. Code Ann. §§ 10.1-2100 to 2116;
- Chesapeake Bay Preservation Area Designation and Management Regulations, 9 VAC 10-20-10 to 280;
- Virginia Natural Areas Preserves Act, Va. Code Ann. §§ 10.1-209 to 217 (1998);
- Endangered Species, Va. Code Ann. §§ 29.1-563 to 570 (1998);
- Department of Game and Inland Fisheries, Definitions and Miscellaneous in General, 4 VAC 15-20-130 to 140;
- Endangered Plant and Insect Species Act, Va. Code Ann. §§ 3.1-1020 to 1030 (1998);
- Rules and Regulations for the Enforcement of the Endangered Plant and Insect Species Act, 2 VAC 5-320-10;
- Virginia Wetlands Act, Code of Virginia-62.1-13.1 et seq.;
- Virginia Wetlands Regulations VR 450-01-0051;

- Clean Water Act-404;
- State Water Control Law, Code of Virginia-621-44.2 et seq.; 33 CFR 323.2(c) and 323.2(e):
- Water Quality Standard, 9 VAC 25-260-5 to 550;
- Virginia Water Protection Permit Regulation, 9 VAC 25-210-10 to 260;
- General Provisions Relating to Marine Resources Commission, Va. Code Ann. §§ 28.2-1300 to 1320 (1998);
- Wetlands Mitigation compensation Policy, VAC 20-390-10 to 50;
- Execution Order 11988. Protection of Floodplains 40 C.F.R. 6, Appendix A;
- Executive Order 11990, Protection of Wetlands, C.F.R. 5, Appendix A; and
- Procedures for Implementing the Requirements of the Council on Environmental Quality on the National Environmental Policy Act, 40 C.F.R. 6, Appendix A.

3.2.2 Real Estate, Easement and Permit Requirements

Two other important aspects of the remedial design process will involve obtaining the appropriate permits for the system (if needed) and access agreements with current property owners. As provided in Section V, Subpart D of the Consent Decree issued for the Arrowhead property and in Section 121(e) of CERCLA, 42 U.S.C.S 9621(e), and 40 C.F.R.S 300.430(e), no permits will be required for any portion of work described in the RDWP for the PRB and Cap System that will be constructed on-site. However, as stated in the Consent Decree, the work conducted on-site "...shall meet the substantive requirements of any applicable or relevant and appropriate requirement subject to the EPA's right of review and approval." Federal, state, or local permits or approvals must be obtained for off-site work when required. A portion of the PRB will be installed on neighboring properties and will require access and permit approvals as detailed in Appendix D of the RDWP (Golder 2000a). Access agreements, permitting, and compliance requirements pertinent to the implementation of the remedial activities are identified in this Appendix of the Remedial Design Work Plan (RDWP). These agreements and authorizations are needed to install and operate a remediation system on the Arrowhead and neighboring property. The Cap System will involve restrictions on land use not covered in the earlier reference appendix. Restrictive land use agreement with the current property owner and tenants will be required.

3.2.3 Design Requirements and Criteria

The PRB must be designed to significantly reduce the levels of VOCs in the groundwater. The overall design methodology for the PRB is illustrated as a flow diagram on Figure 9. The design methodology considers all Site-specific data, defines functional design requirements and design criteria for the system and determines the most appropriate system design by use of a probabilistic forecast model of barrier performance. The PRB must be designed to meet the following functional design requirements and criteria:

- The PRB design must consider geotechnical, hydrogeologic, and groundwater chemistry data collected during previous investigations of the Site;
- The PRB design must consider the use of commercially available zero valent iron filings and the selected emplacement technique;
- The PRB design must accommodate the variability of the Site data, iron reactivity column test data, and installed PRB thickness;
- The PRB must be designed for target VOC parent and daughter product VOC compounds to have effluent concentrations below their MCLs;
- The PRB must be designed to ensure any downgradient remnant plume VOC compounds are lowered over time to below their MCLs;
- The PRB must be designed so that construction quality assurance and quality control procedures can be implemented during construction; and
- The PRB must be designed with a proper monitoring system to evaluate its performance based on the ability of the system to reduce VOC groundwater concentrations.

The Cap System is an integral part of the overall PRB design and a Cap System properly designed will significantly enhance the performance of the PRB. The Cap System must be designed to minimize infiltration of precipitation into the subsurface and to the groundwater. Minimizing the precipitation infiltration rates within the Site will modify the groundwater flow regime/flow gradients within the Site and thus reduce the groundwater flux passing through the PRB. The lower groundwater flow gradients through the PRB will enable a greater reduction of VOC's in the PRB for a lesser amount of zero valent iron filings (effective thickness) required for PRB construction. The Cap System must be designed to meet the following design requirements and criteria:

- The design must consider geotechnical and hydrogeologic data collected during previous investigations of the Site;

- The design must consider weather data (precipitation, temperature, etc) applicable to the Site for Cap System design;

- The design must consider existing Site ground surface topography and structures and surface water drainage patterns;

- The design must consider the impact of Cap System on future land use;

- The design must consider Cap System maintenance (vegetation and drainage) and contingencies plan;

- The design must consider construction schedule including coordination with the property owners for the abandonment of the existing sewer lagoons and associated monitoring wells;

- The design must consider at least three (3) Cap System configurations suitable for the Site;

- The selected Cap System should be designed to have a significant reduction (1/5 to 1/10 of the average annual infiltration rates);

- The Cap System must be designed so that construction quality assurance and quality control procedures can be implemented during construction;

- The Cap System must be designed with proper surface water management, maintenance (vegetation & drainage) and contingency plans; and

- The vegetative cover of the Cap System must stabilize the cover soils, provide a low maintenance, long-term plant community, provide a structurally diverse grassland habitat for birds and other wildlife and use native plant species whose seeds are available commercially.

4.0 PRE-DESIGN FIELD INVESTIGATION

A pre-design field investigation was conducted during April 28 and May 23, 2000 in accordance with the April 11, 2000 PRB Remedial Design Work Plan (Golder 2000a). The following activities were performed:

- Collected groundwater from monitoring well MW33 for iron column bench-scale and soil resistivity testing;
- Installed monitoring well MW37 located near CPT D22 to provide monitoring of groundwater across Route 3 located on the groundwater divide;
- Collected groundwater samples from 25 existing wells and the new well MW37 for VOCs, metals, and general chemistry analysis;
- Collected soil samples and characterized the soil from four (4) geotechnical borings near CPT locations C10, D10, E10 and F12 for correlation with CPT data, and evaluation of site soils geotechnical properties for design of the PRB;
- Collected groundwater samples from four (4) depths at each of four (4) direct push locations, located near CPT points C10, D10, E10 and F12, for characterization of the groundwater contamination;
- Collected soil samples from two deep environmental soil borings, one near SBD1 and the other near CPT C6 to evaluate potential groundwater contamination;
- Collected an additional round of surface water samples at 11 pre-determined locations and one additional location identified at the time of sampling for inorganic analysis;
- Connected the Site with the Virginia State Plane Coordinate System for Survey Control; and
- Conducted a detailed topographical survey on the northeastern portion of the Site and surface water drainage patterns. Site data on storm water drainage were also collected from the current leasee of the property.

The pre-design boring investigation, direct push and monitoring wells installation locations are shown on Figure 10. Surface water sampling locations are shown on Figure 11. Groundwater monitoring wells sampling locations are shown on Figure 12. Golder personnel provided sampling services and oversight during the investigation. Drilling services were provided by Chesapeake Geosystems, Inc. of Baltimore, Maryland. Baldwin and Gregg, Ltd. of Norfolk, Virginia, provided surveying services. Accutest Laboratories of Dayton, New Jersey provided analytical testing services. TechLaw, Inc. of Lakewood, Colorado provided third-party validation of the analytical results. Data validation reports are contained in the May 2000 Sampling Event Data Validation Report (Golder 2000b). Geotechnical and PRB specialized laboratory testing was performed in Golder's laboratory in Atlanta, Georgia. Geotechnical and specialized PRB laboratory results are detailed in Appendix A. Boring and well installation logs are contained in Appendix B.

4.1 Monitoring Well Installation

Monitoring well MW37, shown on Figures 10 and 12, was installed near CPT D22 to provide additional piezometric data and allow long-term monitoring of groundwater VOCs across Route 3 located on the groundwater divide. The boring and installation logs are contained in Appendix B. Monitoring well MW37 was developed until pH, conductivity, and temperature reading stabilized to within ± 0.1 standard units, ± 10% and ± 0.5°C, respectively, and the turbidity was less than 10 NTU.

Monitoring well MW37 was surveyed to establish coordinates and elevations using the Virginia State Coordinate System. The survey data are shown on the boring and well installation logs are contained in Appendix B.

4.2 Deep Borings

Two deep borings SBD2 and SBD3 were drilled near SBD1 and CPT C6, respectively to confirm the absence of groundwater contamination within the lower aquitard. In order to minimize the potential of cross contamination between the upper aquifer and the lower aquitard, the upper 55 ft of the deep borings were cased with 8-inch steel welded casing grouted in place with 95% Portland cement/5% bentonite grout. The upper 55 ft of the deep borings were advanced using 12" roller bit mud rotary drilling techniques. The lower part of the deep borings were drilled using 3 ¼" hollow-stem augers through the steel casing from 55 ft to 111 ft bgs.

Continuous split-spoon sampling was conducted from 55 ft to 111 ft bgs for both borings. Soil samples were monitored using an organic vapor survey instrument with a photo ionization detector (PID). The PID readings were recorded on the boring logs found in Appendix B. The soils were classified according to the United Soils Classification System (USCS).

No water bearing zones (i.e. soils with a permeability greater than 1×10^{-3} cm/sec) were encountered at either boring location. Samples were collected at 8-foot intervals between 55 ft and 111 ft bgs. After each split-spoon was opened, eight (8) to twelve (12) grams of soil was collected using a disposable syringe provided by the laboratory and immediately transferred into a methanol preserved 60-ml vial. The samples were cooled to 4 °C.

Three (3) samples from each boring were selected for analytical laboratory analysis based on sample location and PID readings. The samples were tested for VOCs, metals, and cyanide. The summary of analytical results is shown on Tables 2 and 3. The analytical test results confirmed the absence of groundwater contamination within the aquitard. The only compound detected (methylene chloride) in one of the samples from SBD-3 may have been associated with laboratory contamination (see data validation report in the May 2000 Sampling Event Data Validation Report, Golder 2000b). Two samples from each boring were selected for grain size analysis and the results are presented in Appendix A. The samples had at least 25% passing the #200 sieve. Laboratory flexible wall permeameter tests were performed on two remolded samples collected from the aquitard and hydraulic conductivities quantified from these tests were 1.7×10^{-7} cm/sec and 7.5×10^{-8} cm/sec for samples SBD2 (59.0-61.0'bgs) and SBD3 (105.7-107.0'bgs) as detailed in Appendix A.

4.3 Shallow Borings

Four (4) shallow borings, SBS13, SBS10, SBS11 and SBS12, were drilled near CPT locations C10, D10, E10, and F12, respectively to confirm lithologic interpretation of the CPT data from previous investigations performed by ICF Kaiser (1997). The boring logs are presented in Appendix B as well as comparison of CPT and visual soil classification soil descriptions. Geotechnical laboratory testing was conducted to confirm field visual soil classification, and the results from these tests are contained in Appendix A.

4.4 Groundwater Sampling

Groundwater samples were collected from twenty six (26) monitoring wells and four (4) direct push locations to quantify the contaminant plume at the Site in accordance with the PRB RDWP.

4.4.1 Monitoring Well Sampling

Twenty-six (26) monitoring wells including the new monitoring well MW37 were sampled for VOCs, metals, and general chemistry analysis. Water level measurements obtained during the sampling event are summarized in Table B-1 in Appendix B, and the data are shown as potentiometric groundwater contours on Figure 13. Field parameters (pH, conductivity, turbidity, temperature, and Eh) are summarized in Table 4. The well sampling data (i.e. flow rates, etc.) are included in Table B-2 in Appendix B. Analytical laboratory test results for VOCs, metals and general chemistry are summarized in Tables 5, 6 and 7 respectively. Data validation reports are included in the May 2000 Sampling Event Data Validation Report (Golder 2000b).

4.4.2 Direct Push Sampling

Sixteen (16) groundwater direct push samples were collected, with four (4) groundwater samples collected from each of the four (4) direct push locations (C10A-D, D10A-D, E10-D and F12A-D) for VOC analysis. The existing data and conditions observed from the shallow borings (SBS13, SBS10, SBS11 and SBS12) were used to determine the depth for collection of each of the groundwater direct push samples. At least one sample from each location was collected immediately above the underlying aquitard. The summary of the analytical results can be found in Table 8. Concentration contour maps for TCE, PCE and 1,1-DCE have been prepared for the Site and are shown on Figures 14, 15 and 16, respectively. A geologic cross section showing concentrations with depth of TCE and PCE measured in the direct push samples at various depths is shown on Figure 17.

4.5 Surface Water Sampling

Surface water sampling was conducted concurrently with the groundwater sampling. Twelve (12) surface water points along Scates Branch and Reeds Swamp were sampled, at the locations shown on Figure 11. The surface water locations included surface water location SB3, a spring discovered along Scates Branch emanating from an off-site source. Field parameters (pH, conductivity, temperature, turbidity, and dissolved oxygen) of the surface water samples were measured prior to sampling, and the results are presented in Table 9. Samples were collected for metals and cyanide analysis. The summary of analytical results can be found in Table 10. Groundwater samples collected from monitoring wells MW1, MW3, MW22, MW34 and MW37 were analyzed for a full list of metals in accordance with the PRB RDWP for the surface water metals background evaluation. The analytical results of metals for these wells are also summarized in Table 10. A data validation report for the surface water samples is included in the May 2000 Sampling Event Data Validation Report (Golder 2000b).

4.6 Investigation Derived Waste Management

Drilling mud/soil waste and wastewater were generated during the PRB RDWP Pre-Design field activities at the Site. Golder field personnel supervised waste management activities. The drilling mud/soil waste and wastewater were temporarily stored at the Site in a lined roll-off container for waste characterization and proper disposal. The roll-off container was located just north of the former Drum Storage Area. The waste generated at each boring/well location was first contained in 55-gal drums located at each boring/well location and later transferred into the roll-off containers at the completion of each well installation activity. The 55-gal drums were properly sealed during transportation to the roll-off containers.

Drilling and sampling equipment decontamination activities were conducted on an existing decontamination pad (concrete) located on the north side of the manufacturing building. All waste generated from the steam cleaning was contained in the lined roll-off. Golder personnel collected samples of the wastewater and drilling mud/soil for waste characterization laboratory testing. Accutest Laboratories provided analytical laboratory services for waste characterization. Based on the laboratory analytical results, the wastewater and the drilling mud/soil were characterized as non-hazardous and the analytical laboratory results are summarized in Appendix B-5.

Field activities for the removal of the wastewater and drilling mud/soil were conducted on July 14, 2000 under Golder personnel supervision. The wastewater (1,775 gals) and the drilling mud/soils (2,875 gals) were transported directly from the Site to Clean Harbors Environmental Services Facility in Baltimore, Maryland. Clean Harbors Environmental Services also provided waste removal and transportation services.

Subsequent to the removal of the IDW from the Site, additional wastewater and drill cuttings were generated during an additional soil boring and direct push investigation. The waste (wastewater and drill cuttings) was contained in 55 gal drums properly labeled. Wastewater and drill cuttings samples were collected and sent to the laboratory for waste characterization. Results of the laboratory analysis are summarized in Appendix B-5. All waste generated during the PRB pre-design field investigation program was characterized as non-hazardous.

5.0 TREATABILITY STUDY

5.1 Iron Reactivity Column Test

5.1.1 General

In order to determine the reactivity of the granular iron considered for construction of an iron PRB at the Site, a reactive bench scale column test was conducted on a sample of medium-fine Connelly granular iron filings grade CC-1022 (-14 + 84 Mesh). EnviroMetal Technologies, Inc. (ETI) working in association with the Institute for Groundwater Research, University of Waterloo, Waterloo, Ontario, Canada conducted the bench scale iron reactivity column test. The column test was flushed with contaminated Site groundwater. A schematic of the EnviroMetal Process Column Test Apparatus is shown on Figure 18.

The objectives of the iron reactivity column test are to quantify degradation rates for the VOCs in the Site groundwater, the generation and degradation of any VOC daughter products, and the potential for precipitation and clogging of the iron due to changes in the groundwater chemistry within the PRB. The concentration of VOCs in the groundwater in the column are measured until steady state (unchanging) conditions are achieved, and at such time the groundwater VOC concentrations can be related to the residence time of the groundwater in the presence of the iron, see Figure 19. From such data degradation half-lives of the VOCs see Figure 20, and daughter product generation rates and their respective degradation half-lives can be calculated, see Figure 21.

5.1.2 Laboratory Method

The laboratory bench scale column test was conducted using the EnviroMetal Process (Gillham, 1996; Gillham and O'Hannesin, 1992 & 1994) to determine the rates of degradation of the chlorinated organic compounds that are present in the groundwater at the Site. A groundwater sample from monitoring well MW33 was collected by Golder field personnel and sent to the University of Waterloo for the iron reactivity column test.

The iron reactivity column consists of a Plexiglass™ cylinder with a length of 1.6 ft and an internal diameter of 1.5 in. Seven sampling ports are positioned along the length of the column as shown on Figure 18. The column was carefully loaded with iron, initially flushed with carbon dioxide, then distilled water, before the Site groundwater was introduced. The Site groundwater was fed into the column at a constant rate of 0.94 ft/day (PRB groundwater flow velocity <0.5 ft/day) from a collapsible Teflon® bag. Based on ETI's laboratory experience, a flow velocity of about 2 ft/day is the maximum that can be used for the type of iron tested to minimize piping/channeling conditions in the sample. Samples for organic analyses, Eh and pH were collected periodically from the sample ports along the column. Samples for both organic and inorganic tests, Eh and pH were also collected from the influent and effluent.

The concentration of a particular species was quantified along the column length at a particular time; i.e. after the column was swept by a certain number of pore volumes of the Site groundwater. Concentrations of VOCs were monitored along the column until the values at each point in the column reached a relatively "steady-state" condition. "Steady state" condition is reached when the column test shows a constant (i.e. unchanging) concentration profile along its length. The flow rate used in the test was used to calculate the residence time of groundwater relative to the influent end of the column at each sample point. The residence time was used to determine concentration versus time plots for each of the VOCs. A first-order multi-species kinetic model closely matched the degradation rates of the VOCs in the presence of zero valent iron for each VOC compound.

The degradation of VOC's in the presence of iron can be approximated by a first order degradation model. First order rate constants are quantified that best fit the degradation and daughter product pathway data, see Figures 20 and 21. The first order kinetic degradation model for a single specie is given in equation (1), the first order rate constant in equation (2), and the half life in equation (3).

$$C = C_0 e^{-\lambda_i t} \quad (1)$$

where C is the organic concentration in solution at time t, C_O is the organic concentration in solution at the initial or influent condition, i.e. at t=0, λ_i is the first order rate constant for the species and t is the residence time in the column.

$$\lambda_i = -\frac{\ln\left(\frac{C}{C_0}\right)}{t} \quad (2)$$

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The half life, $t_{0.5}$, is the time for the organic concentration to be reduced to one half of it's initial or influent concentration, i.e. rearranging equation (1) gives:

$$t_{0.5} = {0.693}/{\lambda_i} \tag{3}$$

The Connelly granular iron used in the column test was obtained from Connelly-GPM, Inc., Chicago, Illinois. Geotechnical laboratory testing was conducted on the Connelly granular iron to determine its physical properties. The medium to fine Connelly CC-1022 iron filings tested had a grain size ranging from 0.07 to 2 mm (ASTM D 421), and a specific gravity of 6.93 (particle density of 6.93 g/cm^3) (ASTM D 854). Grain size distribution and specific gravity test results are included in Appendix A-2.

Prior to column testing, a sample of the medium to fine Connelly iron was mixed with Golder's standard cross linked gel to be used for emplacement of the granular iron in the hydrofracturing process. The column sample was prepared and the column filled with 100% iron. Once the iron column was ready for testing, groundwater collected from monitoring well MW33 was flushed through the column. The column experiment was conducted at room temperature (23°C)[2]. The iron column sample had a pore volume of 316 ml, a porosity of 0.56 and a density of 165 lb/ft^3 (2.6 g/cm^3).

A representative sample (dry) of the medium to fine Connelly granular iron filings CC-1022 used for column testing was sent to Golder soils laboratory in Atlanta, Georgia for soil classification (grain size distribution and specific gravity) and permeability testing. Other Connelly iron grades and mixtures were also tested (grain size and permeability) during the selection process to determine the most appropriate type of iron that would be compatible with the site soils and various PRB installation methods. Data from these tests are contained in Appendix A-2.

[2] The column test data are extrapolated to field conditions using other iron reactivity data collected from column tests conducted over a range of temperature conditions. Generally the column test is conducted at Site groundwater temperature; however in this case the Site groundwater being 17-18°C was considered sufficiently close to laboratory temperature that extrapolation to Site conditions could be made without conducting a temperature controlled test. The degradation VOC half lives at field temperature conditions of 17-18°C were determined to be 1.75 times their respective VOC laboratory determined half life at 23°C.

5.1.3 Results

Groundwater from monitoring well MW33 as received in the laboratory contained 7,000 μg/L of tetrachloroethene (PCE), 44,000 μg/L of trichloroethene (TCE), 5,000 μg/L of 1,1-dichloroethene (11DCE), 120 μg/L of cis-1,2-dichloroethene (cDCE), 1,000 μg/L 1,1,1-trichloroethane (111TCA), 40 μg/L of 1,1,2-trichloroethane (112TCA) and 450 μg/L of tretrachloromethane (CT). Trace amounts (about 5 μg/L) of trans-1,2-dichloroethene (tDCE) were also detected in the collected groundwater. The residence time vs. concentration for the species TCE, PCE, and 1,1-DCE along the column are given on Figure 19 for steady state conditions, and similar plots for other VOCs and inorganic data are contained in Appendix C. Organic concentration data, MDLs and influent and effluent inorganic data for the column test are detailed in Appendix C.

Redox potential (Eh) profiles were measured, indicating reducing conditions generated in the column as expected. Eh decrease from an initial value of 345 mV to a value of -483 mV within the column. The pH was observed to increase from an initial value of 7.3 to 9.5 in the column. Eh and pH profiles along the iron column are included in Appendix C.

The potential for precipitation and possible clogging of the iron PRB was addressed by analysis of the inorganic analytical test data from the iron reactivity column test. For the groundwater flux estimated to pass through the full scale PRB, the potential for precipitation resulting in significant loss of porosity is considered low. The inorganic data from the column test confirmed that the Site groundwater acted similar to other laboratory studies on low carbonate groundwater. The column test confirmed that precipitation and/or clogging is not an issue for an iron PRB at this Site. The longevity of the iron PRB can not be determined from the column test; however, from field data of iron PRBs, the proposed system should function satisfactory for at least 10 to 15 years, Gillham and O'Hannesin (1998).

5.2 Degradation Model for VOCs

A VOC degradation model was developed for the Site based on the iron column test results and typical degradation rates of VOCs for similar groundwater chemistry and VOC concentrations in databases assembled by ETI (2000) and Golder (2000d). Reductive dehalogenation pathways for PCE, TCE, 1,1,1-TCA and their daughter products were presented on Figures 7 and 8. The multi-species VOC degradation model developed for the Site groundwater with associated percentage conversions from parent to daughter products is shown on Figure 21. Based on this VOC degradation model, degradation half-lives were determined for the VOCs encountered in the Site groundwater and their VOC respective daughter products generated in the presence of the iron filings.

Half lives for TCE and PCE were determined to be 3.5 and 4 hours, respectively. The flow velocity of the column test was reduced from 0.94 ft/day to 0.39 ft/day after 40 pore volumes when the column had reached "steady state" conditions in order to further evaluate degradation rates for cDCE and VC. Estimated half lives for cDCE, tDCE and VC including generation of these VOCs from their respective parent compounds, see Figure 21 for generation rates assumed, were calculated to be 6, 4 and 7 hours respectively. Significant generation of these daughter products was not measured in the column test; however, such generation rates of daughter product VOCs have been measured in earlier column tests and it was considered conservative to assume that a proportion of these daughter products could be generated as detailed on Figure 21. Other daughter products generated in the column test were 1,1-DCA and 1,2-DCA with a calculated half-life of 15 hours for 1,1-DCA. The iron technology does not treat 1,2-DCA, which had a peak concentration of approximately 20 μg/L in the column test.

5.3 Precipitation/Absorption of Metals and Other Compounds

Certain metals, such as hexavalent chromium, are reduced and thus precipitate in the presence of iron, whereas other metals are directly precipitated or absorbed by the iron and thus rendered immobile. Metals that can be removed from the groundwater flow regime in the presence of iron, include Al, Sb, As Cd, Cu, Cr(VI), Pb, Mg, Hg, Ni, Se, Tc-99, U, V and Zn. A number of workers have constructed iron reactive barriers for the removal of metals, e.g. Gu et. al. (1998), Morrison (1998), Naftz (1998), Puls (1998), Su and Puls (1998), and in some cases a combination of metals and VOCs, Schlicker et. al. (1998) and Puls (1998). Cyanide is immobilized and removed from the groundwater flow regime as it enters the iron PRB due to the formation of complexes of iron and cyanide, which are stable and remain immobile within the PRB.

In some cases the iron PRB can release metals either from the PRB or from the native soils due to changes in pH and Eh. Normally the metals that potentially can be released are Fe and Mn. The inorganic data from the column test show that these metals, Fe and Mn, are reduced in concentrations as the Site groundwater passes through the column, and therefore these metals are not expected to be released by the PRB in situ.

6.0 GEOTECHNICAL AND SPECIALIZED PRB LABORATORY TESTS

6.1 General

Relevant design issues and perceived data gaps were identified in the PRB RDWP. The data gaps relate to soil grain size data for selecting iron filings size gradation and specialized tests relating to the azimuth controlled vertical hydraulic fracturing technology. All of these tests were performed using soils and groundwater collected from the Site in order to provide a close approximation of the existing field chemistry and geotechnical properties of the formation materials. Golder field personnel collected all the samples during the PRB pre-design field investigation program.

Soil and iron filings classification tests, soil resistivity and perm-leak-off column testing were conducted by Golder's Laboratory in Atlanta, Georgia. The laboratory testing program included the following:

- ❑ Soil classification tests (grain size distribution, Atterberg limits, and specific gravity tests) conducted on Site soil samples and different grades and mixtures of Connelly iron filings for selection of the iron to be used for the iron reactivity bench scale column test;
- ❑ Iron hydraulic conductivity tests on different grades and mixtures of Connelly iron filings;
- ❑ Perm-leak-off column testing (1) using reconstituted soils with similar grain size distribution of representative Site soils and Golder's fracturing iron-gel mixture used in hydrofracturing technology; and
- ❑ Soil resistivity tests (saturated condition) using Site soil samples and Site groundwater; and
- ❑ Soil permeability tests conducted on remolded soils collected from the lower aquitard.

6.2 Site Soil and Groundwater Collection

Site groundwater for the iron reactivity column test and the soil resistivity tests were collected from monitoring well MW33 by Golder field personnel during the May 2000 PRB pre-design field program. Approximately 12 gallons of Site groundwater were collected for the iron reactivity bench-scale column test, and two (2) gallons of groundwater were collected for soil resistivity testing and other reactivity tests to be performed at Golder's Laboratory in Atlanta, Georgia. The groundwater was shipped to the UW/ETI for the column test and to Golder in Atlanta for the other specialized PRB tests.

Site soil samples were collected from continuously sampled SPT (ASTM D1586) borings SBS13, SBS10, SBS11 and SBS12 drilled adjacent to C10, D10, E10 and F12, respectively. The samples were collected using a 24-inch long split-spoon sampler. Blow counts required to drive the sampler each 6-inch increment were recorded, the recovery of the sample measured, and the soil classified in the field in accordance with the Unified Soil Classification System (USCS). Boring logs were prepared for the borings and are contained in Appendix A. The soil samples (the complete spoon) were placed in zip-lock plastic bags and then shipped to Golder's Laboratory in Atlanta, Georgia. Golder field personnel conducted all field sampling and classification activities.

6.3 Soil Geotechnical and Hydraulic Conductivity Data

Site soils collected from borings SBS13, SBS10, SBS11 and SBS12 were analyzed for grain size, Atterberg limits, specific gravity and electrical resistivity, with data from these tests summarized in Appendix A and detailed for each sample in Appendix A-1. A summary of the soil grain size and resistivity data is given in Table 11. Soil hydraulic conductivity data are summarized in Table 12 as quantified from well slug and pumping tests conducted in existing monitoring wells and CPT hydraulic conductivity tests (ICF Kaiser, 1991, 1997) and as estimated from grain size data using the Hazen Method (D_{10}). The highest soil hydraulic conductivity values quantified or estimated for the site were obtained from grain size data (SBS-11 and SBS-12) using the Hazen Method (D_{10}) with a value of 4.9×10^{-3} cm/sec. The highest estimate from pumping tests was in well OMW4 with a value of 2.3×10^{-3} cm/sec (constant-rate pumping test - Theis Recovery Method), and of 3.6×10^{-3} cm/sec from a slug test (falling head) conducted in well MW6. From CPT hydraulic tests, the highest hydraulic conductivity value determined was from CPT E20 at 35.5' BGS with a value of 4×10^{-3} cm/sec.

6.4 Soil and Fracturing Fluid Electrical Resistivity

6.4.1 General

Active resistivity is used to monitor the injected geometry of iron permeable reactive barriers during installation by the azimuth controlled vertical hydraulic fracturing technology. The fracture fluid is made conductive and is electrically energized by a 100Hz signal so the receivers in boreholes adjacent to the barrier can detect the fracture location. Induced 100 Hz voltages are monitored and recorded during fracture growth. From these induced voltages, the PRB geometry is calculated using incremental inversion algorithms to provide a high-resolution image of the reactive barrier. This imaging provides a real time feed back of the fracture geometry during injection and thus enables quantification of the continuity of the reactive barrier system.

For the active resistivity technique to be efficient there must be a significant contrast between the resistivity of the formation (soil and groundwater) and the fracturing fluid. Laboratory testing was performed using Site soil samples collected from the soil borings SBS13, SBS10, SBS11 and SBS12 saturated with Site groundwater collected from groundwater monitoring well MW33. The conductivity of the iron-gel fracturing fluid is adjusted by the addition of sodium or potassium chloride to the fracturing fluid. The Golder standard fracturing fluid design resistivity range depends on site conditions, and the possible range of gel resistivity as detailed in Appendix A-5. For the PRB hydrofracturing installation method, the final gel design must consider the Site soil resistivity in the area where the permeable barrier is to be installed.

6.4.2 Laboratory Method

The soil electrical resistance was estimated in the laboratory following the Standard Method for Field Measurement of Soil Resistivity Using the Wenner Four Electrode Method (ASTM G 57). Samples were placed in a soil box with two plate electrodes and two pin electrodes. The soil sample was saturated with groundwater collected from groundwater monitoring well MW33. Using a Nillson Model 400 four-pin soil resistance meter, a voltage potential was applied to the plate electrodes in the soil tray causing a current flow through the sample. The voltage drop and current were measured between the two pin electrodes using the same meter. The geometry of the box is such that a correction factor of 1 is used for the Wenner array and hence electrical resistance measurements are in effect direct.

Electrical resistivity testing of soils required the soil box to be filled with the sample. The source and detector electrodes in the soil box were connected to the meter. A known current was passed between the two source electrodes and a voltage drop measured between the two detector electrodes providing an estimate of resistance. Resistivity values are normalized (ASTM G 57) at 15.5 °C using the following expression:

$$\text{Resistivity @ } 15.5\ °\text{C} = [(24.5 + \text{Temperature})/40] \times \text{Resistivity} \quad (4)$$

6.4.3 Results

The resistivity results for the soil samples are summarized in Table 11 and details are contained in Appendix A-1. Based on the laboratory soil resistivity tests, the iron-gel mix should have a maximum resistivity of 300 ohms-cm for contrast purposes with the existing soils during hydrofracturing active resistivity monitoring.

6.5 Leak Off Testing of Soils

6.5.1 General

During the injection of a fracturing fluid into the formation (hydrofracturing), fluid is lost (leaked off) from the fracturing gel mix to the formation. This leak off characteristic is dependent on both fracture fluid constituents and formation characteristics. The volume of fluid lost during fracturing determines the fracturing fluid efficiency or the ratio of fracture volume to volume of fluid pumped. It is important to know this efficiency to prevent early fracture termination caused by premature deposition of the granular component of the fracturing fluid.

The rate of leak off to the formation is governed by the fracturing fluid leak off coefficient, C, which is a combination of three types of linear flow mechanisms (Gidley et. al., 1989). The three types of flow mechanisms are: fracturing fluid viscosity and relative permeability effects Cv, reservoir-fluid viscosity/compressibility effects Cc, and wall building effects Cw. Cv and Cc can be estimated theoretically from aquifer data and fracture fluid viscosity data while Cw must be investigated experimentally.

6.5.2 Laboratory Method

Golder developed a laboratory leak off test procedure for soils for the estimation of the leak off coefficient *Cw*. The test method is an adaptation of leak off testing on core used in the petroleum industry detailed in API RP-39. Essentially the method utilizes a pressure cell containing a piston as shown on Figure 1 in Appendix A-3. The apparatus has an inlet at the top of the cell (above the piston) and an outlet at the base of the cell. A site soil sample is placed in the cell with enough water to saturate the sample. The sample is consolidated at a normal pressure equivalent to the estimated in-situ effective vertical stress at the approximate depth where the hydrofracture will be initiated (typically within the lower 10 feet of the barrier) by applying pressure above the piston to compact the soil. During consolidation, the excess water is allowed to exit through the outlet at the base of the pressure cell. The dry unit weight and porosity of the sample are calculated and recorded. Fracturing fluid is placed between the soil sample and the piston. The fracturing fluid is then pressurized against the soil sample by the piston, using a pressure in the vicinity of the expected down hole fracturing fluid pressure. The volume of fluid expelled from the base of the cell is monitored and is equivalent to the volume of fracturing fluid that leaked off to the sample.

Leak off test data are plotted as filtrate volume vs. the square root of time as shown in the laboratory test results detailed in Appendix A-1. The test shows two phases of the leak off phenomenon. The first stage is the wall building stage of leak off where the fracturing fluid penetrates the formation causing a filter cake to build up on the formation - fluid interface. The volume of fluid lost in the wall building stage of fracturing is called spurt loss. The first stage of leak off can be recognized on Figure A-1 as the early time curvature of filtrate volume versus time. During the second stage, after the filter cake has built up, viscosity and compressibility effects resist the rate of fluid loss only. The later time straight line of the test results represents this stage. The slope of this line is used in the following equation to determine *Cw:*

$$Cw = (m/2Ac) \tag{5}$$

where *Cw* is the wall building coefficient (cm/min$^{1/2}$), m is the slope of the best-fit straight line (cm^3/min$^{1/2}$), and Ac is the cross sectional area of the soil sample in the test cell (cm^2).

The volume loss determined as the ordinate intercept of the straight line used to determine the *Cw* coefficient at time zero is used to determine the Spurt value for the leak off test. The Spurt is obtained using the following expression:

$$\text{Spurt value} = (\text{Fluid loss}/2\text{Ac}) \qquad (6)$$

6.5.3 Results

The test was carried out at 49 psi pressure on a reconstituted sand sample representative of the soils collected from borings SBS13, SBS10, SBS11 and SBS12. Prior to placement of the cross-linked gel iron mix over the soil, the soil was consolidated at an effective stress of 30 psi. The confining stress was applied at increments of 5 psi to minimize excessive pore water pressure during the consolidation process. The remolded dry unit weight and porosity of the soil were 95.1 pounds per cubic foot (PCF) and 0.43. The test results are included in Appendix A-3.

6.6 Micro-Head and Hydraulic Conductivity Testing of Iron Reactive Mixture

6.6.1 General

Hydraulic conductivity testing was conducted on several iron samples to ensure that the iron filings selected for the PRB were compatible with the soils at the Site. For the PRB hydrofracturing installation method, the hydraulic conductivity of the fracture emplaced iron was tested to verify that breaking of the cross-linked fracturing fluid would take place and that the remaining iron filings would have a similar or greater hydraulic conductivity than the host formation. An emplaced PRB with a hydraulic conductivity significantly less than the formation would impact the groundwater flow regime and the contaminated groundwater may be diverted around the PRB and thus not be remediated.

6.6.2 Laboratory Method

Iron Hydraulic Conductivity Tests

Hydraulic conductivity testing was conducted on different grades of Connelly iron filings using the constant head permeability method (ASTM D 2434). Grain size distribution analysis (ASTM D 422) was conducted on all samples prior to testing as detailed in Appendix A-2. Air dry samples were placed in the cells in uniform lifts until the sample height was reached. Minimum compacting effort was applied to the samples. Porosity determinations were made at the completion of each test.

Micro-Head Iron-Gel Hydraulic Conductivity Test

Hydraulic conductivity testing was conducted on an iron-gel sample following the leak-off test after the enzyme breaker present in the mix broke the cross-link of the iron-gel mix. The iron-gel mix consisted of gel cross-linked with medium fine Connelly iron filings CC-1022. The test was conducted using the constant head permeability method (ASTM D 2434) using a 3-inch diameter cell and the soil leak-off micro-head permeameter as shown on Figure A-1 in Appendix A-3.

The leak-off test was first conducted on the sample as described in Section 6.5 above with results detailed in Appendix A-3. Following the leak-off test the pressure was reduced to a closing pressure of 19 psi as expected after construction of the PRB using the hydrofracturing technology. The closing pressure was maintained and tap water was used to permeate the iron-gel sample during the test. The test was continued for a minimum of 10 pore volumes or until hydraulic conductivity values reached an approximately steady state condition. Concurrent with the hydraulic conductivity test, effluent samples were monitored for changes in total organic carbon (TOC). At the completion of the tests the final porosity of the iron filings layer above the soil sample was determined.

6.6.3 Results

Iron Hydraulic Conductivity Tests

The results of the iron hydraulic conductivity tests are summarized in Appendix A-2. The hydraulic conductivity of the Connelly CC-1022 sample selected for the PRB and used in the iron column test was 1.2×10^{-1} cm/sec. A porosity of 0.6 was determined for the sample at the end of the test. The hydraulic conductivity test data are included in Appendix A-2.

Micro-Head Iron-Gel Hydraulic Conductivity Test

Hydraulic conductivity values increased with the number of pore volume flushes and the levels of TOC in the effluent decreased. The reduction of TOC in the effluent water was associated with the reduction of gel compounds in the iron sample. The hydraulic conductivity and effluent analytical (TOC) data are included in Appendix A-4. The hydraulic conductivity of the iron-gel soil sample after 15 pore volume flushes approached 1 x 10^{-2} cm/sec, which is comparable to the soil hydraulic conductivity within laboratory measurement accuracy.

6.7 Viscosity of Fracturing Fluid

6.7.1 General

The viscosity of the gel and cross-linked fracturing fluid was measured in order to quantify the selected gel fluid for use as a fracturing fluid in the PRB hydrofracturing technology installation method. Viscosity data are also used for quality control of the gel during construction and for hydraulic fracturing design analyses.

6.7.2 Laboratory Method

The viscosity of 48 lb. gel (cross-linked) per 1000 gallons of water fracturing fluid, and uncross-linked samples (guar fluid) was measured in the laboratory using an EG&G Chandler Model 35 coaxial cylinder viscometer. The viscosity was measured for a range of shear rates between 1 and 100 sec^{-1} at temperatures ranging from 6° to 36° C.

6.7.3 Results

The test results are included in Appendix A-6. The gel fluid displayed a pseudo-plastic (or shear rate thinning) behavior from 1 to approximately 50 sec^{-1} with viscosity values ranging from 1,800 to 145 cp (centipoise). From 50 to 100 sec^{-1} shear rate the sample displayed approximately a constant viscosity of 145 cp displaying the characteristics of a Newtonian fluid.

7.0 DESIGN OF CAP SYSTEM

7.1 General

Saltire and the USEPA have agreed to implement an alternative remedy for groundwater at the Arrowhead Plating Site. The major components of the newly selected remedy action (RA) described in the ESD are:

- A PRB to transform dissolved VOCs into non-toxic products before groundwater discharges into the tributaries of Scates Branch;
- Implementation of an environmental monitoring plan to evaluate the effectiveness of the RA and to ensure the protection of environmental receptors in Scates Branch; and
- Implementation of appropriate institutional control measures, if needed, prohibiting the use of contaminated surficial groundwater to ensure protection of public health and the environment.

Discussions on the selected PRB Remedy, process description of the zero valent iron technology and the design requirements and criteria for the PRB system were presented in the Preliminary (30%) PRB Design Report (Golder 2000a). Following the submittal of the Preliminary (30%) PRB Design Report, additional evaluations were completed and it was determined that the addition of a Cap System as part of the PRB Remedy would improve and make more cost-effective the PRB Remedy for OU-2. The Cap System was proposed to EPA and VDEQ during the October 24, 2000 meeting and further discussed during the October 30, 2000 conference call. The proposed layout of the PRB and Cap System at the Site is shown on Figure 22.

The design of the Cap System for the Site required the evaluation of the existing Site conditions in terms of ground surface drainage patterns, precipitation infiltration rates, Site geotechnical and hydrogeologic characteristics, and quantification of the impact of the Cap System on the groundwater flow gradients (lower flow gradients) across the PRB and the amount of groundwater flux passing through the PRB System. This Section provides the Cap System design methodology, Cap System design requirements and criteria (as earlier detailed in Section 3.2.3), the evaluation of infiltration rates before and after placing the Cap System, the impact of the Cap System on the PRB Design based on site wide (regional) groundwater flow modeling, and finally the Cap System design.

7.2 Cap System Design Requirements and Criteria

The Cap System must be designed to significantly reduce the infiltration of precipitation into the subsurface and to have a significant impact on the groundwater recharge conditions within the Site, and therefore to reduce both groundwater flow gradients across the PRB and the amount of groundwater flux passing through the PRB System.

The overall design methodology for the Cap System consisted of modeling existing site wide (regional) precipitation infiltration and groundwater flow conditions, modeling the effect of different Cap Systems on infiltration rates, and modeling the impact of the selected Cap System on the groundwater flow gradients across the PRB.

The Cap System must be designed to meet the design requirements and criteria as detailed in *Section 3.2.3. The Cap System is an integral part of the PRB since its intent is to limit the* infiltration of surface water into the subsurface and thus reduce the groundwater flow gradients *across the PRB. Therefore the objective of the Cap System is to enhance the PRB performance* by reducing the mass flux of contaminants that the PRB must degrade.

7.3 Infiltration Rates Evaluation

7.3.1 Methodology

The Hydrologic Evaluation of Landfill Performance, or HELP, model developed by the U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, Ohio (Schroeder et. al. 1994) was used to determine the impact of a Cap System on the precipitation infiltration rates and the Site groundwater flow conditions. Precipitation infiltration rates for the Site were determined without (i.e. existing conditions) and with a Cap System.

The HELP model is a quasi-two-dimensional hydrologic model for conducting water balance analyses. The model accepts weather, soil and design data, and utilizes solution techniques that account for the effects of surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture storage, lateral subsurface drainage, unsaturated vertical drainage, and leakage through soil, geomembrane or composite liners. The program uses weather (climatic), soil and design data to generate daily estimates of water movement across, into.

through and out of landfills. To accomplish this objective and compute a water balance, daily precipitation is partitioned into surface storage (snow), snowmelt, interception, runoff, infiltration, surface evaporation, evapotranspiration from soil, subsurface moisture storage, liner leakage (percolation) and subsurface lateral drainage to collection, removal and recirculation systems.

The hydrologic processes modeled by the program are divided into two categories: surface processes and subsurface processes. The surface processes modeled are snowmelt, interception of rainfall by vegetation, surface runoff, and surface evaporation. The subsurface processes modeled are evaporation from soil profile, plant transpiration, unsaturated vertical drainage, containment soil liner percolation, geomembrane leakage and saturated lateral drainage.

Daily infiltration into the subsurface is determined indirectly from a surface water balance. Infiltration is assumed to equal the sum of rainfall, surface storage and snowmelt, minus the sum of runoff, additional storage in snow pack and evaporation of surface water. No liquid water is assumed to be held in surface storage from one day to the next except in the snow pack or when the topsoil is saturated and runoff is not permitted. Each day, the free available water for infiltration, runoff, or evaporation from water on the surface is determined from the surface storage, discharge from the snow pack, and rainfall. Snowfall is added to the surface snow storage, which is depleted by either evaporation or melting.

Snowmelt is added to the free available water and is treated as rainfall except that it is not intercepted by vegetation. The free available water is used to compute the runoff by the Soil Conservation Service (SCS) rainfall-runoff relationship. The interception is the measure of water available to evaporate from the surface. Interception in excess of the potential evaporation is added to infiltration. Surface evaporation is then computed. Potential evaporation from the surface is first applied to the interception; any excess is applied to the snowmelt, then to the snow pack and finally to the ground melt. Potential evaporation in excess of the evaporation from the surface is applied to the soil column and plant transpiration. The snowmelt and rainfall that does not run off or evaporate is assumed to infiltrate into the subsurface along with any ground melt that does not evaporate.

The first subsurface processes considered are soil evaporation and plant transpiration from the evaporative zone of the upper sub profile. A vegetative growth model accounts for the daily growth and decay of the surface vegetation. The other subsurface processes are modeled one sub profile at a time, from top to bottom, using a design-dependent time step ranging from 30 minutes to 6 hours. A storage-routing procedure is used to redistribute the soil water among the modeling segments that comprise the sub profile. This procedure accounts for infiltration or percolation into the sub profile and evapotranspiration from the evaporative zone. Then, if the sub profile contains a liner, the program computes the head on the liner. The head on the containment layer is then used to compute the leakage/percolation through the layer and, if lateral drainage is permitted above the top of the containment layer, the head on the liner is determined from lateral drainage to the collection and removal system.

Containment systems modeled include various combinations of vegetation, cover soils, lateral drain layers, low permeability barrier soils, and synthetic geomembrane liners. The model facilitates rapid estimation of the amounts of runoff, evapotranspiration, drainage, leachate collection (in the case of landfills) and liner leakage that may be expected to result from wide variety of containment system configurations. The primary purpose of the model is to assist in the comparison of design alternatives.

7.3.2 Weather Conditions

The weather data required in the HELP model are classified into four groups: evapotranspiration, precipitation, temperature and solar radiation data. Weather data may be entered using several options depending on the type of weather data being considered.

The HELP model does not have weather data for Montross, VA. It was, thus necessary to synthetically generate the required data based on precipitation and temperature data obtained from Colonial Beach, VA (located 20 miles north of Montross) and weather patterns from Norfolk and/or Richmond, VA (see Figure 1 for location of cities/towns). Norfolk weather patterns input was the preferred model because Norfolk is located close to the ocean, like Montross, and thus, the weather patterns are expected to be similar and influenced by ocean currents and winds. However, Norfolk was not always available as a model city and in that case, Richmond was used. The different weather input parameters used in the HELP model include:

- Evapotranspiration;
- Evaporation Zone Depth;

- ❑ Maximum Leaf area Index;
- ❑ Growing Season;
- ❑ Precipitation Data;
- ❑ Temperature Data; and
- ❑ Solar Radiation Data.

The weather data input used for the evaluation of infiltration rates at the Site is provided in Appendix D in the HELP output runs. The synthetically generated mean precipitation and temperature data for the Site is presented for each month as plots on Figure 23.

7.3.3 Subsurface Soil Conditions

Soil data used in the HELP model can be either the HELP model default soil/material textures data or specifically defined soil texture data. For the determination of infiltration rates without and with a Cap System, default soil data (from a data base of 42 default soil/material textures) for similar soils encountered at the Site and Cap System design components were used in the evaluations. For the evaluation of the existing conditions the following soil input parameters were used for the subsurface soils above the water table (unsaturated zone):

- ❑ Soil Type (Unified Soil Classification System);
- ❑ Soil Porosity;
- ❑ Soil Wilting Point (lowest soil water storage/volumetric content that can be achieved);
- ❑ Soil Initial Water Content; and
- ❑ Soil Effective Saturated Hydraulic Conductivity (above and below the evaporative/root zone)

When a default soil type in the HELP model is used to describe the topsoil layer, the program adjusts the saturated hydraulic conductivities of the soils in the top half of the evaporative zone for the effects of root channels. The saturated hydraulic conductivity value is multiplied by an empirical factor that is computed as a function of the maximum leaf area index (LAI). Example values of this factor are 1.0 for a maximum LAI of 0 (bare ground), 1.8 for a maximum LAI of 1 (poor stand of grass), 3.0 for a maximum LAI of 2 (fair stand of grass), 4.2 for a maximum LAI of 3.3 (good stand of grass) and 5.0 for a maximum LAI of 5 (excellent stand of grass).

The soil data input used for the evaluation of infiltration rates at the Site is provided in Appendix D (HELP output runs).

7.3.4 Existing Infiltration Rates Evaluation

The first part of this evaluation included estimating the amount of infiltration through the exiting in-situ soils down into the groundwater. Due to the variability of surface slopes and subsurface unsaturated thickness, a sensitivity analysis was completed to determine infiltration rates for the expected range of surface slopes and unsaturated soil thickness conditions at the Site. The area considered for the evaluation is shown on Figure 24, which shows the location of the Cap System with respect to the PRB System and the Upper Aquifer groundwater-modeling region. For this purpose, the model was run for 12 different conditions for unsaturated zones (depth to groundwater table) of 10, 15 and 20 ft thick and surface grades of 0.5%, 2.5%, 10% and 25% for each case analyzed.

For runoff calculations, Runoff Curve Numbers were computed by the HELP model based on surface slope, slope length, soil texture and quantity of vegetation cover for each option evaluated.

In general, the precipitation infiltration rates at the Site for the range of conditions evaluated ranged from 6.7 inches per year (in/year) (20 ft unsaturated soil thickness and 25% slope grade) to 7.2 in/year (10 ft unsaturated soil thickness and 0.5% slope grade). The infiltration evaluation results for the existing conditions are shown as plots on Figure 25. The average precipitation per year was estimated to be 41 in/year. Of this, about 9% goes into runoff, 74% into evapotranspiration and 17% into infiltration/groundwater recharge. Input data and output results of the HELP modeling runs are included in Appendix D-1.

7.3.5 Cap System Infiltration Rates Evaluation

The second part of the evaluation consisted in estimating the infiltration of rainwater through the Cap System down to the groundwater also using the HELP model. In order to select the most cost-effective Cap System, four (4) cover system configurations were evaluated in terms of technical effectiveness and cost. The different cover systems considered are shown on Figure 26 and the components of the cover systems are described below from the top down for each alternative evaluated:

- ❑ *Alternative A*: 24 inches of vegetative cover, a geotextile/geonet/geotextile composite (geocomposite) drainage layer and a low permeability geosynthetic clay liner (GCL);

- ❑ *Alternative B*: 24 inches of vegetative cover, 12 inches of sand drainage layer and a low permeability geosynthetic clay liner (GCL);

- ❑ *Alternative C*: 24 inches of vegetative cover, 12 inches of sand drainage layer and a low permeability high-density polyethylene (HDPE) geomembrane liner; and

- ❑ *Alternative D*: 24 inches of vegetative cover, a geocomposite drainage layer and a low permeability high-density polyethylene (HDPE) geomembrane liner.

The Cap System is modeled in the HELP model as a layered system with different material properties to incorporate the vegetative cover (vertical percolation layer), the lateral drainage layer, the barrier soil layer (in this case the GCL) and/or the geomembrane liner if used in conjunction with a barrier soil. For determining the amount of infiltration down to the groundwater table, an unsaturated soil layer 17 ft thick below the Cap System was used for modeling. In addition to the evaluations completed for the above alternatives, an evaluation was completed without a Cap System for the existing conditions to determine the effectiveness of the Cap System.

The input data used for the evaluation of each of the Cap System alternatives is shown in the HELP model computer run outputs included in Appendix D-2. Based on the Cap System modeling results, Alternatives A and D would reduce the infiltration rates from 7 in/yr (existing conditions) to about 0.9 in/yr and 0.2 in/yr, respectively. A summary of the infiltration evaluation results with the associated estimated installation costs per acre for each Cap System alternative are presented on Table 13. Alternative A, 24-in vegetative cover, a geocomposite and a GCL is considered the most appropriate Cap System for the Site in terms of effectiveness on reducing infiltration rates, ease of installation, less QA/QC and oversight required and an installed cost per acre similar to Alternative D (with a geomembrane liner instead of a GCL as the low vertical hydraulic conductivity barrier). The lower infiltration rate of 0.2 in/yr for Alternative D would not have any greater reduction on groundwater flow gradients across the PRB compared with Alternative A Cap System with an infiltration of 0.9 in/yr.

7.4 Groundwater Modeling

7.4.1 General

The occurrence and movement of groundwater in the Upper Aquifer at the Site is controlled by the aquifer parameters (e.g. thickness, transmissivity, leakage, etc.) and by the boundary conditions and external stresses (e.g. recharge areas, no-flow boundaries, pumping wells, etc.). These characteristics are manifested in the potentiometric data presented on Figure 13 for water levels collected in May 2000.

As indicated in Section 2, regional groundwater flow conditions at the Site are controlled by existing surface water drainage features and the amount of rainfall infiltration into the subsurface to the groundwater. The area is predominantly a groundwater recharge area with a documented groundwater flow divide (Golder 2000b) at or about U.S. Route 3.

An average of 6.7 to 7.2 inches per year depending on ground surface slope and depth to the groundwater table (unsaturated thickness) was estimated to infiltrate through the subsurface into the groundwater within the area of study as shown on Figure 24. This infiltration corresponds to about 17% of the average precipitation per year of 41 in/year as determined from the HELP modeling (see Section 7.3.4).

The objective of this modeling analysis was to predict the effect of the Cap System on the groundwater flow conditions at the Site in terms of groundwater flow gradients and flow direction changes. It should be noted that no model could provide an exact representation of the hydrogeologic system being studied. While this model was based on the best available data and conservative assumptions were used where appropriate, the simulations presented herein are, as with any model, only an approximation of the way the system will behave when a Cap System is constructed at the Site.

7.4.2 Methodology

The numerical modeling investigation was conducted using the computer model MODFLOW (USGS, 1988) to simulate the aquifer system. A brief description of the model code and the general approach to the modeling investigation are presented below.

MODFLOW was developed by the United States Geological Survey (USGS, 1988) for three-dimensional analysis of groundwater flow systems. The model uses a finite-difference approach to approximate the analytical solution of the partial-differential groundwater flow equation. MODFLOW has been used for similar aquifer studies in numerous areas nationwide and is generally considered to be the most widely used and accepted three-dimensional model available.

MODFLOW is based on approximations of flow through a three dimensional array of cells. Various aquifer input parameters are assigned to each individual cell within the model, which allows for spatial variations in aquifer parameters throughout the modeled system. This approach limits the number of inherent simplifying assumptions required by the model. The only major assumption is that Darcy's Law of flow is applicable.

The general approach to the groundwater flow modeling investigation is as follows:

- Develop a conceptual model of the aquifer system to define the hydrogeologic parameters and boundary conditions which control groundwater flow within the Upper Aquifer in the study area;
- Create a realistic numerical model using appropriate parameters and boundary conditions as input data;
- Calibrate the model by adjusting the parameter values until hydraulic heads conform, as close as practical, to known data; and
- Perform predictive simulations after a Cap System has been constructed at the Site.

7.4.3 Model Set-up

Model set-up included the creation of a suitable model grid to represent the Upper Aquifer within the area of interest. For the Cap System Design, a grid system of 67 rows and 113 columns resulting in 7,571 blocks (or cells) with a uniform cell size of 50 ft by 50 ft was used to model local groundwater flow regime, covering a representative area of approximately 435 acres.

The system was modeled using a single layer with an impermeable base at 105 ft. msl. The lateral model boundaries were primarily simulated as drains with specified heads based on elevations representing the streams and drainages that surround the Site. No-flow boundaries were specified in areas where streams are not present. The model grid is shown on Figure 27 and the surface water drainage features were modeled as drains deplicted as small circles on this figure.

The modeling grid includes the modeled area above 105 ft. msl, which represents the limits of the Upper Aquifer. Therefore, the minimum elevation of the drains was set at 105 ft. msl to simulate the effects of seepage faces occurring near the base of the aquifer (above 105 ft. msl) at the point of discharge.

7.4.4 Model Input Parameters

Model input parameters used in MODFLOW (those representing the hydraulic characteristics of the system) consist of the following:

- Lateral hydraulic conductivity (K);
- Recharge from infiltration due to precipitation (I); and
- Bottom of Aquifer.

Site-specific hydrogeologic data was used as input parameters as follows:

- Hydraulic Conductivity ranging between 4.0×10^{-4} cm/sec to 1.5×10^{-3} cm/sec (i.e. 1.1 ft/day to 4.3 ft/day)

- Recharge = 7 in./yr (0.0016 ft/day)

- Bottom of Aquifer = 105 ft. msl

The aquifer was assumed to be heterogeneous (varying lateral hydraulic conductivity) within the range of values obtained from previous hydrogeologic tests performed at the Site (Table 13). Uniform recharge was applied across the Site except in those areas covered by buildings and paved parking lots, which were assumed to have zero recharge (see Figure 27) with adequate surface water drainage and management. Current and proposed surface water drainage and management are detailed later in the Cap System design, Section 7.5.3, which will ensure infiltration is zero in these paved areas. All simulations were run under steady state conditions. The output of the model is generated in the form of potentiometric head contours across the modeled area.

7.4.5 Model Calibration

The numerical flow model was calibrated by varying selected input parameters and comparing calculated heads to known heads until a reasonable match was obtained. The calibration strategy was to initially vary the best know parameters as little as possible, and vary the lesser-known values the most. Hydraulic heads were calibrated to the May 2000 potentiometric groundwater level data (see Figure 13).

The model was primarily calibrated by varying hydraulic conductivity and comparing calculated heads to known heads until a reasonable match was obtained. Hydraulic heads were calibrated to potentiometric levels measured in May 2000. Hydraulic conductivity was varied between 4.0 x 10^{-4} cm/sec and 1.5 x 10^{-3} cm/sec (i.e. 1.1 ft/day to 4.3 ft/day), representative of pump test data (see Table 12). The hydraulic conductivity data selected for calibration of the model are shown on Figure 27, with three distinct areas of differing hydraulic conductivities based on pump test data. Drain elevations were also varied slightly in selected areas to simulate changes in elevation. Recharge and aquifer thickness were not varied during the calibration process.

Calibrated potentiometric heads are shown on Figure 28. In general, calculated heads were within 0.5 feet of the observed heads in the May 2000 sampling event. The groundwater flow model prepared for the Cap System Design is considered appropriate for determining the impact of the Cap System on the PRB Design.

7.4.6 Predictive Simulation

Using the calibrated groundwater model, the Cap System was incorporated into the model to evaluate the impact the Cap System would have on the groundwater flow and ultimately the design of the PRB System. The model was modified by adding the Cap System area and reducing the average infiltration rate of 7 in/yr for the existing conditions to the predicted 0.9 in/yr within the area covered by the Cap System (Alternative A). The new potentiometric contours depicting changes in groundwater flow based on this reduction in infiltration are shown on Figure 29.

The new flow gradients perpendicular to the PRB alignment are shown on Figure 30. In general, the Cap System reduced groundwater flow gradients perpendicular to the PRB by 19 to 31% along the PRB alignment for Design Case I, by 27 to 70% along the PRB alignment for Design Case II, by 30 to 51% along the PRB alignment for Design Case III and by 22 to 30% along the PRB alignment for Design Case IV.

7.4.7 Impact of Cap System on PRB Design

The VOC degradation performance of a PRB is dependent on the residence time of the contaminated groundwater in the presence with the iron fillings. The velocity of groundwater in a highly permeable reactive barrier can be quantified from the natural hydraulic gradient of the Site, hydraulic conductivity of the soils, and the porosity of the PRB as described in the PRB design, Section 8.2.

The actual contact time of the contaminated groundwater with the iron filings is calculated from the groundwater velocity in the PRB, the PRB thickness and the volume percent of iron filings comprising the reactive barrier material. The required residence time, and hence PRB thickness and required iron filings depend on the extent of contaminant degradation required. This residence time depends on the influent contaminant concentration, degradation half life and pathway, daughter product generation and degradation and the design effluent contaminant concentration.

The addition of the Cap System as part of the PRB Remedy will have a significant impact on the groundwater flow gradients perpendicular to the PRB alignment as shown on Figure 30. This reduction in horizontal flow gradients across the PRB will result in lower flow velocities and an increased residence time in the PRB and therefore reduce the required PRB effective thickness for the same reduction in VOCs. The impact of the Cap system on the PRB system was first evaluated following completion of the groundwater modeling for the PRB section designated as Design Case III (see Section 8.0). For PRB Design Case III without a Cap System, the PRB would need to be at least eight (8) inches thick; whilst, with the Cap System the PRB could be reduced to 4.5 inches in thickness to achieve effluent VOCs concentration levels below their respective MCLs. The impact of the Cap System on the PRB effective thickness makes azimuth controlled vertical hydrofracturing technology (see Section 9.0) more competitive, and thus reduces issues associated with surface water management during construction as well as potential waste management and waste disposal costs. The final groundwater modeling analysis of the Cap System was used directly as input data into the PRB design, as described in the PRB design in Section 8.0.

7.5 Cap System Design

7.5.1 General

The functional requirement of the Cap System is to significantly reduce infiltration rates of rainfall into the subsurface and ultimately reduce the groundwater hydraulic flow gradients across the PRB System. The addition of the Cap System as predicted by the groundwater modeling had a significant impact on the groundwater recharge conditions within the Site, and therefore reduced both groundwater flow gradients across the PRB and the amount of groundwater flux passing through the PRB System.

In general, the evaluation and design of the Cap System considered the following:

- ❑ Geotechnical and hydrogeologic data collected for the Site during previous investigations and the additional data collected during the PRB Pre-Design Field Investigation Program;
- ❑ Topography and Surface Water drainage Patterns;
- ❑ Existing Site Features and Structures;

- Climate Data (precipitation, temperature, etc);
- Cap System Composition and Thickness;
- Cap System Configuration, Construction and Vegetation;
- Cap System Surface Water and Internal Drainage;
- Cap System Long Term Maintenance and Contingencies Plan;
- Impact of Cap System on Future Land Use; and
- Impact of Vegetative Cover on Natural Wildlife Habitat.

7.5.2 Cap System Configuration

The design of the Cap System considered existing topography, climatic data (rainfall, frost penetration, temperature, etc), availability of on-site borrow soils for the vegetative cover, cover surface and internal drainage management and long term maintenance. A topographic map was developed for the area where the Cap System is proposed detailing existing surface water management features.

The proposed location of the Cap System is shown in plan on Figure 31 and covers an area of approximately four and one half (4-1/2) acres. The cover system is designed with a 1 % minimum surface slope and a maximum slope of 3H:1V. Surface water drains from the cover system to two (2) main ditches for proper surface water management as shown on Figure 31.

The HELP model (Schroeder, et. al. 1994) was used to evaluate different cover system configurations (Alternatives A through D) as discussed in Section 7.3.5 and shown on Figure 26. The selected cover system for the Site (Alternative A) consists from top to bottom of 24 inches of vegetative cover, a geotextile/geonet/geotextile (geocomposite) drainage layer and a geosynthetic clay liner (GCL). The cover system internal geocomposite drainage layer will drain on a minimum slope of 1% towards two (2) infiltration collection drains draining at a minimum slope of 1% as shown on plan on Figure 32. A cross section of the Cap System showing surface and internal drainage grades and as well as typical details are shown on Figures 33 and 34.

7.5.3 Surface Water Management

The existing surface water management of the Site includes a network of underground storm drainage pipes collecting rainfall water from the existing building and parking lot, and surface water ditches collecting surface water within the proposed footprint of the Cap System as shown on Figure 35. The design of the surface water management control structures for the proposed Cap System has considered existing drainage patterns and modification to drainage patterns caused by the final Cap System grades. In general, the drainage patterns after the construction of the cover system will be similar to those of the existing conditions. The proposed Cap System Surface Water Management Plan is shown on Figure 36.

The computer program TR-55 (Soil Conservation Service 1986) was used to determine peak flows based on proposed cover final grades and rainfall as detailed in the TR-55 reference manual for the 2 yr (3.4 inches) and 25 yr (6.3 inches) 24-hr storm events. Drainage catchment delineation and time of concentration data were determined based on the cover configuration. Ground cover and soil type were conservatively assumed to be short grass and low-permeability soil, respectively. Soil Type C was used in the analysis and the drainage catchment areas were assumed to be grassed in fair condition with 50% to 75% cover. A maximum peak flow of 16 cfs (Drainage Area A) was produced from the cover system catchment areas. The TR-55 model uses sheet flow for lengths of less than 300 feet and shallow concentrated flow for drainage lengths greater than 300 feet. The drainage catchment areas and the ditch design calculations are detailed in Appendix E. The ditches are labeled on Figure 36 and are denoted as Ditch A, Ditch B-1, etc.

Flow velocities in the two (2) channels (Ditches A and B) were determined using Manning's equation for open channel flow. Ditch A flows at a slope of 2.2% while Ditch B flows at slopes of 1%, 7.5% (Section B-1) and 4.8% (Section B-2 including Culvert B). Flow velocities in Ditch A and in the 1% slope section of Ditch B will be less than 5 ft/sec and therefore grass is sufficient for surface erosion control. However, the portion of the ditch with slopes of 7.5% (Section B-1) and 4.8% (Section B-2 including Culvert B) will require either rip-rap or a reinforced erosion control mat for surface erosion control as flow velocities will be 6.2 and 5.3 ft/sec, respectively. Flow quantities from melting snowfall were estimated and compared to the design flows for the ditches. The ditches were designed with a trapezoidal cross section with

3H:1V side slopes, 1.5 feet deep and 2 feet wide at the bottom draining at a minimum slope of 1%. A typical detail of the drainage ditches is shown on Figure 33.

Proper vegetation of cover systems is essential for proper cover performance, erosion control and long-term maintenance. The objective of the vegetative cover for the Site is as follows:

- ❑ To stabilize the Soils;
- ❑ To provide a low maintenance, long-term plant community;
- ❑ To provide a structurally diverse grassland habitat for birds and other wildlife; and
- ❑ To use native plant species whose seeds are available commercially.

The vegetative cover will be planted with a mix of native warm and cool season grasses. The following seeding rates per acre will be used:

Big Bluestem (*andropogon gerardi*)	4lbs/acre
Little Bluestem (*schizacrium scorparium*)	6 lbs/acre
Switchgrass (*panicum virgatum*)	2 lbs/acre
Indiangrass (*sorghastrum nutans*)	6 lbs/acre
Canada Wild Rye (*elymus candensis*)	10 lbs/acre
Partridge Pea (*cassia fasciculata*)	2 lbs/acre
Annual Rye Grass (*lolium multiflorum*)	25 lbs/acre.

The above seeding rates are acceptable for planting in the early spring, late summer or fall.

8.0 DESIGN OF IRON PRB SYSTEM

8.1 Full Scale Iron PRB Geometry

The proposed location of the PRB is shown in plan on Figure 37 and in profile on Figure 38. The PRB is proposed to extend for a length of 1,165 ft in plan from a depth of approximately 15 ft down to 42 ft below ground surface and keyed into the underlying aquitard covering an area of approximately 24,000 ft^2. The PRB is orientated approximately perpendicular to the groundwater flow direction, as indicated from the groundwater potentiometric levels shown on Figure 13. The groundwater VOC concentrations for TCE and PCE along the PRB cross section are detailed on Figure 38. VOC concentration contour maps for TCE, PCE, and 1,1-DCE are shown on Figures 14, 15 and 16, respectively.

8.2 PRB Groundwater Residence Time

The VOC degradation performance of a PRB is dependent on the residence time of the contaminated groundwater within the iron fillings. The PRB is designed to be more permeable that the site soils, to ensure the permeable barrier does not impede the groundwater flow, and also to have a high PRB porosity to maximize the groundwater residence time within the iron. In order to select the final iron size gradation suitable for the Site, it is essential to have Site specific soil gradation data to design the PRB. Modified filter pack design criteria are used to confirm that the selected iron filings material and native soils do not commingle due to the groundwater flow velocity.

The velocity of groundwater in a highly permeable reactive barrier can be quantified from the natural hydraulic gradient of the Site, hydraulic conductivity of the soils, and the porosity of the PRB as shown in the following equation:

$$V_{PRB} = \frac{K_{soil} \cdot i}{n_{PRB}} \tag{5}$$

where V_{PRB} is the groundwater flow velocity through the PRB, K_{soil} is the hydraulic conductivity of the soils, i is the natural horizontal hydraulic gradient of the Site and n_{PRB} is the porosity of the PRB.

The actual residence time of the contaminated groundwater with the iron filings is calculated from the groundwater velocity in the PRB, the PRB thickness and the volume percent of iron filings comprising the reactive barrier material as shown in the following equation:

$$t_{iron} = \frac{T_{PRB} \cdot I_v}{V_{PRB}} \qquad (6)$$

where t_{iron} is the residence time of the groundwater in contact with the iron filings, T_{PRB} the thickness of the PRB, and I_v is the volume percent of iron filings in the PRB.

The required residence time, and hence PRB thickness and required iron filings depend on the extent of contaminant degradation required. This residence time depends on the influent contaminant concentration, degradation half life and pathway, daughter product generation and degradation and the design effluent contaminant concentration.

8.3 Design Approach

The iron filings size gradation used for construction of the PRB needs to be selected to ensure the native soils do not enter the reactive barrier material and likewise the iron filings are not flushed out of the PRB into the native soil. Modified filter pack design criteria are used to confirm that the selected iron filings material and native soils do not commingle due to the groundwater flow velocity.

The design of the iron reactive material requires optimizing the hydraulic conductivity of the iron filings to be greater than the native soils, and also ensure a high PRB porosity without violating the filter pack design criteria. Thus by optimizing the iron reactive mixture, the greatest residence time can be achieved resulting in the use of less iron which lowers the cost of the PRB.

The input parameters, site soil hydraulic conductivity, iron porosity and site hydraulic gradients determine the groundwater flow velocity within the barrier. The iron column test quantifies the degradation half lives of the contaminants in the presence of the iron, and addresses potential impact of any precipitation or clogging of the iron. The influent contaminant concentration and the target effluent contaminant concentration (the design criteria), enable quantification of the minimum residence time and hence barrier thickness to achieve the required target effluent concentrations.

Deterministic design procedures, whilst adequate for feasibility evaluation design, are not sufficient for final iron permeable reactive barrier design because factors of safety from past practices are not available for such systems. Probabilistic methods, on the other hand, can accommodate variability in parameter data and are ideally suited for system design such as an iron permeable reactive barrier. The probabilistic method enables quantification of the degree of confidence that contaminant effluent concentrations are not exceeded. Probabilistic analyses quantify the impact of parameter variability on overall system performance and thus rank the parameter by sensitivity.

PRBs are designed for effluent concentrations that in combination with natural attenuation (NA) (biodegradation, dispersion, absorption, etc.) would meet target concentrations at a determined Site Compliance Point (SCP). This proposed design methodology (Hocking et. al., 2001a) is shown on Figure 39 and has been utilized at a number of sites, including Superfund sites, for PRB design. At this Site the PRB and Cap System is deemed sufficient as the means to reduce VOCs to below MCLs immediately downgradient of the PRB. An overview of the probabilistic design methodology was given on Figure 9. Probabilistic distributions are assigned to all of the system's parameters based on their expected variability. Not only are site data; such as hydraulic conductivity and hydraulic gradient, system parameters, but so are installed barrier thickness and porosity. The probabilistic analysis quantifies the impact of each respective system parameter on system performance; that is, a sensitivity analysis, which ranks the parameter from the most to the least sensitive.

A multi-species first order VOC degradation model coupled with the probabilistic model was used to determine effluent concentrations emanating from the PRB. A one dimensional (1D) fate and transport deterministic model was used for determining degradation rates of the remnant plume of TCE (worst case) downgradient from the PRB as treated effluent groundwater with VOCs concentration levels less than MCLs emanates from the PRB and flushes the downgradient formation soils.

8.4 Prediction of Iron PRB Performance

8.4.1 PRB Design Cases Analyzed

The iron reactive barrier system performance was evaluated based on the ability of the system to reduce VOC groundwater concentrations to less than their MCL levels. Four (4) critical design cases were evaluated in the PRB design for four sections of the PRB alignment as shown on Figures 40 and 41. The four design cases arise due to the differences in estimated groundwater flow hydraulic gradients and the concentration levels of VOC contamination (mainly TCE, PCE, and 1,1-DCE) present. Probabilistic distributions for prime design input parameters (formation hydraulic conductivity, groundwater flow gradient, and TCE, PCE and 1,1-DCE concentrations) are shown on Figures 40 and 41 for the four design cases analyzed. Probabilistic distributions for other design input parameters (VOCs degradation half lives, other VOC concentrations, PRB iron porosity and iron PRB effective thickness) are included in Appendix F for the Design Cases I, II, III and IV. An additional analysis was completed for Design Case III without the Cap System (utilizing groundwater flow gradients for the existing conditions, see Section 7.4.5 and Figure 30). The sections below describe in more detail each design case and expected PRB performance.

Design Case I: This design case is for the segment of the PRB (high groundwater flow gradient and medium to low VOC concentrations) located immediately upgradient from the head waters of Scates Branch for a length of 200 ft along the PRB alignment, where the PRB is located close to where the groundwater discharges into the Scates Branch. This design case requires a 4.5-in average iron-effective-thickness PRB installed in soils with a hydraulic conductivity (K) ranging from 3×10^{-4} to 3×10^{-3} cm/sec with a geometric mean of 1×10^{-3} cm/sec, a groundwater flow gradient (i) ranging from 0.011 to 0.025 ft/ft with a mean of 0.016 ft/ft, influent VOC concentrations for PCE ranging from 1,145 to 1,840 μg/l with a mean of 1,530 μg/l, for TCE ranging from 100 to 2,875 μg/l with a mean of 1,055 μg/l, for 1,1,1-TCA ranging from 35 to 350 μg/l with a mean of 200 μg/l and for 1,1-DCE ranging from 35 to 1,035 μg/l with a mean of 355 μg/l. The PRB VOC effluent concentrations along this section of the PRB are predicted to be less than their respective MCLs.

Design Case II: This design case is for the segment of the PRB (low groundwater flow gradients and medium to high VOC concentrations) located downgradient from the existing sewage lagoons along the property line extending for a length of 350 ft along the PRB alignment. This design case requires a 3-in average iron-effective-thickness PRB installed in soils with a hydraulic conductivity (K) ranging from 3 x 10^{-4} to 3 x 10^{-3} cm/sec with a geometric mean of 1 x10^{-3} cm/sec, a groundwater flow gradient (i) ranging from 0.0017 to 0.016 ft/ft with a mean of 0.0062 ft/ft, influent concentrations for PCE ranging from 1,275 to 5,030 μg/l with a mean of 3,120 μg/l, for TCE ranging from 2,125 to 41,975 μg/l with a mean of 22,110 μg/l, for 1,1,1-TCA ranging from 400 to 1,600 μg/l with a mean of 1,000 μg/l and for 1,1-DCE ranging from 765 to 4,945 μg/l with a mean of 3,325 μg/l. The PRB VOC effluent concentrations along this section of the PRB are predicted to be less than their respective MCLs.

Design Case III: This design case is for the segment of the PRB (medium groundwater flow gradients and high VOC concentrations) located downgradient from the large existing sewage lagoon along the property line extending for a length of 300 ft along the PRB alignment. This design case requires a 4.5-in average iron-effective-thickness PRB installed in soils with a hydraulic conductivity (K) ranging from 3 x 10^{-4} to 3 x 10^{-3} cm/sec with a geometric mean of 1 x10^{-3} cm/sec, a groundwater flow gradient (i) ranging from 0.0051 to 0.015 ft/ft with a mean of 0.011 ft/ft, influent concentrations for PCE ranging from 1,485 to 5,465 μg/l with a mean of 4,270 μg/l, for TCE ranging from 10,625 to 46,575 μg/l with a mean of 35,000 μg/l, for 1,1,1-TCA ranging from 400 to 1,600 μg/l with a mean of 1,000 μg/l and for 1,1-DCE ranging from 700 to 4,140 μg/l with a mean of 2,780 μg/l. The PRB VOC effluent concentrations along this section of the PRB are predicted to be less than their respective MCLs.

Design Case IV: This design case is for the segment of the PRB (medium groundwater flow gradient and medium to low VOC concentrations) located upgradient from the head waters of South Fork Scates Branch for a length of 315 ft along the PRB alignment. This design case requires a 3.5-in average iron-effective-thickness PRB installed in soils with a hydraulic conductivity (K) ranging from 3 x 10^{-4} to 3 x10^{-3} cm/sec with a geometric mean of 1 x10^{-3} cm/sec, a groundwater flow gradient (i) ranging from 0.0043 to 0.015 ft/ft with a mean of 0.0093 ft/ft, influent VOC concentrations for PCE ranging from 425 to 2,015 μg/l with a mean of 1,300 μg/l, for TCE ranging from 975 to 14,375 μg/l with a mean of 6,145 μg/l, for 1,1,1-TCA ranging from 50 to 200 μg/l with a mean of 125 μg/l and for 1,1-DCE ranging from 380 to 950 μg/l with a mean of 640 μg/l. The PRB VOC effluent concentrations along this section of the PRB are predicted to be less than their respective MCLs.

8.4.2 PRB Design Performance Forecast

Forecasts of groundwater effluent VOC concentrations for Design Cases I, II, III and IV are presented on Figures 42, 43, 44 and 45 respectively. The probabilistic design output data are presented as frequency charts for select VOCs (PCE, TCE, cDCE, 1,1-DCE and VC) and as 85 percentiles for all VOCs encountered in the groundwater or VOC daughter products generated by the PRB. The results of the probabilistic analysis performed for Design Cases I, II, III and IV indicate that a 3 to 4.5-in average iron-effective-thickness PRB (depending on design case) is required to bring VOCs encountered in the Site groundwater to less than their respective MCLs.

For determining degradation rates of the remnant plume of TCE (worst case) downgradient from the PRB, a one dimensional (1D) fate and transport transient model was used for the analysis. The model was calibrated to TCE concentrations in monitoring wells MW33 and MW26 as shown on Figure 46. Plume degradation profiles for TCE were calculated at 0.5, 1, 2 and 5 years after the PRB and the Cap System are installed. The results, shown on Figure 46 and in Appendix F-2, indicate that concentrations of TCE and other VOCs encountered in the groundwater will be quickly reduced immediately downgradient of the PRB, and the remnant plume downgradient of the PRB will slowly recede depending on groundwater flow velocities and soil desorption rates.

8.5 Proposed Iron Manufacturer Type and Gradation

The proposed iron filings to be used in the construction of the PRB are Connelly type CC-1022, which has typical mineralogy, grain size distribution, specific gravity and permeability as given in Appendix A. This iron grade is typically classified as a –18/+84 mesh size. CC-1022 has a hydraulic conductivity of approximately 1×10^{-1} cm/sec as detailed from permeability tests contained in Appendix A-2. The mineralogy of the iron is typically as detailed in Appendix A-7. Golder has been using this iron type successfully in azimuth controlled vertical hydraulic fracture installed PRBs over the past two (2) years and this iron type could also be used for a PRB constructed by either the slurry wall or continuous trencher installation methods.

An iron soil filter analysis is conducted to ensure the iron and soil particles do not commingle, i.e. either the soil particles do not invade the iron and thus reduce the iron PRB porosity and permeability or the iron particles do not migrate into the Site soils. The iron soil filter analysis involves comparing the grain size gradation coefficients (D_{15} and D_{85}) with the following criteria as detailed in equation (7) for particle commingling and in equation (8) for permeability contrast, Cedergren (1985).

$$D_{15}(\text{iron})<5D_{85}(\text{soil})$$
$$D_{15}(\text{soil})<5D_{85}(\text{iron}) \qquad (7)$$

If the following criteria is satisfied as detailed in equation (8), then from grain size data the iron PRB will have greater permeability than the neighboring formation soils.

$$D_{15}(\text{iron})>5D_{15}(\text{soil}) \qquad (8)$$

The Connelly CC-1022 iron filings satisfied the above criteria, and the Site soils satisfied the first criterion for particle commingling. Therefore the Connelly CC-1022 iron filing was considered suitable for the construction of the iron PRB as regards iron soil filter requirements.

8.6 Groundwater Well Sand Pack Screen Analysis

The sand pack to be used in the construction of the PRB groundwater monitoring/pulse test wells needs to satisfy both the sand pack Site soil filter analysis to avoid Site soil migrating into and clogging the sand pack but also the sand pack gradation needs to be compatible with the well screen to avoid clogging of the screen and migration of fines into the wellbore. The sand pack filter analysis involves satisfying both of the following criteria, equation (9) for the Site soils filter criteria and equation (10) for the slotted well screen, Cedergren (1985).

The sand pack filter criteria for the Site soils are:

$$D_{15}(\text{sand}) < 5\ D_{85}(\text{soil})$$
$$D_{15}(\text{sand}) > 5\ D_{15}(\text{soil}) \qquad (9)$$

and the sand pack gradation criterion for the slotted well screen is:

$D_{85}(\text{sand}) > 1.2$ Slot Width (10)

A typical 20/40 gradation sand pack will satisfy the above criteria, however the size gradation tolerances of the sand pack must be detailed in the specifications to ensure all above criteria are met.

9.0 PROPOSED PRB INSTALLATION METHOD

9.1 Background

In situ passive iron reactive permeable barriers have been placed at a number of sites, dating back to the first constructed at CFB Borden in 1991 by the University of Waterloo. The early iron reactive barriers had been designed on the funnel and gate concept, Starr and Cherry (1994). Recently continuous permeable barriers have been installed by continuous trenching and azimuth controlled vertical hydrofracturing. The continuous permeable barriers do not modify the natural groundwater flow whereas funnel and gate systems impact the natural groundwater flow.

Iron reactive barriers have significant advantages over conventional technologies for remediation of chlorinated solvent contaminated groundwater, with the prime advantage being that the system is passive. It is a simple process that has been proven both in the laboratory and the field. Site characterization and laboratory bench scale studies are sufficient to design and construct an iron reactive barrier. The number of iron reactive barriers installed to date is detailed in Table 1. The first reactive barrier was constructed in 1991 as a field trial, followed by two in early '95, and during the past five years a number of full scale and pilot systems have been installed. The rapid increase in the number of iron PRBs installed reflects the increasing maturity and acceptance of the zero valent iron technology.

9.2 Zero Valent Iron

Zero valent metals have been known to abiotic degrade certain compounds; such as, pesticides as described by Sweeny and Fisher (1972), and halogenated compounds such as TCE, tetrachloroethene (PCE), vinyl chloride (VC) and isomers of dichloroethene (DCE) as detailed in Gillham and O'Hannesin (1994). In the case of zero valent iron, a first order reduction process can approximate the abiotic degradation of halogenated aliphatics. The compounds are progressively degraded and eventually broken down into ethanes and ethenes, as described by Orth and Gillham (1996) and shown as reactive dehalogenation pathways on Figure 7. In the presence of iron, the chlorinated compound, TCE, is predominantly degraded through the chloroacetylene pathway with only a minor generation of daughter product c-DCE. Therefore the reductive process in the presence of iron generates significantly less daughter products than those generated due to natural degradation. In column experiments, the mol fraction of TCE degraded into chlorinated daughter products such as c-DCE and VC is typically less than 5 -

10%, Gillham and O'Hannesin (1994). Five (5) year performance data of the Borden iron reactive barrier indicated no decline in degradation performance over time, minimal precipitation, and expectations that the reactive barrier will continue performing satisfactory for at least another five years, Gillham and O'Hannesin (1998).

9.3 Emplacement Methods

The placement of iron filings in the subsurface for passive in situ treatment of contaminated groundwater was first discussed by Gillham (1993). The mode of placing the iron filings has been by conventional technologies such as shoring and excavation, and trenching and recently during the past five (5) years by azimuth controlled vertical hydrofracturing. Seven alternate emplacement techniques were considered for the construction of the reactive barrier at the Site including a) slurry wall, b) continuous trenching, c) braced excavation, d) jet grouting, e) hydrofracturing technology, f) driven/vibrated beam and g) deep soil mixing.

The criteria utilized in selection of the most appropriate emplacement technology at the Site are: 1) minimal change to the natural groundwater flow regimes, 2) proven technology (maturity of the technology and previous installation of iron reactive systems), 3) minimal impact on the iron reactivity and permeability, 4) minimal excavation and disturbance (aerial extent of the impact, noise, volumes of excavated materials, etc.), and finally 5) cost.

A funnel and gate system involves the installation of an impermeable funnel by sheet piling, or slurry wall techniques and a permeable gate constructed by braced excavation. The funnels are generally keyed into impermeable strata to avoid contaminated groundwater flowing beneath the system. Such a reactive wall significantly impacts the natural groundwater flow regime and requires excavation to full depth of the system; therefore, this system was not considered a viable option.

A continuous permeable reactive barrier was selected as an optimum system since such a system has minimal impact on the natural groundwater flow regime. Hubble, Gillham and Cherry (1997) have completed an extensive review of emplacement technologies for permeable reactive barrier systems at similar depths to those encountered at the Site. This review assessed the maturity and applicability of the emplacement methods to construct a permeable reactive wall and finally determined cost comparisons for construction by each method. Of the seven emplacement methods considered; jet grouting, driven/vibration beams and deep soil mixing were removed from further consideration because all of these installation methods are not mature methods for the construction of an iron PRB. The braced excavation method was also not considered further due to its significant cost and site wide excavation and dewatering impacts.

The emplacement methods left for consideration are vertical biopolymer slurry wall, continuous trenching and azimuth controlled vertical hydrofracturing technology installation methods.

9.3.1 Slurry (Biodegradable-BioPolymer) Wall

Installation of a treatment zone of iron using biodegradable slurry is similar to constructing a conventional impermeable slurry wall. The biodegradable slurry used is typically guar based. As the trench is excavated, biodegradable slurry provides stability to the trench walls. Granular iron can then be placed into the trench through the slurry. After some time, the biodegradable slurry breaks down (i.e. become less viscous) allowing groundwater to flow through the iron treatment zone. The PRB is constructed in segments (alternate panel construction) to prevent iron filings placed in the neighboring segment from flowing into the current excavated segment.

Two full-scale and one pilot-scale systems application have been constructed in 1999 and in 2000, there have been three full-scale installations. These systems have included two continuous iron reactive barriers, one in New Hampshire and the other in Missouri. The continuous iron PRB installed in New Hampshire was more than 800 ft in length.

Some construction issues associated with this installation method include:

- ❑ Large quantities of potentially contaminated waste must be transported and disposed of and would be in a slurry consistency (even if waste is characterized as non-hazardous it may require stabilization before disposal);
- ❑ The clean soil above the water table is cross contaminated with the soils below the water table;
- ❑ Large quantities of hydrated gel need to be disposed of properly and could be contaminated;
- ❑ With over 20' of hydraulic head of bio-slurry gel on the soils below the water table, horizontal migration of gel with no enzyme can occur;

- The width of the trench ~2.5' will require blending of sand with the iron aggregate;

- The width of the trench along with the depth to the sand-iron mixture, approximately 20', will dictate a higher level of safety for personnel performing job related tasks (i.e. placement of iron, placement of enzyme recirculation wells, sounding the height of the sand-iron mix);

- The production rate of PRB installation is relatively slow, estimated at 33 feet per day based on contractors experience installing PRBs using alternate panel construction technologies;

- With all slurry wall excavations, the repeated entry into the slurry to continue the excavation depth with a backhoe bucket or clam shell progressively blends fines; i.e. siltys and clay, into the slurry which combined with the hydraulic head of the slurry may deposit a low permeability filter cake on the walls of the excavation. The long term effect of this may decrease the permeability of the installed PRB and could cause local damming; and

- The continuous trucking of waste hauling, excavator movement and iron placement activities requires a high level of health and safety oversight in order to maintain a safe working environment.

9.3.2 Continuous Trenching

Continuous trenching machines have been used for several years to install horizontal groundwater collection drains and impermeable barriers. These machines allow simultaneous excavation and backfilling without an open trench. Excavation is performed by a cutting chain immediately in front of a trench-box (boot), which extends the width and depth of the finished treatment zone. Both the cutting chain and boot are attached to the trenching machine. As the trencher moves forward, iron is added to the boot creating a continuous treatment zone. Trenchers are available to install treatment zones from 1 to 2 ft in width to depths of 25 ft. Excavating a bench on which to operate the trencher may extend the total depth.

Continuous trenching was first used to install a PRB in 1996 at a site in Elizabeth City, North Carolina. About 450 tons of iron was placed in a trench 150 ft long and 24 ft deep. Since then, trenchers have been used for PRBs at sites in South Carolina, Oregon, Vermont, New York and Louisiana.

Some construction issues regarding this installation method:

- ❑ Wider bench bottom should be considered because two parallel excavations may be required for the following scenarios: 1) the required loading may be lower than the design due to soil rebound, 2) feed problems or 3) restart of trenching operations after prolonged shutdown of excavation process;

- ❑ The presence of running or loose sands and silts below the water table can result in low iron feed to these horizons making the PRB deficient in thickness in these loose sediments;

- ❑ For a high water table condition, benching may not be sufficient to allow for the continuous trencher to install the PRB down to its full depth (i.e. down to the aquitard unit);

- ❑ If iron density is higher than design take in excavation, then sand would have to be blended requiring equipment and graded sand to be on site during construction; and

- ❑ The production rate of a continuous trencher from cost estimates is from 140 to 210 a linear ft/day. If any supply or delivery problems occur standby time for the trencher contractor would occur. Contingencies such as extra blending equipment, trucks, crane, etc. must be considered against the stand-by costs.

9.3.3 Hydrofracturing Technology

Hydrofracturing technology has been used for other applications primarily in petroleum recovery for installing sand and sintered bauxite proppants into the subsurface and in environmental applications for enhancing permeability for soil vapor extraction systems. Azimuth controlled vertical hydrofracturing has been used to construct full-scale PRBs from moderate (~50') to significant depth (>120'), Hocking et. al. (1998 a & b and 2001b). Using the hydrofracturing technology, the PRB is constructed from a series of conventionally drilled boreholes along the PRB alignment with a specialized frac casing grouted into the boreholes. The PRB is constructed by injection of the iron filings into these frac casings with real time quality assurance monitoring of the injections to quantify the PRB geometry and iron loading densities. The hydrofracturing technology can place PRBs up to 8 inches thick (Hocking et al, 2000). For thicker PRBs, multiple parallel PRBs are required to be installed.

Some construction issues regarding this installation method:

- ❑ Proven technology with demonstrated effectiveness of placement of iron PRBs in similar geology and depth;

- ❑ Generally, not cost effective for shallow PRBs, i.e. < 30' depth;

- High standard of quality assurance and verification testes for assurance on constructed barrier geometry, continuity, iron loading and minimal impact on natural groundwater flow regimes;

- Minimal excavation and site disturbance; and

- Low personnel and property risk exposure.

9.4 Selected Emplacement Method Technology

The method considered most suitable, considering the PRB depth, PRB thickness and cost to install is the azimuth controlled vertical hydraulic fracturing technology. This technology has installed iron PRBs in similar geology and depths.

A detailed cost analysis on the preferred installation method for the iron PRB at the Site is summarized in Table 14. The method is capable of installing an iron PRB from 3" to 8" thick. Estimated costs for this method for construction of the PRB at this Site are significantly less than that of a continuous trencher or biopolymer trench. The selected method has no excavated waste, no excavation and of all the methods has the least disturbance and least impact to the Site groundwater flow regimes and the overall Site in general.

9.5 HydroFrac PRB Design

9.5.1 Overview of the Installation Method

The azimuth controlled vertical hydraulic fracturing placed iron PRB is constructed from conventionally drilled wells installed along the barrier alignment as shown diagrammatically on Figure 47. A controlled vertical fracture is initiated at the required azimuth orientation and depth in each well inside of a specialized frac casing utilizing downhole frac initiation tools. The iron filings are blended and injected in the form of a highly viscous degradable food grade quality gel, hydroxypropylguar (HPG). Multiple well heads are injected with the iron-gel mixture to form a continuous PRB. The gel biodegrades into water and sugars by the use of a suitable enzyme, and leaves in situ a permeable iron reactive treatment zone. The hydraulic fracturing technology is capable of installing iron permeable barriers from 3" to 9" in thickness.

Azimuth controlled vertical hydrofracturing technology, (Hocking, 1996, Hocking and Wells, 1997 and Hocking et. al. 1998a and b), consists of an injection delivery system comprising three prime components; 1) the fracture initiation device, 2) the controlled pumping equipment and 3) the real time monitoring and inverse algorithms for determining fracture geometry. The fracture initiation device is used to control the fracture orientation and is comprised of a suite of tools and fracture well casings. The selection of the initiation device is dependent on the geological formation, depth and the fracturing fluid required for the particular application. The hydraulic fracturing injection system consists of a mixing/blending and pumping system, which is specially designed to achieve a precise control of fracture fluid pressures and flow rates. The real time monitoring system provides feed back response to ensure the fractures are propagating and constructed as planned.

Field experiments have demonstrated that a) the vertical fractures can be placed at the required azimuth or bearing, b) continuous coalesced fractures are formed by the simultaneous injection of multiple fracture well heads, and c) fracture thickness can be controlled by a process of tip screen out or multiple fracture initiations. The technology, see Figure 47, involves installing injection wells along the PRB alignment, initiating the fracture at the correct orientation at depth and creating a continuous barrier by controlled injection of multiple well heads. To date the technique has been demonstrated to work in a range of soil and stress conditions, from loose cohesionless sands, to partly cemented dense sands, gravel, clay and silts.

The iron filings are transported to the site in either 55 gallon sealed numbered drums or 3,000 lb sealed numbered bags. Pre-shipment quality assurance tests on the iron are required to be completed and must be within specification prior to shipment. In the case of the iron filings in 55 gallon drums, the iron is discharged into the mixing and blending tank by a remote drum handler attached to an all terrain forklift. In the case of the iron filings being in 3,000 lb bags, the iron filings are pre-loaded into 3,000 lb capacity hoppers for discharge into the mixing and blending equipment.

The HPG is pre-mixed in a 3,000 gallon mixing tank utilizing a venturi blender and fed along with the iron filings into a 500 gallon mixing/blending tank. The iron and HPG are mechanically agitated to ensure the iron filings remain suspended and the mixture is then fed to the hydrofracturing pump and cross-linked in line on the pressure side of the pump. The pumping system is specially designed to achieve a precise control of fracture fluid pressures and flow rates.

The PRB installation is monitored in real time to ensure mixture consistency, determine volume and weights of iron injected, and to determine the geometrical extent of the barrier thus ensuring it is constructed as designed. A general layout of the monitoring system used during construction of a PRB is shown on Figure 48. The real time monitoring of the PRB geometry involves active resistivity instrumentation equipment and specialized software, as shown on Figure 49. During injection, the iron-gel mixture is electrically energized with a low voltage 100 Hz signal. Downhole and/or surface resistivity receivers are monitored to record the in phase induced voltage by the propagating fracture. From monitoring the fracture fluid induced voltages and utilizing an incremental inverse integral model, the fracture fluid geometry can be quantified and displayed during the installation process.

High precision hydraulic pulse interference tests are utilized to demonstrate the minimal impact of the PRB on the site hydrogeology. Hydraulic pulse interference tests, Johnson et. al. (1966) and Kamal (1983), involve a cyclic injection of fluid into the source well, and by high precision measurement of the pressure pulse in a neighboring well, detailed hydraulic characterization between wells can be made, see Figure 50. The pulse interference test is highly sensitive to hydrogeological properties between the wells, and relatively insensitive to conditions outside of the wells. The hydraulic pulse interference tests are relatively short duration tests of approximately two (2) minutes maximum and involves the injection typically of less than ten (10) gallons of potable water. The test is a truly hydraulic transient test and can determine site hydrogeological properties, such as transmissivity and storativity, from generated "type-curves". Pulse interference tests are proposed to be conducted from new and existing pulse test/groundwater monitoring wells prior to PRB installation and after PRB installation. Comparison of before and after pulse interference data will confirm the minimal impact the PRB has on the site hydrogeology and thus the minimal impact on groundwater flow regimes.

Golder implements strict quality control procedures during construction of the PRB to provide the necessary assurance that the reactive barrier system's design performance requirements are achieved. Golder's construction quality control procedures and acceptance criteria concentrate on the following:

- ❑ In-line and batch consistency tests of the iron reactive mixture;
- ❑ Thickness and injected quantities of reactive iron;
- ❑ Geometry of the iron PRB monitored (active resistivity) during injection; and
- ❑ Quantification of hydraulic impact of the PRB from hydraulic pulse tests.

9.5.2 HydroFrac PRB Design Issues

The design of the iron PRB involves analyses to ensure the system can be constructed as planned and to detail those system requirements and material parameters necessary for PRB construction by the azimuth controlled vertical hydraulic fracturing technology. The analyses presented in this section are as follows:

- ❑ Crosslinked gel rheological and iron settling analysis to determine settling rate of the iron proppant in the crosslinked gel;
- ❑ Determination of in situ stress state with depth at the Site;
- ❑ Determination of the Site formation soil moduli with depth;
- ❑ Crosslinked gel leak off analysis simulating propagation of the hydraulic fractures in the Site soils;
- ❑ Iron proppant transport analysis to determine iron transport distances in the hydraulic fracture; and,
- ❑ Hydraulic fracture design analysis to simulate and to determine hydraulic fracture geometrical propagation, fracture thickness, and fracture propagation injection pressures and flow rates.

The above analyses and simulations are described in detail in the following sections. These analyses utilized data described earlier in the previous Section 6.0 and contained in Appendix A.

9.5.3 Crosslinked Gel Rheology and Iron Settling Analysis

The crosslinked HPG gel rheological properties were determined by a rotating cylinder viscometer as shown in Appendix A-6 (see Figure 1 and associated test results in Appendix A-6). The viscosity of the crosslinked gel is significantly greater than that for the uncrosslinked gel, and exhibits a non-Newtonian behavior which can be represented by a non-linear power law model as given by equation (11), Gidley et al (1989).

$$\mu = K \dot{\gamma}^{n-1} \tag{11}$$

where μ is the viscosity, K and n are power law constants and $\dot{\gamma}$ is the shear rate. The best fit power law constants for the crosslinked gel are detailed on Figure 1 in Appendix A-6. The crosslinked gel viscosity model is utilized to determined iron transport properties within the hydraulic fracture and fracture propagation injection pressures.

The hydrofracturing installation method can place the iron filings in situ without mixing with the native soils. However, the iron filings size gradation needs to be selected to ensure the native soils do not enter the reactive barrier material and likewise the iron filings are not flushed out of the PRB into the native soil. Modified filter pack design criteria are used to confirm that the selected iron filings material and native soils do not commingle due to the groundwater flow velocity.

The design of the iron reactive material requires optimizing the permeability of the iron filings to be greater than the native soils, whenever possible, and also ensuring a high PRB porosity without violating the iron soil filter design criteria. Thus by optimizing the iron reactive mixture, the greatest residence time can be achieved resulting in the use of less iron which lowers the cost of the PRB.

The Site formation soil grain size and hydraulic conductivity data were presented in Section 6.3 and summarized in Tables 11 and 12, respectively. Iron filings grain size, specific gravity and hydraulic conductivity data are detailed in Appendix A-2. An iron soil filter analysis was conducted as detailed in Section 8.5 to ensure the iron and soil particles do not commingle, i.e. either the soil particles do not invade the iron and thus reduce the iron PRB porosity and permeability or the iron particles do not migrate into the Site soils.

The Connelly CC-1022 iron filings satisfied the criteria detailed in equations (7) and (8), and the Site soils satisfied the criterion, as given in equation (7), to avoid particle commingling of soil particles entering the PRB. The Connelly CC-1022 iron filings was therefore considered suitable for the construction of the iron PRB as regards iron soil filter requirements.

The grain size and specific gravity data for the iron filings, CC-1022, selected for construction of the PRB, are contained in Appendix A-2. The iron settling rate in the crosslinked gel is given by Stoke's Law for simple settling in a non-Newtonian fluid as given by equation (12), Gidley et al (1989).

$$v_s = \left[\frac{g\, d_p^{\,n+1} (\rho_p - \rho_f)}{18\, K\, (3)^{n-1}} \right]^{1/n} \tag{12}$$

where v_s is the settling velocity, g is the acceleration due to gravity, d_p is the particle diameter for a spherical particle, ρ_p and ρ_f are the proppant and gel fluid densities respectively and K and n are the non linear power law viscosity constants. The calculated settling velocity of the iron particles in the crosslinked HPG gel is less than 10^{-4} feet/sec and highlights that the iron filings will remain completely suspended in the crosslinked gel prior to breaking of the gel.

9.5.4 In Situ Stress State Profile with Depth

The in situ stress state in the Site soils need to be estimated in order hydraulic fracture design analyses can be conducted to determine optimal injection propagating pressures and flow rates. The estimate of both vertical and horizontal stress state with depth was developed from SPT blow count N values and from CPT data. First, the unit weight of the soils at various depths are estimated from the SPT N values and CPT data. From the soil unit weights the profile of vertical stress with depth can be easily determined. Pore water pressures were determined from CPT data and monitoring wells screened in the upper and lower aquifers.

Estimation of the horizontal and vertical stress state requires a series of correlations and corrections, as detailed in the following steps:

- ❑ The CPT data are referenced to SPT N values by the correlation detailed in Robertson and Campanella (1983);
- ❑ The SPT and CPT data, both referenced to SPT N values are corrected for overburden effects, as detailed by Skempton (1986) for fine sands;

- The relative density of the Site soils were determined from the corrected N values as detailed by Kulhawy and Mayne (1990);

- The vertical overburden stress profile was calculated from the relative densities of the Site formation soils;

- The friction angle of the soils was calculated from the correlation with relative density as described by Peck, Hanson and Thornburn (1974); and,

- The Ko (Coefficient of horizontal stress at rest) was determined from the friction angle of the formation soils, and the horizontal effective stress determined from Ko and the vertical effective stress.

The estimated in situ stress state profile at the Site is shown on Figure 51 for the horizontal and vertical effective stresses as determined from the available SPT and CPT data for borings and direct push measurements in the vicinity of the PRB alignment. The horizontal effective stress at 40 ft depth is approximately 10 to 12 psi.

9.5.5 In Situ Soil Modulus with Depth

The in situ soil modulus is estimated from correlations between pressuremeter tests, which provide a direct measurement of the horizontal modulus of cohensionless soils and corrected SPT N values. The soil modulus measured directly by the pressuremeter is approximately equivalent to the soil Young's Modulus (E_d). The estimation of soil Young's modulus from corrected SPT N values were determined from equation (13) as detailed in Ohya, Imai and Matsubara (1982).

$$E_d = 9.08\, N_c^{0.66}\, P_a \tag{13}$$

Where N_c is the corrected SPT N values and P_a is atmospheric pressure in pounds per square foot (psf).

The estimated in situ soil Young's modulus with depth are shown on Figure 51 as determined from available SPT and CPT data collected in the vicinity of the PRB alignment. In general, the Site soils are of medium relative density and stiffness.

9.5.6 Hydraulic Fracture Design Analysis

Hydraulic fracture design analyses have evolved from relatively simple models such as PKN (Perkins-Kern-Nordgren) and GdK (Geertsma-de-Klerk), as detailed in Gidley et al (1989), to three dimensional simulators incorporating poroelasticity continuum idealizations to discrete element discontinuum models modeling individual discrete particles. The objectives of conducting analyses by these models is to determine leak off of the fracturing fluid into the formation, transport of the iron proppant in the fracture, determination of fracture geometrical propagation for various fracture propagation injection pressures and flow rates. The simple elastic continuum models based on PKN assumptions are not suitable for analysis of hydraulic fracturing of unconsolidated sediments since the poroelastic effects and material behavior of the formation soils is not adequately represented.

Hydraulic fracture simulations were conducted using a proprietary model for the determination of fracture geometrical propagation, injection pressures and flow rates. Fracturing fluid leak off and iron proppant transport are also quantified in the model. The impact of pore pressure changes and dilatancy of the host formation soils during the fracturing process are essential parameters to be represented to achieve a realistic simulation. Input into the hydraulic fracturing model include:

- Leak off test coefficients Cw and Spurt for the crosslinked HPG gel;
- In-situ total and effective vertical and horizontal stress states with depth in the vicinity of the PRB alignment;
- Stiffness of the host formation being fractured;
- Viscosity of the crosslinked gel defined as a power law model;
- Specific gravity of the iron filings and grain size distribution; and,
- Specific gravity of the crosslinked gel without iron filings.

The horizontal effective stresses for the Site formation soils were estimated from SPT and CPT data as described in Section 9.5.4 and shown as a depth profile on Figure 51. The viscosity of the crosslinked gel was determined from tests conducted by a rotating cylinder viscometer as described in Section 6.7 and detailed in Appendix A-6 (see Figure 1 and associated test results in Appendix A-6). The rheological behavior of the crosslinked gel was idealized as a power law model as given by equation (11) and shown on Figure 1 in Appendix A-6. The leak off coefficient of the crosslinked gel was determined at stress levels representative of in situ stress conditions in a laboratory leak off apparatus, as described in Section 6.5 and illustrated along with test results in Appendix A-3 (see Figure 1 and associated test results in Appendix A-3). The stiffness of the Site formation soils were estimated from SPT and CPT data as detailed in Section 9.5.5 and shown on Figure 51.

The hydraulic fractures are initiated and propagated at the desired azimuth orientation as shown on Figure 52. The frac casing initiates the fracture and by controlling injection pressures and flow rates fracture azimuth is maintained. The fracturing fluid is water soluble in the uncrosslinked state and requires mechanical agitation to maintain suspension of the iron filings. In the crosslinked state the gel is insoluble in water and has sufficient viscosity to maintain suspension of the iron filings throughout fracture propagation and closure, see Figure 52. The iron filings are transported by the crosslinked gel to the extremities of the fracture as indicated on Figure 52. The various phenomena, such as leak off, non-linear viscosity and iron transport are computed throughout the simulations.

For the desired fracture propagation lengths and heights, the fracture injection pressures will be typically less than 15 psi above the in situ total horizontal ground stress at the fracture propagating tip. The injection pressures and flow rates for such fracture propagation will result in minimal leak off in even the most permeable of the formation soil horizons, i.e. generally *unmeasurable in the field. Iron proppant will be transported to the full extents of the fracture* geometry, and in the crosslinked gel the iron filings can be transported significantly greater distances, at least an order of magnitude greater, than the fracture propagated dimensions considered for construction of the PRB. The crosslinked fracturing fluid has sufficient viscosity and transport efficiency to create fully efficient fracture propagation dimensions contemplated in the construction of the PRB. In order to achieve the required density of iron loading, multiple fracturing initiations may be required at particular formation horizons; however, field data from earlier field hydraulic fractures will provide more accurate assessment of the required fracture injection pressures, flow rates and propagation dimensions.

10.0 CAP SYSTEM CONSTRUCTION

10.1 Cap System

Prior to the start of the Cap System construction activities, the existing sewage lagoons on the northeast of the property (see Figures 2 and 31) will need to be closed. The property owner, Mattatuck Electronics Technology, Inc. (Mattatuck) is responsible for closure of the lagoons. A lagoon closure plan dated April 19, 2000 was prepared and submitted by Mattatuck to the Virginia Department of Health, Water Division for review and approval. The proposed closure plan was approved by VDEQ in a letter dated May 26, 2000.

The proposed Cap System Design has incorporated the proposed lagoon closure plan submitted by Mattatuck and approved by VDEQ. Potential generation of gas from decomposition of the sludge in the lagoon will be vented out through the Cap System. A gas collection sand layer 12-in thick, 10 ft wide will be placed immediately underneath the Geosynthetic Clay Liner (GCL) along the crest (high point) of the Cap System. Two vent pipes installed through the Cap System and connected to a 3" diameter perforated gas collection pipe placed within the sand layer will vent any gas entrapped underneath the Cap System.

A 7-foot high soil surcharge will be placed over the large lagoon area after the lagoon has been backfilled with compacted fill (Mattatuck's Plan) and left in place for three (3) months. Two temporary settlement plates will be installed over the top of the backfill material and underneath the surcharge fill to monitor settlement and settlement rates for three (3) months. The settlement and settlement rate data will be reviewed to verify expected long-term settlement is within the expected limits. The surcharge will then be removed and the Cap System constructed. The proposed surcharge program and revised change in Cap System grades (1 to 3%) will allow for expected remaining settlement to occur after removal of the surcharge and still result in final Cap System grades (vegetative cover and internal drainage system) greater than 1%.

There are six (6) existing monitoring wells, AR1, AR2 and AR3 associated with the monitoring of the two existing sewage lagoons and site monitoring wells MW10, MW11 and MW21, that lie in the proposed surface impermeable cap area. All of these existing wells will remain and the Cap System will be constructed around them. These existing wells will be monitored solely for potentiometric levels during each groundwater sampling event after Cap System construction.

The Cap System is designed so that soil borrow materials for the vegetative covers are excavated within the footprint of the Cap System area and, if necessary, from a borrow area adjacent to the Cap System within the Site. The surface slope of the Cap System will be graded with a minimum initial slope of 3% and a maximum of 3H:1V. The Cap System will consist from the top down of 24-in of vegetative cover, a geocomposite drainage layer and a geosynthetic clay liner (GCL) low permeability layer. Reinforced GCL will be used on the Cap System slopes (not including the 3H:1V surface water ditches side slopes) steeper than 10H:1V (10%) for cap stability.

Two main drainage ditches will be constructed to collect surface water runoff from the Cap System for surface water management as shown on Figure 36. The ditches and the vegetative cover will be grassed (seeded) using a mix as described in Section 7.5.3 and in the Technical Specifications. The vegetative cover will be planted with a mix of native warm and cool season grasses. The vegetative cover will stabilize the soils, provide a low maintenance, long-term plant community, provide a structurally diverse grassland habitat for birds and other wildlife, and will use native plant species whose seeds are available commercially.

Rip-Rap will be used for surface erosion protection at the outfalls of the two (2) new culverts discharging into the existing site drainage features, and erosion control matting will be placed along Ditch B-2 as required from ditch design calculations. The areas where rip-rap and erosion control matting are required are shown on Figure 36 and on the Construction Drawings.

Corrugated metal pipe (CMP) will be used for the two (2) new culverts that will be installed as part of the Cap System surface water management control structures. One culvert (Culvert A) will consist of two (2) 18" diameter CMPs and the other culvert (Culvert B) will consist of one (1) 24" diameter CMP to allow for design peak flows of 16 and 12 cfs, respectively. The locations of the two new culverts are shown on Figure 36 and on the Construction Drawings.

Typical details and cross sections for the construction the Cap System and surface water management controls (ditches, culverts, etc) are shown on Figures 33 and 34. A number of monitoring wells exist within the footprint of the Cap System and the new PRB construction and monitoring wells will also be constructed within the Cap System footprint. The Cap System geosynthetics (GCL and geocomposite) will be properly installed around the wells to minimize rainfall infiltration through the Cap System.

10.2 Construction Sequence

The construction of the Cap System will require a specific construction sequence to be followed. The construction sequence of the main activities for the Cap System construction is detailed below:

1. Site Preparation
2. Site Layout/Surveying
3. Implementation of Erosion and Sediment Control Measures
4. Construction of temporary surface water management control structures (i.e. ditches, etc)
5. Excavation of Soil Borrow Materials and Stockpiling
6. Cap System Internal Drainage Grading
7. Deployment of Geosynthetic Clay Liner (GCL)
8. Deployment of Geocomposite Drainage Layer
9. Placement of Vegetative Cover
10. Construction of Final Surface Water Management Ditches and Culverts
11. Grassing of Cap System Area, Ditches and Other Disturbed Areas (i.e. borrow areas)
12. Site Restoration
13. Construction Final Inspection, and
14. Demobilization

10.3 Cap System Technical Specifications

Technical specifications were developed for the different construction elements of the Cap System. The Technical Specifications have been prepared to ensure the Cap System is constructed in accordance with the intent of the design and the Construction Drawings. The Technical Specifications for the Cap System are included with the Cap System Construction Quality Assurance Plan in Appendix G-1.

10.4 Construction Quality Assurance Monitoring

Construction Quality Assurance (QA) procedures were developed for the construction of the Cover System. The QA procedures were developed to ensure that the Cap System is installed in accordance with the Construction Drawings and Technical Specifications. The QA procedures address as a minimum the following:

- ❑ Geosynthetic Clay Liner (GCL) meets materials specifications and is installed in accordance with the Construction Drawings and Technical Specifications.
- ❑ Geocomposite Drainage Layer meets materials specifications and is installed in accordance with the Construction Drawings and Technical Specifications.
- ❑ Vegetative Cover Layer meets material requirements and is placed to the grades in accordance with the Construction Drawings and Technical Specifications.
- ❑ Protective vegetation and erosion control for Cap System, ditches and disturbed ground meet material requirements and are placed in accordance with the Construction Drawings and Technical Specifications.
- ❑ Aggregate Materials for the Cap System Internal Drainage Collection Ditch meet material requirements and are placed in accordance with the Construction Drawings and Technical Specifications.

The QA procedures are included in the Cap System Construction Quality Assurance Plan (CQAP) included in Appendix G-1.

10.5 Construction Quantities and Cost

The Cap System will cover an area of approximately four and one half (4-1/2) acres. The construction of the Cap System will require clearing and striping of approximately 5 acres, the excavation and stockpiling of approximately 25,000 yd^3 of soils within the Cap System footprint and if necessary from a borrow area within the Site adjacent to the Cap System, deployment of approximately 200,000 ft^2 of GCL and 200,000 ft^2 of geocomposite drainage layer, placement of approximately 400 tons of No. 57 drainage stone along the Cap System internal drain ditches, placement of approximately 20,000 yd^3 soils for the vegetative cover, installation of two (2) 18" diameter CMP culvert approximately 30 ft (60 ft total) long and one (1) 24" diameter CMP culvert approximately 40 ft long, placement of approximately ten (10) tons of 6" to 12" size rip-rap and 15,000 ft^2 of erosion control matting for ditch surface erosion control, approximately 2,000 linear feet of ditches for the Cap System internal drain and surface water management, seeding and mulching of approximately 5 acres, and installation of approximately 1,000 ft of 6' high chain link fence around the footprint of the Cap System Easement/Property Line.

The estimated cost for the 4-1/2-acre Cap System is $0.52M. Of this, $0.20M is for earthwork, $0.26M is for geosynthetics, $0.03M is for drainage ditches and culverts, $0.01M is for seeding and mulching, rip-rap and erosion control matting and $0.05M is for construction QA/QC and Project Management. A summary breakdown of the different costs by labor, unit pricing and expenses is provided in Table 14 for the Cap System and PRB.

10.6 Cap System Final Design and Construction Schedules

A schedule for the Final Cap System, PRB and Cap System Design Submittals and PRB construction is outlined in Table 15. Provided Final (100%) Design EPA and VDEQ review comments are received by May 9, 2001, the PRB and Cap System contractor selection and contracting is scheduled to start by mid May 2001. The construction of the Cap System is dependent on the completion of the lagoon closure as detailed in the Mattatuck plan, see Task 25 in the schedule contained in Table 15. Cap construction activities, Task 26 and higher, can not be initiated until the lagoon closure is completed. Construction of the PRB and Cap System Remedy is expected to be completed by the end of November 2001, provided Mattatuck complete lagoon closure by the end of June 2001. The construction of the Cap System will take approximately three (3) months and the construction of the PRB will take approximately four (4) months. Construction of the Cap System will be delayed if lagoon closure to be undertaken by Mattatuck is not completed by the end of June 2001. Some of the activities of the Cap System and PRB installation will be completed concurrently.

10.7 Performance Monitoring and Action Plan

A Performance Monitoring and Action Plan was developed for the construction of the Cap System and PRB. The Performance Monitoring and Action Plan is composed of seven (7) major components: a Construction Quality Assurance Plan (CQAP), a Performance Standard Verification Plan (PSVP), a Contingency Plan (CP), a Waste Management Plan (WMP), a Groundwater Monitoring Plan (GWMP), a Health and Safety Plan (HSP) and an Operations & Maintenance Plan (O&M). Separate CQAPs were prepared for the Cap System and the PRB. The Cap System CQAP is included in Appendix G-1 including the Technical Specifications. The other Plans are discussed under Section 11.5.

10.7.1 Cap System Construction Quality Assurance Plan (CQAP)

The CQAP describes the procedures, which are to be used during construction of the Cap System to ensure that the materials used meet or exceed specifications, and the Cap System is constructed in accordance with the Construction Drawings and Technical Specifications. The plan also details the records needed so that an appropriate "as-built" construction record can be prepared at the end of each phase of construction. The CQAP is supported by material technical specifications, which provide the criteria to be used to evaluate the suitability and/or acceptability of all of the materials required for construction. Technical specifications for the materials and installation requirements are included in the CQAP.

11.0 IRON REACTIVE PERMEABLE BARRIER SYSTEM CONSTRUCTION

11.1 Reactive Barrier System

The iron reactive permeable barrier system consists of installing a reactive barrier perpendicular to the natural groundwater flow direction as shown on Figure 37. The reactive barrier will be installed using the azimuth controlled vertical hydrofracturing installation method. The reactive barrier is 1,165 feet long in plan, and ranges in depth from approximately 15 feet down to a depth of 42 feet, as shown on Figure 38. The reactive barrier thickness will range between 3 and 4.5 inches in effective thickness depending on the design case, Design Cases I through IV, for the four (4) sections along the PRB alignment as detailed in Section 8.4 and shown in plan on Figures 40 and 41.

The PRB design will require the installation of a cross-sectional area of approximately 24,000 ft^2 of iron PRB. The PRB will be constructed from eighty two (82) hydraulic fracturing wells (denoted as F1 through F82) along the PRB alignment as shown on Figure 53 in plan and in section on Figure 54. The iron PRB will be 1,165 ft in length, orientated approximately perpendicular to the groundwater flow regime, be approximately 3" to 4.5" in average iron-effective-thickness for a total of 650 tons of iron filings injected into the subsurface, and extend from a depth of 15' down to a total depth of 42'. A total of thirty nine (39) subsurface active resistivity receiver strings (denoted as RR1 through RR39) will be installed offset from the PRB alignment as shown on Figure 53 to monitor the geometry of the PRB during construction.

The hydraulic effectiveness (impact of PRB installation method) of the PRB will be quantified from hydraulic pulse interference tests conducted from upgradient and downgradient wells installed along the alignment of the PRB. These wells will be installed to serve as PRB performance groundwater monitoring wells and construction monitoring hydraulic pulse test wells. The location of the proposed PRB construction and performance monitoring wells are shown on Figure 37. The hydraulic pulse interference source well will be pulsed and the hydraulic pressure response recorded on the other side of the barrier in the downgradient groundwater monitoring wells. From the response of these monitored pressure pulses the extent of the hydraulic effectiveness of the barrier can be quantified. The upgradient and downgradient wells will be screened at similar depth intervals.

The installed thickness of the PRB will be verified by inclined direct push electrical resistivity (Beck et. al., 2000) and magnetometer (Hocking et. al., 2001a) profiles. Eight (8) inclined (approximately 30° to the vertical) profiles will be completed along the PRB alignment to verify installed PRB thickness.

Existing monitoring wells AR1, MW12 and MW33 and sixteen (16) new monitoring wells will be used for PRB groundwater performance monitoring and construction hydraulic pulse testing. Six (6) new monitoring wells will be installed upgradient of the PRB and ten (10) new monitoring wells will be installed downgradient of the PRB. These sixteen (16) new wells will be used for both PRB construction hydraulic pulse testing and PRB performance groundwater sampling events. Pulse tests will be conducted prior to PRB installation and after the PRB is completed to ensure groundwater flow is restored through the PRB.

The dehalogenation effectiveness of the iron reactive barrier will be quantified by measurement of volatile organic contamination in the groundwater sampled from both upgradient and downgradient groundwater wells.

11.2 Construction Sequence

The construction of the iron reactive permeable barrier system for the Site will require a specific construction sequence to be followed. The construction sequence of the main activities for the PRB construction is detailed below:

15. Site Preparation
16. Install and Develop Pulse Test/Groundwater Monitoring Wells
17. Conduct Pre-Wall Groundwater Sampling
18. Conduct Pre-Wall Pulse Tests
19. Install Active Resistivity Strings
20. Install Hydrofracturing Well Heads
21. Install Reactive Barrier
22. Conduct Real Time PRB Installation Monitoring and PRB Thickness Verification
23. Conduct Pulse Tests After Barrier Installation
24. Begin Post Wall Groundwater Monitoring
25. Clean Site and Demobilize

11.2.1 Site Preparation

As in any other construction project, the Site will need to be prepared to accommodate the different activities associated with the construction of the reactive barrier system. In general, the following activities will be required to be completed before barrier construction commences:

1. Grade Site and Install Decontamination Pad
2. Place Geotextile Fabric and Gravel / Access Roads
3. Set up Waste Handling/Storage System
4. Install Utilities, Fences and Signs

11.2.2 Performance Monitoring System Installation

The performance monitoring of the reactive barrier system is based on groundwater samples collected from downgradient of the barrier and tested for VOCs, metals and general analytical chemistry parameters as detailed in the GWMP. The groundwater monitoring wells will be installed immediately upon completion of Site preparation activities. Sixteen (16) new groundwater monitoring wells will be installed in addition to the three (3) existing wells (AR1, MW12 and MW33) as shown on Figure 37 for a total of nineteen (19) PRB groundwater monitoring wells. The wells will be screened (10ft) in the lower portion of the aquifer as detailed in the Construction Drawings.

The groundwater monitoring wells will be constructed with a 2-inch diameter polyvinyl chloride (PVC) casing (with a 2 foot long riser section extending above the ground surface) and extended to the top of the aquitard and grouted in place. The wells will be flush threaded 2-inch interior diameter (ID) Schedule 40 polyvinyl chloride PVC well casing with 0.010-inch slotted schedule 40 PVC screens installed inside the PVC.

The wells will be completed with a 20/40 grade quartz-sand filter pack, in the screen horizon and 2 feet above top of screen, 5 feet of bentonite slurry above the sand pack, followed by the 5% bentonite powder/95% Portland® cement grout all in accordance with the Groundwater Monitoring Plan (GWMP). The wells will be capped with a concrete pad and locking steel or annodized aluminum protective cover.

Following installation, all of the wells will be developed with a bailer or submersible pump in accordance with the site specific GWMP.

11.2.3 Construction Quality Assurance Monitoring

Construction Quality Assurance (QA) procedures were developed to ensure that the PRB is installed in accordance with the Construction Drawings and Technical Specifications. QA procedures will address as a minimum the following:

- ❑ Iron filings grain size distribution and mineralogy;
- ❑ Iron/gel mix design including mix density, resistivity and viscosity (gel only);
- ❑ Hydrofracturing injection pressures;
- ❑ Iron filings placement rate per square foot of PRB by determining the PRB geometry by active resistivity mapping and the weight of iron injected in each hydrofracturing well; and
- ❑ Verification of PRB thickness by inclined profiling by electrical resistivity and magnetometer probes.

11.3 Construction Quantities and Cost

The PRB construction will require the installation of a cross-sectional area of approximately 24,000 ft^2 of iron PRB. The PRB will be constructed to have an average iron-effective-thickness, in the groundwater flow direction, of 3 to 4.5 inches depending on the PRB Design Case. Approximately 650 tons of iron filings will be required to construct the PRB. A total of sixteen (16) hydraulic pulse test/groundwater monitoring wells will be installed, as well as thirty nine (39) active resistivity strings and eighty two (82) hydrofracturing wells.

The estimated cost of the PRB and Cap System groundwater remedy is $3.12M as detailed in Table 14. Of this cost, $0.05M is for mobilization, procurement and demobilization, $0.19M is for site preparation and site restoration, $2.09 PRB construction and groundwater monitoring well installation, $0.52 is for construction of the Cap System, $0.16M is for the ETI license for the placement of zero valent iron into the subsurface for VOC degradation, and $0.09M is for waste disposal. A summary breakdown of the different costs by labor, unit pricing and expenses is provided in Table 14 for the construction of the Cap System and PRB.

11.4 PRB Final Design and Construction Schedules

A schedule for the Final Cap System, PRB and Cap System Design Submittals and PRB construction is outlined in Table 15. Provided Final (100%) Design EPA and VDEQ review comments are received by May 9, the PRB and Cap System contractor selection and contracting is scheduled to start by mid May 2001. Site preparation is expected to start in late May 2001 along with the installation of groundwater monitoring wells and hydrofrac wells, installation of the PRB System to start in late June 2001 and the Cap System construction to begin in early July 2001, depending upon the lagoon closure by Mattatuck as discussed in Section 10.6. Construction of the PRB and Cap System Remedy is expected to be completed by the end of November 2001. The construction of the Cap System will take approximately three (3) months and the construction of the PRB will take approximately four (4) months. Some of the activities of the Cap System and PRB installation will be completed concurrently as shown in the proposed schedule. Start of construction of the Cap System is dependent on lagoon closure by Mattatuck. Construction of the Cap System will be delayed if lagoon closure by Mattatuck is not completed by the end of June 2001.

11.5 Performance Monitoring and Action Plan

A performance monitoring and remedial action work plan was developed for the PRB and Cap System and consists of eight (8) major components, a Construction Quality Assurance Plan (CQAP), a Performance Standard Verification Plan (PSVP), a Groundwater Monitoring Plan (GWMP), a Contingency Plan (CP), a Health and Safety Plan (HSP), a Operations & Maintenance Plan (O&M), Quality Assurance Project Plan (QAPP) and a Waste Management Plan (WMP). *Separate CQAPs were developed for the Cap System and the PRB as detailed in* Appendices G-1 and H-1 respectively. The PSVP, GWMP, CP, HSP, O&M, QAPP and WMP are contained in Appendices I through O respectively. The performance monitoring and remedial action work plan activities for the PRB Groundwater Remedy are summarized on Figure 55 and those activities are detailed in the CQAP, PSVP and GWMP for the PRB. The performance monitoring and remedial action work plan activities for the Cap System are contained in the CQAP and O&M for the Cap System. Construction project organization charts for the Cap System and the PRB System are contained in their respective CQAPs contained in Appendices G-1 and H-1, respectively.

11.5.1 PRB Construction Quality Assurance Plan (CQAP)

The CQAP describes the procedures that are to be used during construction of the iron reactive permeable barrier system to ensure that the materials used meet or exceed specifications and the PRB is constructed in accordance with the Construction Drawings. The plan also details the records needed so that an appropriate "as-built" construction record can be prepared at the end of each phase of construction. The CQAP is supported by material technical specifications, which provide the criteria to be used to evaluate the suitability and/or acceptability of all of the materials required for construction. Technical specifications for the materials and installation requirements are included in the CQAP.

11.5.2 Performance Standard Verification Plan (PSVP)

A groundwater and surface water monitoring plan was prepared for the project to monitor the performance of the PRB and Cap System remedy on the dehalogenation of the chlorinated solvent contamination encountered at the Site to non-toxic end products. Groundwater wells will be installed upgradient and downgradient of the PRB to monitor the reduction VOCs across the PRB system. Monitoring well installation, groundwater and surface water sampling and analytical analyses will be conducted in accordance to the GWMP and the QAPP. The PSVP outlines the frequency of groundwater well and surface water sampling and the list of analyte parameters for analysis. The plan details performance expectations and details actions to be performed if performance expectations are not meet, including a change of frequency of sampling, the list of analytes measured and in certain cases contingency actions to rectify deficiencies in the PRB and Cap System remedial performance.

11.5.3 Groundwater Monitoring Plan (GWMP)

A groundwater monitoring plan was prepared for the project to monitor the performance of the PRB and Cap System remedy on the dehalogenation of the chlorinated solvent contamination encountered at the Site to non-toxic end products. The groundwater at the Site is contaminated with predominantly PCE, TCE, 1, 1-DCE and 1,1,1-TCA. Groundwater wells will be installed upgradient and downgradient of the PRB to monitor the reduction VOCs across the reactive barrier system. Monitoring well installation and groundwater and surface water sampling will be conducted in accordance to the GWMP, the QAPP and the HSP. The frequency of groundwater well and surface water sampling and the list of analyte parameters for analysis are detailed in the PSVP. In general, the following activities will be performed:

- ❑ Installation and development of upgradient and downgradient monitoring wells;
- ❑ Field parameter measurements including water levels, temperature, pH, Eh, dissolved oxygen, specific conductance, and turbidity of the groundwater samples;
- ❑ Groundwater and surface water sampling at designated frequency and particular analyte parameter list as detailed in the PSVP. Sampling and analysis of groundwater samples will be conducted in accordance with the GWMP; and
- ❑ Decontamination of drilling and sampling equipment.

11.5.4 Health and Safety Plan (HSP)

A health and safety plan was prepared for the project for protection of the construction project team and other persons that may be exposed to hazards associated with the installation of the PRB and the Cap System. The HSP addresses all the potential Cap System and PRB construction specific hazards, physical hazards, and chemical hazards with associated action levels. Proper personal protection equipment will be used to minimize personal exposure to chemical and physical hazards expected at the Site. Emergency response procedures are clearly defined in the event of an emergency.

11.5.5 Operation and Maintenance Plan (O&M)

An Operations & Maintenance (O&M) Plan for the PRB is not appropriate, since this remedy does not constitute an operations and maintenance component. The Performance Standard Verification Plan (PSVP) provided *in Appendix I discusses a Contingency Plan for the PRB in* the event the PRB is not performing as designed. O&M activities will be required for the proper performance of the vegetative cover of the Cap System. An O&M Plan for the Cap System is detailed in Appendix M.

11.5.6 Waste Management Plan (WMP)

Handling, transportation and disposal/treatment of construction derived waste will be conducted in accordance with all Municipal, State and Federal requirements and as outlined in the Waste Management Plan contained in Appendix O. The WMP outlines the procedures for handling, transporting and disposal of all waste, either hazardous or non-hazardous, generated during equipment decontamination, well installation and PRB and Cap System construction. All wastes generated from decontamination activities will be handled, transported and disposed of as detailed in the WMP. All decontamination activities will be performed in accordance to the Health and Safety Plan (HSP) and the Waste Management Plan (WMP).

12.0 SUMMARY AND CONCLUSIONS

Golder Sierra LLC (Golder) was retained by Saltire Holdings, Inc. to design an iron permeable reactive barrier (PRB) and impermeable surface Cap System to be constructed at the former Arrowhead Plating Facility Site (Site), located in Montross, VA. The work will be conducted as part of the Former Arrowhead Plating Superfund Site Remedial Action.

Zero valent iron can effectively reduce the groundwater contaminants present at the Site. The geology, groundwater conditions and depth of the PRB are suitable for construction of the PRB by the azimuth controlled vertical hydrofracturing installation method. This PRB installation method has previously installed three (3) full-scale iron PRB systems and one full depth pilot scale system. An impermeable Cap System has been incorporated into the PRB groundwater remedy to enhance the PRB performance by reducing infiltration into the subsurface and thus lowering the hydraulic gradients across the PRB. The proposed PRB and Cap System Remedy is the most cost-effective groundwater remedy for OU-2. Infiltration and groundwater modeling indicate that the addition of a Cap System to the PRB Remedy will reduce groundwater flow gradients perpendicular to the PRB alignment by a minimum of 20% and up to a maximum of 70%.

The Cap System has been designed to enhance the effectiveness of the PRB by reducing the influent contaminant fluxes of VOCs flowing into the PRB. The PRB has been designed to achieve effluent VOCs concentrations below their respective MCL levels. The PRB design methodology described in this report utilized a multi-species VOC probabilistic model to quantify the overall reactive barrier system performance based on the expected variability of design input parameters, such as Site parameters including hydrogeologic data and VOC influent concentrations, and PRB System parameters including VOC degradation half lives and pathways, PRB porosity and PRB iron-effective-thickness.

The proposed PRB will be 1,165 ft in length, orientated approximately perpendicular to the groundwater flow regime, be approximately 3" to 4.5" in average iron-effective-thickness for a total of 650 tons of iron filings injected into the subsurface, and extend from a depth of 15' down to a total depth of 42' covering an area of 24,000 ft^2. The Cap System will cover an area of approximately 4-1/2 acres and consist from top to bottom of 24-in vegetative cover, a geocomposite drainage layer and a geosynthetic clay liner (GCL).

A Construction Quality Assurance Plan (CQAP), a Performance Standard Verification Plan (PSVP), a Groundwater Monitoring Plan (GWMP), a Contingency Plan (CP), a Health and Safety Plan (HSP), an Operation and Maintenance Plan (O&M) and a Quality Assurance Project Plan (QAPP) were prepared as part of the performance monitoring and remedial action workplan activities required for the construction and performance evaluation of the PRB and Cap System.

The estimated construction costs of the PRB and Cap System remedy including site preparation and waste disposal is \$3.1M, of which approximately \$2.1M is for construction of the PRB, \$0.5M is for construction of the Cap System and \$0.5M for site preparation, waste disposal and license fee. These costs include construction derived waste storage, waste characterization and disposal costs. The construction of the PRB and Cap System is expected to take six and a half (6-1/2) months. The construction activities are expected to start in mid May 2001 and be completed by the end of November 2001. Construction of the Cap System will be delayed if lagoon closure to be undertaken by Mattatuck is not completed by the end of June 2001.

GOLDER SIERRA LLC

Rafael I. Ospina

Rafael I. Ospina, P.E.
Senior Project Manager

Grant Hocking, Ph.D.
President

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REFERENCES

Beck, P. B. Jr., P. J. Clark and R. W. Puls (2000). Location and Characterization of Subsurface Anomalies Using a Soil Conductivity Probe, *Ground Water Monitoring Review*, Spring, pp 55-59.

Burris, D. R., and C. A. Delcomyn (1997a). Reactivity of Metallic Iron and Bimetallic Ni/Fe to Trichloroethylene after Exposure to Crosslinked Guar Gum Slurry. Interim Progress Report #1, AFCEE, Tyndall AFB, FL, June 30.

Burris, D. R., and C. A. Delcomyn (1997b). Reactivity of Metallic Iron and Bimetallic Ni/Fe to Trichloroethylene after Exposure to Crosslinked Guar Gum Slurry. Interim Progress Report #2, AFCEE, Tyndall AFB, FL, November 10.

Burris, D. R., and C. A. Delcomyn (1998). Reactivity of Metallic Iron and Bimetallic Ni/Fe to Trichloroethylene after Exposure to Crosslinked Guar Gum Slurry. Interim Progress Report #3, AFCEE, Tyndall AFB, FL, March 24.

Cedergren, H.R. (1977). Seepage, Drainage and Flow Nets, 2nd Ed., John Wiley & Sons, New York.

Conway Data Inc. (1990). The Weather Handbook.

Envirometal Technologies, Inc. (2000). Degradation Half Life Database of VOCs in the Presence of Zero Valent Iron at Various Temperatures, memorandum to Golder Sierra LLC, September.

Gidley, J. L., S. A. Holditch, D. E. Nierode and R. W. Veatch Jr. (1989). Recent Advances in Hydraulic Fracturing. SPE Monograph Series, Richardson, TX.

Gillham, R. W. (1993). Cleaning Halogenated Contaminants from Groundwater. U.S. Patent No. 5,266,213.

Gillham, R. W. (1996). In Situ Treatment of Groundwater: Metal-Enhanced Degradation of Chlorinated Organic Contaminants. Advances in Groundwater Pollution Control and Remediation, M. M. Aral (ed.), Kluwer Academic Publishers, Netherlands, pp. 249-274

Gillham, R. W. and S. F. O'Hannesin (1992). Metal-Catalysed Abiotic Degradation of Halogenated Organic Compounds. IAH Conference "Modern Trends in Hydrogeology", Hamilton, Ontario, May 10-13, pp. 94-103.

Gillham, R. W. and S. F. O'Hannesin (1994). Enhanced Degradation of Halogenated Aliphatics by Zero-Valent Iron, *Ground Water*, Vol. 32, No. 6, pp 958-967.

Gillham, R. W. and S. F. O'Hannesin (1998). Long-Term Performance of an In Situ "Iron Wall" for Remediation of VOCs, *Ground Water*, Vol. 36, No. 1, pp 164-170.

Golder Sierra LLC (2000a). Remedial Design Work Plan, Permeable Reactive Subsurface Barrier (PRSB) For Former Arrowhead Plating Facility, Montross, Virginia, Golder Job No. 996-1100, April 11.

Golder Sierra LLC (2000b). Analytical Testing Validation Report, May 2000 Sampling Event, Former Arrowhead Plating Facility, Montross, Virginia, Golder Job No. 996-1100, August 10.

Golder Sierra LLC (2000c). Groundwater Flow Divide and Surface Water Quality Evaluation Report, Former Arrowhead Plating Facility, Montross, Virginia, Golder Job No. 996-1100, September 15.

Golder Sierra LLC (2000d). Laboratory and Large Scale Column Test Degradation Half Life Database of VOCs in the Presence of Zero Valent Iron at Various Temperatures, Confidential Internal Report, April.

Gu, B.D. Watson, W. Golberg, M. A. Bogle and D. Allred. (1998). "Reactive Barriers for the Retention and Removal of Uranium, Technetium, and Nitrate in Groundwater", RTDF Meeting, Beaverton, OR, April 15-16.

Hocking, G. (1996). Azimuth Control of Hydraulic Fractures in Weakly Cemented Sediments. 2nd North American Rock Mechanics Symp, Montreal, A.A. Balkema, Rotterdam, pp 1043-1048.

Hocking, G. and S. L. Wells (1997). Oriented Vertical Hydraulic Fracture Iron Reactive Walls. ASCE Environmental Group Meeting, Atlanta, GA, March.

Hocking, G., S. L. Wells, and R. I. Ospina (1998a). Field Performance of Vertical Hydraulic Fracture Placed Iron Reactive Permeable Barriers. Emerging Remediation Technologies for Soil and Groundwater Cleanup, Florida Remediation Conf., Orlando, FL, November 10-11.

Hocking, G., S. L. Wells, and R. I. Ospina (1998b). Performance of the Iron Reactive Permeable Barrier at Caldwell Superfund Site. RTDF Meeting, Oak Ridge, TN, November 17-18.

Hocking, G., S. L. Wells, and R. I. Ospina (2000). Deep Reactive Barriers for Remediation of VOCs and Heavy Metals, 2nd Int. Conf. On Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, May 22-25.

Hocking, G., S. L. Wells, and R. I. Ospina (2001a). Probabilistic Design of Permeable Reactive Barriers, submitted to the 2001 Int. Containment & Remediation Conf, Orlando, FL, June 10-13.

Hocking, G., S. L. Wells, and R. I. Ospina (2001b). Performance of a Deep Iron Permeable Reactive Barrier for Groundwater Remediation of VOCs, submitted to the 2001 Int. Containment & Remediation Conf, Orlando, FL, June 10-13.

Hubble, D. W., E. R. W. Gillham and J. A. Cherry (1997). Emplacement of Zero-Valent Metal for Remediation of Deep Contaminant Plumes. International Containment Technology Conf. & Exhibition, St. Petersburg, FL.

ICF Kaiser (1997). Pre-Remedial Design Summary Report, Former Arrowhead Plating Facility, Montross, VA, prepared for Saltire Industrial, Inc., submitted to USEPA Region III, August 12.

Johnson, C. R., R. A. Greenhorn and E.G. Woods (1966). Pulse-testing: A New Method for Describing Reservoir Flow Properties Between Wells. *JPT*, Vol. 237, pp 1599-1604, Trans., AIME.

Kamal, M. M. (1983). Interference and Pulse Testing - A Review. *JPT*, pp 2257-2270.

McDonald, M. G. and A. W. Harbaugh (1988). Techniques of Water-Resources Investigations of the United States Geological Survey; MODFLOW – A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model; Book 6.

Morrison, S. J. (1998). "Status of a Permeable Reactive Barrier Project for Uranium Containment at Monticello, Utah", RTDF Meeting, Beaverton, OR, April 15-16.

Naftz, D. (1998). "Status and Preliminary Results of the Fry Canyon Reactive Chemical Wall Project", RTDF Meeting, Beaverton, OR, April 15-16.

Ohya, S., T. Imai and M. Matsubara (1982). Relationships between N Value by SPT and LLT Pressuremeter Results, Proc. 2nd European Symp. On Penertration Testing, Vol 1, pp125-130.

Orth, S. and R. W. Gillham (1996). Dehalogenation of Trichlorethene in the Presence of Zero-Valent Iron. *Environ. Sci. Technol.*, Vol. 30, pp 66-71.

Peck, R. B., W. E. Hanson and T. H. Thornburn (1974). Foundation Engineering, 2nd Ed., John Wiley & Sons, New York.

Pennelly, J. P. and A. L. Roberts (1998). Reaction of 1,1,1-Trichloroethane with Zero-Valent Metals and Bimetallic Reductants. Environ. Sci. Technol., Vol32, pp1980-1988.

Puls, R. W. (1998). "Elizabeth City, North Carolina Permeable Reactive Barrier Site Update", RTDF Meeting, Oak Ridge, TN, November 17-19.

Roberts, A. L., L. A. Totten, W. A. Arnold, D. R. Burris and T. J. Campbell (1996) Reductive Elimination of Chlorinated Ethylenes by Zero-Valent Iron, Env. Sci. & Technol., Vol 30, No 8, pp2654-2659.

Robertson, P. K., R. G. Campanella and A. Wightman (1983). SPT-CPT Correlations, Journal of Geotechnical Engineering, ASCE, Vol 112, No 3, pp373-377.

Schlicker, O., M. Ebert, R. Kober, W. Wust and A. Dahmke (1998). "The Effect of Competing Chromate and Nitrate Reduction on the Degradation of TCE with Granular Iron", RTDF Meeting, Oak Ridge, TN, November 17-19

Schroeder, P. R., Aziz, N. M., Lloyd, C. M. and P. A. Zappi (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3," EPA/600/9-94/xxx, U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, OH.

Sivavec, T. M. and D. P. Horney (1995). "Reactive Dechlorination of Chlorinated Ethenes by Iron Metal", Proc. 209th. American Chemical Society National Meeting, Vol. 35, No. 1, pp 695-698

Sivavec, T. M., P. D. Mackenzie, D. P. Horney and S. S. Bagel (1997). "Redox-Active Media Selection for Permeable Reactive Barriers", Int. Containment Conf., St Petersburg, FL, February 10-12.

Skempton, A. W. (1986). Standard Penertration Test Procedures and the Effects in Sands of Overburden Pressure, relative Density, Particle Size, Aging, and Overconsolidation, Geotechnique, Vol 36, No 3, pp425-447.

Soil Conservation Service (1986). Urban Hydrology for Small Watersheds, Technical Release 55 (TE-55).

Starr, R. C. and J. A. Cherry (1994). In Situ Remediation of Contaminated Groundwater: The Funnel-and-Gate System. *Ground Water*, Vol. 32, No. 4, pp 465-476.

Su, C. and R. W. Puls (1998). Retention of Arsenic by Elemental Iron and Iron Oxides. RTDF Meeting, Oak Ridge, TN, November 17-19.

Su, C. and R. W. Puls (1998). Temperature Effect on Reductive Dechlorination of Trichloroethene by Zero-Valent Metals, 1st Int. Conf. On Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, May 18-21

Surface Data for Colonial Beach, Virginia, 1963 to 2000. NOAA.

Sweeny, K. H. and J. R. Fisher (1972). Reductive Degradation of Halogenated Pesticides. U.S. Patent No. 3,640,821.

Virginia Erosion and Sediment Control Handbook, Third Edition, 1992.

TABLE 1

INSTALLED IRON PERMEABLE REACTIVE BARRIERS
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

Iron Reactive Barriers	Location	Installation Method	Date
Full Scale Remediation Projects			
Industrial Facility	California	continuous wall	Dec-94
Industrial Facility	California	continuous wall	Sep-95
Industrial Facility	Northern Ireland	in-situ reactive vessel and slurry wall	Dec-95
Industrial Facility	Kansas	gate and slurry wall	Jan-96
USCG Facility	North Carolina	continuous reactive wall	Jun-96
Government Facility	Colorado	sheet pile funnel(s) and multiple gates (4)	Oct-96
Industrial Facility	South Carolina	continuous iron/sand reactive wall	Oct-97
Industrial Facility	Colorado	gate and slurry funnel	Nov-97
Research Facility	Tennessee		Nov-97
Industrial Facility	New York	continuous wall	Dec-97
Industrial Facility	Oregon	gates (2) and slurry funnel	Feb-98
Superfund Site	New Jersey	continuous wall - hydrofracturing	Mar-98
DOE Facility	Missouri	continuous wall	Apr-98
Industrial Facility	Denmark	continuous wall	Jun-98
DOE Facility, RFETS	Colorado	in-situ reactive vessel and collection system	Jul-98
Industrial Facility	New Jersey	continuous walls (2)	Aug-98
Industrial Facility	Vermont		Aug-98
Industrial Facility	Germany		Oct-98
DOD Facility	New York		Oct-98
Shaw AFB	South Carolina	continuous walls (4)	Nov-98
Industrial Facility	Denmark	continuous walls and recirculation system	Nov-98
Industrial Facility	Louisiana	continuous wall	Nov-98
DOD Facility	New York	continuous wall	Dec-98
Industrial Facility	North Carolina		Aug-99
DOD Facility	Colorado		Aug-99
DOD Facility	New Hampshire		Aug-99
Industrial Facility	Massachusetts		Aug-99
Industrial Facility	Denmark		Aug-99
DOE Facility	Colorado		Sep-99
Industrial Facility	Kansas		Oct-99
Industrial Facility	Washington		Oct-99
Industrial Facility	Ohio		Oct-99
Superfund Site	Iowa	continuous wall - hydrofracturing	Oct-99
Industrial Facility	California		Nov-99
Industrial Facility	California	continuous wall - hydrofracturing	Jan-01
In-Situ Pilot Demonstrations			
Research Facility	Borden		Jun-91
Industrial Facility	New York	funnel and gate	May-95
Lowry AFB	Colorado	funnel and gate	Dec-95
Moffet Field Air Station	California	funnel and gate	Apr-96
Industrial Facility	Georgia		Apr-96
Superfund Site	New Hampshire	funnel and gate	Nov-96
Alameda Air Station	California	funnel and sequence gate	Dec-96
Savannah River Site	South Carolina	GeoSiphon	Jul-97
Cape Canaveral	Florida	Mandrel & Vibrated Beam (Iron & Guar)	Nov-97
Argonne National Laboratory	Illinois	Iron/Soil Mixing	Nov-97
Dover AFB	Delaware	funnel and caisson gates	Nov-97
NASA Demonstration	Florida	Soil Mixing	Feb-98
Otis ANGB	Massachusetts	hydrofracturing	Jul-98
Maxwell AFB	Alabama	hydrofracturing	Jul-98
Industrial Facility	Germany		Jul-98
Industrial Facility	Germany		Jul-98
Industrial Facility	Australia		Feb-99

TABLE 2

VOLATILE ORGANICS SUMMARY - DEEP BORINGS
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

BORING No.	DEPTH (ft BGS)	Date	VOLATILE ORGANICS (ug/kg)																			
			1,1,1-Trichloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethane	1,2-Dichloroethene (trans)	1,2-Dichloroethene (cis)	2-Butanone	4-Methyl-2-pentanone	Acetone	Benzene	Carbon Disulfide	Chloroethane	Chloroform	Ethylbenzene	Methylene Chloride	Tetrachloroethene	Toluene	Trichloroethene	Vinyl Chloride	Xylenes (total)
SBD2	77 - 79	May-00	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U	2400 U
	99 - 101	May-00	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U	2100 U
	109 - 111	May-00	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U	1500 U
	109 - 111 (duplicate)	May-00	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	240 B	1700 U	1700 U	1700 U	1700 U	1700 U
SBD3	61 - 63	May-00	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	1400 U	190 J	1400 U	1400 U	1400 U	1400 U	1400 U
	93 - 95	May-00	1800 U	1800 U	1800 U	1800 U	1800 U	1800 U	1800 U	1800 U	1800 U	1800 U	1800 U	1800 U	1800 U	1800 U	1800 U	250 J	1800 U	1800 U	1800 U	1800 U	1800 U
	101 - 103	May-00	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	210 J	1700 U	1700 U	1700 U	1700 U	1700 U

NOTES:
B = *Not detected substantially above the level reported in the blanks.* (Indicates result qualified by blank contamination.)
J = Analyte is present. Reported value may not be accurate or precise. (The associated numerical value is an estimated quantity.)
U = The analyte was analyzed for, but was not detected.

TABLE 3

METALS AND CYANIDE SUMMARY - DEEP BORINGS
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

BORING No.	DEPTH (ft BGS)	Date	METALS (mg/kg)										Cyanide (mg/kg)
			Cadmium	Calcium	Copper	Iron	Magnesium	Manganese	Nickel	Potassium	Sodium	Zinc	
SBD2	77 - 79	May-00	0.06 U	2260	8.0	21700	3710	217	12.5	3340	87.0 B	58.3 B	0.73 UL
	99 - 101	May-00	0.24 B	3250	18.2	34200	4370	212	18.1	3510	110 B	57.7 B	0.79 UL
	109 - 111	May-00	1.2 B	1280	3.2	9830	1210	74.1	7.0	965	44.8 U	31.6 B	0.66 UL
	109 - 111 (duplicate)	May-00	1.3	1250	3.9	10300	1520	78.0	7.9	1190	69.6 B	33.4 B	0.66 UL
SBD3	61 - 63	May-00	0.13 B	1660	4.3	14000	1820	130	8.0	2150 J	141 B	31.7 B	0.65 U
	93 - 95	May-00	0.22 B	3570	8.8	25200	3970	200	14.1	2860 J	122 B	54.3 B	0.74 U
	101 - 103	May-00	0.40 B	3460	18.0	26000	3480	218	20.6	2820 J	100 B	65.1 B	0.70 U

NOTES:
B = Not detected substantially above the level reported in the blanks. (Indicates result qualified by blank contamination.)
J = Analyte is present. Reported value may not be accurate or precise. (The associated numerical value is an estimated quantity.)
U = The analyte was analyzed for, but was not detected.
UL = Not detected. Reported value may be biased low. The actual quantitation limit is probably higher.

AR301218

TABLE 4

FIELD PARAMETERS SUMMARY
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	FIELD PARAMETERS[1]					
		pH	Conductivity (umhos/cm)	Turbidity (NTU)	DO (mg/l)	Temperature[2] (°C)	Eh (mV)
MW1	May-00	4.1	418	4	6.5	18.0*	322
MW2	May-00	5.1	37	4	8.4	18.2	178
MW3	May-00	5.1	81	8	8.6	18.1*	186
MW4	May-00	6.4	229	10	3.4	16.6	112
MW5	May-00	6.4	265	38	6.4	17.2*	134
MW6	May-00	5.1	127	7	7.7	17.2	238
MW7	May-00	6.7	1000	7	0.0	17.2	69
MW8	May-00	4.6	364	6	0.5	19.9	233
MW9	May-00	5.8	157	10	8.5	16.6	197
MW10	May-00	4.5	2470	8	0.0	18.8	257
MW11	May-00	5.2	641	5	0.0	15.9	160
MW12	May-00	4.8	840	10	0.0	16.0*	237
MW13	May-00	6.0	446	6	0.8	14.3	158

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TABLE 4

FIELD PARAMETERS SUMMARY
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	FIELD PARAMETERS[1]					
		pH	Conductivity (umhos/cm)	Turbidity (NTU)	DO (mg/l)	Temperature[2] (°C)	Eh (mV)
MW21	May-00	3.8	1860	9	0.0	18.4	342
MW22	May-00	4.9	99	0	7.8	16.7	306
MW23	May-00	5.2	1960	7	0.5	20.0*	179
MW24	May-00	4.8	1630	67	1.9	19.4*	269
MW25	May-00	5.0	170	7	8.6	14.9*	259
MW26	May-00	5.0	243	2	7.0	15.7*	250
MW31	May-00	6.2	123	10	0.0	16.2	81
MW32	May-00	4.1	879	9	0.0	18.5	233
MW33	May-00	5.3	1040	10	0.0	14.6	109
MW34	May-00	4.9	504	23	0.0	18.1*	179
MW35	May-00	4.4	197	0	7.7	17.2	396
MW36	May-00	4.7	125	2	7.3	16.0*	240
MW-37	May-00	6.5	251	8	0.0	17.8*	14

NOTES:
(1) Field parameters were measured using HORIBA U-22 Water Checker meter. Electrodes/probes were submerged in a flow-through-cell.
(2) Asterisk (*) indicates the first temperature measurement taken. Due to low flow rates through the flow-through-cell, ambient temperature may have affected subsequent temperature measurements.

TABLE 5

VOLATILE ORGANICS SUMMARY
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	VOLATILE ORGANICS (ug/l)																			
		1,1,1-Trichloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethane	1,2-Dichloroethene (trans)	1,2-Dichloroethene (cis)	2-Butanone	4-Methyl-2-pentanone	Acetone	Benzene	Carbon Disulfide	Chloroethane	Chloroform	Ethylbenzene	Methylene Chloride	Tetrachloroethene	Toluene	Trichloroethene	Vinyl Chloride	Xylenes (total)
MW1	May-00	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW2	May-00	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	2 J	10 U	10 U
MW3	May-00	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW4	May-00	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW5	May-00	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW6	May-00	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	6 J	10 U	10 U	10 U	10 U
MW7	May-00	10 U	10 U	10 U	2 J	10 U	10 U	7 J	1 J	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	49	10 U	5 J	10 U	10 U
MW8	May-00	200 U	200 U	77 J	36 J	200 U	200 U	42 J	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	2500	200 U	74 J	200 U	200 U
MW9	May-00	78 J	100 U	100 U	18 J	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	8 J	100 U	100 U	1100	100 U	100 U	100 U	100 U
MW10	May-00	980	500 U	56 J	1900	500 U	500 U	260 J	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	5500	500 U	3700	500 U	500 U
MW11	May-00	24 J	200 U	21 J	42 J	200 U	200 U	120 J	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	2900	200 U	190 J	200 U	200 U
MW12	May-00	100 U	100 U	28 J	34 J	100 U	100 U	49 J	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	1300	100 U	86 J	100 U	100 U
MW13	May-00	170	100 U	16 J	360	100 U	100 U	120	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	1600	100 U	1200	100 U	100 U
MW21	May-00	1700	250 U	47 J	2000	250 U	250 U	570	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	3800	250 U	3100	250 U	250 U
MW22	May-00	7 J	20 U	20 U	8 J	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	7J	20 U	20 U	290	20 U	4 J	20 U	20 U
MW23	May-00	280 J	500 U	500 U	1200	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	1400	500 U	8200	500 U	500 U
MW24	May-00	44 J	250 U	250 U	200 J	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250	250 U	2800	250 U	250 U
MW25	May-00	24 J	25 U	7 J	41	25 U	25 U	270	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	120	25 U	470	25 U	25 U
MW26	May-00	380 J	500 U	500 U	830	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	1600	500 U	8800 *	500 U	500 U
MW26 (duplicate)	May-00	380 J	500 U	500 U	880	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	1800	500 U	10000 *	500 U	500 U
MW31	May-00	130	20 U	9 J	70	20 U	20 U	80	20 U	20 U	20 U	20 U	2 J	20 U	20 U	20 U	20 U	34	20 U	200	20 U	20 U
MW32	May-00	1000	250 U	100 J	3800	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	2200	250 U	950	250 U	250 U

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TABLE 5

VOLATILE ORGANICS SUMMARY
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	VOLATILE ORGANICS (ug/l)																			
		1,1,1-Trichloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethane	1,2-Dichloroethene (trans)	1,2-Dichloroethene (cis)	2-Butanone	4-Methyl-2-pentanone	Acetone	Benzene	Carbon Disulfide	Chloroethane	Chloroform	Ethylbenzene	Methylene Chloride	Tetrachloroethene	Toluene	Trichloroethene	Vinyl Chloride	Xylenes (total)
MW33	May-00	810	400 U	43 J	3500	400 U	400 U	330 J	400 U	400 U	400 U	400 U	400 U	400 U	400 U	400 U	400 U	5700	400 U	44000 *	400 U	400 U
MW33 (duplicate)	May-00	670	400 U	39 J	3000	400 U	400 U	300 J	400 U	400 U	400 U	400 U	400 U	400 U	400 U	400 U	400 U	4800	400 U	43000 *	400 U	400 U
MW34	May-00	10 U	10 U	10 U	2 J	10 U	10 U	10 U	7 J	10 U	2 B	10 U	1 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW35	May-00	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW36	May-00	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-37	May-00	4 J	10 U	10 U	6 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	5 J	10 U	10 U

NOTES:
B = Not detected substantially above the level reported in the blanks. (Indicates result qualified by blank contamination.)
J = Analyte is present. Reported value may not be accurate or precise. (The associated numerical value is an estimated quantity.)
U = The analyte was analyzed for, but was not detected.
UJ = Not detected. The reported quantitation limit may be inaccurate or imprecise. (The associated reporting limit is an estimated quantity.)
* = Result reported from a dilution.

TABLE 6

METALS AND CYANIDE SUMMARY
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	METALS (ug/l)											Cyanide (ug/l)
		Cadmium	Calcium	Copper	Iron	Magnesium	Manganese	Mercury	Nickel	Potassium	Sodium	Zinc	
MW1	May-00	0.52 B	**7770**	1.1 B	**69.6**	**4050**	**40.0**	0.10 U	**21.6 K**	1700 B	**33100**	48.5 B	10.0 U
MW2	May-00	0.20 U	**525**	**9.5**	**264**	**1410**	**6.9**	0.10 U	3.3 B	1640 B	**4190**	14.4 B	10.0 U
MW3	May-00	0.42 B	**942**	3.8 B	**1450**	**2660**	**18.1**	0.10 U	3.5 B	1140 B	**7140**	9.2 B	10.0 U
MW4	May-00	0.20 U	**625**	5.4 B	**4520**	**568**	**123**	0.10 U	4.2 B	1100 B	**41800**	14.0 B	10.0 U
MW5	May-00	0.20 U	**644**	3.4 B	**2230**	**1200**	**6.2**	0.10 U	3.6 B	1770 B	**34300**	22.9 B	10.0 U
MW5 (filtered)	May-00	0.20 U	**553**	1.0 U	**269**	**1130**	1.0 U	0.10 U	2.2 B	1790 B	**37100**	12.2 B	10.0 U
MW6	May-00	0.28 B	**1250**	2.0 B	**922**	**1360**	**19.8**	0.10 U	2.6 B	1160 B	**12500**	10.7 B	10.0 U
MW7	May-00	0.70 B	**1040**	6.7 B	**184**	136 B	**2.2**	0.10 U	6.1 B	1270 B	**159000**	13.8 B	10.0 U
MW8	May-00	**4.4**	**3620**	6.0 B	**613**	**7420**	**2060**	0.10 U	**28.3**	1980 B	**34900**	**125**	10.0 U
MW9	May-00	0.27 B	168 B	4.4 B	**295**	193 B	**4.0**	0.10 U	2.0 B	371 B	**24800**	4.0 B	10.0 U
MW10	May-00	**3.2**	**25200**	**3280**	**1630**	**16300**	**7450**	**0.25**	**168**	1120 B	**49700**	**1410**	10.0 U
MW11	May-00	1.8 B	**36800**	1.0 U	**4000**	**27100**	**4380**	0.10 U	**216**	**4680**	**22400**	**1180**	10.0 U
MW12	May-00	0.75 B	**12300**	1.0 U	**7940**	**4200**	**1010**	0.10 U	10.4 B	**5420**	**78300**	28.8 B	10.0 U
MW13	May-00	0.27 B	**1600**	1.4 B	**295**	**1430**	**211**	**0.12**	6.0 B	1840 B	**70000**	4.3 B	**19.2**

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TABLE 6

METALS AND CYANIDE SUMMARY
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	METALS (ug/l)											Cyanide (ug/l)
		Cadmium	Calcium	Copper	Iron	Magnesium	Manganese	Mercury	Nickel	Potassium	Sodium	Zinc	
MW21	May-00	**4.1**	**27800**	**7040**	**4210**	**16100**	**6700**	0.10 U	**250**	1400 B	**30900**	**1770**	10.0 U
MW22	May-00	0.39 B	**455**	1.5 B	**155**	**1610**	**9.4**	0.10 U	3.6 B	1580 B	**8940**	45.1 B	10.0 U
MW23	May-00	0.57 B	**40000**	1.9 B	**6820**	**17600**	**3100**	0.10 U	**27.2**	**5430**	**346000**	88.2 B	10.0 U
MW24	May-00	0.70 B	**37300**	2.2 B	**1520**	**14800**	**1830**	0.10 U	17.2 B	**4880**	**201000**	43.5 B	10.0 U
MW24 (filtered)	May-00	0.78 B	**38700**	1.0 U	**917**	**14400**	**1890**	0.10 U	17.7 K	**4510**	**191000**	51.6 B	NA
MW25	May-00	0.48 B	**473**	1.0 U	**102**	**2150**	**4.2**	0.10 U	4.7 B	1030 B	**19300**	13.5 B	10.0 U
MW26	May-00	0.30 B	**1940**	2.2 B	**169**	**3970**	**16.4**	0.10 U	4.0 B	**2650**	**24500**	28.2 B	10.0 U
MW26 (duplicate)	May-00	0.25 B	**1940**	1.5 B	**223**	**4080**	**16.8**	0.10 U	3.2 B	**2650**	**24500**	18.8 B	10.0 U
MW31	May-00	0.20 U	**5910**	1.7 B	**3750**	**1540**	**645**	0.10 U	4.4 B	**3610**	**9090**	25.8 B	10.0 U
MW32	May-00	0.82 B	**26900**	**187**	**42400**	**9320**	**5380**	0.10 U	**211**	**2560**	**17900**	**817**	10.0 U
MW33	May-00	0.20 U	**10300**	7.6 B	**6270**	**3990**	**1230**	0.10 U	6.3 B	**2590**	**155000**	32.9 B	10.0 U
MW33 (duplicate)	May-00	0.20 U	**11900**	6.7 B	**7410**	**4520**	**1440**	0.10 U	8.0 B	**2810**	**158000**	55.6 B	10.0 U
MW34	May-00	0.70 B	**16800**	5.4 B	**16700**	**5560**	**4320**	0.10 U	16.3 B	**4290**	**22500**	49.6 B	10.0 U
MW-34 (filtered)	May-00	0.42 B	**17400**	1.0 U	**7230**	**5450**	**4570**	0.10 U	13.0 B	**4310**	**24300**	65.7 B	NA

AR301224

TABLE 6

METALS AND CYANIDE SUMMARY
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	METALS (ug/l)											Cyanide (ug/l)
		Cadmium	Calcium	Copper	Iron	Magnesium	Manganese	Mercury	Nickel	Potassium	Sodium	Zinc	
MW35	May-00	0.32 B	**1280**	1.3 B	52.2 U	**10500**	**42.0**	0.10 U	7.2 B	**3320**	**1480**	17.8 B	10.0 U
MW36	May-00	0.50 B	**721**	1.4 B	52.2 U	**6220**	**43.6**	0.10 U	4.7 B	**2130**	**1500**	25.9 B	10.0 U
MW-37	May-00	0.52 B	**17200**	1.9 B	**3010**	**3330**	**502**	0.10 U	7.8 B	**4820**	**13200**	22.9 B	10.0 U

NOTES:
B = Not detected substantially above the level reported in the blanks. (Indicates result qualified by blank contamination.)
K = Analyte is present. Reported value may be biased high. Actual value is expected to be lower.
NA = Not Analyzed.
U = The analyte was analyzed for, but was not detected above the instrument detection limit (IDL).

AR301225

TABLE 7

GENERAL CHEMISTRY SUMMARY
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	GENERAL CHEMISTRY (mg/l)										
		Alkalinity	Ammonia	Chloride	Hardness	Nitrate	Nitrite	Orthophosphate	Sulfate	Total Dissolved Solids (TDS)	Total Organic Carbon	Total Suspended Solids (TSS)
MW1	May-00	5.0 U	0.10 U	86.6	53.8	2.9	0.010 U	0.10 U	20 UL	132	1.0 U	9.0
MW2	May-00	5.0 U	0.10 U	20 U	279	0.76	0.010 U	0.10 U	20 U	38.0	1.0 U	4.0 U
MW3	May-00	5.0 U	0.10 U	20 U	4.0 U	1.6	0.010 U	0.10 U	20 U	69.0	1.0 U	27.0
MW4	May-00	89.7	0.10 U	20 U	243	0.35	0.010 U	0.10 U	20 U	172	1.0 U	12.0
MW5	May-00	47.9	0.10 UJ	20 U	4.0 U	0.68	0.010 U	0.10 U	35.2	150	1.0	4.0 U
MW6	May-00	5.0 U	0.10 UJ	20 U	40.1	3.0	0.010 U	0.10 U	20.4	68.0	1.0 U	54.0
MW7	May-00	216	0.51	20 U	281	0.43	0.010 U	0.33	170	537	5.7	4.0 U
MW8	May-00	5.0 U	0.10 U	20 U	202	23.5	0.010 U	0.10 U	31.0	10 U	1.1	13.0
MW9	May-00	39.7	0.10 UJ	20 U	4.0 U	0.33	0.010 U	0.10 U	20.5	86.0	1.0 U	9.0
MW10	May-00	5.0 U	3.3	40.7	553	3.9	0.010 U	0.30	1580	1760	7.9	101
MW11	May-00	5.0	0.41	20 U	212	2.5	0.010 U	0.10 U	249	325	1.0 U	12.0
MW12	May-00	5.0 U	0.86	35.8	34.6	1.5	0.010 U	0.10 U	207	321	1.4	8.0
MW13	May-00	57.0	0.98	20.0	11.5	1.2	0.010 U	0.10 U	92.2 L	146	2.6	4.0 U
MW21	May-00	5.0 U	1.3	29.6	385	2.9	0.010 U	0.17	1660	1960	4.7	7.0
MW22	May-00	5.0 U	0.10 UJ	20 U	4.0 U	1.1	0.010 U	0.10 U	20 U	37.0	1.0 U	4.0 U

AR301226

TABLE 7

GENERAL CHEMISTRY SUMMARY
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	GENERAL CHEMISTRY (mg/l)										
		Alkalinity	Ammonia	Chloride	Hardness	Nitrate	Nitrite	Orthophosphate	Sulfate	Total Dissolved Solids (TDS)	Total Organic Carbon	Total Suspended Solids (TSS)
MW23	May-00	**15.2**	**0.18 J**	**86.5**	122	1.6	0.010 U	0.10 U	**753**	**1120**	**2.6**	**12.0**
MW24	May-00	**7.1**	0.10 UJ	**71.6**	78.3	**4.8**	0.010 U	0.10 U	**410 L**	**770**	**1.2**	**6.0**
MW25	May-00	**6.5**	0.10 UJ	20 U	4.0 U	**2.9**	0.010 U	0.10 U	20 U	**73.0**	**1.3**	**6.0**
MW26	May-00	**6.0**	0.10 UJ	20 U	**21.0**	3.1	0.010 U	0.10 U	**44.1**	**129**	1.0 U	**4.0**
MW26 (duplicate)	May-00	5.0 U	0.10 UJ	20 U	**22.9**	**3.1**	0.010 U	0.10 U	**42.6**	**128**	1.0 U	4.0 U
MW31	May-00	**12.7**	0.10 U	20 U	**28.8**	0.10 U	0.010 U	0.10 U	20 UL	**29.0**	**2.0**	**8.0**
MW32	May-00	5.0 U	**1.6**	20 U	**720**	0.10 U	0.010 U	0.10 U	20 UL	**1130**	**7.9**	**9.0**
MW33	May-00	**15.8**	**0.15**	**37.2**	23.0	2.7	**0.016**	0.10 U	**300 L**	**486**	**7.2**	**4.0**
MW33 (duplicate)	May-00	5.0 R	**0.16**	**35.5**	28.8	2.6	**0.029**	0.21 B	**341 L**	**543**	**2.1**	4.0 U
MW34	May-00	5.0 U	0.10 U	**90.7**	82.6	0.10 U	0.010 U	0.10 U	**28.0 L**	**97.0**	**1.1**	**75.0**
MW35	May-00	5.0 U	0.10 UJ	20 U	38.2	**10.6**	0.010 U	0.10 U	20 U	**86.0**	1.0 U	4.0 U
MW36	May-00	5.0 U	0.10 UJ	20 U	21.0	**4.0**	0.010 U	0.10 U	20 U	**26.0**	1.0 U	4.0 U
MW-37	May-00	**37.5**	0.10 U	**26.6**	**61.4**	0.10 U	0.010 U	0.18 B	**22.4 L**	**97.0**	**15.3**	**24.0**

NOTES:
L = Analyte is present. Reported value may be biased low. Actual value is expected to be higher.
U = The analyte was analyzed for, but was not detected above the instrument detection limit (IDL).
UJ = Not detected. The reported quantitation limit may be inaccurate or imprecise. (The associated *reporting limit is an estimated quantity.*)

TABLE 8

VOLATILE ORGANICS SUMMARY - DIRECT PUSH
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

DIRECT PUSH No	DEPTH (ft BGS)	Date	VOLATILE ORGANICS (ug/l)																				
			1,1,1-Trichloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethane	1,2-Dichloroethene (trans)	1,2-Dichloroethene (cis)	2-Butanone	4-Methyl-2-pentanone	Acetone	Benzene	Carbon Disulfide	Chloroethane	Chloroform	Ethylbenzene	Methylene Chloride	Tetrachloroethene	Toluene	Trichloroethene	Vinyl Chloride	Xylenes (total)
C10	22	Jul-00	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	3 B	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
	26	Jul-00	16	10 U	10 U	24	10 U	10 U	5 J	10 U	10 U	3 B	10 U	10 U	10 U	10 U	10 U	10 U	32	10 U	67	10 U	10 U
	31	Jul-00	400	12 J	36 J	840	100 U	100 U	100	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	180	100 U	2000	100 U	100 U
	35	Jul-00	300	200 U	35 J	1300	200 U	200 U	31 J	200 U	200 U	200 U	200 U	200 U	200 U	21 J	200 U	200 U	820	200 U	6700 *	200 U	200 U
	35 (duplicate)	Jul-00	270	250 U	31 J	1100	250 U	250 U	27 J	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	720	250 U	7200 *	250 U	250 U
D10	23	May-00	11	10 U	10 U	30	10 U	10 U	1 J	10 U	10 U	7 B	10 U	10 U	10 U	10 U	10 U	10 U	34	10 U	170	10 U	10 U
	26	May-00	300 J	500 U	500 U	840	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	1200	500 U	7300	500 U	500 U
	29	May-00	1300 J	2000 U	2000 U	4800	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2800	2000 U	22000	2000 U	2000 U
	32	May-00	250 U	250 U	250 U	35 J	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	3800	250 U	250 U
E10	24	May-00	64	50 U	50 U	95	50 U	50 U	28 J	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	91	50 U	800	50 U	50 U
	28	May-00	470 J	500 U	500 U	970	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	770	500 U	8400 *	500 U	500 U
	31	May-00	800 J	2000 U	2000 U	3000	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	2000 U	3800	2000 U	37000	2000 U	2000 U
	31 (duplicate)	May-00	830 J	2500 U	2500 U	3400	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U	3400	2500 U	37000	2500 U	2500 U
	35	May-00	500 U	500 U	500 U	520	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	7400	500 U	500 U
F12	25	May-00	11 J	25 U	25 U	48	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	17 J	25 U	480	25 U	25 U
	27	May-00	9 J	25 U	25 U	41	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	26	25 U	430 *	25 U	25 U
	32	May-00	500 U	500 U	500 U	170 J	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U	8000	500 U	500 U
	35	May-00	250 U	250 U	250 U	120 J	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	4800 *	250 U	250 U

NOTES
B - Not detected substantially above the level reported in the blanks. (Indicates result qualified by blank contamination.)
J = Analyte is present. Reported value may not be accurate or precise. (The associated numerical value is an estimated quantity.)
K = Analyte is present. Reported value may be biased high. Actual value is expected to be lower.
U = The analyte was analyzed for, but was not detected.
* = Result reported from a dilution

TABLE 9

SURFACE WATER FIELD PARAMETERS SUMMARY
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

LOCATION	STATION No.	Date	FIELD PARAMETERS[1]				
			pH	Conductivity (umhos/cm)	Turbidity (NTU)	DO (mg/l)	Temperature (°C)
Reeds Swamp	RS1	May-00	6.2	139	12.3	6.8	18.5
	RS2	May-00	6.5	123	2.1	8.7	17.5
	RS3	May-00	6.5	117	2.6	9.3	17.1
	RS4	May-00	6.4	111	9.8	8.8	16.9
Scates Branch	SB1	May-00	5.9	153	2.6	8.8	16
	SB2	May-00	6.0	134	6.8	5.0	16.6
	SB3	May-00	4.0	96	2.4	2.9	15.8
	ST1	May-00	6.7	744	10.2	9.8	14.8
	ST2	May-00	6.3	368	5.8	9.0	16.3
South Fork	SF2	May-00	6.3	108	2.3	8.0	18.9
	SF6	May-00	6.5	113	0	8.4	18.8
Mid Fork	MF1	May-00	6.2	312	0	7.5	16.1

NOTES:
(1) Field parameters were measured using HORIBA U-22 Water Checker meter.

TABLE 10

METALS AND CYANIDE SUMMARY - SURFACE WATER
MAY 2000 SAMPLING EVENT
FORMER ARROWHEAD PLATING FACILITY
MONROSS, VA

LOCATION	STATION No.	Date	METALS (ug/l) Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	Cyanide (ug/l)
Mid Fork	MF1	May-00	1300	2.5 U	2.3 U	36.8	0.10 B	0.20 U	5330	1.2	3.4 B	1.7 B	3420	2.1 UL	4180	135	0.10 U	7.9 B	2180	4.1 UL	0.90 U	[illegible]	4.6 U	6.3 B	68.4	10.0 U
South Fork	SF2	May-00	192 B	2.5 U	2.3 U	30.7	0.10 U	0.48 B	3730	0.80 U	2.2 B	1.3 B	1300	2.1 UL	4120	112	0.10 U	5.0 B	2700	4.1 UL	0.90 U	[illegible]	4.6 U	3.7 B	17.3 K	10.0 U
	SF6	May-00	243 B	2.5 U	2.3 U	41.8	0.10 U	0.29 B	3870	0.80 U	1.8 B	1.3 B	1250	2.1 UL	4130	114	0.10 U	5.2 B	2730	4.1 UL	0.90 U	4640	4.6 U	4.4 B	12.7 K	10.0 U
	SF6 (duplicate)	May-00	218 B	2.5 U	2.3 U	45.6	0.10 U	0.20 B	4180	0.80 U	1.4 B	1.0 U	1400	2.1 UL	4200	121	0.10 U	4.8 B	2700	4.1 UL	0.90 U	[illegible]	4.6 U	3.9 B	21.3 K	10.0 U
Scates Branch	SB1	May-00	341 B	2.5 U	2.3 U	30.9	0.10 U	0.20 U	6240	0.80 U	2.7 B	4.4 B	2010	2.1 UL	4200	347	0.10 U	6.4 B	2970	4.1 UL	0.90 U	8440	4.6 U	0.80 B	32.2 K	10.0 U
	SB2	May-00	326 B	2.5 U	2.3 U	34.9	0.16 B	0.20 U	6300	0.80 U	4.2 B	4.6 B	4000	2.1 UL	3000	631	0.10 U	6.3 B	1660 B	4.1 UL	0.90 U	7900	4.6 U	5.3 B	25.3 K	10.0 U
	SB3	May-00	444 B	2.5 U	2.5 B	32.7	0.10 U	0.20 U	2910	0.80 U	12.3	1.9 B	2420	2.1 UL	1920	374	0.10 U	10.4 B	1230 B	4.1 UL	0.90 U	3920	4.6 U	2.7 B	53.7	10.0 U
	ST1	May-00	128 B	2.5 U	2.3 U	8.9	0.10 U	0.36 B	13100	0.80 U	22.0	10.5	530	2.1 UL	9150	1270	0.10 U	14.6 B	2000	4.1 UL	0.90 U	71300	4.6 U	4.0 B	100	10.0 U
	ST2	May-00	503 B	2.5 U	2.9 B	40.3	0.10 U	0.20 B	10000	0.80 U	6.0 B	3.0 B	4210	2.1 UL	6170	1030	0.10 U	7.1 B	3910	4.1 UL	0.90 U	[illegible]	4.6 U	4.7 B	37.0	10.0 U
Reeds Swamp	RS1	May-00	298 B	2.5 U	2.3 U	34.8	0.10 U	0.36 B	4810	0.80 U	4.6 B	1.3 B	3420	2.1 UL	3840	401	0.10 U	5.6 B	2020 B	4.1 UL	0.90 U	[illegible]	5.1 B	3.8 B	15.7 K	10.0 U
	RS2	May-00	429 B	2.5 U	2.3 U	33.8	0.10 U	0.31 B	4400	0.80 U	4.1 B	2.0 B	3830	2.1 UL	3610	385	0.12 B	6.6 B	1950 B	4.1 UL	0.90 U	7000	4.6 U	3.6 B	19.8 K	10.0 U
	RS3	May-00	167 B	2.5 U	2.3 U	30.7	0.10 U	0.2 U	4130	0.80 U	3.2 B	1.6 B	2800	2.1 UL	3400	300	0.10 U	7.0 B	1810 B	4.1 UL	0.90 U	7100	4.6 U	3.6 B	30.0 K	10.0 U
	RS4	May-00	302 B	2.5 U	2.3 U	30.4	0.12 B	0.30 B	3000	0.80 U	3.3 B	1.4 B	2970	2.1 UL	3370	242	0.10 U	5.6 B	1840 B	4.1 UL	0.90 U	6740	4.6 U	4.7 B	18.8 K	10.0 U
Monitoring Wells	MW1	May-00	2130	2.5 U	2.3 U	63.3	0.27 B	0.52 B	7770	0.80 U	30.2	1.1 B	60.6	2.1 UL	4050	40.0	0.10 U	21.6 K	1700 B	4.1 UL	0.90 U	33100	4.6 U	3.5 B	48.5 B	10.0 U
	MW3	May-00	825	2.5 U	2.3 U	30.2	0.1 U	0.42 B	942	0.80 U	1.9 B	3.8 B	1450	2.1 UL	2000	10.1	0.10 U	3.5 B	1140 B	4.1 UL	0.90 U	7140	4.6 U	1.8 B	9.2 B	10.0 U
	MW22	May-00	171	2.5 U	2.3 U	14.6	0.1 U	0.39 B	486	0.80 U	2.1 B	1.5 B	155	2.1 UL	1610	9.4	0.10 U	3.6 B	1580 B	4.1 UL	0.90 U	8940	4.6 U	1.1 B	45.1 B	10.0 U
	MW34	May-00	1300	2.5 U	5.2 B	60.2	0.1 U	0.70 B	10000	2.8	48.0	5.4 B	16700	14.4	5000	4320	0.10 U	16.3 B	4290	4.1 UL	0.90 U	22500	4.6 U	2.8 B	49.6 B	10.0 U
	MW34 (filtered)	May-00	97.8 U	2.5 U	2.3 U	72.6	0.1 U	0.42 B	17400	0.80 U	40.9	1.0 U	7230	5.7 L	5450	4570	0.10 U	13.0 B	4310	4.1 UL	0.90 U	24300	4.6 UL	0.7 UL	65.7 B	NA
	MW37	May-00	482	2.5 U	2.3 U	37.1	0.64 B	0.52 B	17200	4.0 B	6.1	1.9 B	3010	2.1 UL	3330	562	0.10 U	7.8 B	4020	4.1 UL	0.90 U	13200	4.6 UL	1.3 B	22.9 B	10.0 U

NOTES:
B = Not detected substantially above the level reported in the blanks. (Indicates result qualified by blank contamination.)
K = Analyte is present. Reported value may be biased high. Actual value is expected to be lower.
L = Analyte is present. Reported value may be biased low. Actual value is expected to be higher.
NA = Not Analyzed.
U = The analyte was analyzed for, but was not detected above the instrument detection limit (IDL).
UL = Not detected. Reported value may be biased low. The actual quantitation limit is probably higher.

TABLE 11

SUMMARY OF SOIL GRAIN SIZE AND RESISTIVITY DATA
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

Sample ID (Depth)	USCS	Soil Description	Grain Size (mm)				Resistivity @ 15.5 °C (ohms-cm)
			D_{10}	D_{15}	D_{50}	D_{85}	
SBS-10 (22.0-24.0')	(SP-SM)	MEDIUM TO FINE SAND, little clayey silt, trace fine gravel	0.06	0.11	0.25	0.51	8,010
SBS-11 (26.0-28.0')	(SP-SM)	MEDIUM TO FINE SAND, little clayey silt, trace fine gravel	0.07	0.093	0.22	0.57	8,121
SBS-11 (32.0-34.0')	(SP-SM)	MEDIUM TO FINE SAND, little clayey silt, trace fine gravel	0.065	0.11	0.23	0.40	3,449
SBS-12 (30.0-32.0')	(SP-SM)	MEDIUM TO FINE SAND, little clayey silt, trace fine gravel	0.065	0.11	0.24	0.40	11,125
SBS-12 (34.0-36.0')	(SP-SM)	MEDIUM TO FINE SAND, little clayey silt	0.07	0.11	0.22	0.90	1,115
SBS-13 (24.0-26.0')	(SM)	MEDIUM TO FINE SAND, some clayey silt	NA	NA	0.22	0.62	5,655
SBS-13 (28.0-30.0')	(SM)	MEDIUM TO FINE SAND, some clayey silt	NA	NA	0.21	0.43	3,763
SBS-13 (32.0-34.0')	(SM)	MEDIUM TO FINE SAND, and clayey silt	NA	NA	0.21	0.90	2,936

NOTE:
Soil resistvity values were measured on soil samples saturated with site soil groundwater collected from monitoring well MW33.

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TABLE 12

SUMMARY OF SOIL HYDRAULIC CONDUCTIVITY DATA
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

Sample	Soil Description	Sample Depth (ft)	D_{10} (mm)	Hydraulic Conductivity (cm/sec)
Hazen Method[1]				
SBS-10 (22.0-24.0')	(SP-SM)	22-24	0.06	3.6E-03
SBS-11 (26.0-28.0')	(SP-SM)	26-28	0.07	4.9E-03
SBS-11 (32.0-34.0')	(SP-SM)	32-34	0.065	4.2E-03
SBS-12 (30.0-32.0')	(SP-SM)	30-32	0.065	4.2E-03
SBS-12 (34.0-36.0')	(SP-SM)	34-36	0.07	4.9E-03
CPT Investigation[2]				
A4	FINE SAND	34	-	1.0E-04
A12	SILTY FINE SAND	32	-	1.6E-04
A16	FINE SAND W/ CLAY	56	-	3.2E-06
A20	SILTY FINE SAND	35	-	7.7E-04
A22	FINE SAND W/ CLAY	32	-	3.8E-03
B2	CLAYEY FINE SAND	31	-	2.6E-05
B8	FINE SAND	30	-	1.5E-03
B18	FINE SAND W/ CLAY	39	-	1.5E-04
B22	SILTY FINE SAND	33	-	1.1E-03
C1	CLAYEY FINE SAND	30.5	-	3.0E-04
C6	SILTY FINE SAND	31	-	1.7E-03
C8	FINE SAND W/ CLAY	33	-	5.6E-04
C10	CLAYEY FINE SAND	33	-	1.3E-03
C16	SILTY FINE SAND	32	-	1.5E-03
C22	FINE SAND	34	-	1.2E-03
D2	SILTY FINE SAND	31	-	2.2E-03
D4	SILTY FINE SAND	31	-	1.4E-04
D8	FINE SAND W/ CLAY	32.5	-	9.0E-05
D10	FINE SAND W/ CLAY	34.5	-	7.1E-05
D10A	FINE SAND W/ CLAY	53	-	5.8E-04
D14	CLAY	36	-	1.3E-04
D15	FINE SAND W/ CLAY	33	-	3.5E-04
D16	SILTY FINE SAND	33	-	3.7E-03
D16	FINE SAND	32	-	1.4E-03
D20	FINE SAND W/ CLAY	37	-	1.8E-04
D22	SILTY FINE SAND	33	-	7.1E-04
E4	FINE SAND W/ CLAY	31	-	5.1E-04
E6	FINE SAND W/ CLAY	30	-	6.9E-04
E10	SILTY FINE SAND	35	-	1.3E-04
E12	FINE SAND W/ CLAY	36	-	2.2E-04
E20	FINE SAND W/ CLAY	35.5	-	4.0E-03
E22	SILTY FINE SAND	33	-	1.1E-03
F12	FINE SAND W/ CLAY	35	-	2.6E-04
F14	FINE SAND W/ CLAY	35	-	2.8E-04
F18	FINE SAND W/ CLAY	34	-	4.6E-03
G14	CLAYEY FINE SAND	36	-	8.6E-04
G18	FINE SAND	36	-	1.4E-03
H16	FINE SAND	33	-	8.7E-04

TABLE 12

SUMMARY OF SOIL HYDRAULIC CONDUCTIVITY DATA
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

Sample	Soil Description	Sample Depth (ft)	D_{10} (mm)	Hydraulic Conductivity (cm/sec)
Constant-Rate Pumping Tests - Cooper-Jacob Method [2]				
MW31	-	33.5-43.5	-	8.1E-05
MW33	-	28-38	-	3.1E-04
MW33A	-	28-38	-	2.9E-04
OMW1	-	33.5-43.5	-	3.4E-04
OMW2	-	33.5-43.5	-	8.9E-04
OMW3	-	30-40	-	4.2E-04
OMW3A	-	30-40	-	3.8E-04
OMW4	-	30-40	-	8.0E-04
OMW4A	-	30-40	-	8.5E-04
SMW3	-	41-43	-	3.6E-04
Constant-Rate Pumping Tests - Quick Neuman Method [2]				
MW31	-	33.5-43.5	-	6.0E-05
MW33	-	28-38	-	1.4E-04
MW33A	-	28-38	-	8.8E-05
OMW1	-	33.5-43.5	-	2.2E-04
OMW2	-	33.5-43.5	-	6.1E-04
OMW3	-	30-40	-	2.0E-04
OMW3A	-	30-40	-	2.1E-04
OMW4	-	30-40	-	4.1E-04
OMW4A	-	30-40	-	5.5E-04
SMW3	-	41-43	-	2.4E-04
Constant-Rate Pumping Tests - Theis Recovery Method [2]				
MW33	-	28-38	-	1.1E-03
OMW3	-	30-40	-	1.3E-03
OMW4	-	30-40	-	2.3E-03
Step-Rate Pumping Tests - Cooper-Jacob Method [2]				
MW6	-	25-35	-	1.5E-03
MW21	-	25-35	-	1.5E-04
MW32	-	34-44	-	1.9E-03
OMW1A	-	33.5-43.5	-	8.1E-05
OMW2A	-	33.5-43.5	-	1.4E-04
Step-Rate Pumping Tests - Quick Neuman Method [2]				
MW6	-	25-35	-	1.0E-03
MW21	-	25-35	-	5.3E-05
MW32	-	34-44	-	1.7E-03
OMW1A	-	33.5-43.5	-	2.5E-05
OMW2A	-	33.5-43.5	-	4.6E-05

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TABLE 12

SUMMARY OF SOIL HYDRAULIC CONDUCTIVITY DATA
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

Sample	Soil Description	Sample Depth (ft)	D_{10} (mm)	Hydraulic Conductivity (cm/sec)
Falling Head Slug Tests - Bouwer-Rice Method[3]				
MW1	-	23-33	-	6.5E-04
MW2	-	20-30	-	1.1E-03
MW3	-	25-35	-	1.0E-03
MW4	-	20-30	-	2.7E-03
MW5	-	25-35	-	1.2E-03
MW6	-	20-30	-	3.6E-03
MW7	-	20-30	-	2.7E-03
MW9	-	20-30	-	1.6E-03
MW10	-	20-30	-	1.3E-03
MW11	-	15-25	-	8.5E-04
MW12	-	10-20	-	8.6E-04
MW13	-	4-14	-	7.4E-04
Rising Head Slug Tests - Bouwer-Rice Method[3]				
MW1	-	23-33	-	2.3E-03
MW2	-	20-30	-	2.3E-03
MW3	-	25-35	-	4.6E-04
MW4	-	20-30	-	1.3E-03
MW5	-	25-35	-	8.6E-04
MW6	-	20-30	-	2.5E-03
MW7	-	20-30	-	8.4E-04
MW9	-	20-30	-	1.7E-03
MW10	-	20-30	-	6.3E-04
MW11	-	15-25	-	1.0E-03
MW12	-	10-20	-	9.1E-04
MW13	-	4-14	-	7.5E-04

NOTES:

(1) The hydraulic conductivity values are calculated using the Hazen method based on D_{10} grain size data.

(2) Tests conducted by ICF Kaiser Engineers, Inc., Pre-Remedial Design Summary Report, Former Arrowhead Plating Facility, Montross, Virginia, August 1997.

(3) Tests conducted by ICF Kaiser Engineers, Inc., Remedial Investigation Report, Arrowhead Plating Site, Montross, Virginia, August 1991.

TABLE 13

SUMMARY OF CAP SYSTEM ALTERNATIVES INFILTRATION EVALUATION
AND ESTIMATED CONSTRUCTION COSTS
FORMER ARROWHEAD PLATING FACILITY

Alternatives	Description	Infiltration (inches per year)	Estimated Cost per Acre		Total Estimated Cost per Acre
			Construction	QA/QC & Project Management	
No Cover	NA	7.0	NA	NA	NA
A	GCL - Geocomposite - 24" Soil	0.9	$82,000	$11,500	$93,500
B	GCL - 12" Sand - 24" Soil	3.0	$88,500	$12,500	$101,000
C	HDPE - 12" Sand - 24" Soil	0.7	$78,000	$21,000	$99,000
D	HDPE - Geocomposite - 24" Soil	0.2	$71,000	$19,500	$90,500

Notes:
(1) Infiltration rates have been calculated based on an average precipitation of 41 inches per year.

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Table 14

PRB and Cap System Estimated Construction Costs
Former Arrowhead Plating Facility, Montross, VA

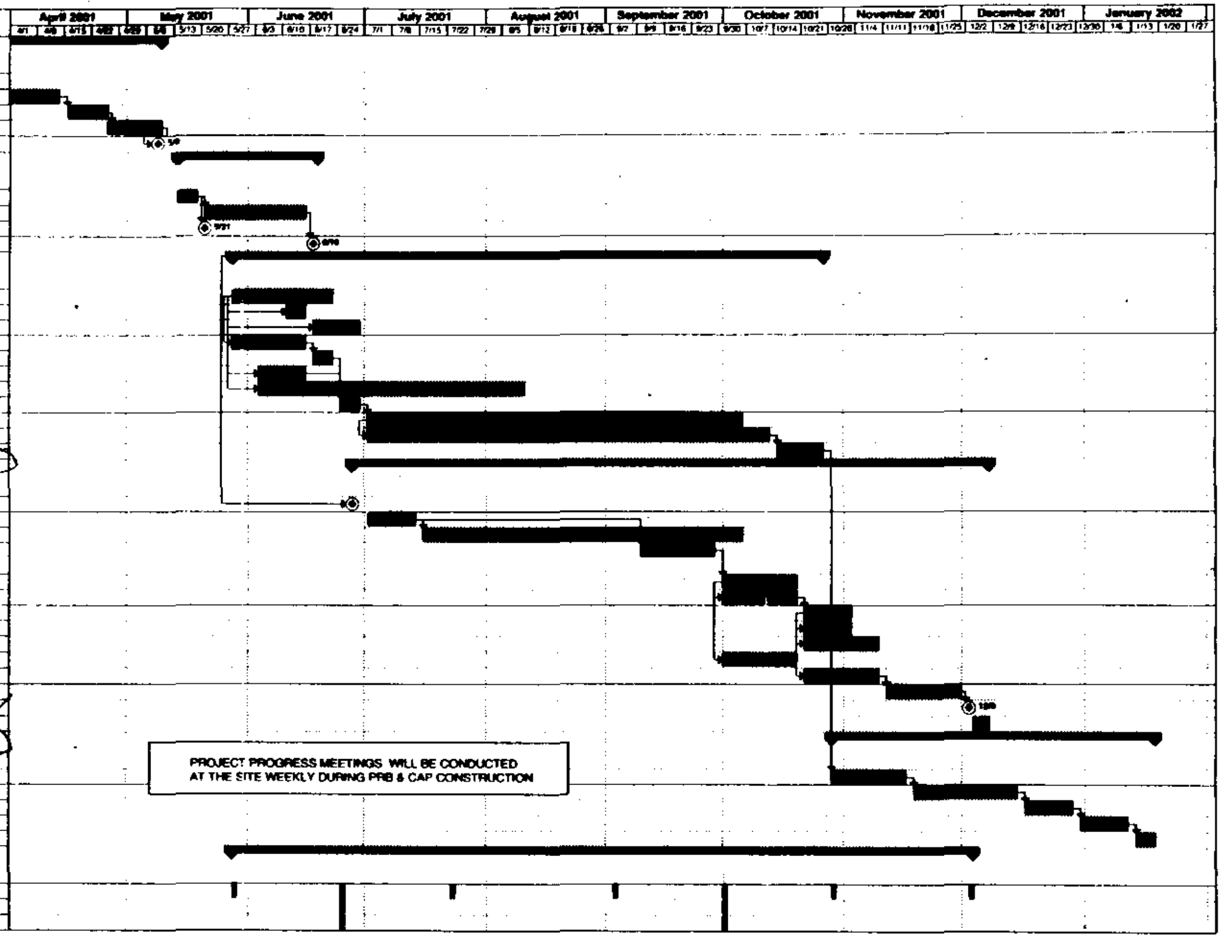
TASK DESCRIPTION	LABOR COST	UNIT PRICE ITEMS	EXPENSES	TOTAL
PRB & Cap System Construction, QA and Verification Testing				
Task 001 - Mobilization, Procurement & Demobilization	$6,770	$27,520	$11,060	$45,350
Task 002 - Site Preparation & Site Restoration	$23,110	$47,100	$116,060	$186,270
Task 003 - Drilling & Frac Inject Well Heads Install	$69,620	$158,420	$205,030	$433,070
Task 004 - Frac Inject PRB Installation	$0	$1,218,434	$112,925	$1,331,359
Task 005 - PRB Verification and Quality Assurance Tests	$44,530	$144,815	$138,450	$327,795
Task 006 - Cap System Construction	$28,680	$420,300	$55,638	$504,618
Task 007 - Cap System Verification and Quality Assurance Tests	$8,060	$0	$11,244	$19,304
Task 008 - PRB and Cap System Construction Report	$19,040	$0	$3,920	$22,960
Task 009 - Waste Storage, Characterization and Disposal	$27,660	$0	$63,000	$90,660
TOTAL ESTIMATED PRB & CAP SYSTEM COST	**$227,470**	**$2,016,589**	**$717,327**	**$2,961,386**

MOBILIZATION, PROCUREMENT & DEMOB	$45,350
SITE PREPARATION & RESTORATION	$186,270
PRB SYSTEM CONSTRUCTION	$2,092,224
CAP SYSTEM CONSTRUCTION	$523,922
CONSTRUCTION REPORT	$22,960
WASTE DISPOSAL	$90,660
ETI LICENSE FEE	$160,000
TOTAL REMEDY COST	**$3,121,386**

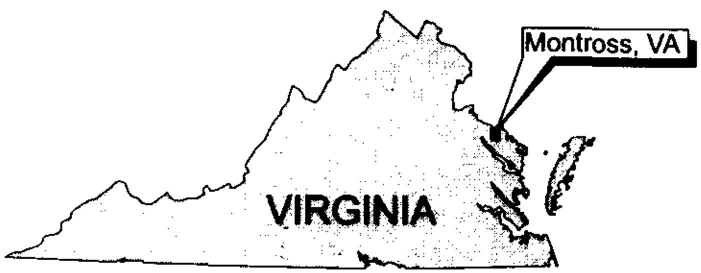
1) Labor and expense distributions are estimated; actual distributions may vary.
2) Costs include on-site waste handling and storage.
3) Site preparation includes earthworks, culverts, GCL and erosion control for northern section of Cap & along PRB alignment.
4) Assumed PRB length of 1160'; PRB will extend on average from 20' to 40' bgs, with an average iron loading of 54 lb/sft.
5) *The final estimated costs for Transport/Disposal depend on Hazardous Waste Type Designation.*
6) Total Waste Quantities: 100 cyds soil/drill cuttings & mud, 20,000 gals of cleaning & decant water.
7) EnviroMetal Technologies, Inc. Site License assumed to be 12% of Task 004 ($1,330,000) for a License Fee of $160,000 over the total project cost (total with License Fee of $3,121,500)

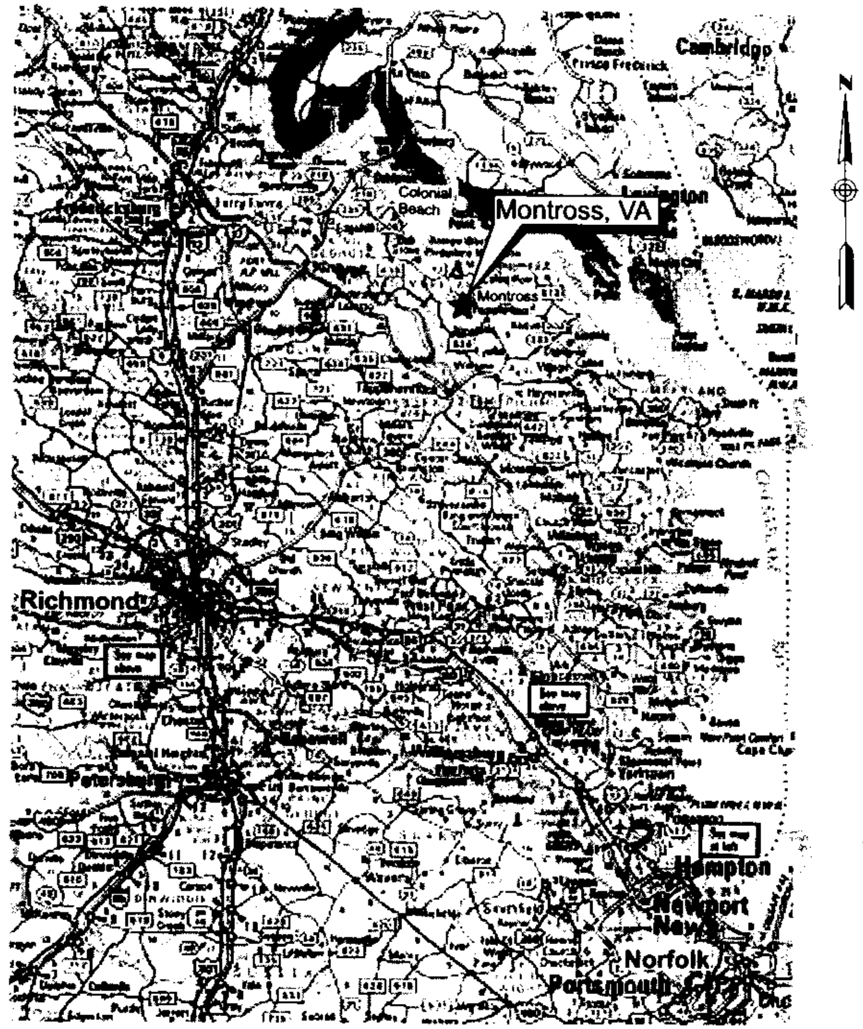
TABLE 15
PRB and Cap System Final Design and Construction Schedule
Former Arrowhead Plating Facility, Montross, Virginia

ID	Task Name	Duration	Start	Finish
1	**(1) PRB & Cap System Design**	**69 days**	**Fri 2/2/01**	**Wed 5/9/01**
2	Pre-Final (90%) PRB & Cap System Submittal out to EPA	1 day	Fri 2/2/01	Fri 2/2/01
3	**EPA Pre-Final (90%) PRB & Cap Design Review**	10 wks	Mon 2/5/01	Fri 4/13/01
4	Final (100%) PRB & Cap Design	8 days	Mon 4/16/01	Wed 4/25/01
5	**EPA Final (100%) PRB & Cap Design Review**	2 wks	Thu 4/26/01	Wed 5/9/01
6	**EPA Final (100%) PRB & Cap Design Approval**	1 day	Wed 5/9/01	Wed 5/9/01
7	**(2) PRB and Cap System Contractor Selection**	**26 days**	**Mon 5/14/01**	**Mon 6/18/01**
8	Preparation of Bid Documents	1 wk	Mon 5/14/01	Fri 5/18/01
9	Bidding and Contractor Selection	4 wks	Mon 5/21/01	Fri 6/15/01
10	PRB Construction Contract Award	1 day	Mon 5/21/01	Mon 5/21/01
11	Cap System Construction Contract Award	1 day	Mon 6/18/01	Mon 6/18/01
12	**(3) PRB System Construction**	**110 days**	**Mon 5/28/01**	**Fri 10/26/01**
13	Site Preparation/Access Earthwork/Temporary Drainage Structures	4 wks	Mon 5/28/01	Fri 6/22/01
14	Access Permanent Culverts/Culverts Cap System/Backfill	1 wk	Mon 6/11/01	Fri 6/15/01
15	Permanent Sediment & Erosion Control (ditches, seeding/rip-rap)	2 wks	Mon 6/18/01	Fri 6/29/01
16	Monitoring Wells Installation and Development	3 wks	Mon 5/28/01	Fri 6/15/01
17	PRB Baseline Groundwater Sampling	1 wk	Mon 6/18/01	Fri 6/22/01
18	Resistivity Receiver Strings Installation	2 wks	Mon 6/4/01	Fri 6/15/01
19	Hydrofracturing Wells Installation	10 wks	Mon 6/4/01	Fri 8/10/01
20	Pre Barrier Active Resistivity and Hydraulic Pulse Testing	1 wk	Mon 6/25/01	Fri 6/29/01
21	Permeable Reactive Barrier Installation	14 wks	Mon 7/2/01	Fri 10/5/01
22	Verification and Quality Assurance Tests	15 wks	Mon 7/2/01	Fri 10/12/01
23	Site Restoration and Demobilization	2 wks	Mon 10/15/01	Fri 10/26/01
24	**(4) Cap System Construction**	**117 days**	**Thu 6/28/01**	**Fri 12/7/01**
25	Mattatuck Lagoon Closure	1 day	Thu 6/28/01	Thu 6/28/01
26	Temporary Surcharge Fill	2 wks	Mon 7/2/01	Fri 7/13/01
27	Survey Settlement of Lagoon	12 wks	Mon 7/16/01	Fri 10/5/01
28	Site Preparation/Temporary Erosion & Sediment Controls/Clearing and Grubbing	3 wks	Mon 9/10/01	Fri 9/28/01
29	Vegetative Cover Borrow Material Excavation & Stockpiling	3 wks	Mon 10/1/01	Fri 10/19/01
30	Excavation Grades Verification Surveying	3 wks	Mon 10/1/01	Fri 10/19/01
31	Geosynthetic Clay Liner (GCL) Deployment	2 wks	Mon 10/22/01	Fri 11/2/01
32	Geocomposite Deployment and Internal Drain Construction	2 wks	Mon 10/22/01	Fri 11/2/01
33	Vegetative Cover Earthwork	3 wks	Mon 10/22/01	Fri 11/9/01
34	Geosynthetics and Earthwork Construction Quality Assurance	3 wks	Mon 10/1/01	Fri 10/19/01
35	Final Cover Grades Verification Surveying	3 wks	Mon 10/22/01	Fri 11/9/01
36	Permanent Surface Water Management & Sediment and Erosion	3 wks	Mon 11/12/01	Fri 11/30/01
37	Cap System Construction Final Inspection	1 day	Mon 12/3/01	Mon 12/3/01
38	Cap System Construction Equipment Demobilization	0.8 wks	Tue 12/4/01	Fri [illegible]
39	**(5) PRB & Cap System Construction Report**	**60 days**	**Mon 10/29/01**	**Fri 1/18/02**
40	Draft Construction Completion Report	3 wks	Mon 10/29/01	Fri 11/16/01
41	**EPA Draft Construction Completion Report Review**	4 wks	Mon 11/19/01	Fri 12/14/01
42	Final Construction Completion Report	2 wks	Mon 12/17/01	Fri 12/28/01
43	**EPA Final Construction Completion Report Review**	2 wks	Mon 12/31/01	Fri 1/11/02
44	**EPA Final Construction Report Approval**	1 wk	Mon 1/14/02	Fri 1/18/02
45	**(6) Quality Assurance and Health & Safety Meetings and Audits**	**136 days**	**Mon 5/28/01**	**Mon 12/3/01**
46	Internal Project Team Safety and Quality Assurance Meetings	136 days	Mon 5/28/01	Mon 12/3/01
54	External (non Project Team) Safety Audits	71 days	Mon 6/25/01	Mon 10/1/01
57	External (non Project-Team) Quality Assurance Audits	71 days	Mon 6/25/01	Mon 10/1/01



FIGURES



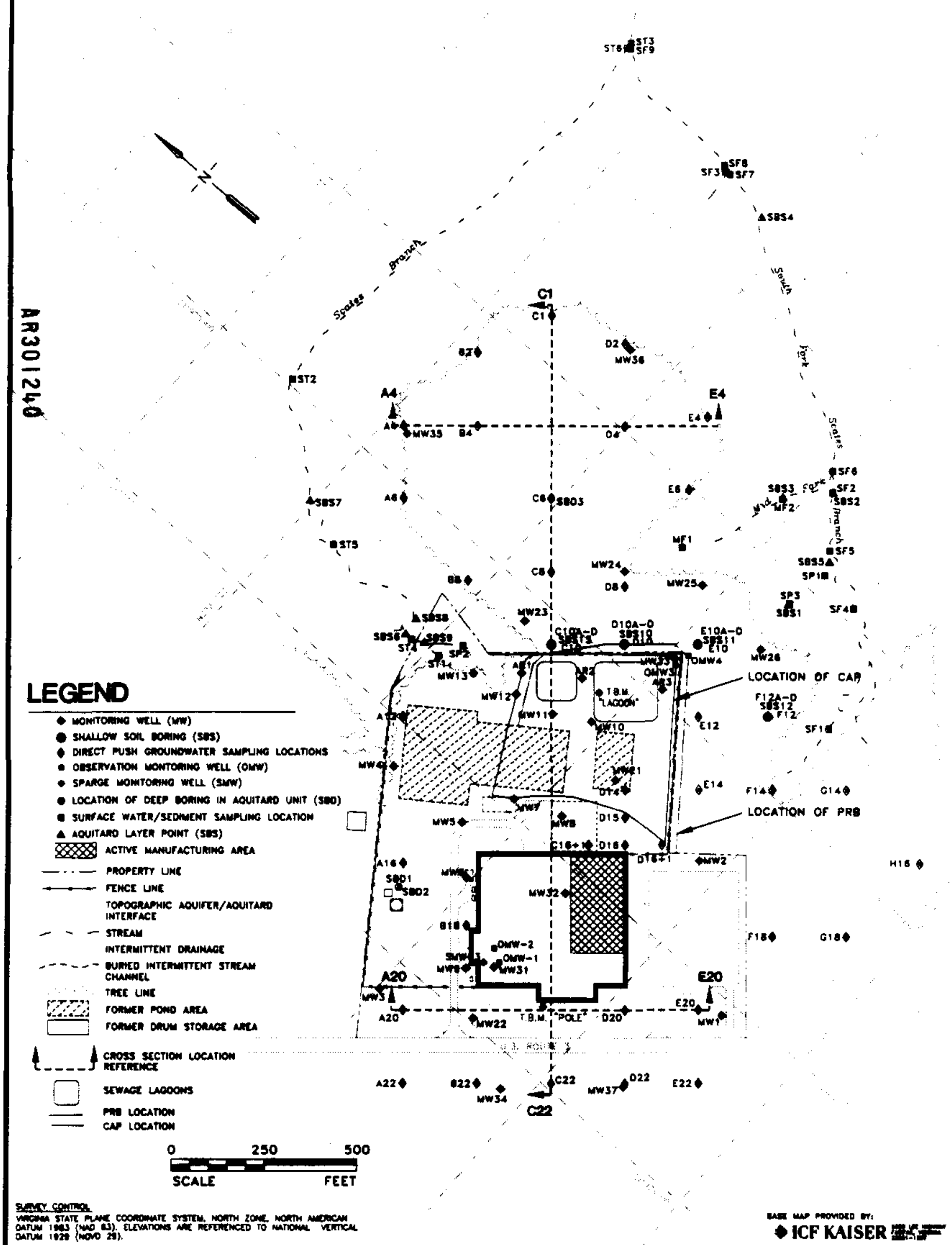


Site Location Map
Map Source: Rand McNally Road Atlas

0 10 mi. 20 mi.

CLIENT/PROJECT						TITLE		
SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA			GOLDER SIERRA Atlanta, Georgia			SITE LOCATION MAP		
DRAWN MAT	CHECKED RIO	REVIEWED	DATE 12/4/00	SCALE as shown	FILE NO. 1100-d27.cdr	JOB NO. 996-1100	DWG NO./REV NO.	FIGURE 1

AR301239



CLIENT/PROJECT

SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

GOLDER SIERRA
Atlanta, Georgia

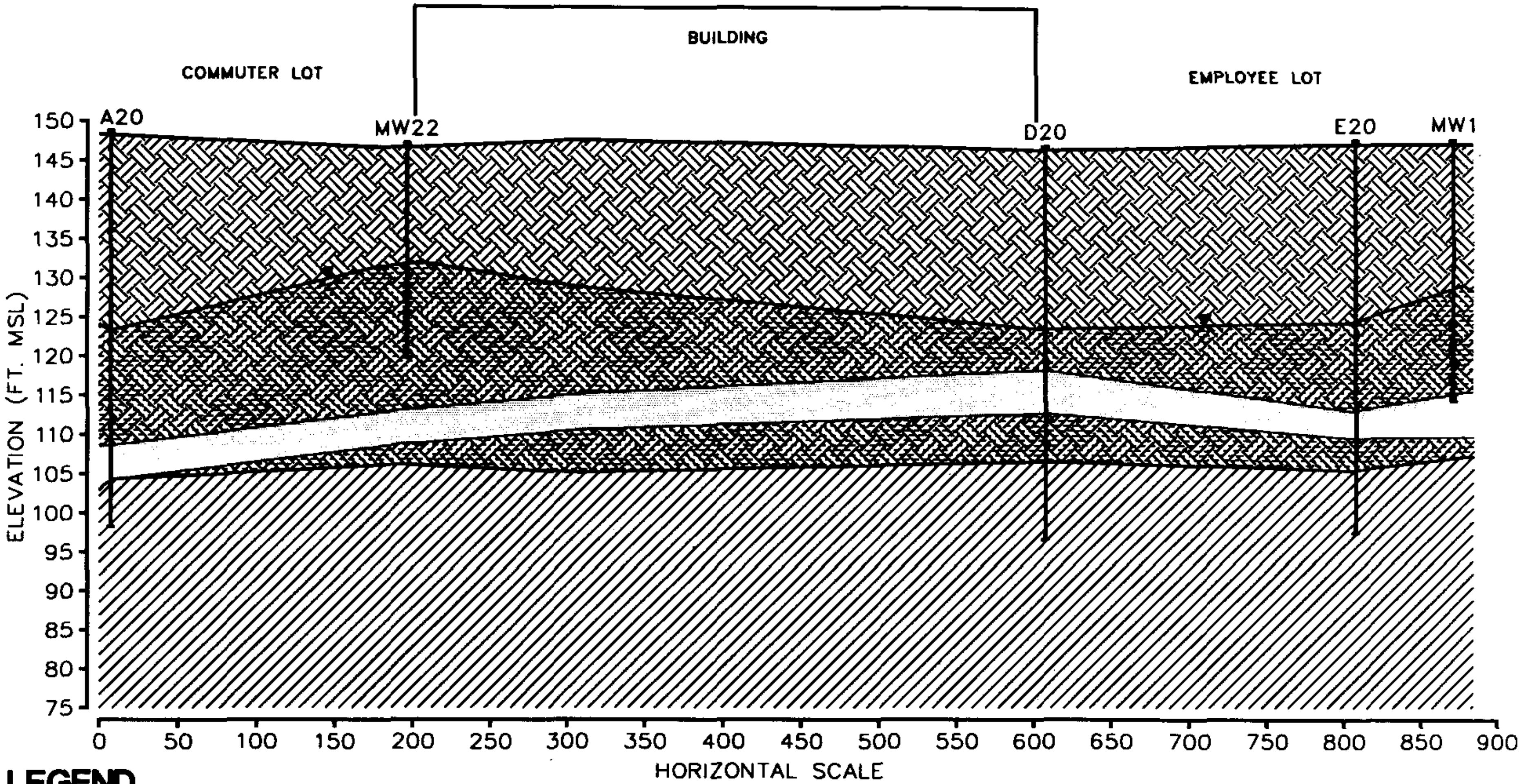
TITLE

EXISTING SITE PLAN

DATE	DRAWN	CHECKED	REVIEWED
6/20/00	MAT	RIO	

SCALE	FILE NO.	JOB NO.
1:250	1100-C01.dwg	996-1100

DWG NO.	SUBTITLE	REV. NO.	FIGURE
1100-C01		C	2



LEGEND

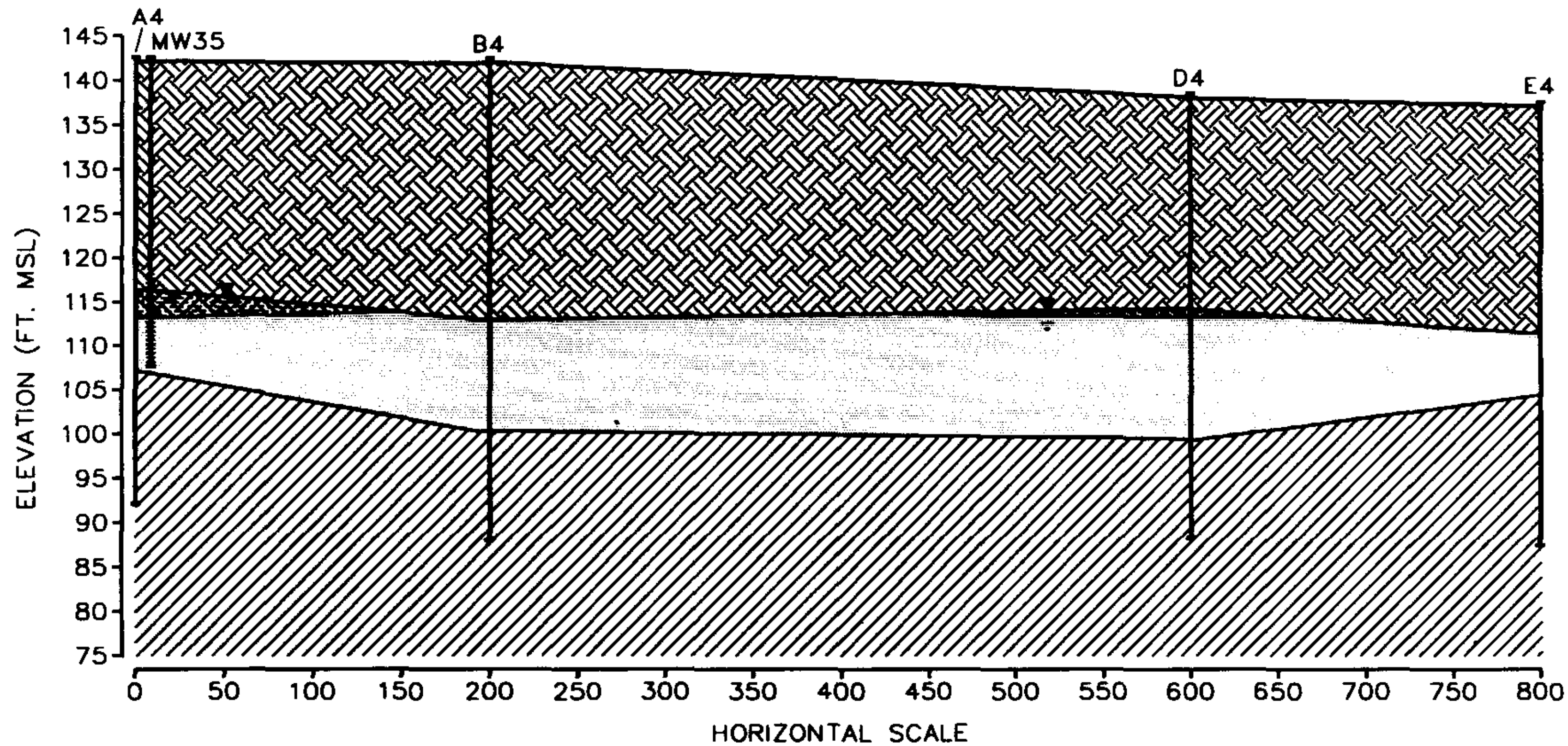
- VADOSE ZONE
- SATURATED ZONE
- AQUITARD
- POTENTIAL PREFERRED PATHWAY
- WATER TABLE

BASE MAP PROVIDED BY: ICF KAISER

CLIENT/PROJECT			
SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA			
DATE 10/6/99	DRAWN MAT	CHECKED RIO	REVIEWED
SCALE AS SHOWN	FILE NO. 1100-C08.dwg	JOB NO. 996-1100	

GOLDER SIERRA Atlanta, Georgia

TITLE			
CROSS SECTION A20-E20			
DWG NO. 1100-c08	SUBTITLE	REV. NO.	FIGURE 3



LEGEND

VADOSE ZONE

SATURATED ZONE

AQUITARD

POTENTIAL PREFERRED PATHWAY

WATER TABLE

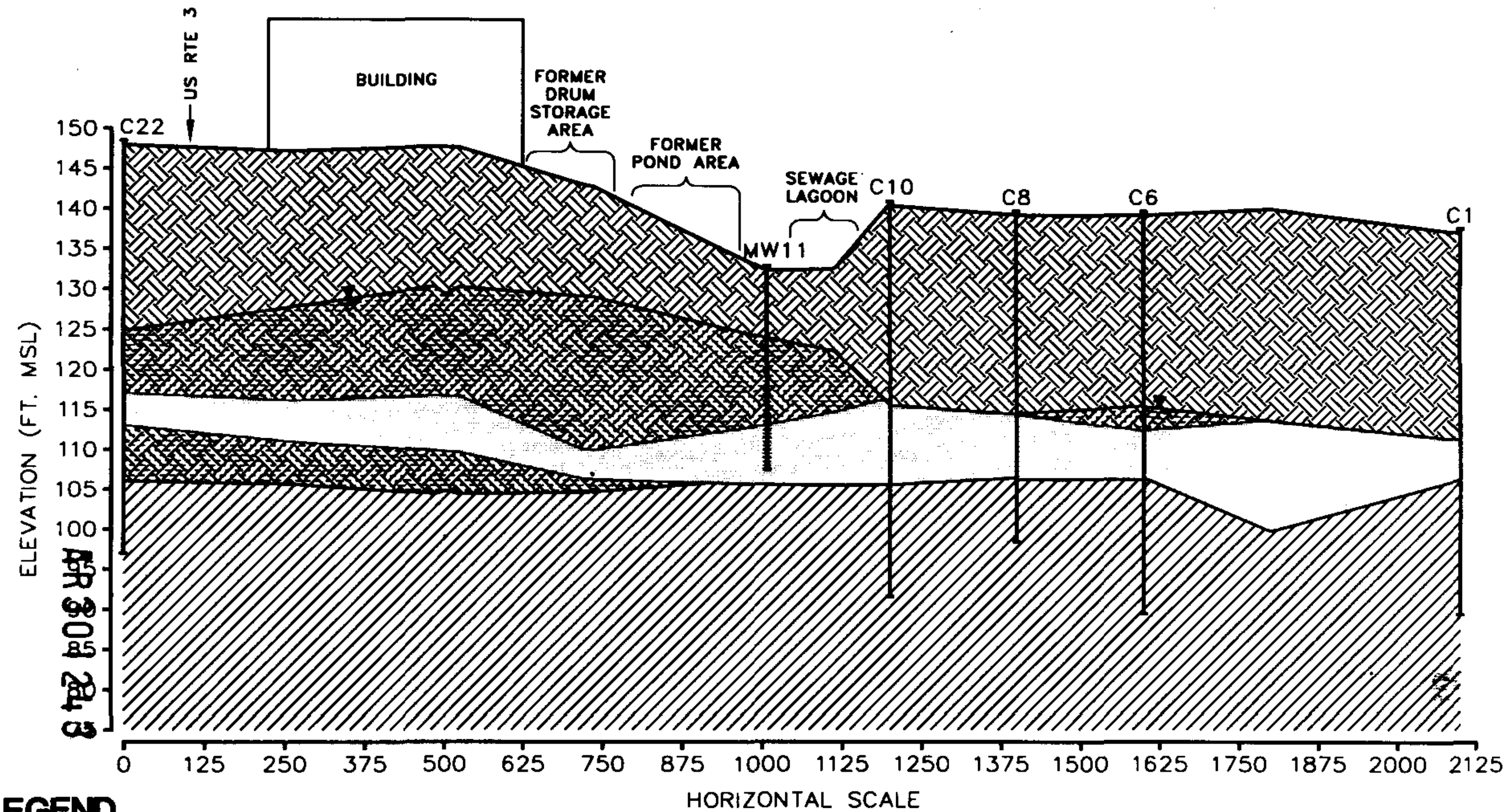
BASE MAP PROVIDED BY: ICF KAISER

CLIENT/PROJECT: SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA			
DATE 10/6/99	DRAWN MAT	CHECKED RIO	REVIEWED
SCALE AS SHOWN	FILE NO. 1100-C09.dwg	JOB NO. 996-1100	

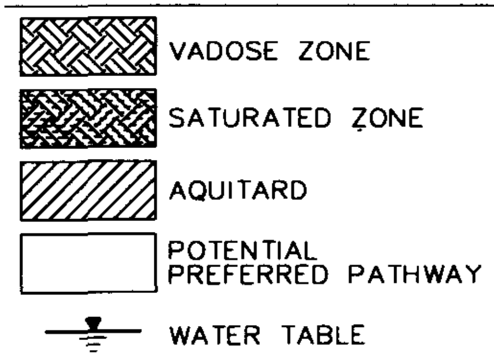
GOLDER SIERRA Atlanta, Georgia

TITLE: CROSS SECTION A4-E4			
DWG NO. 1100-c09	SUBTITLE	REV. NO.	FIGURE 4

AR301242



LEGEND

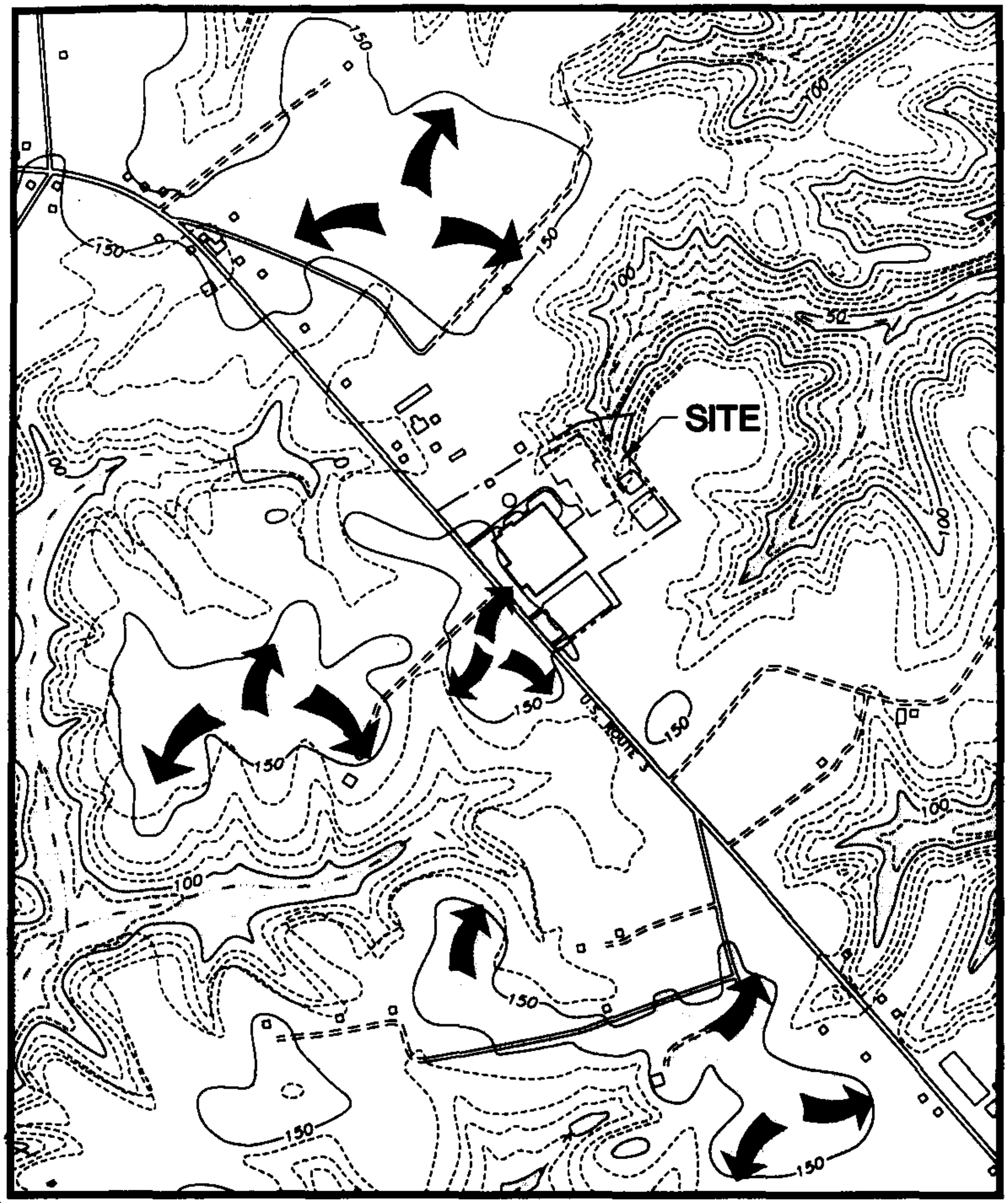


BASE MAP PROVIDED BY: ICF KAISER

CLIENT/PROJECT			
SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA			
DATE 10/6/99	DRAWN MAT	CHECKED RIO	REVIEWED
SCALE AS SHOWN	FILE NO. 1100-C10.dwg	JOB NO. 996-1100	

GOLDER SIERRA Atlanta, Georgia

TITLE			
CROSS SECTION C22-C1			
DWG NO. 1100-c10	SUBTITLE	REV. NO.	FIGURE 5



AR301244

LEGEND

SURFACE WATER FLOW DIRECTION

>150 FEET ABOVE MSL – RADIAL GROUNDWATER FLOW AWAY FROM THESE AREAS

<100 FEET ABOVE MSL – SHALLOW AQUIFER ABSENT DUE TO EROSION

0 1000 2000
SCALE FEET

BASE MAP PROVIDED BY:
ICF KAISER

CLIENT/PROJECT
SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

GOLDER SIERRA Atlanta, Georgia

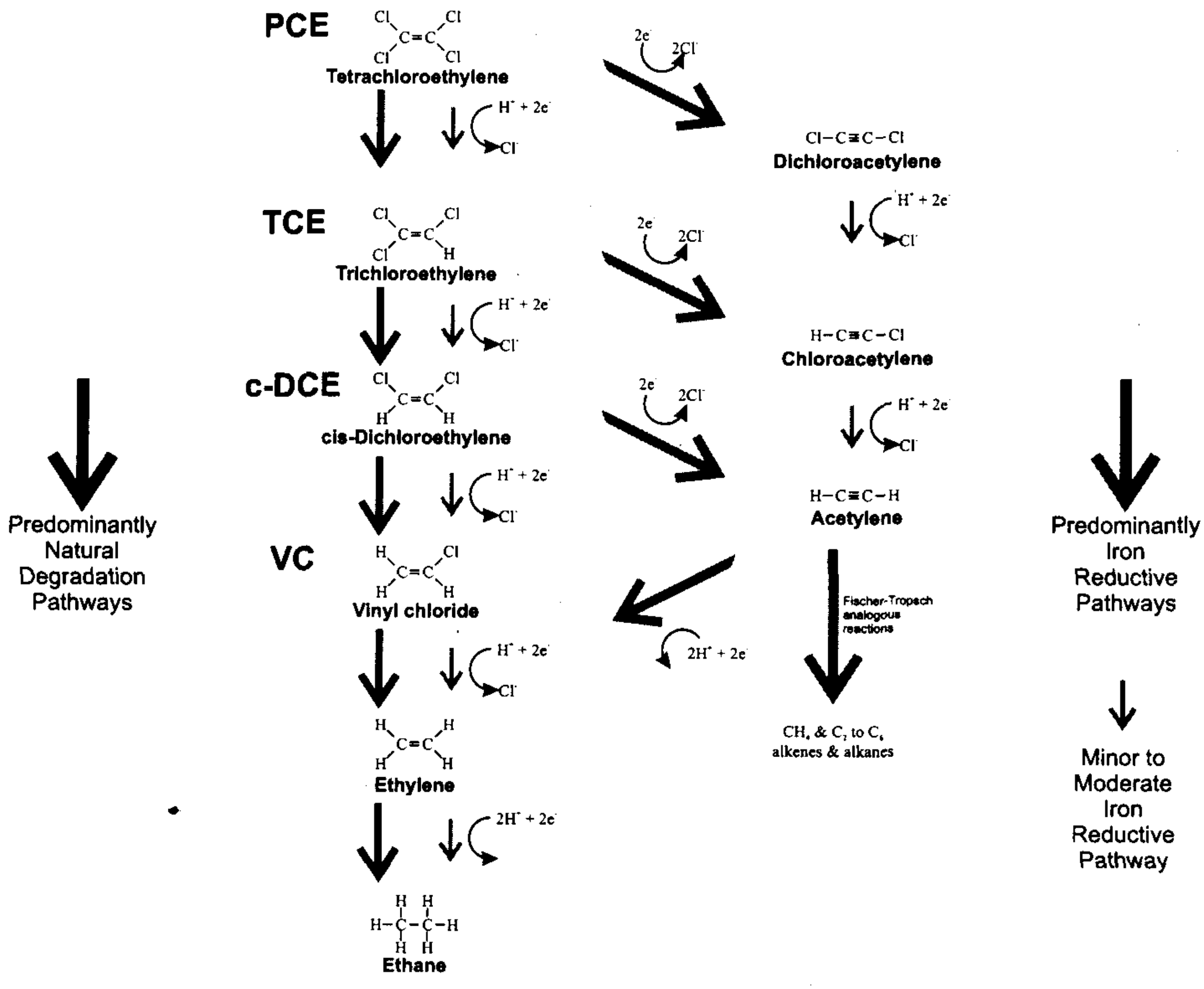
TITLE
GROUNDWATER FLOW PATTERNS AND SHALLOW AQUIFER EXTENT

DATE	DRAWN	CHECKED	REVIEWED
10/6/99	MAT	RIO	

SCALE	FILE NO.	JOB NO.
AS SHOWN	1100-C11.dwg	996-1100

DWG NO.	SUBTITLE	REV. NO.	FIGURE
1100-C11			6

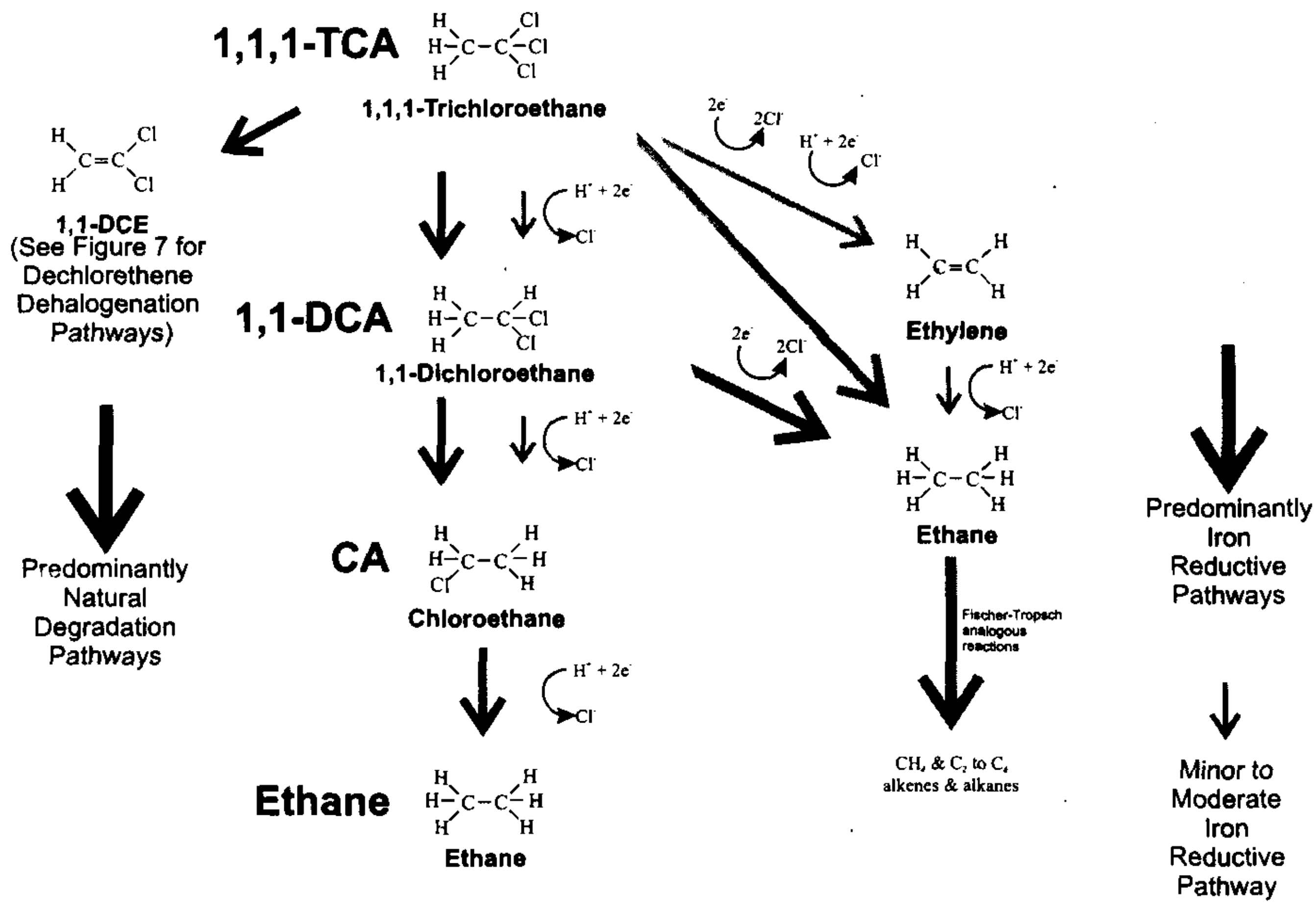
Reductive Dehalogenation Pathways



GOLDER SIERRA Atlanta, Georgia	TITLE: REDUCTIVE DEHALOGENATION PATHWAYS - PCE, TCE AND DAUGHTER PRODUCTS					
CLIENT/PROJECT: SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA	DRAWN: MAT	DATE: 1/22/01	JOB NO. 996-1100			
	CHECKED: RIO	SCALE: NTS	DWG NO.	REV. NO.		
	REVIEWED: [signature]	FILE NO. 1100-d32.cdr	SUBTITLE	FIGURE NO. 7		

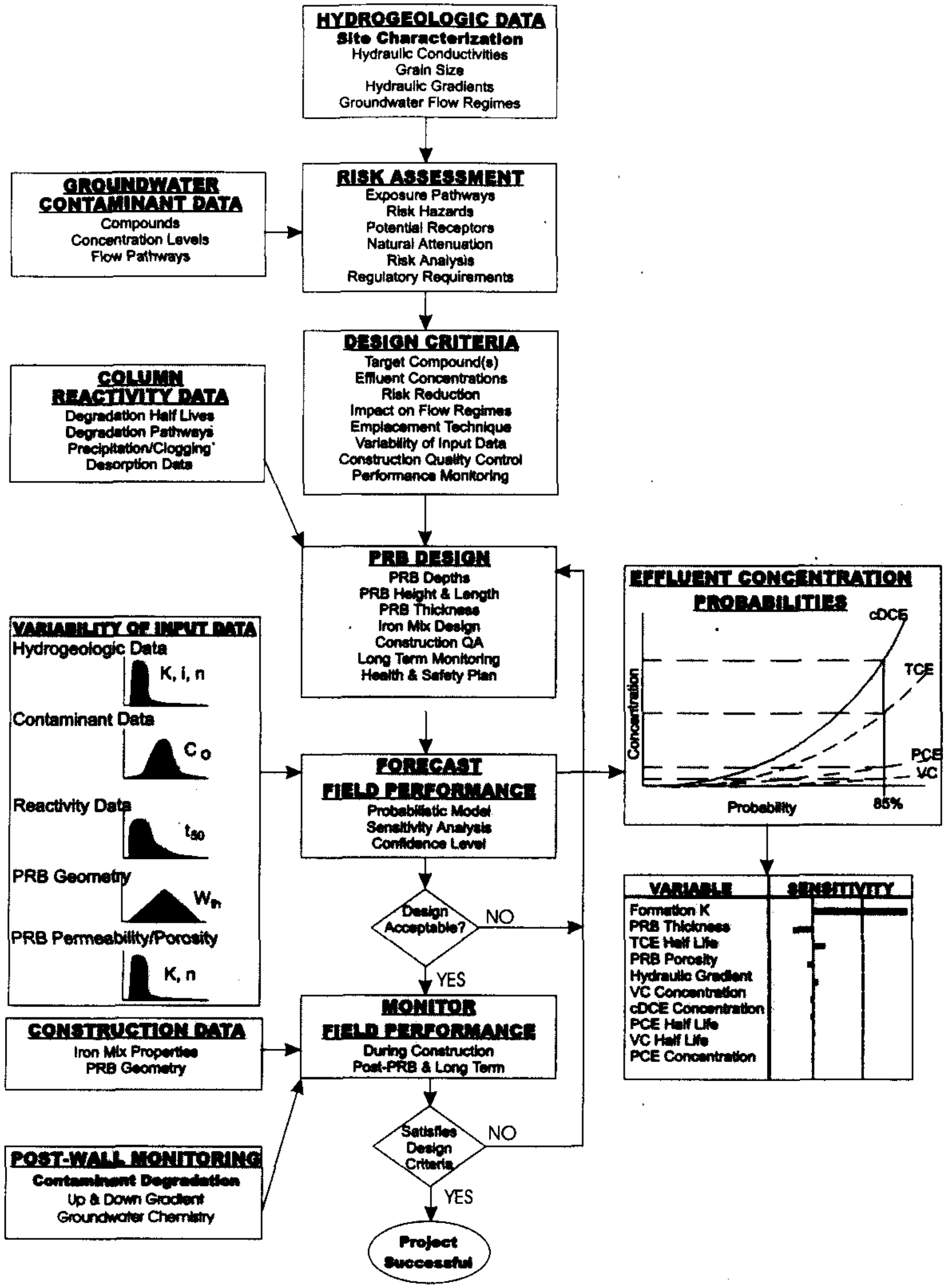
AR301245

Reductive Dehalogenation Pathways



GOLDER SIERRA Atlanta, Georgia	TITLE REDUCTIVE DEHALOGENATION PATHWAYS - 1,1,1-TCA AND DAUGHTER PRODUCTS				
CLIENT/PROJECT SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA	DRAWN MAT	DATE 1/22/01	JOB NO. 996-1100		
	CHECKED RIO	SCALE NTS	DWG NO.	REV. NO.	
	REVIEWED	FILE NO. 1100-d31.cdr	SUBTITLE	FIGURE NO. 8	

AR301246

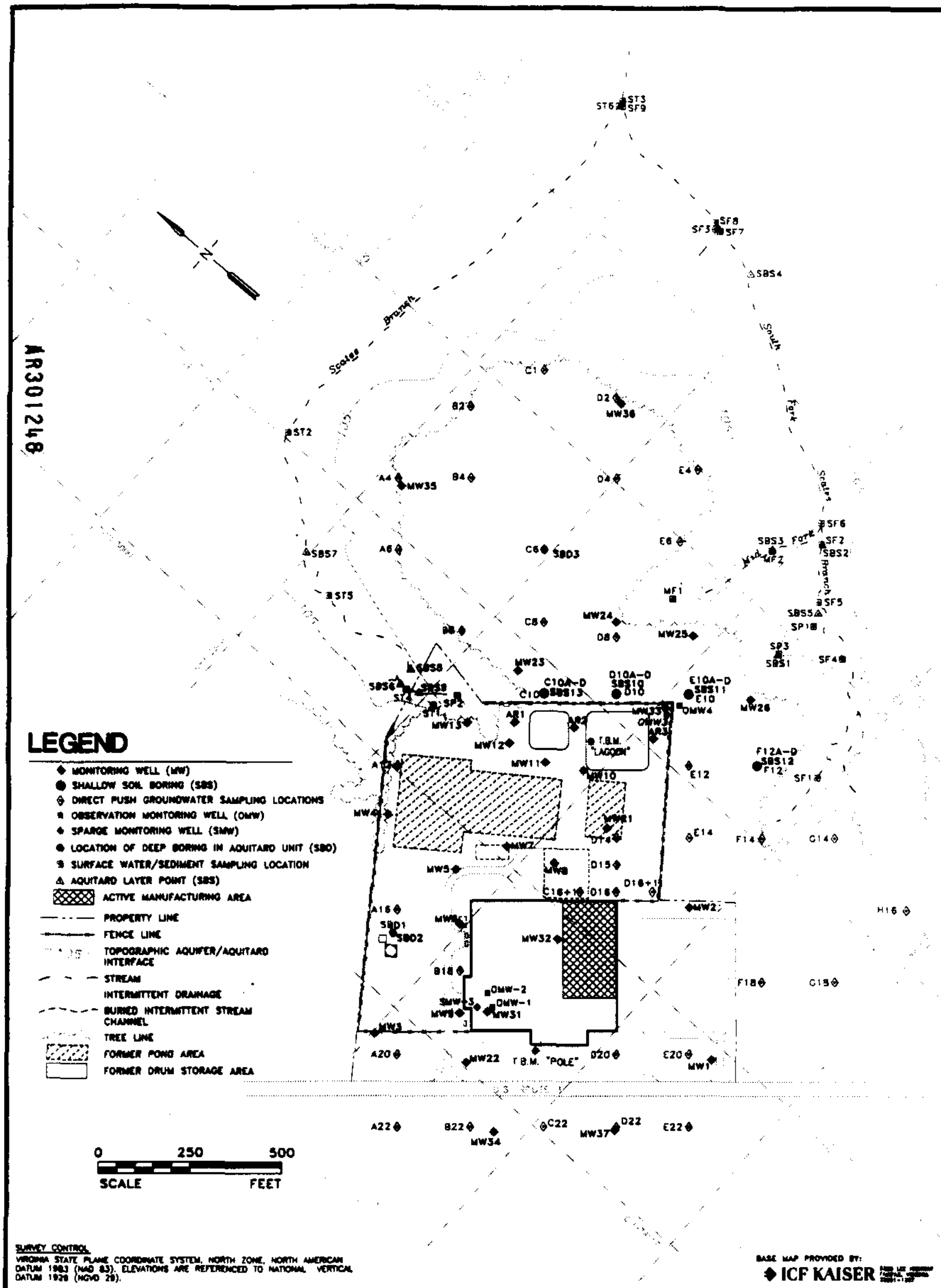


AR301247

GOLDER SIERRA Atlanta, Georgia

TITLE
IRON PERMEABLE REACTIVE BARRIER
DESIGN METHODOLOGY

CLIENT/PROJECT	DRAWN MAT	DATE 7/12/00	JOB NO. 996-1100	
SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA	CHECKED RIO	SCALE N/A	DWG NO.	REV. NO. A
	REVIEWED	FILE NO. 1100-d02.cdr	SUBTITLE	FIGURE NO. 9



CLIENT/PROJECT

SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

GOLDER SIERRA

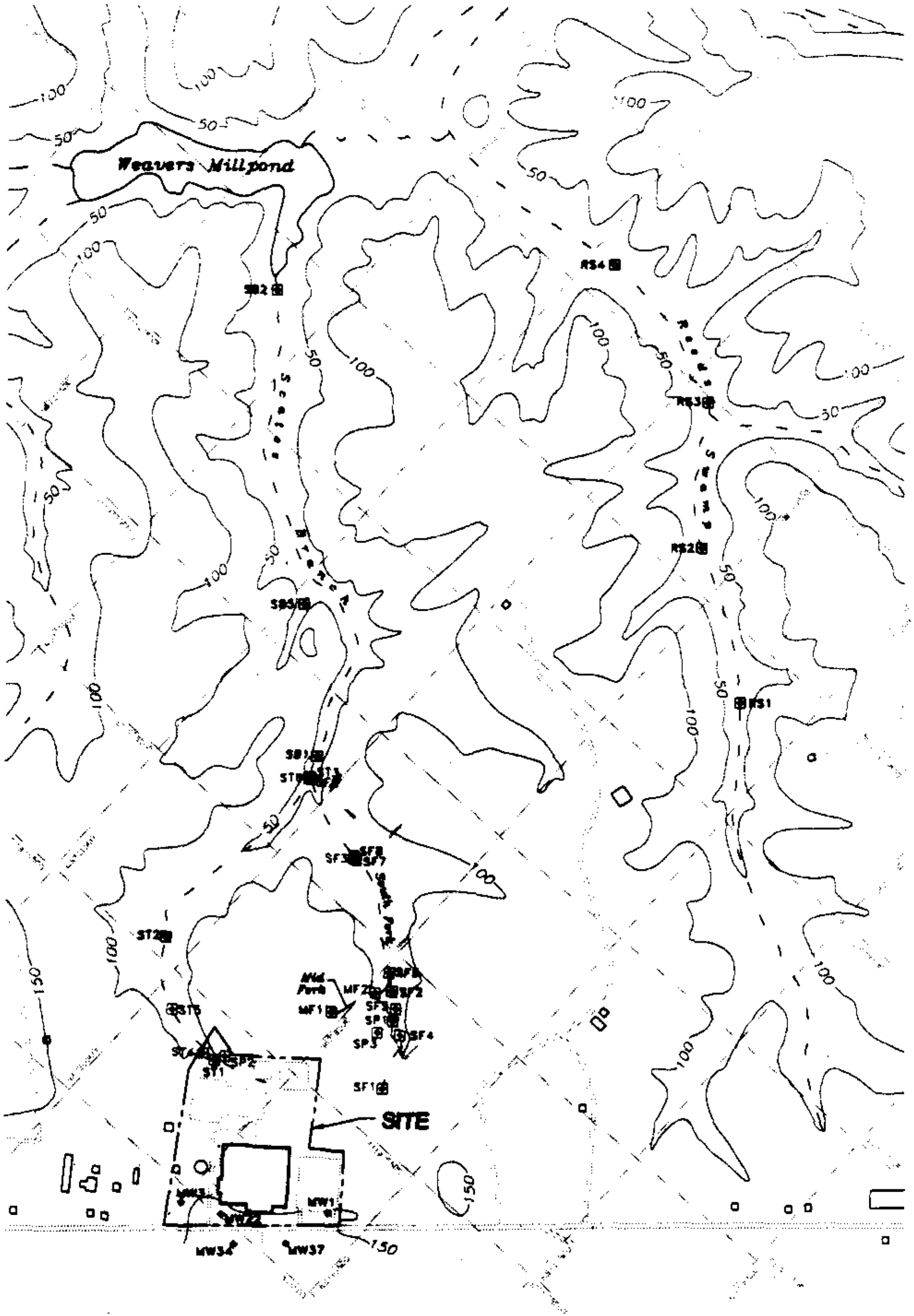
Atlanta, Georgia

TITLE

BORING, DIRECT PUSH AND MONITORING WELL LOCATION MAP

DATE	6/20/00	DRAWN	MAT	CHECKED	RJO	REVIEWED	
SCALE	1:250	FILE NO.	1100-C04.dwg	JOB NO.	996-1100		

DWG NO.	SUBTITLE	REV. NO.	FIGURE
1100-C04		0	10



LEGEND

- ⊞ SURFACE WATER SAMPLING LOCATION
- ◆ BACKGROUND GROUNDWATER MONITORING WELL LOCATION
- – – – PROPERTY LINE

0 750 1500

SCALE FEET

BASE MAP PROVIDED BY: ICF KAISER

AR301249

CLIENT/PROJECT

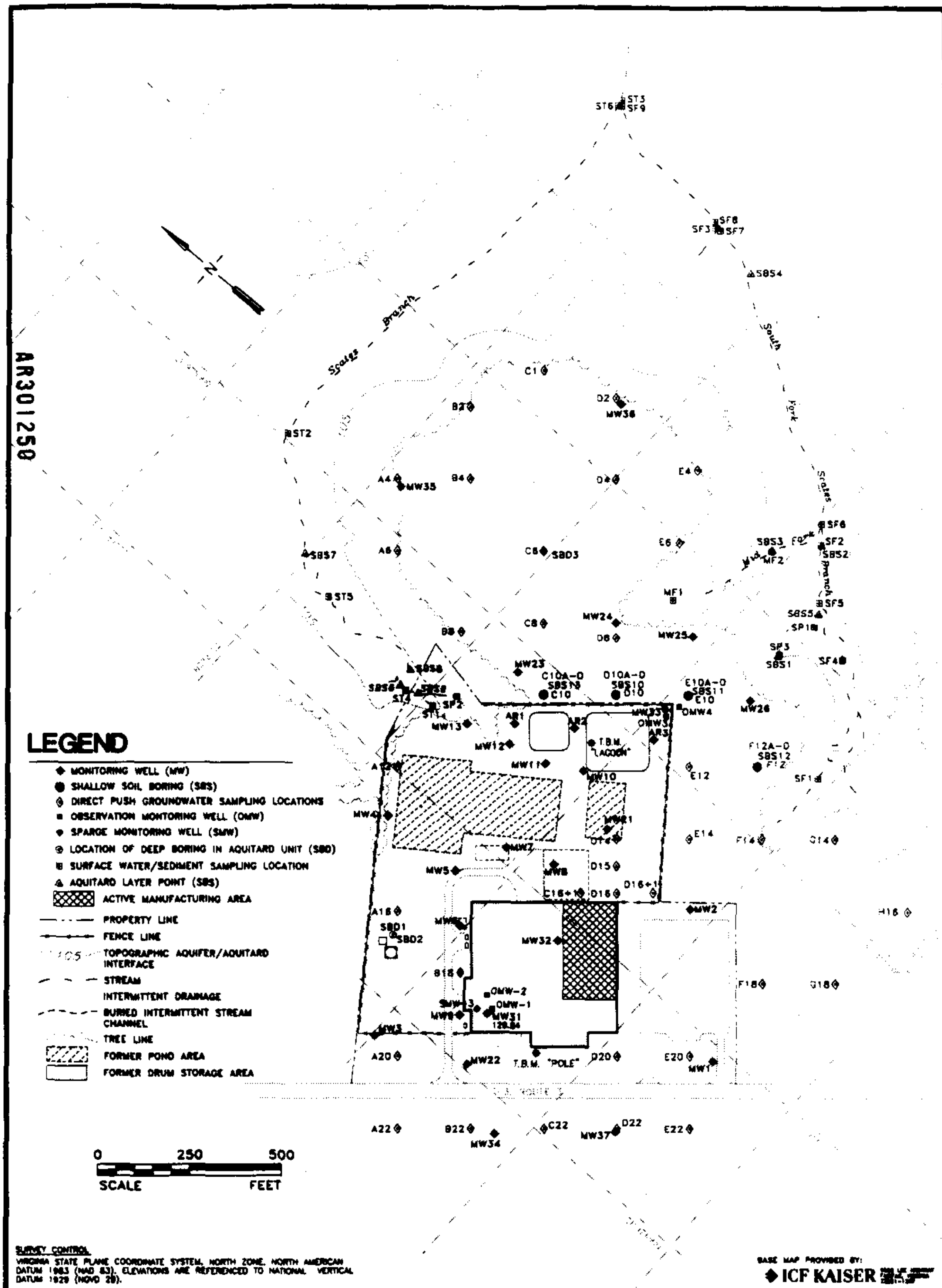
SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

GOLDER SIERRA Atlanta, Georgia

TITLE

SURFACE WATER
SAMPLING LOCATIONS

DATE	10/21/99	DRAWN	MAT	CHECKED	RIO	REVIEWED	
SCALE	1:750	FILE NO.	1100-C13.dwg	JOB NO.	966-1100		
DWG NO.	1100-C13	SUBTITLE		REV. NO.	0	FIGURE	11



CLIENT/PROJECT

SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

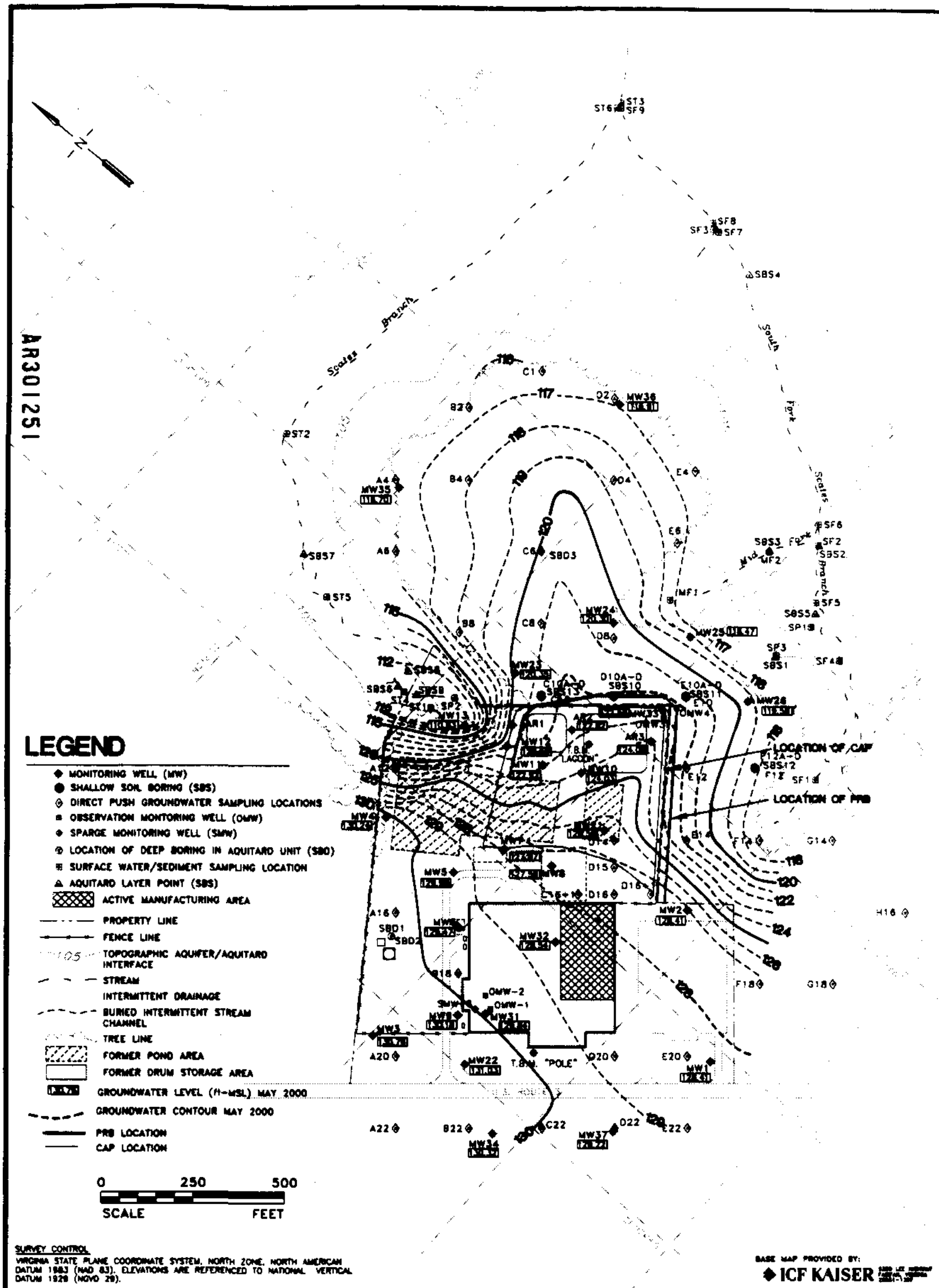
GOLDER SIERRA Atlanta, Georgia

TITLE

GROUNDWATER MONITORING WELL SAMPLE LOCATION MAP

DATE	6/20/00	DRAWN	MAT	CHECKED	RIO	REVIEWED	
SCALE	1:250	FILE NO.	1100-C24.dwg	JOB NO.	996-1100		

DWG NO.	SUBTITLE	REV. NO.	FIGURE
1100-C24			12



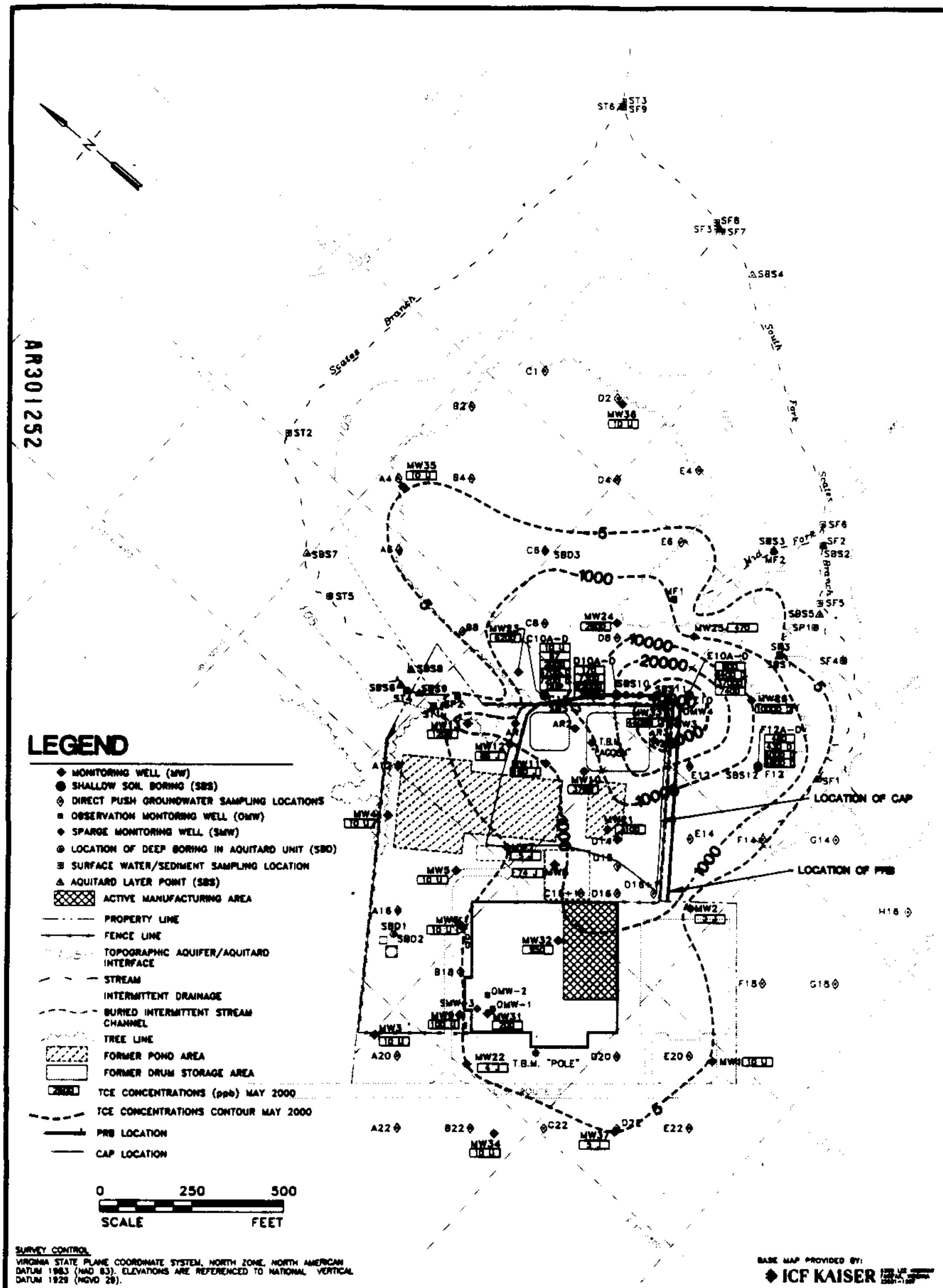
SURVEY CONTROL
VIRGINIA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NORTH AMERICAN DATUM 1983 (NAD 83). ELEVATIONS ARE REFERENCED TO NATIONAL VERTICAL DATUM 1929 (NGVD 29).

BASE MAP PROVIDED BY: ICF KAISER

CLIENT/PROJECT			
SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA			
DATE 6/20/00	DRAWN MAT	CHECKED RIO	REVIEWED
SCALE 1:250	FILE NO. 1100-C22.dwg	JOB NO. 998-1100	

GOLDER SIERRA Atlanta, Georgia

TITLE			
GROUNDWATER LEVEL POTENTIOMETRIC CONTOUR MAP (MAY 2000)			
DWG NO. 1100-C22	SUBTITLE	REV. NO. E	FIGURE 13



CLIENT/PROJECT

SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

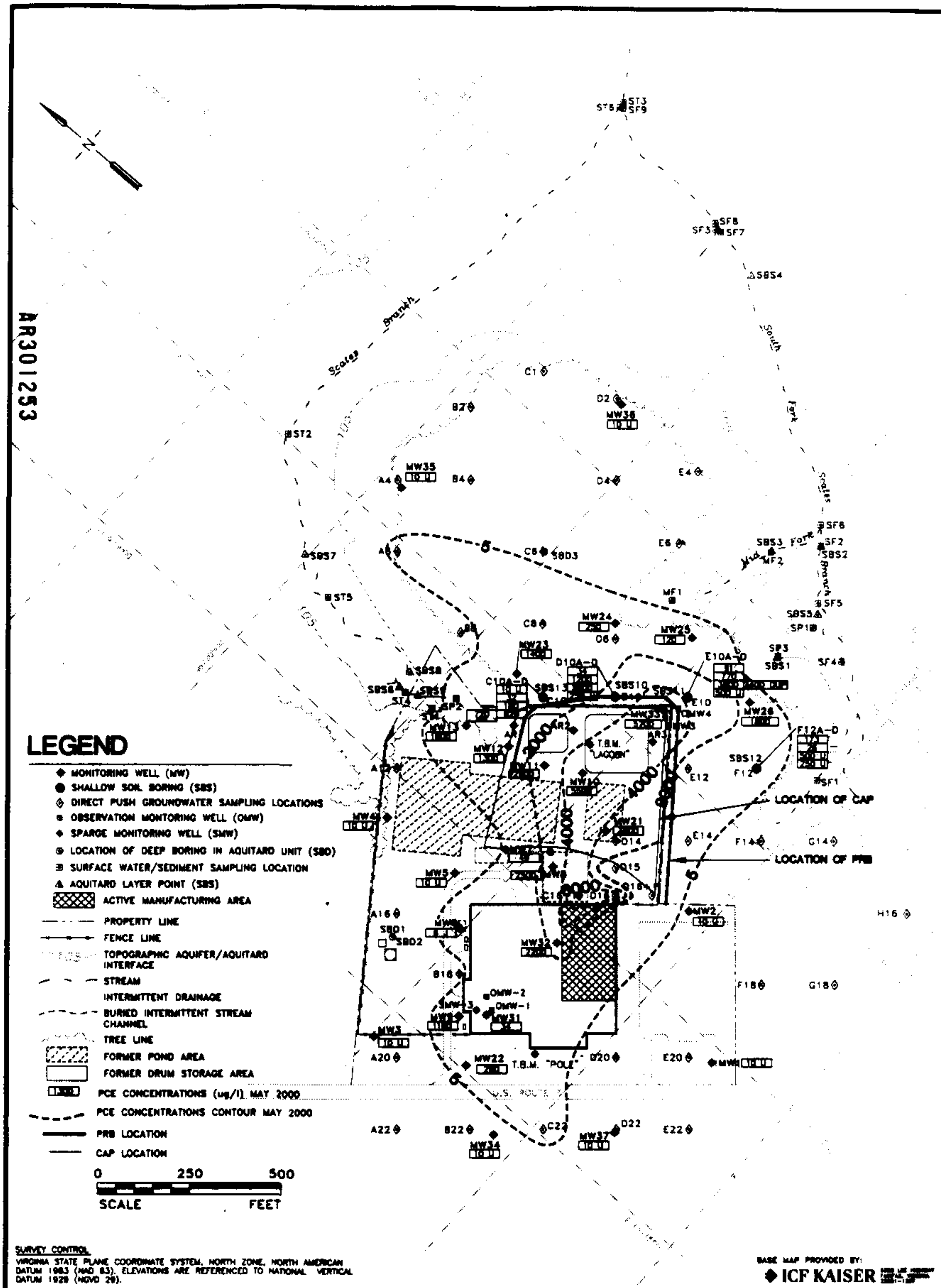
GOLDER SIERRA Atlanta, Georgia

TITLE

TCE CONCENTRATION
CONTOUR MAP (MAY 2000)

DATE	6/20/00	DRAWN	MAT	CHECKED	RIO	REVIEWED	
SCALE	1:250	FILE NO.	1100-C23.dwg	JOB NO.	996-1100		

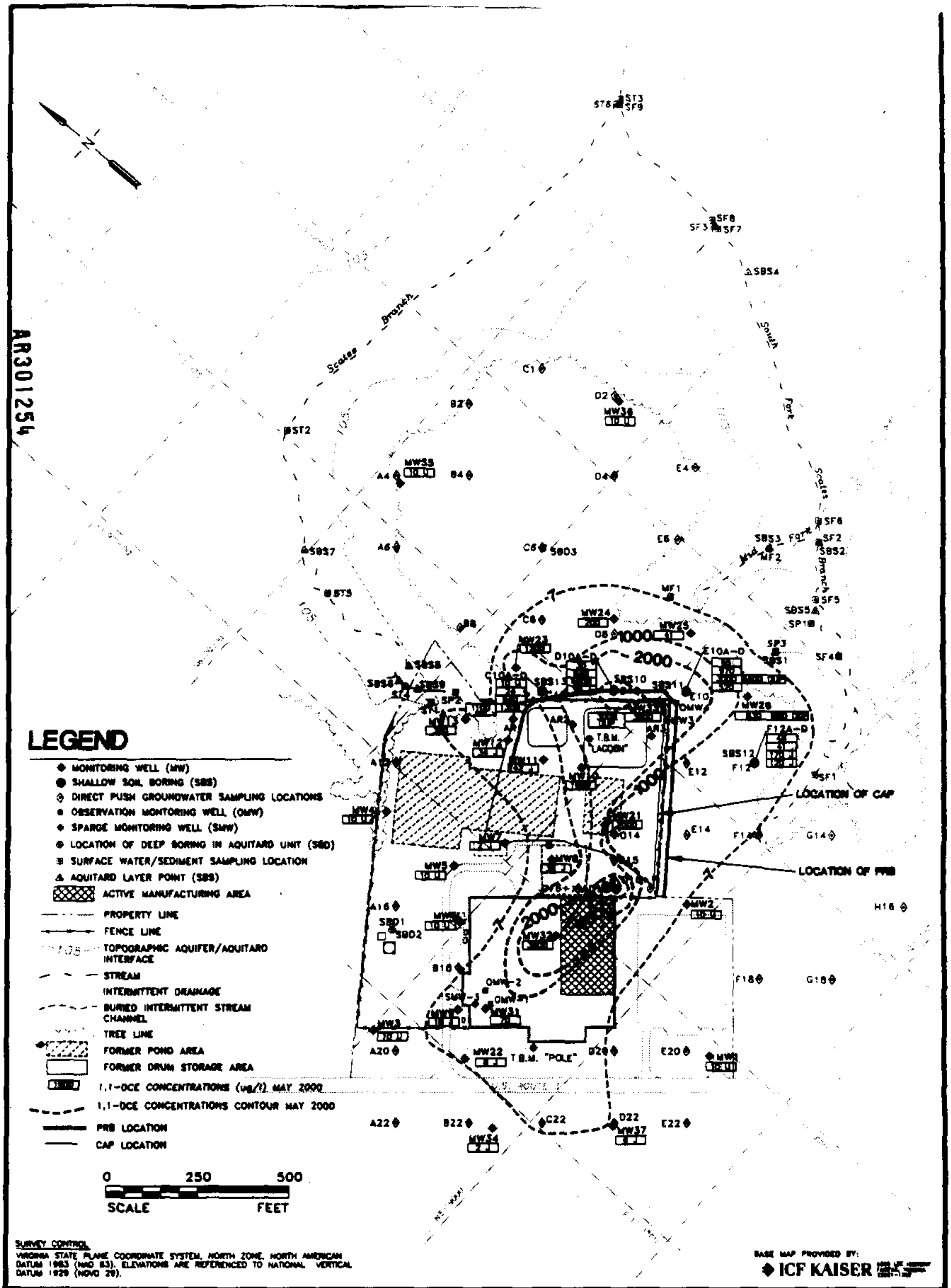
DWG NO.	SUBTITLE	REV. NO.	FIGURE
1100-C23		C	14



CLIENT/PROJECT							
SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA							
DATE	6/20/00	DRAWN	MAT	CHECKED	RIO	REVIEWED	
SCALE	1:250	FILE NO.	1100-C27.dwg	JOB NO.	998-1100		

GOLDER SIERRA — Atlanta, Georgia

TITLE							
PCE CONCENTRATION CONTOUR MAP (MAY 2000)							
DWG NO.	1100-C27	SUBTITLE		REV. NO.	8	FIGURE	15



CLIENT/PROJECT

SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

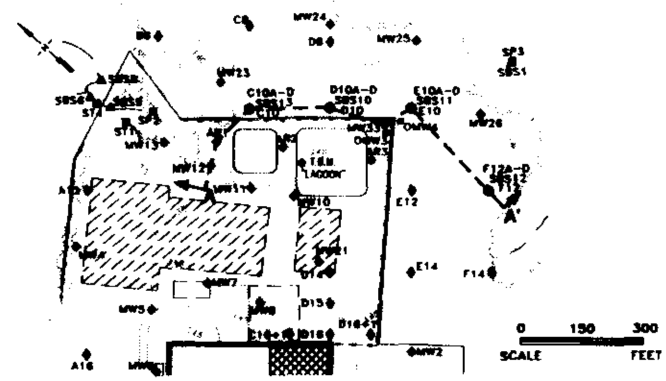
GOLDER SIERRA Atlanta, Georgia

TITLE

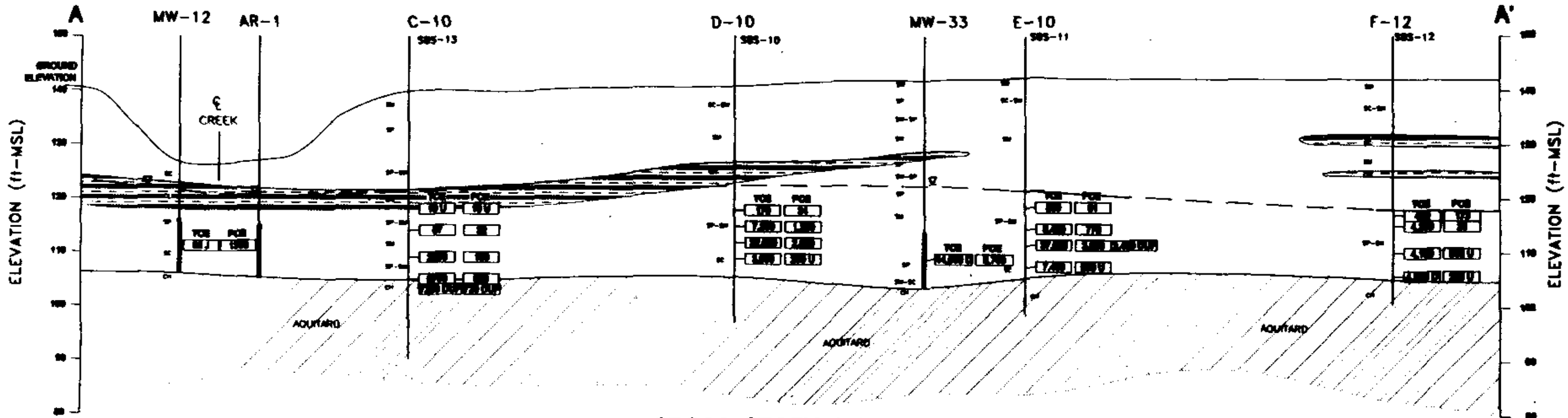
1,1-DCE CONCENTRATION
CONTOUR MAP (MAY 2000)

DATE	6/20/00	DRAWN	MAT	CHECKED	KIO	REVIEWED	
SCALE	1:250	FILE NO.	1100-C30.dwg	JOB NO.	996-1100		

DWG NO.	SUBTITLE	REV. NO.	FIGURE
1100-C30		5	16



PLAN VIEW



CROSS SECTION A-A'

LEGEND

- MONITORING WELL (MW)
- SHALLOW SOIL BORING (SBS)
- DIRECT PUSH GROUNDWATER SAMPLING LOCATIONS
- SURFACE WATER / SEDIMENT SAMPLING LOCATIONS
- TCE AND PCE DATA (MAY 2000) (ug/l)
- MONITORING WELL SCREEN
- OBSERVATION MONITORING WELL (OMW)
- GROUNDWATER LEVEL (MAY 2000)
- CLAY
- AQUITARD

Scale in Feet
0 40 80
Vertical Scale X4

GOLDER SIERRA
Atlanta, Georgia

DWG. NO.	1100-c25
REV. NO.	A
JOB NO.	996-1100
DATE	7/14/00
DRAWN	MAT
SCALE	
CHECKED	flo
FILE NO.	1100-C25.DWG
REVIEWED	

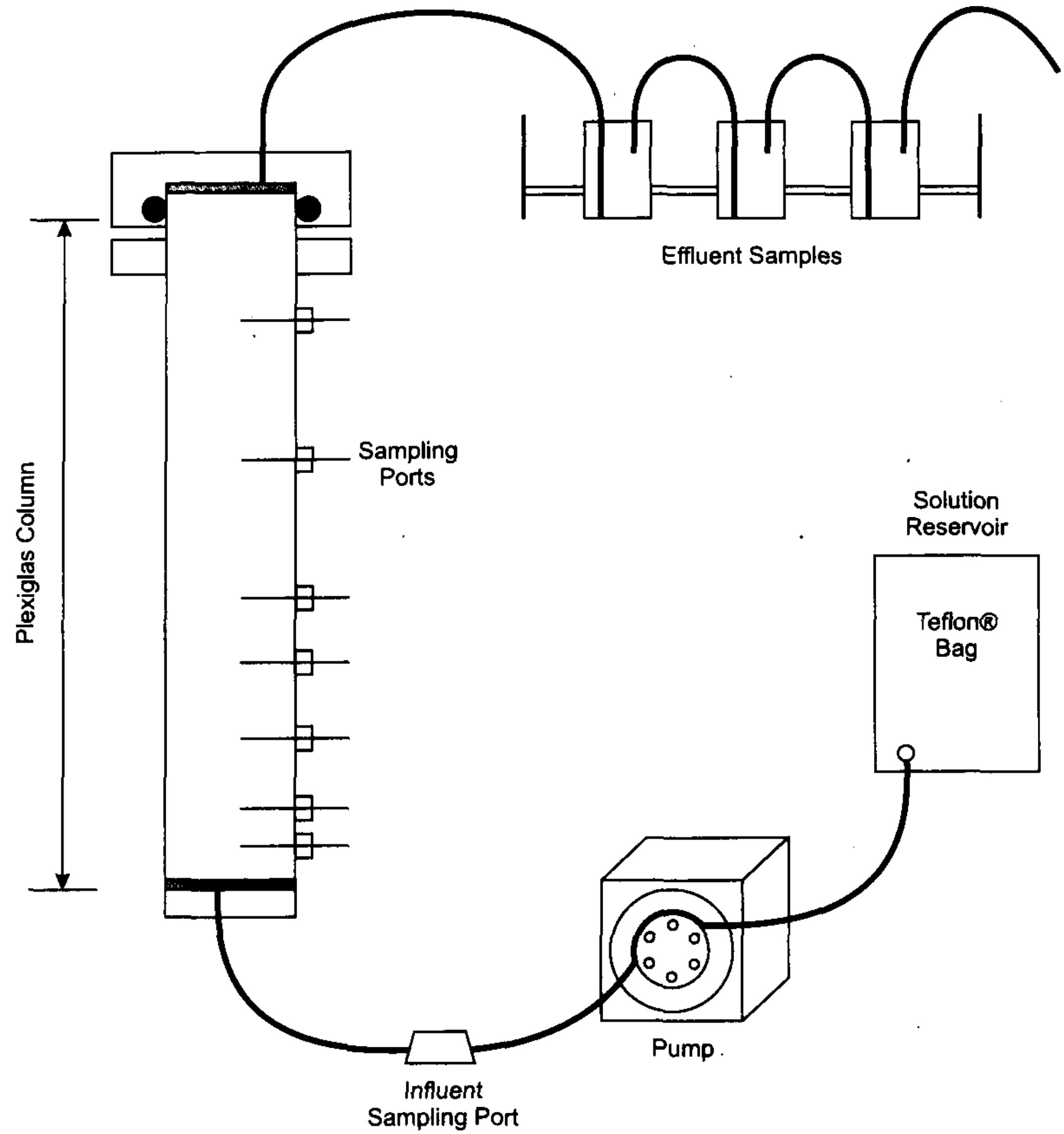
CLIENT/PROJECT: SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA

TITLE: CROSS SECTION A-A' GEOLOGY AND CHEMISTRY

FIGURE NO. 17

AR301255

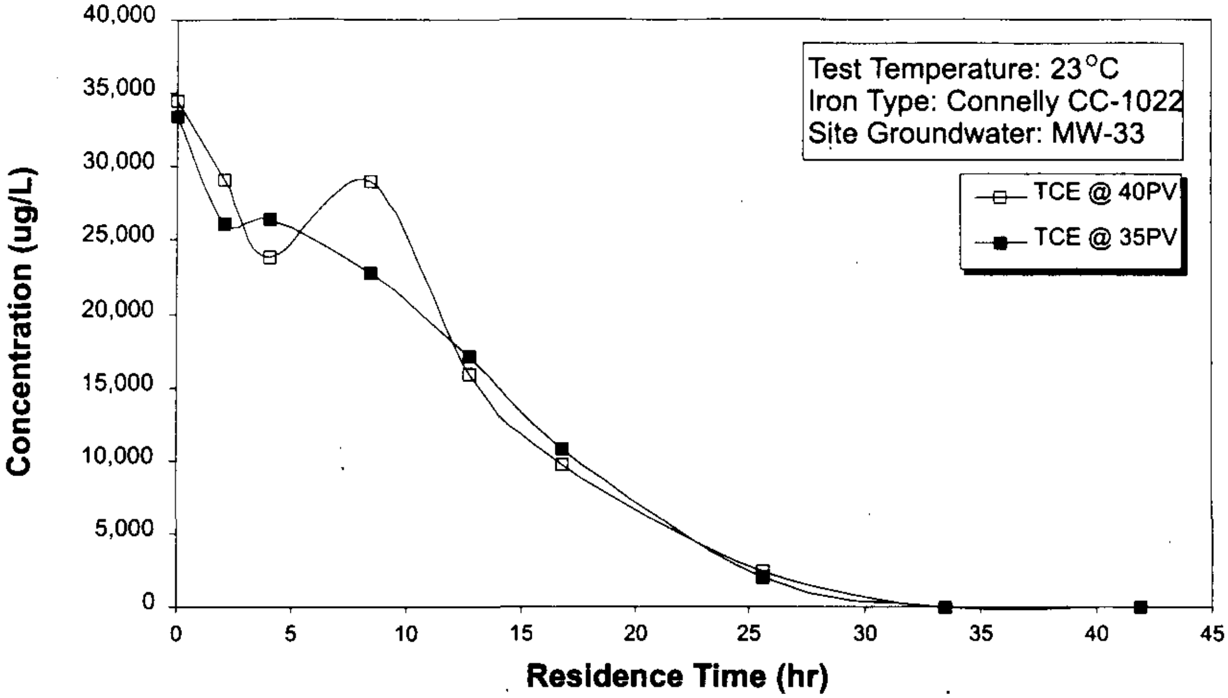
PLOT 80

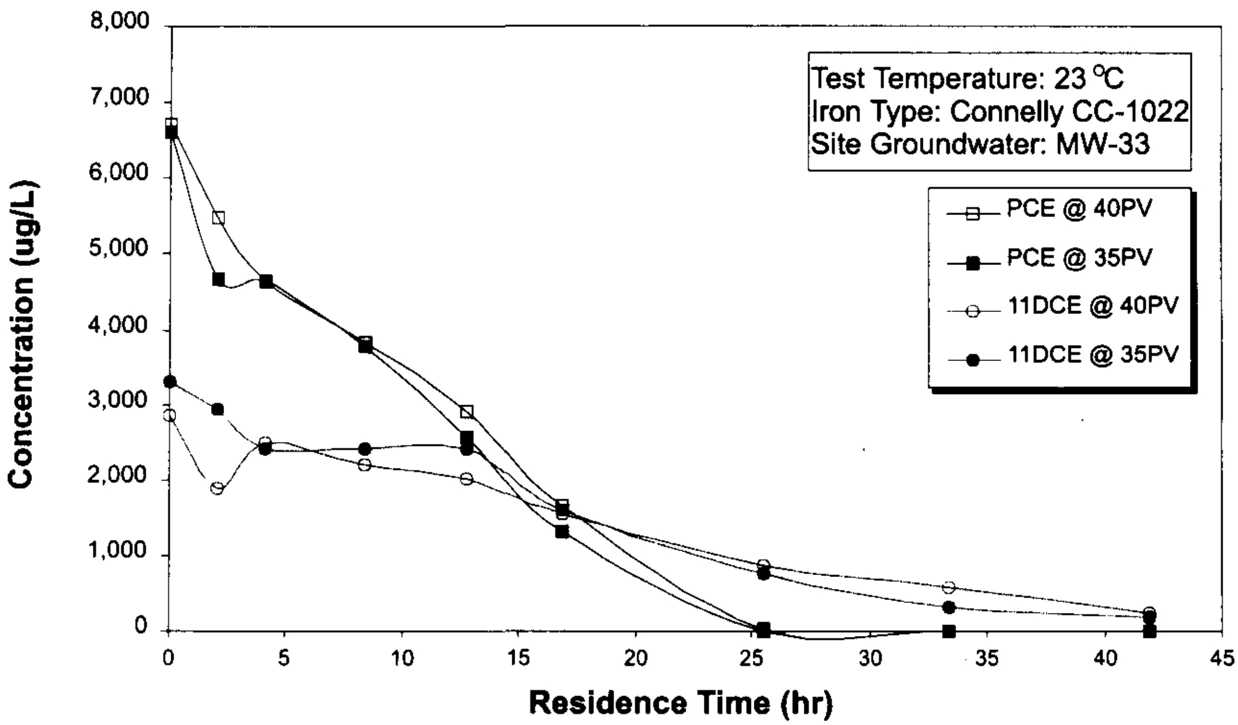


AR301256

GOLDER SIERRA Atlanta, Georgia	TITLE EnviroMetal Process Column Test Apparatus

CLIENT/PROJECT	DRAWN	MAT	DATE	1/22/01	JOB NO.	996-1100	
SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA	CHECKED	RIO	SCALE	N/A	DWG NO.		REV. NO.
	REVIEWED		FILE NO.	1100-d33.cdr	SUBTITLE		FIGURE NO. 18





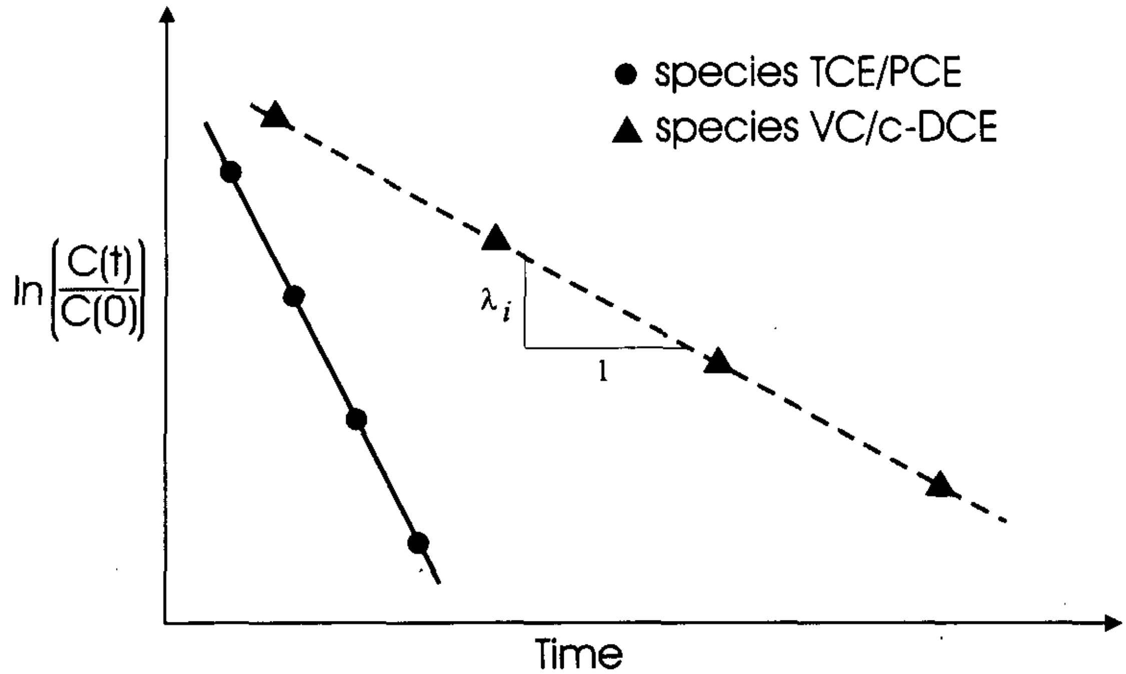
GOLDER SIERRA Atlanta, Georgia

TITLE

TCE, PCE and 1,1-DCE Degradation Profiles in Column Test at Steady State Conditions

CLIENT/PROJECT: SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA	DRAWN: MAT	DATE: 7/26/00	JOB NO.: 996-1100
	CHECKED: RIO	SCALE: N/A	DWG NO.: / REV. NO.:
	REVIEWED:	FILE NO.: 1100-d07.cdr	SUBTITLE: / FIGURE NO.: 19

AR301257



Results of Column Reactivity Tests with Iron

First Order Reduction: $\frac{dC}{dt} = \lambda_i C$

i.e. $C(t) = C(0)\, e^{-\lambda_i t}$

First order reductive reaction is dependent on surface area of iron filings:

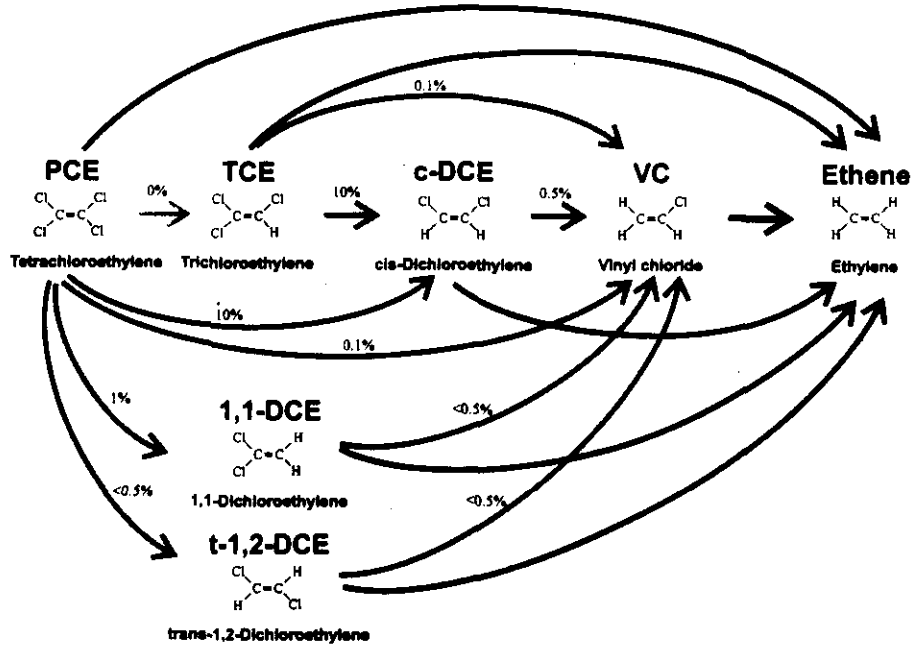
$$\lambda_i = k(SA) \cdot A$$

where k(SA) is proportional constant of reductive medium and is in units of litre/m^2hr and A is surface area of reductive medium per volume with units of m^2/litre.

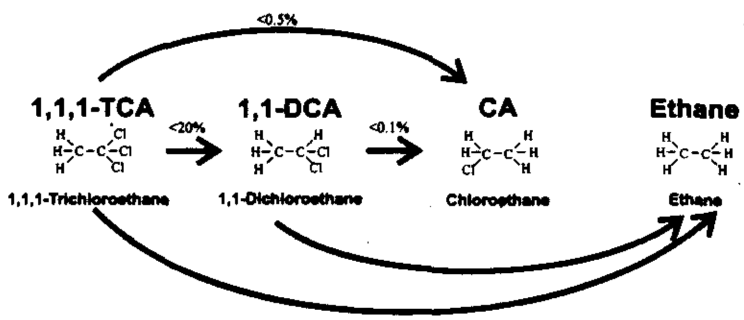
AR301258

GOLDER SIERRA	Atlanta, Georgia	TITLE	FIRST ORDER REDUCTION BY ZERO VALENT IRON				
CLIENT/PROJECT SALTIRE INDUSTRIAL INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA		DRAWN	MAT	DATE	2/22/01	JOB NO.	996-1100
		CHECKED	RIO	SCALE		DWG NO.	REV. NO.
		REVIEWED	[illegible]	FILE NO.	1100-d34.cdr	SUBTITLE	FIGURE NO. 20

Reductive Dehalogenation Pathways and Daughter Product Generation



AR301259



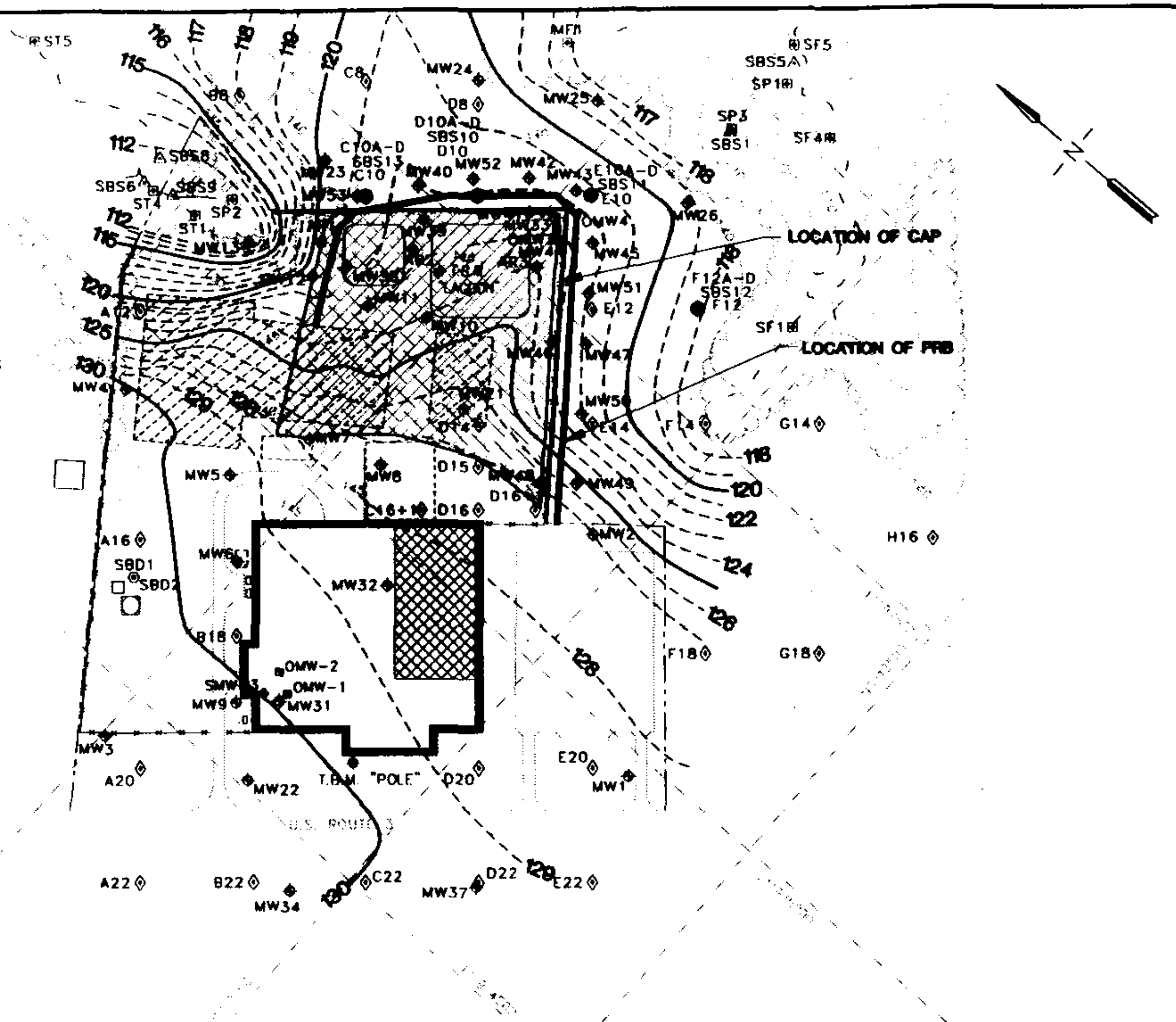
LEGEND

→ Major Degradation Pathway

→ Minor Degradation Pathway

1% Mol % Conversion range for Daughter Product by Connelly CC-1022 Iron Fillings.

CLIENT/PROJECT						TITLE		
SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA			GOLDER SIERRA Atlanta, Georgia			IRON REDUCTIVE PROCESSES FOR CHLOROETHENES AND CHLOROETHANES AND DAUGHTER PRODUCT GENERATION		
DRAWN MAT	CHECKED RIO	REVIEWED	DATE 7/27/00	SCALE NTS	FILE NO. 1100-d35.cdr	JOB NO. 996-1100	DWG NO./REV NO. A	FIGURE 21



LEGEND

- PRB MONITORING WELLS
- EXISTING MONITORING WELL (MW)
- SHALLOW SOIL BORING (SBS)
- DIRECT PUSH GROUNDWATER SAMPLING LOCATIONS
- OBSERVATION MONTORING WELL (OMW)
- SPARGE MONITORING WELL (SMW)
- LOCATION OF DEEP BORING IN AQUITARD UNIT
- SURFACE WATER/SEDIMENT SAMPLING LOCATION
- AQUITARD LAYER POINT (SBS)
- ACTIVE MANUFACTURING AREA
- PROPERTY LINE
- FENCE LINE
- TOPOGRAPHIC AQUIFER/AQUITARD INTERFACE
- STREAM
- INTERMITTENT DRAINAGE
- BURIED INTERMITTENT STREAM CHANNEL
- TREE LINE
- FORMER POND AREA
- FORMER DRUM STORAGE AREA
- PRB LOCATION
- 130 GROUNDWATER CONTOUR MAY 2000
- CAP LOCATION

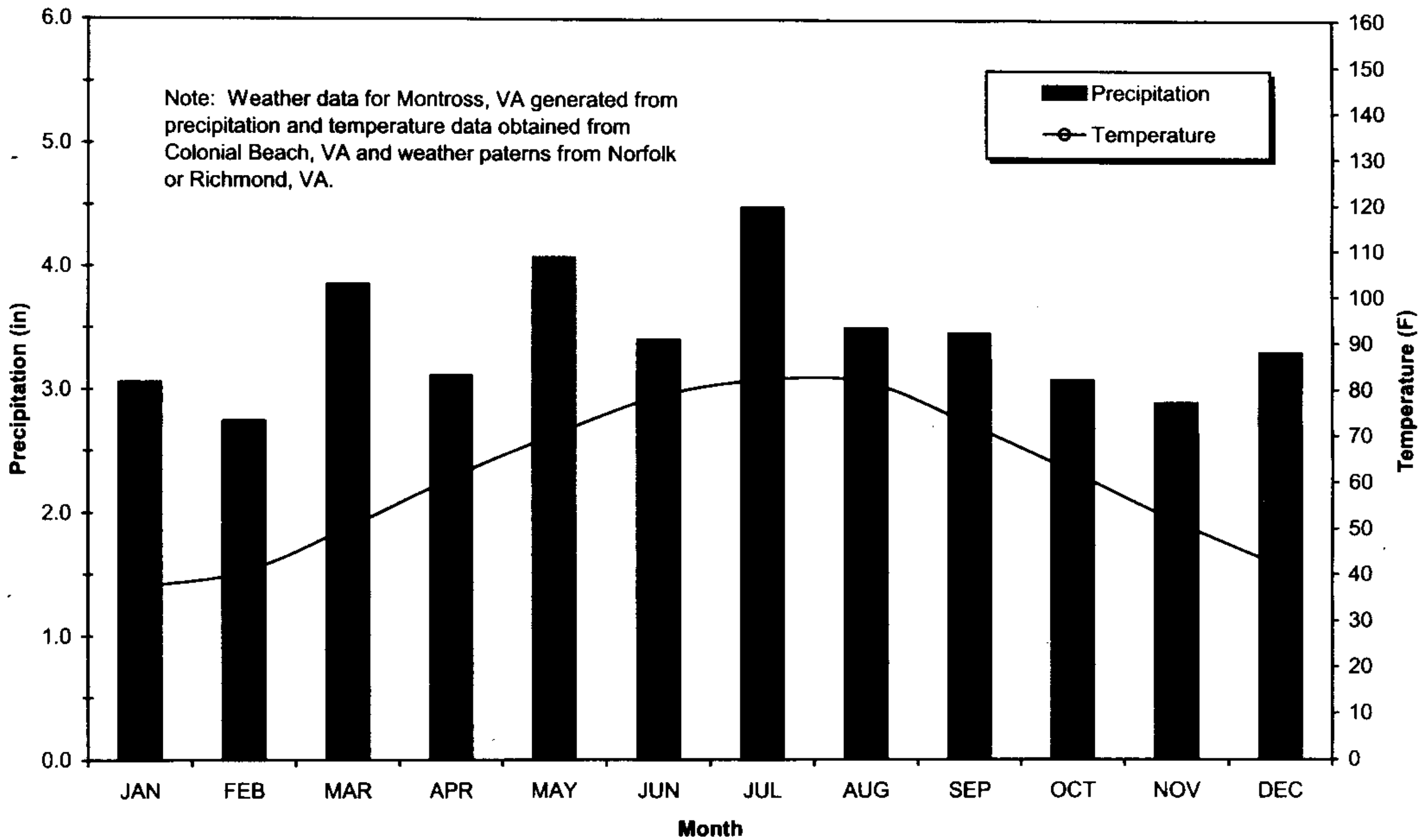
0 200 400
SCALE FEET

NOTE: TOPOGRAPHIC SURVEYING SERVICES PROVIDED BY: BALDWIN & GREGG, LTD NORFOLK, VA (DECEMBER 2000)

GOLDER SIERRA
Atlanta, Georgia

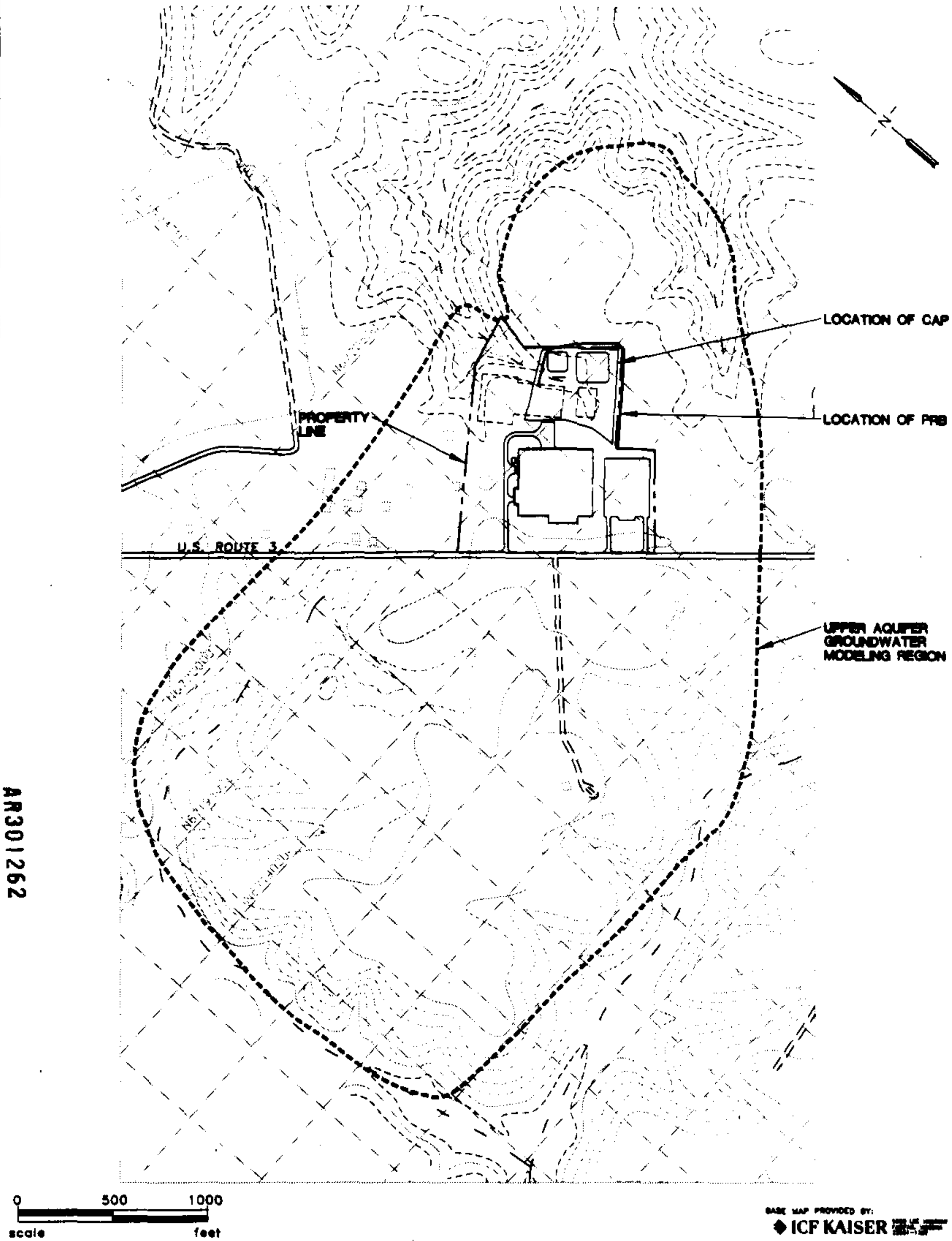
DWG. NO. 1100-C36		CLIENT/PROJECT	SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
REV. NO. C	JOB NO. 996-1100		
DATE 10/20/00	DRAWN MAT	TITLE	PRB ALIGNMENT, IMPERMEABLE CAP AND MONITORING WELLS LOCATION PLAN
SCALE AS SHOWN	CHECKED [illegible]		FIGURE NO. 22
FILE NO. 1100-C36.dwg	REVIEWED [illegible]		

AR301260



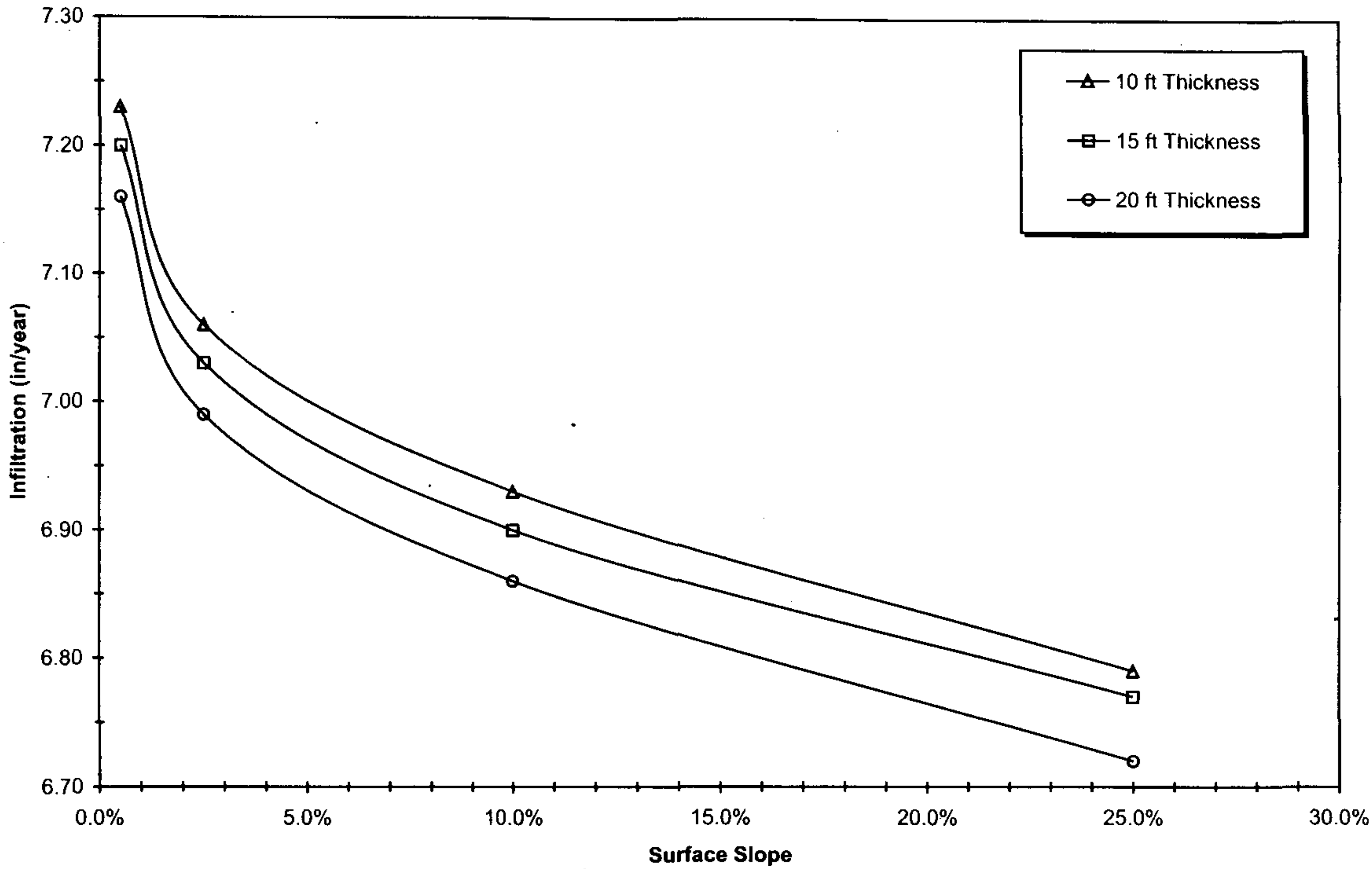
CLIENT/PROJECT						TITLE		
SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA			GOLDER SIERRA Atlanta, Georgia			MEAN MONTHLY PRECIPITATION AND TEMPERATURE DATA		
DRAWN MAT	CHECKED RIO	REVIEWED	DATE 11/30/00	SCALE as shown	FILE NO. 1100-d25.cdr	JOB NO. 996-1100	DWG NO./REV NO.	FIGURE 23

AR301261



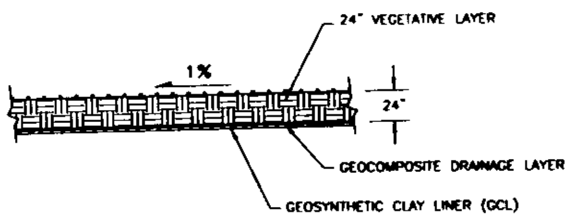
BASE MAP PROVIDED BY:
ICF KAISER

CLIENT/PROJECT					
SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA					
GOLDER SIERRA	Atlanta, Georgia				
TITLE	UPPER AQUIFER GROUNDWATER MODELING REGION				
DATE 11/16/00	DRAWN MAT	CHECKED	REVIEWED		
SCALE 1:500	FILE NO. 1100-C39.dwg	JOB NO. 986-1100	DWG NO. 1100-C39	SUBTITLE	REV. NO. 8	FIGURE 24



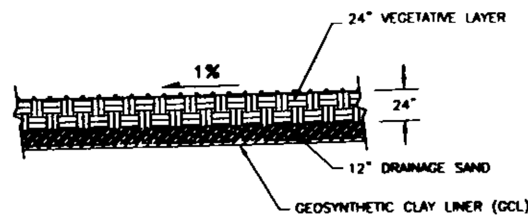
CLIENT/PROJECT		TITLE
SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA	GOLDER SIERRA Atlanta, Georgia	INFILTRATION vs. SURFACE SLOPE FOR DIFFERENT UNSATURATED THICKNESS (EXISTING CONDITIONS)

DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO.	JOB NO.	DWG NO./REV NO.	FIGURE
MAT	RIO		11/30/00	as shown	1100-d26.cdr	996-1100	A	25



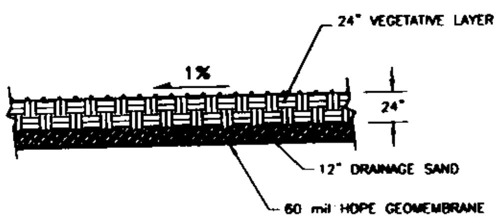
A) SOIL/GEOCOMPOSITE/GCL

(NTS)



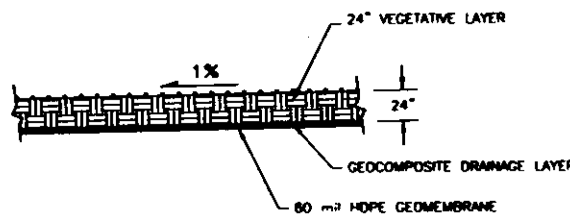
B) SOIL/GCL

(NTS)



C) SOIL/HDPE GEOMEMBRANE

(NTS)



D) SOIL/GEOCOMPOSITE/HDPE GEOMEMBRANE

(NTS)

0 4 8
SCALE FEET

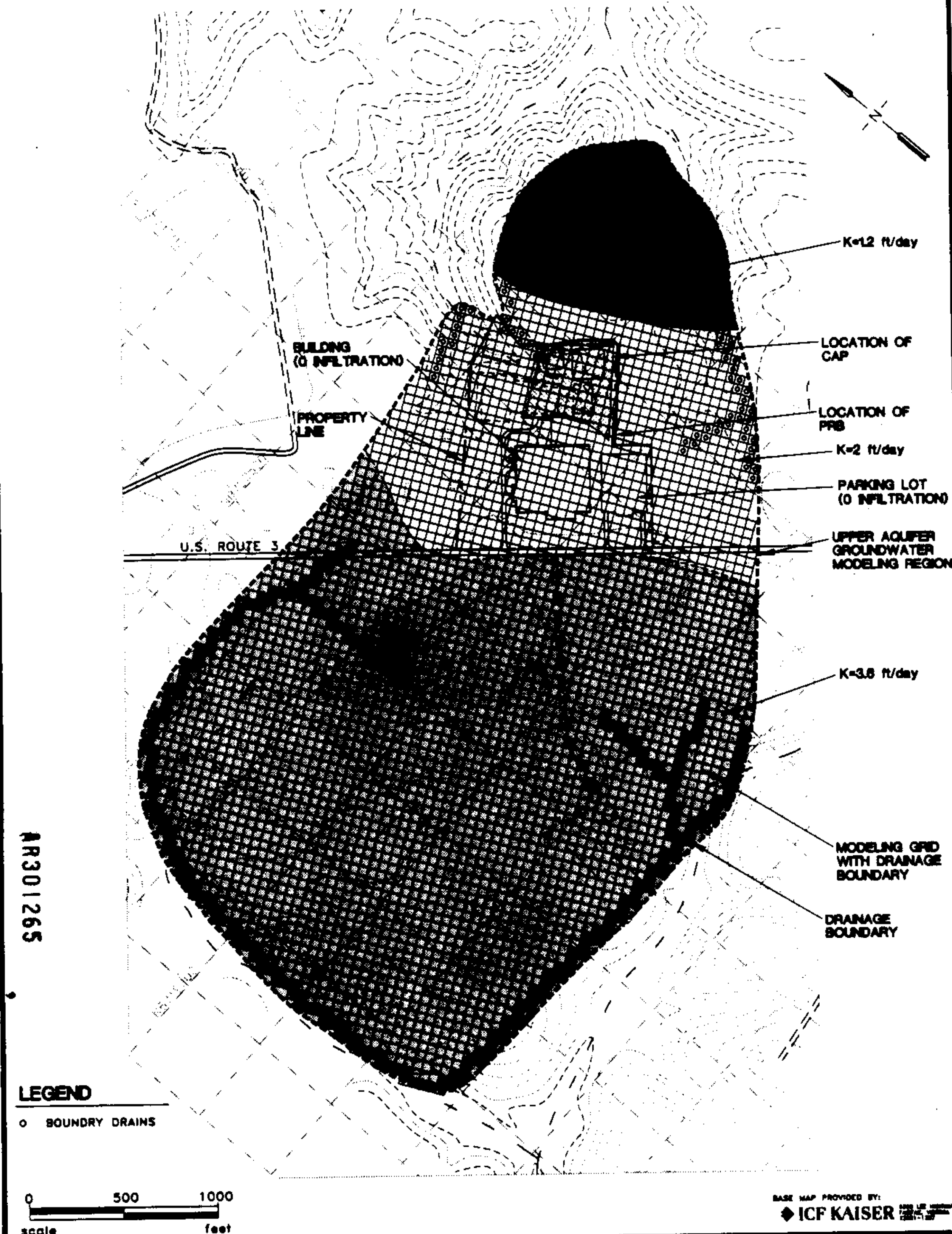
GOLDER SIERRA
Atlanta, Georgia

DWG. NO. 1100-C41
JOB NO. 996-1100
DATE 11/29/00
DRAWN MAT
SCALE AS SHOWN
FILE NO. 1100-C41.dwg

CLIENT/PROJECT
SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

TITLE
CAP SYSTEM ALTERNATIVES
A, B, C AND D

FIGURE NO. 28



CLIENT/PROJECT

SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

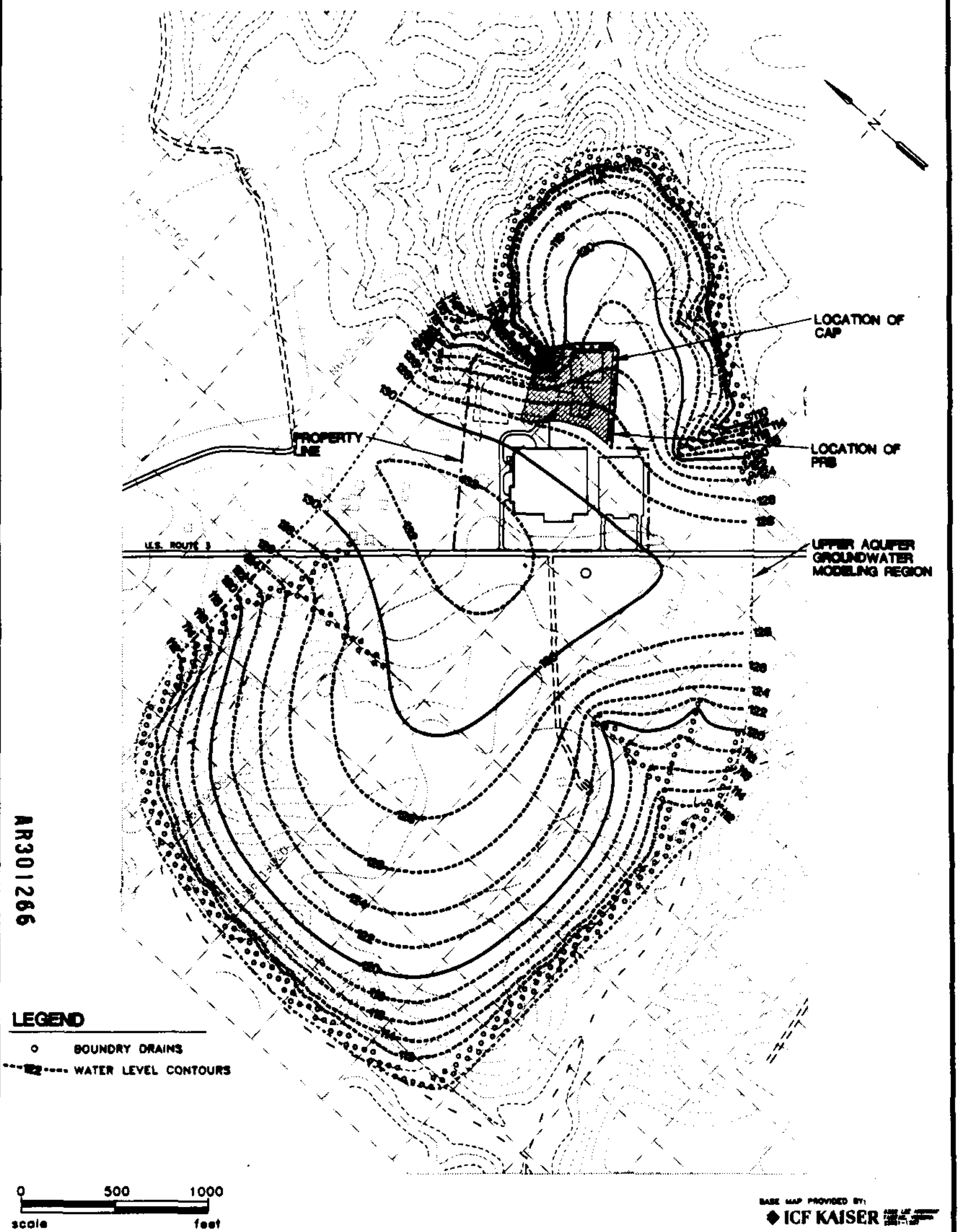
GOLDER SIERRA Atlanta, Georgia

TITLE

REGIONAL GROUNDWATER MODELING
GRID AND HYDROGOLOGICAL DATA

DATE	11/16/00	DRAWN	MAT	CHECKED	RIO	REVIEWED	
SCALE	1:500	FILE NO.	1100-C44.dwg	JOB NO.	966-1100		

DWG NO.	SUBTITLE	REV. NO.	FIGURE
1100-C44		8	27



AR301266

CLIENT/PROJECT

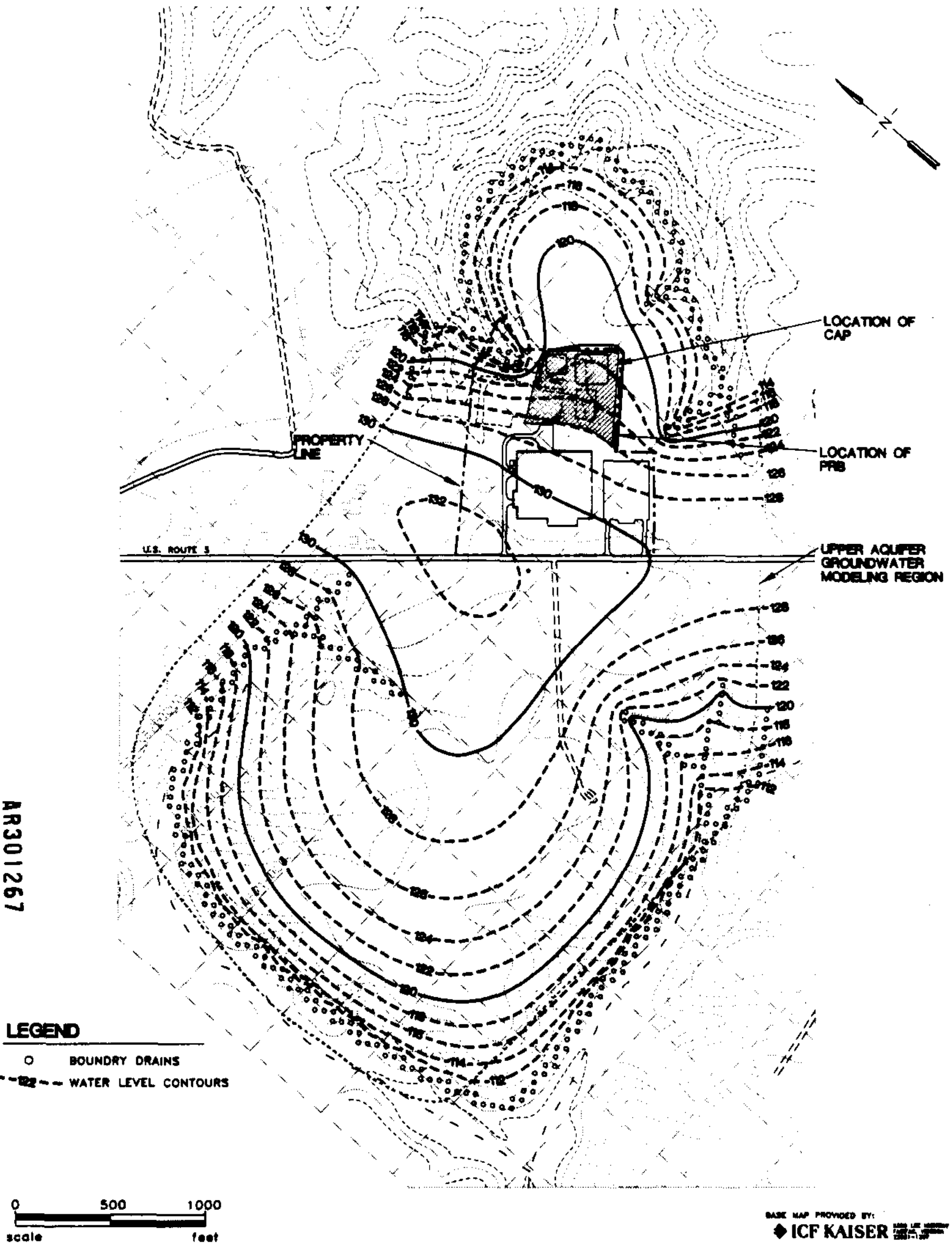
SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

GOLDER SIERRA Atlanta, Georgia

TITLE

REGIONAL MODEL GROUNDWATER
POTENTIOMETRIC CONTOURS
EXISTING CONDITIONS

DATE	12/4/00	DRAWN	MAT	CHECKED	RIO	REVIEWED	
SCALE	1:500	FILE NO.	1100-C45.dwg	JOB NO.	966-1100	DWG NO.	1100-C45
SUBTITLE		REV. NO.	C	FIGURE	28		



CLIENT/PROJECT

SALTIRE INDUSTRIAL, INC/
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

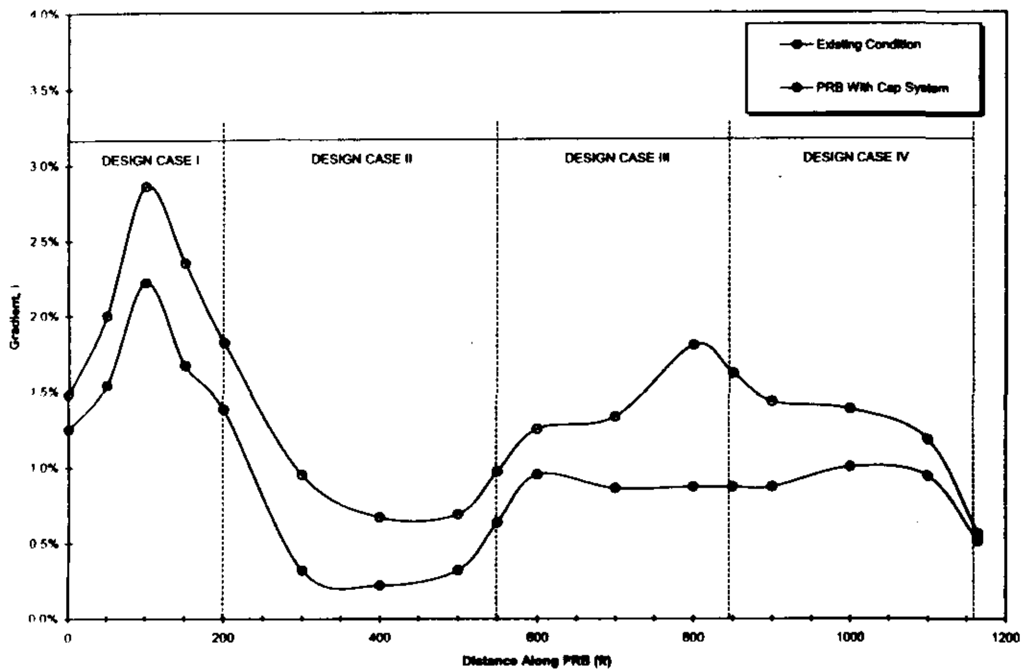
GOLDER SIERRA Atlanta, Georgia

TITLE

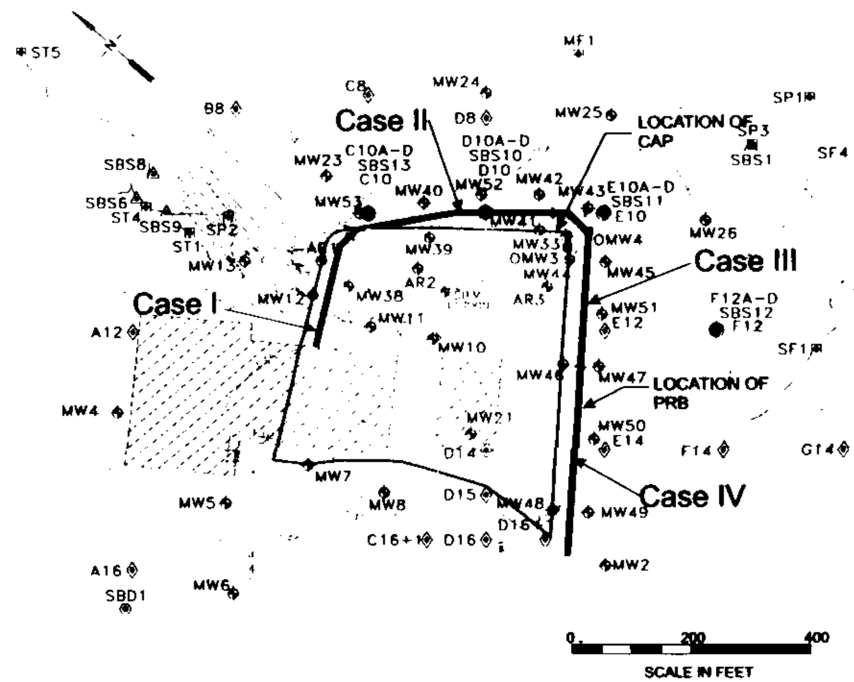
REGIONAL MODEL GROUNDWATER
POTENTIOMETRIC CONTOURS
WITH CAP SYSTEM

DATE	12/4/00	DRAWN	MAT	CHECKED	RIO	REVIEWED	
SCALE	1:500	FILE NO.	1100-C46.dwg	JOB NO.	966-1100		

DWG NO. 1100-C46	SUBTITLE	REV. NO. B	FIGURE 29



Groundwater Flow Gradients Profiles
Along PRB Alignment

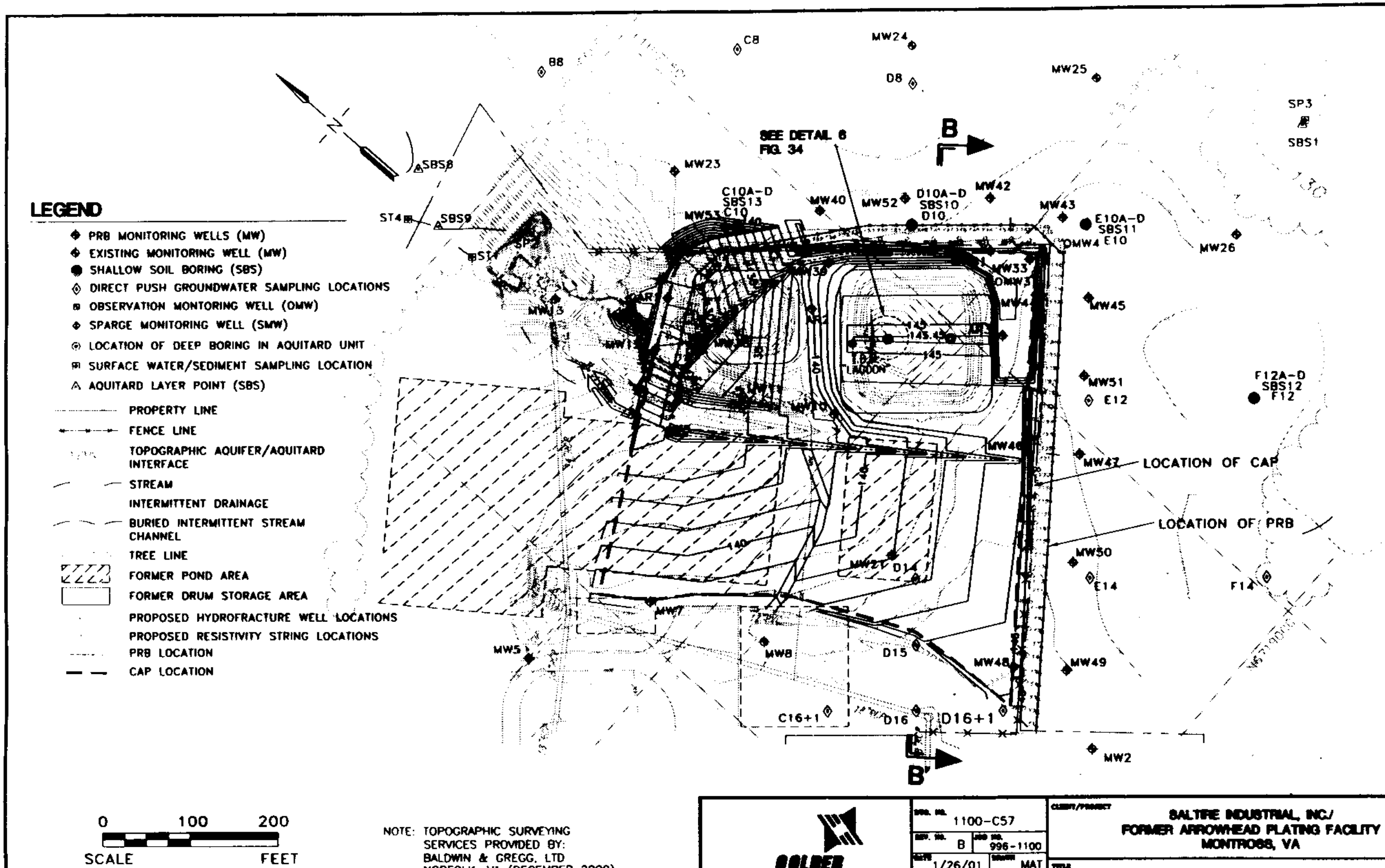


Plan View of PRB Design Cases

AR301268

GOLDER SIERRA
Atlanta, Georgia

DWG NO. 1100-D28		CLIENT/PROJECT	SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
REV. NO. D	JOB NO. 996-1100		
DATE 1/24/01	DRAWN MAT	TITLE	IMPACT OF CAP SYSTEM ON PRB DESIGN GROUNDWATER FLOW GRADIENTS
SCALE	CHECKED RIO		
FILE NO. 100-d28.cdr	REVIEWED	FIGURE NO.	30

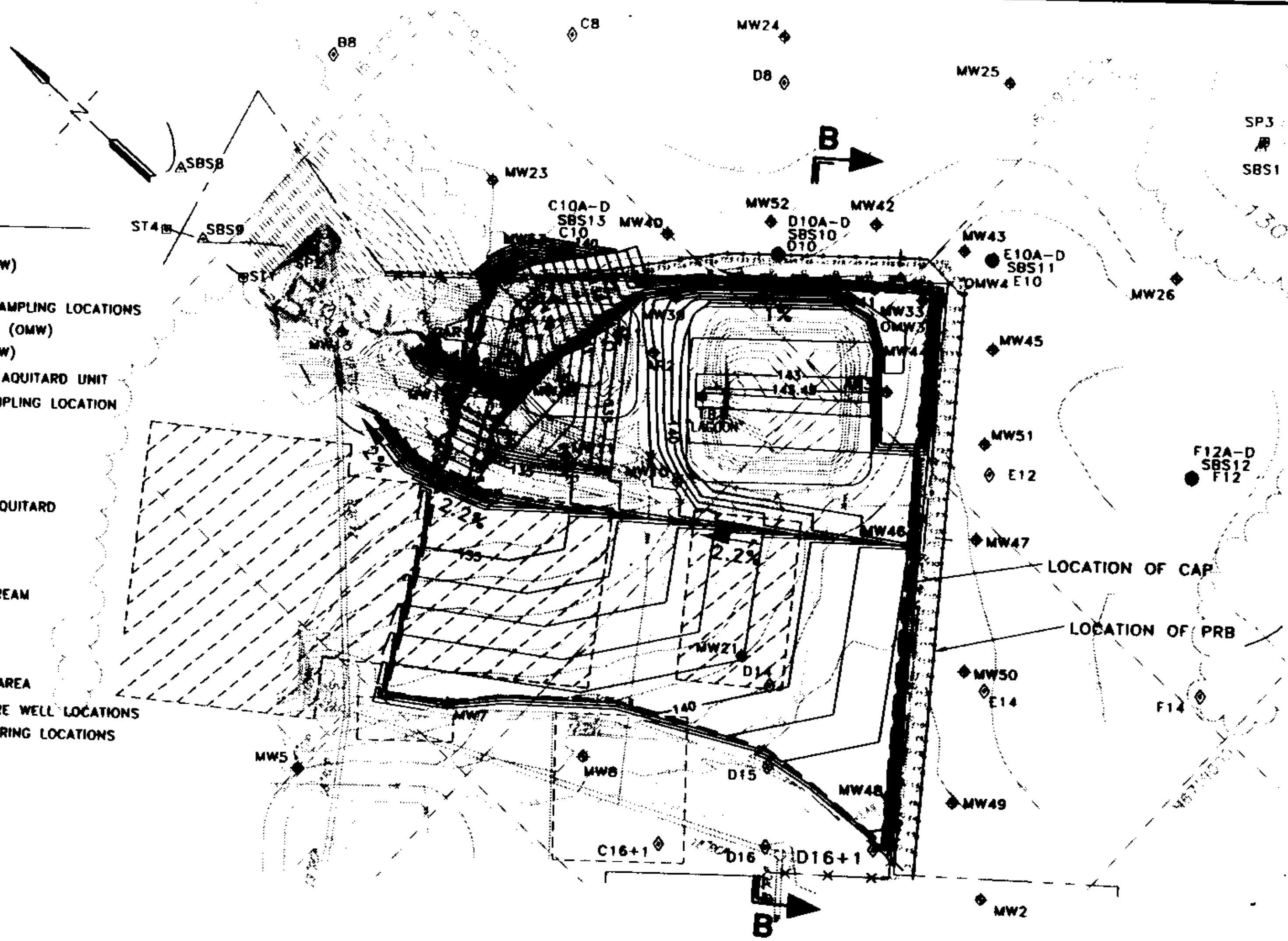


NOTE: TOPOGRAPHIC SURVEYING SERVICES PROVIDED BY: BALDWIN & GREGG, LTD NORFOLK, VA (DECEMBER 2000)

GOLDER SIERRA
Atlanta, Georgia

DWG. NO. 1100-C57		CLIENT/PROJECT: SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
REV. NO. B	JOB NO. 996-1100	
DATE 1/26/01	DRAWN MAT	TITLE: CAP SYSTEM FINAL GRADES
SCALE AS SHOWN	CHECKED [illegible]	
FILE NO. 1100-C57.dwg	REVIEWED [illegible]	FIGURE NO. 31

AR301269



LEGEND

- PRB MONITORING WELLS(MW)
- EXISTING MONITORING WELL (MW)
- SHALLOW SOIL BORING (SBS)
- DIRECT PUSH GROUNDWATER SAMPLING LOCATIONS
- OBSERVATION MONTORING WELL (OMW)
- SPARGE MONITORING WELL (SMW)
- LOCATION OF DEEP BORING IN AQUITARD UNIT
- SURFACE WATER/SEDIMENT SAMPLING LOCATION
- AQUITARD LAYER POINT (SBS)
- PROPERTY LINE
- FENCE LINE
- TOPOGRAPHIC AQUIFER/AQUITARD INTERFACE
- STREAM
- INTERMITTENT DRAINAGE
- BURIED INTERMITTENT STREAM CHANNEL
- TREE LINE
- FORMER POND AREA
- FORMER DRUM STORAGE AREA
- PROPOSED HYDROFRACTURE WELL LOCATIONS
- PROPOSED RESISTIVITY STRING LOCATIONS
- PROPOSED PRB LOCATION
- CAP LOCATION
- DRAINAGE

0 100 200
SCALE FEET

NOTE: TOPOGRAPHIC SURVEYING SERVICES PROVIDED BY: BALDWIN & GREGG, LTD NORFOLK, VA (DECEMBER 2000)

GOLDER SIERRA
Atlanta, Georgia

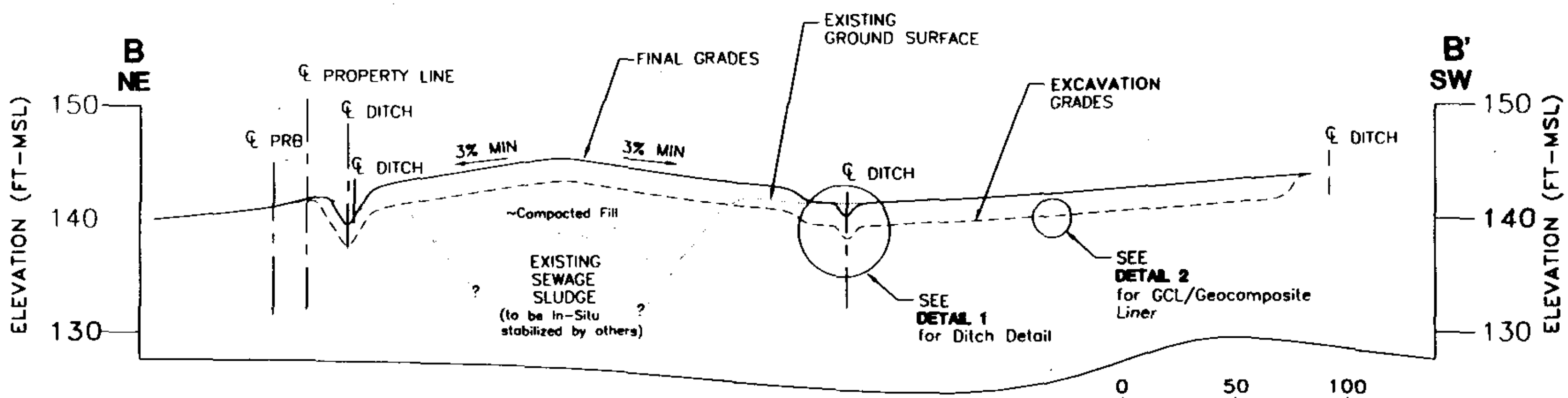
DWG. NO.	1100-C60
REV. NO. A	JOB NO. 996-1100
DATE 1/26/01	DRAWN MAT
SCALE AS SHOWN	CHECKED
FILE NO. 1100-C60.dwg	APPROVED

CLIENT/PROJECT
SALTIRE INDUSTRIAL, INC./
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

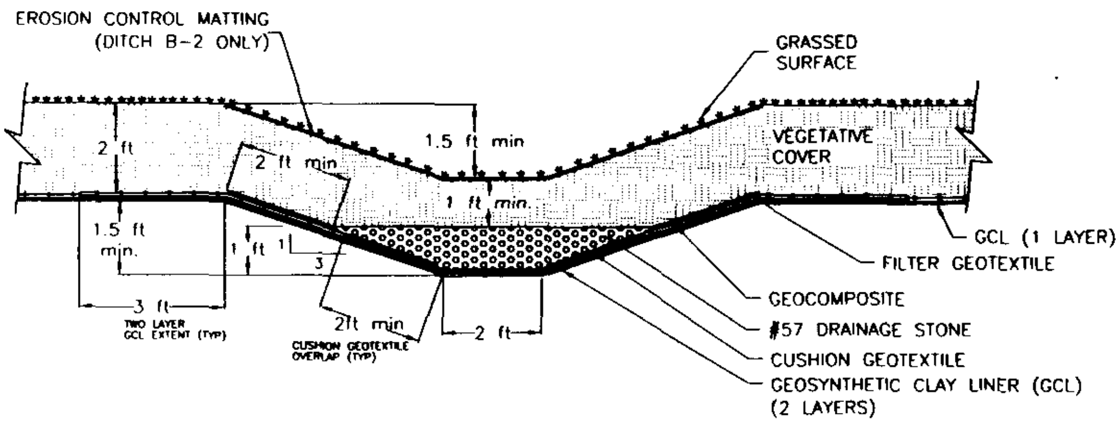
TITLE
CAP SYSTEM INTERNAL DRAINAGE GRADES

FIGURE NO. 32

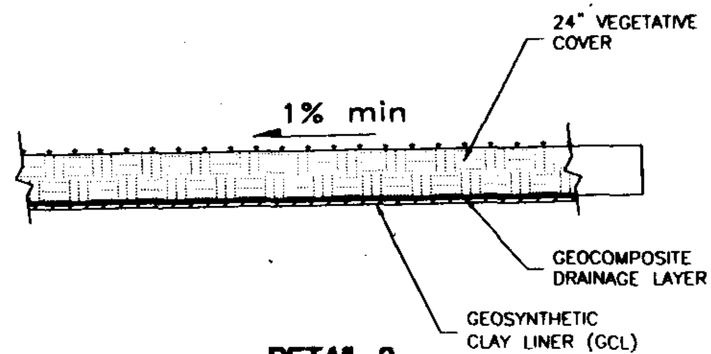
AR301270



CROSS SECTION B-B'



DETAIL 1
SURFACE WATER / INTERNAL DRAIN DITCH
(NTS)



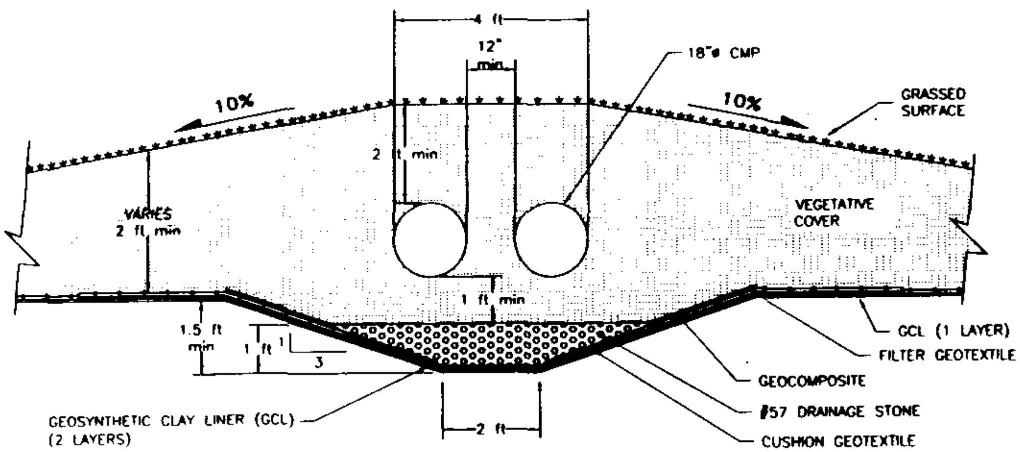
DETAIL 2
SOIL/GEOCOMPOSITE/GCL COVER
(NTS)

GOLDER SIERRA
Atlanta, Georgia

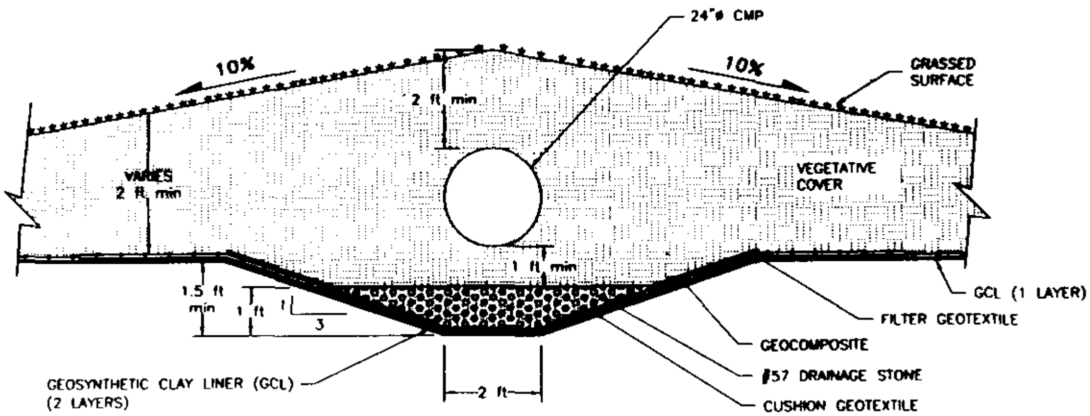
DOC. NO. 1100-C66F33		CLIENT/PROJECT	SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
REV. NO. B	JOB NO. 996-1100	TITLE	CAP SYSTEM CROSS SECTION B-B' AND DETAILS
DATE 1/26/01	DRAWN MAT		
SCALE AS SHOWN	CHECKED		
FILE NO.	REVIEWED		FIGURE NO. 33

AR301271

PLOT 1:50

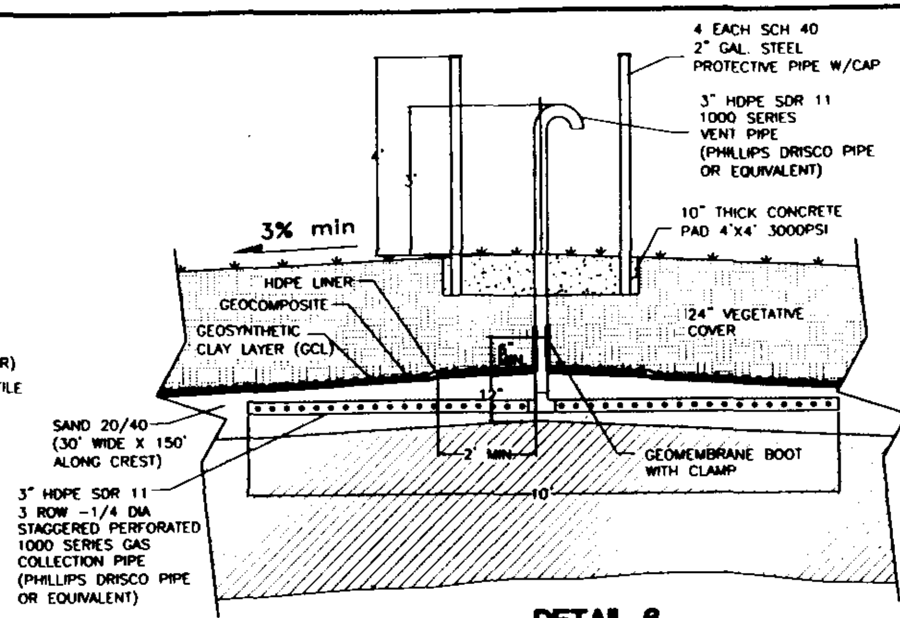


DETAIL 3
CULVERT A / INTERNAL DRAIN
TYPICAL DETAIL
SEE FIG. 36
SCALE 20:1

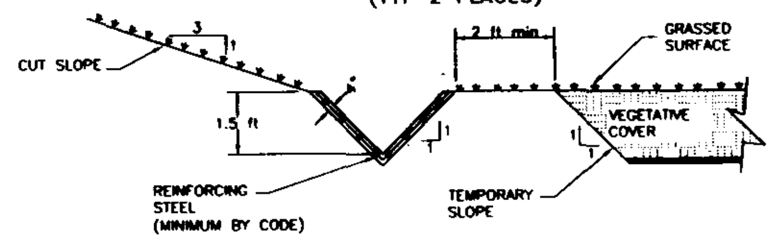


DETAIL 4
CULVERT B / INTERNAL DRAIN
TYPICAL DETAIL
SEE FIG. 36
SCALE 20:1

AR301272



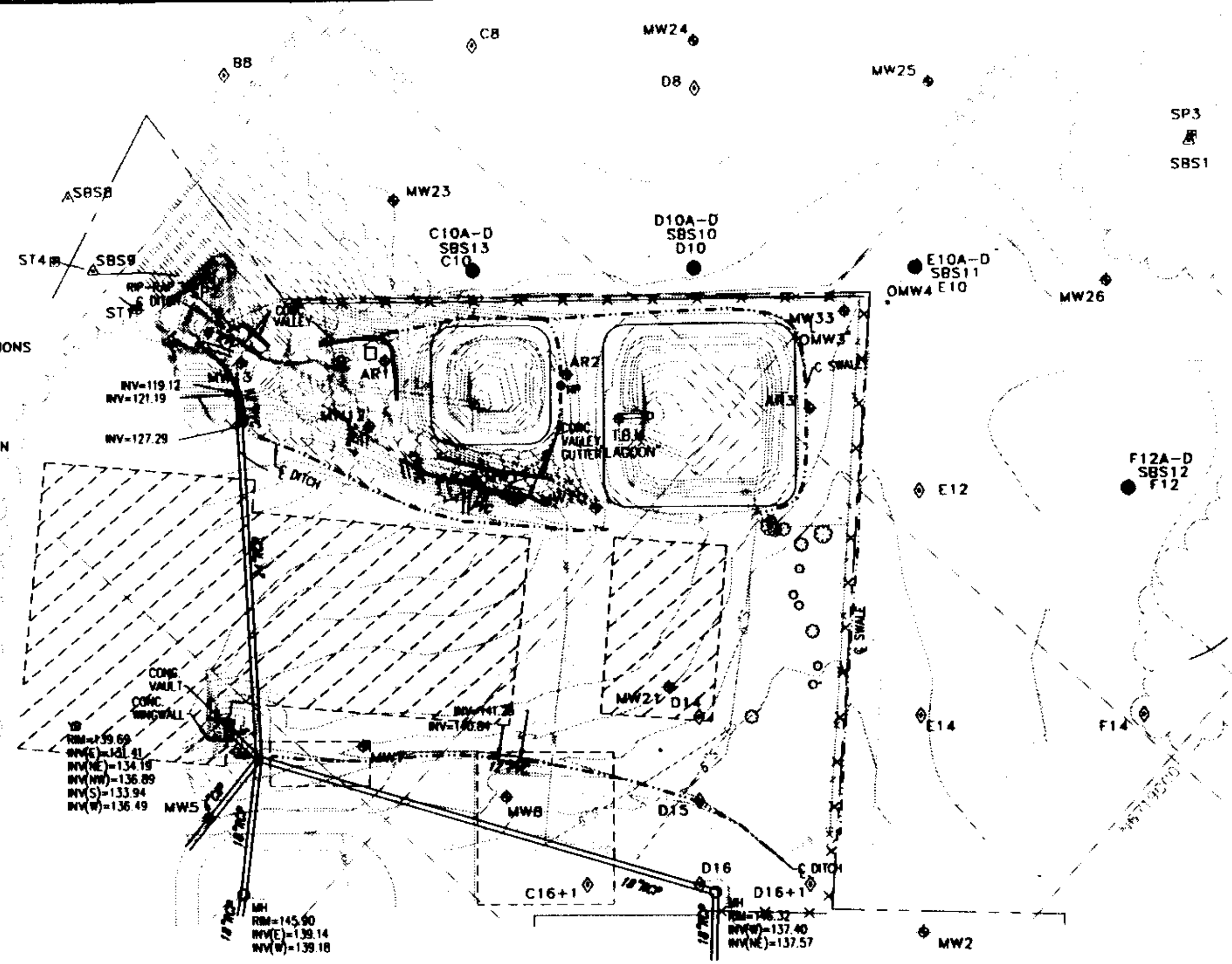
DETAIL 6
GAS EXTRACTION VENT DETAIL
SEE FIG. 31
(NTS)
(TYP 2 PLACES)



DETAIL 5
PERIMETER CONCRETE DITCH
SEE FIG. 36
SCALE 20:1

GOLDER SIERRA, Atlanta, Georgia	DWG. NO. 1100-C64F34	CLIENT/PROJECT: SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
	REV. NO. C; JOB NO. 996-1100	
	DATE 1/29/01; DESIGN MAT	TITLE: CAP SYSTEM DETAILS
	SCALE AS SHOWN; CHECKED	FIGURE NO. 34
	FILE NO. 1100-C64F34.dwg	

PLOT · 50



LEGEND

- EXISTING MONITORING WELL (MW)
- SHALLOW SOIL BORING (SBS)
- DIRECT PUSH GROUNDWATER SAMPLING LOCATIONS
- OBSERVATION MONTORING WELL (OMW)
- SPARGE MONITORING WELL (SMW)
- LOCATION OF DEEP BORING IN AQUITARD UNIT
- SURFACE WATER/SEDIMENT SAMPLING LOCATION
- AQUITARD LAYER POINT (SBS)
- PROPERTY LINE
- FENCE LINE
- TOPOGRAPHIC AQUIFER/AQUITARD INTERFACE
- STREAM
- INTERMITTENT DRAINAGE
- BURIED INTERMITTENT STREAM CHANNEL
- TREE LINE
- FORMER POND AREA
- FORMER DRUM STORAGE AREA
- RCP REINFORCED CONCRETE PIPE
- CIP CAST IRON PIPE
- CMP CORRUGATED METAL PIPE

0 100 200

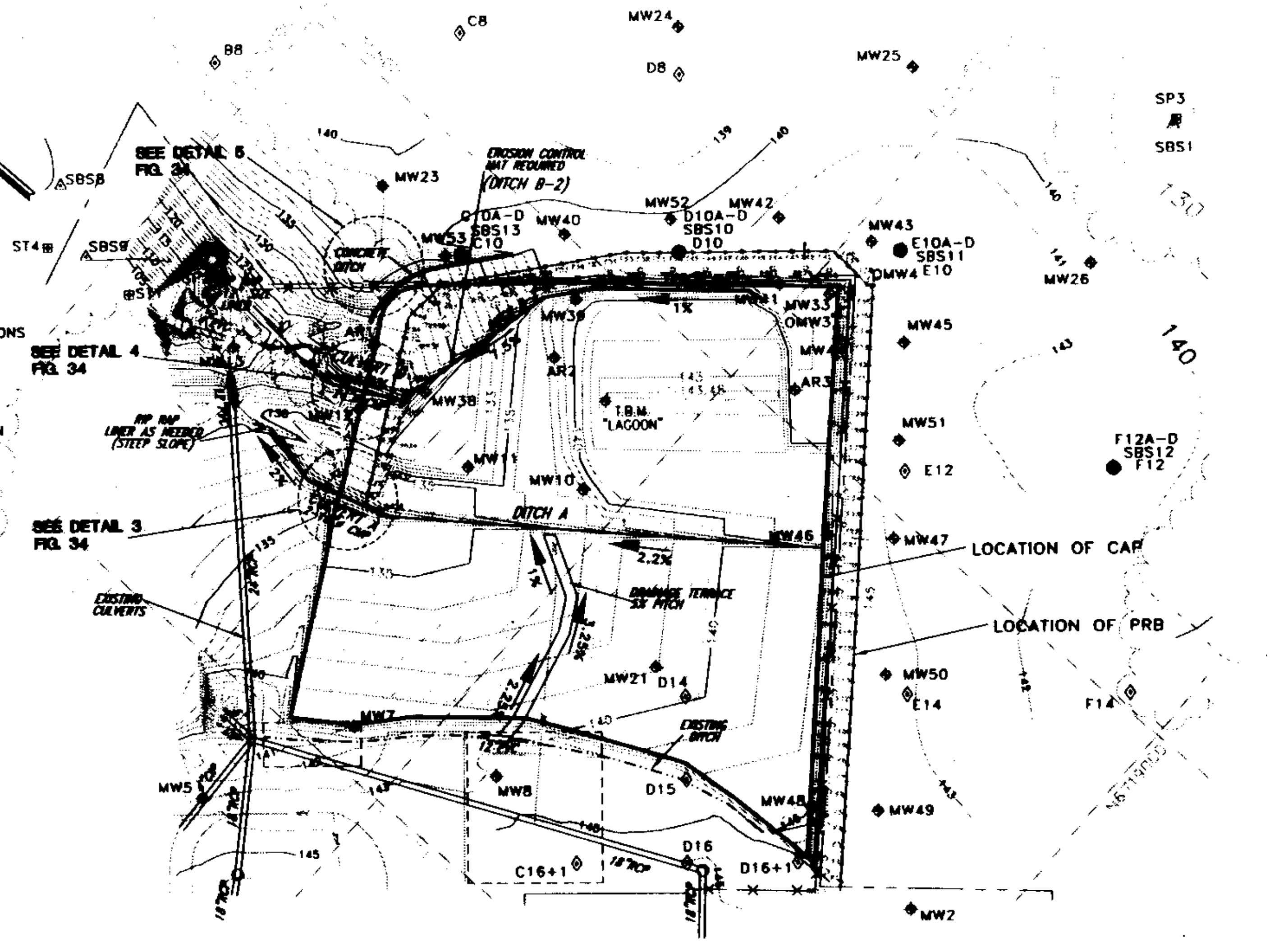
SCALE FEET

NOTE: TOPOGRAPHIC SURVEYING SERVICES PROVIDED BY: BALDWIN & GREGG, LTD NORFOLK, VA (DECEMBER 2000)

GOLDER SIERRA Atlanta, Georgia	DWG. NO. 1100-C62	CLIENT/PROJECT SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
	REV. NO. / JOB NO. 996-1100	
	DATE 1/26/01 / DRAWN MAT	TITLE EXISTING SURFACE WATER MANAGEMENT
	SCALE AS SHOWN / CHECKED RJO	FIGURE NO. 35
	FILE NO. 1100-C62.dwg / REVIEWED	

AR301273

PLOT 1:100



LEGEND

- PRB MONITORING WELLS (MW)
- EXISTING MONITORING WELL (MW)
- SHALLOW SOIL BORING (SBS)
- DIRECT PUSH GROUNDWATER SAMPLING LOCATIONS
- OBSERVATION MONITORING WELL (OMW)
- SPARGE MONITORING WELL (SMW)
- LOCATION OF DEEP BORING IN AQUITARD UNIT
- SURFACE WATER/SEDIMENT SAMPLING LOCATION
- AQUITARD LAYER POINT (SBS)
- PROPERTY LINE
- FENCE LINE
- TOPOGRAPHIC AQUIFER/AQUITARD INTERFACE
- STREAM
- INTERMITTENT DRAINAGE
- BURIED INTERMITTENT STREAM CHANNEL
- TREE LINE
- FORMER POND AREA
- FORMER DRUM STORAGE AREA
- HYDROFRACTURE WELL LOCATIONS
- RESISTIVITY STRING LOCATIONS
- PRB LOCATION
- CAP LOCATION
- RCP REINFORCED CONCRETE PIPE
- CIP CAST IRON PIPE
- CMP CORRUGATED METAL PIPE
- CULVERT
- CONCRETE DITCH

0 100 200
SCALE FEET

NOTE: TOPOGRAPHIC SURVEYING SERVICES PROVIDED BY: BALDWIN & GREGG, LTD NORFOLK, VA (DECEMBER 2000)

GOLDER SIERRA
Atlanta, Georgia

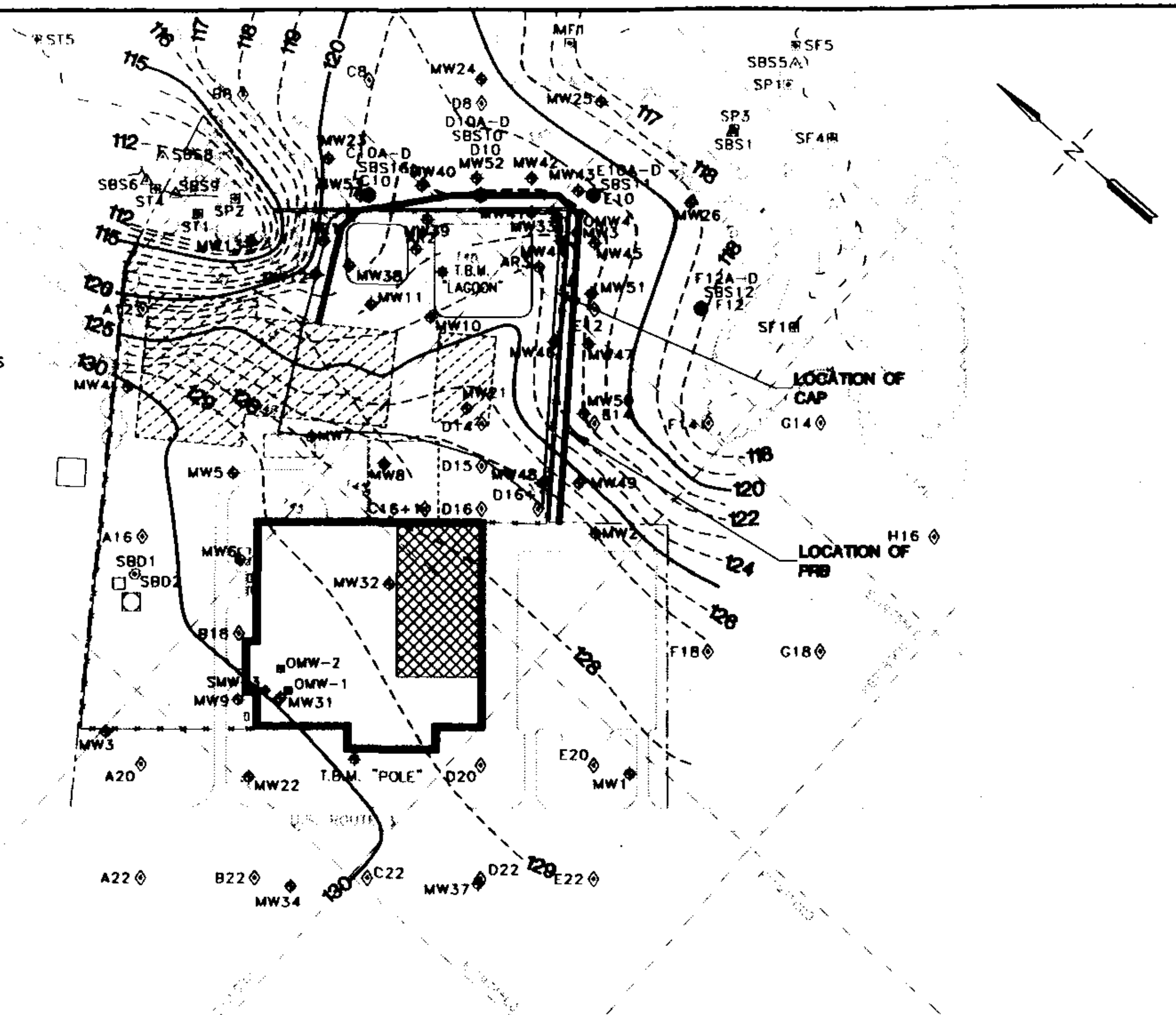
DWG. NO.	1100-C63F36		
REV. NO.	C	JOB NO.	996-1100
DATE	1/26/01	DRAWN	MAT
SCALE	AS SHOWN	CHECKED	[illegible]

CLIENT/PROJECT
SALTIRE INDUSTRIAL, INC./
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

TITLE
CAP SYSTEM SURFACE
WATER MANAGEMENT PLAN

FIGURE NO. 36

AR301274



LEGEND

- PRB MONITORING WELL (MW)
- EXISTING MONITORING WELL (MW)
- SHALLOW SOIL BORING (SBS)
- DIRECT PUSH GROUNDWATER SAMPLING LOCATIONS
- OBSERVATION MONTORING WELL (OMW)
- SPARGE MONITORING WELL (SMW)
- LOCATION OF DEEP BORING IN AQUITARD UNIT
- SURFACE WATER/SEDIMENT SAMPLING LOCATION
- AQUITARD LAYER POINT (SBS)
- ACTIVE MANUFACTURING AREA
- PROPERTY LINE
- FENCE LINE
- TOPOGRAPHIC AQUIFER/AQUITARD INTERFACE
- STREAM
- INTERMITTENT DRAINAGE
- BURIED INTERMITTENT STREAM CHANNEL
- TREE LINE
- FORMER POND AREA
- FORMER DRUM STORAGE AREA
- PRB LOCATION
- CAP LOCATION
- 130 GROUNDWATER CONTOUR MAY 2000

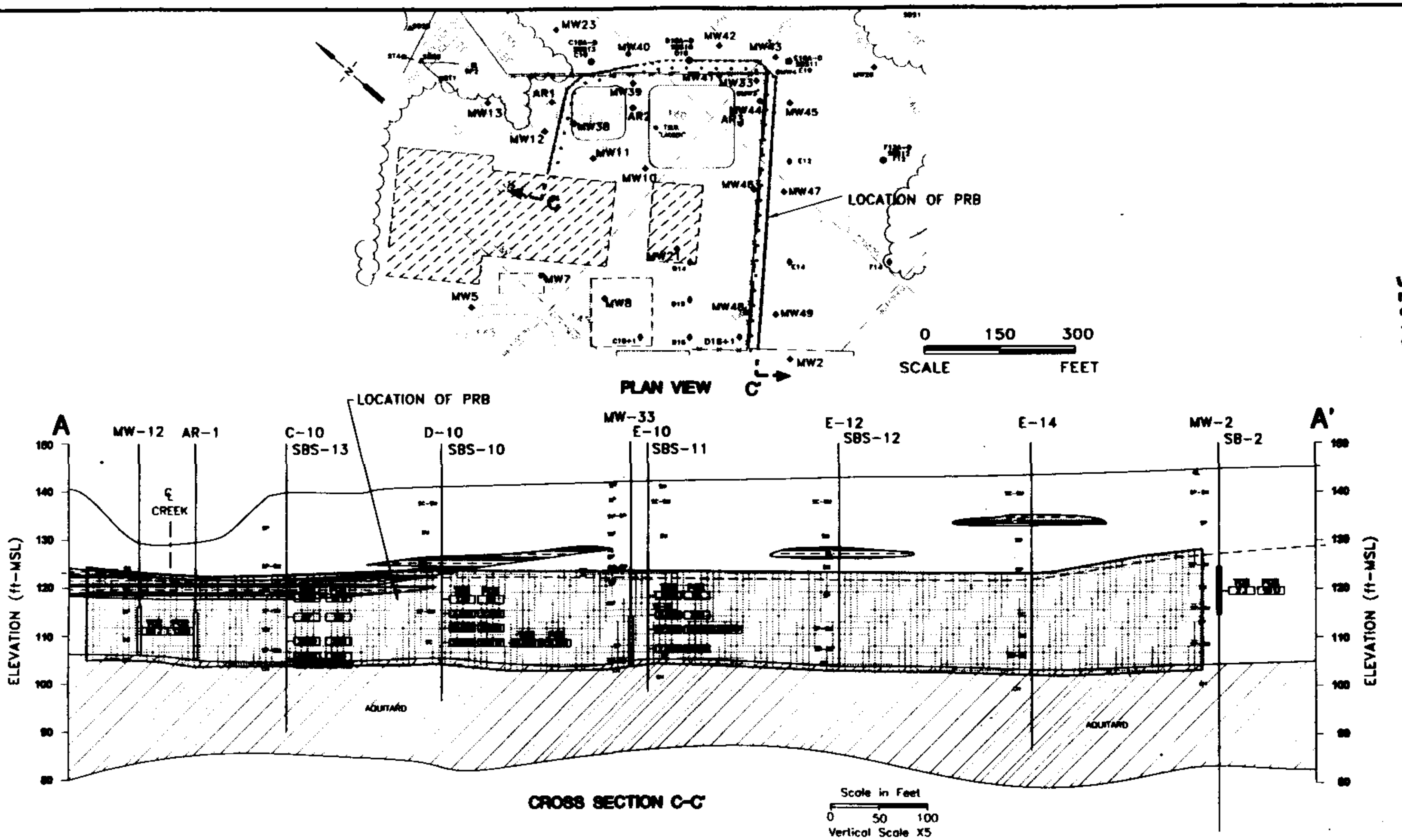
0 200 400
SCALE FEET

NOTE: TOPOGRAPHIC SURVEYING SERVICES PROVIDED BY: BALDWIN & GREGG, LTD NORFOLK, VA (DECEMBER 2000)

GOLDER SIERRA
Atlanta, Georgia

DWG. NO. 1100-C29		CLIENT/PROJECT	SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
REV. NO. B	JOB NO. 996-1100		
DATE 7/14/00	DRAWN MAT	TITLE	PRB PLAN VIEW LOCATION
SCALE AS SHOWN	CHECKED [illegible]		
FILE NO. 1100-C29.dwg	REVIEWED [illegible]	FIGURE NO.	37

AR301275



LEGEND

- MONITORING WELL (MW)
- SHALLOW SOIL BORING (SBS)
- DIRECT PUSH GROUNDWATER SAMPLING LOCATIONS
- SURFACE WATER / SEDIMENT SAMPLING LOCATIONS
- TCE AND PCE DATA (MAY 2000) (ug/l)
- MONITORING WELL SCREEN
- OBSERVATION MONITORING WELL (OMW)
- GROUNDWATER LEVEL (MAY 2000)
- CLAY
- AQUITARD
- LOCATION OF PRB
- SOIL UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

GOLDER SIERRA
Atlanta, Georgia

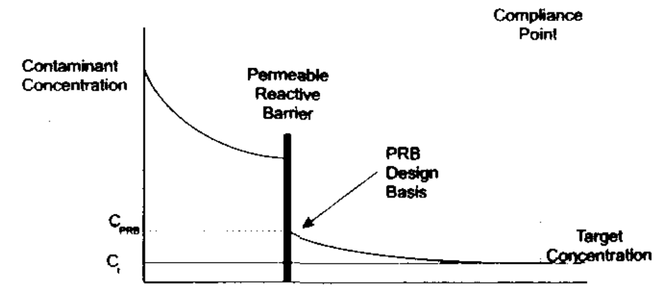
DWG. NO.	1100-c31F38
REV. NO.	D
JOB NO.	996-1100
DATE	7/28/00
DRAWN	MAT
CHECKED	RO

CLIENT/PROJECT: SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA

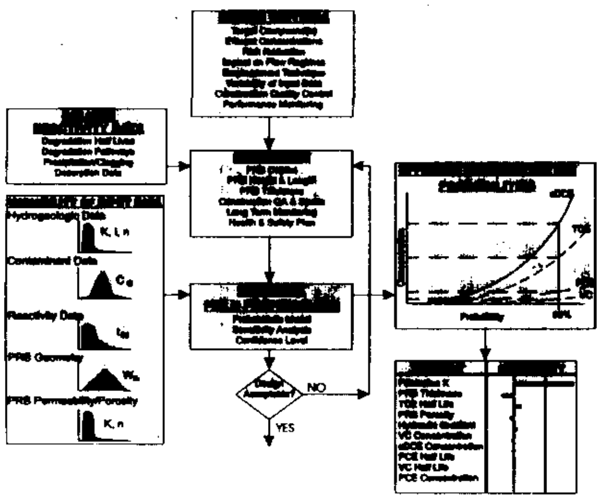
TITLE: PERMEABLE REACTIVE BARRIER CROSS SECTION C-C' GEOLOGY AND CHEMISTRY

FIGURE NO. 38

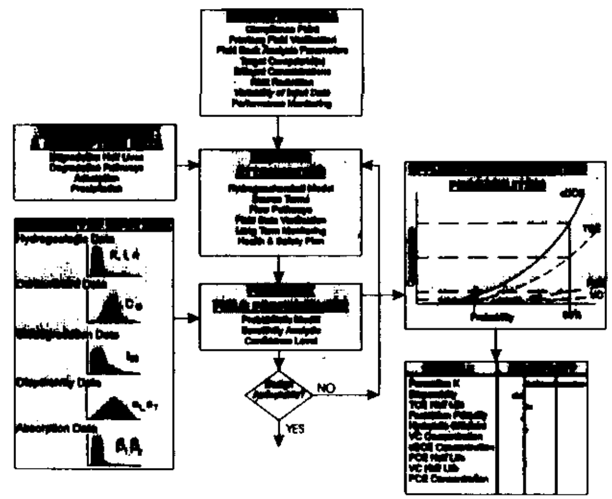
AR301276



PRB and NATURAL ATTENUATION DESIGN BASIS



PRB DESIGN FORECAST

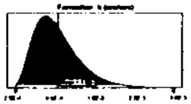
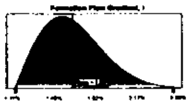


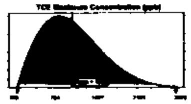
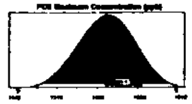
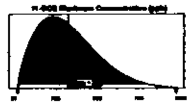
NATURAL ATTENUATION DESIGN FORECAST

LEGEND

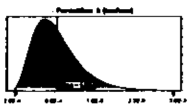
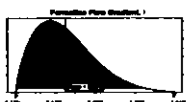
PRB- Iron Permeable Reactive Barrier
NA- Natural Attenuation

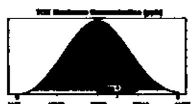
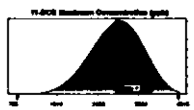
GOLDER SIERRA Atlanta, Georgia	DWG NO. 1100-D12		CLIENT/PROJECT SALTIRE INDUSTRIAL, INC. FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
	REV. NO. B	JOB NO. 996-1100	
	DATE 7/26/00	DRAWN MAT	TITLE DESIGN METHODOLOGY FOR PRB SYSTEM and NATURAL ATTENUATION
	SCALE	CHECKED RIO	
	FILE NO. 1100-d12.cdr	REVIEWED	FIGURE NO 39

Prime Input Parameters	Parameter Distributions
Formation Hydraulic Conductivity (cm/sec)	
Hydraulic Gradient (ft/ft)	

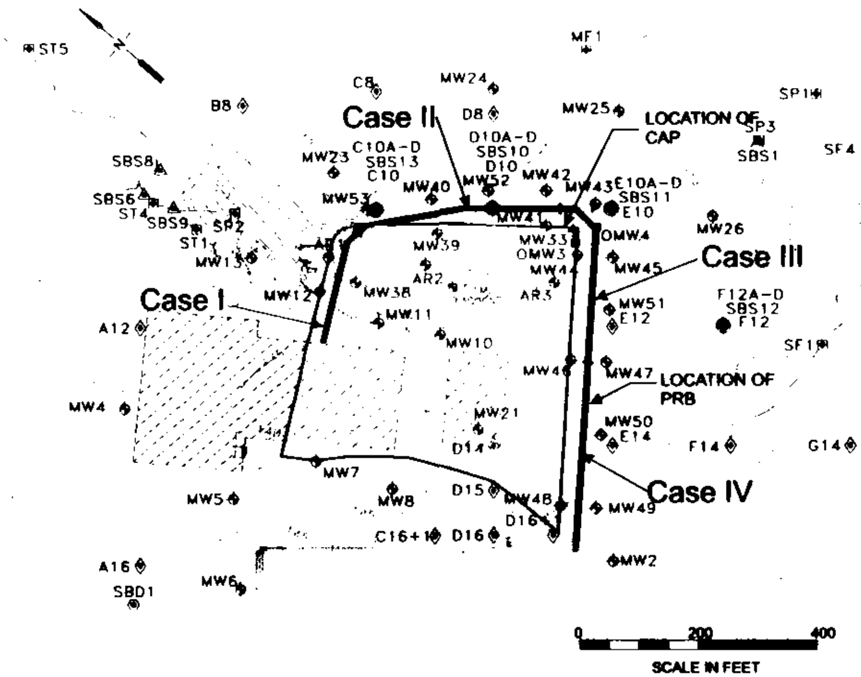
Prime Input Parameters	Parameter Distributions
Prime VOC Contaminants	
TCE (ppb)	
PCE (ppb)	
11-DCE (ppb)	

Design Case I

Prime Input Parameters	Parameter Distributions
Formation Hydraulic Conductivity (cm/sec)	
Hydraulic Gradient (ft/ft)	

Prime Input Parameters	Parameter Distributions
Prime VOC Contaminants	
TCE (ppb)	
PCE (ppb)	
11-DCE (ppb)	

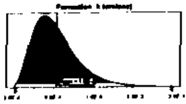
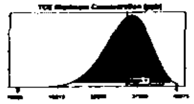
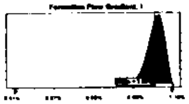
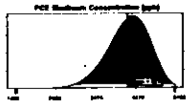
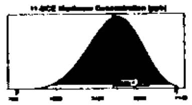
Design Case II

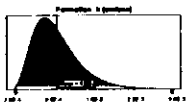
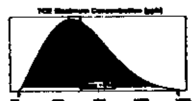
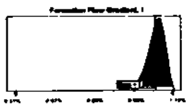
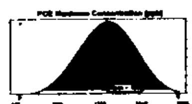
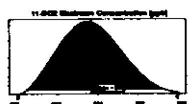


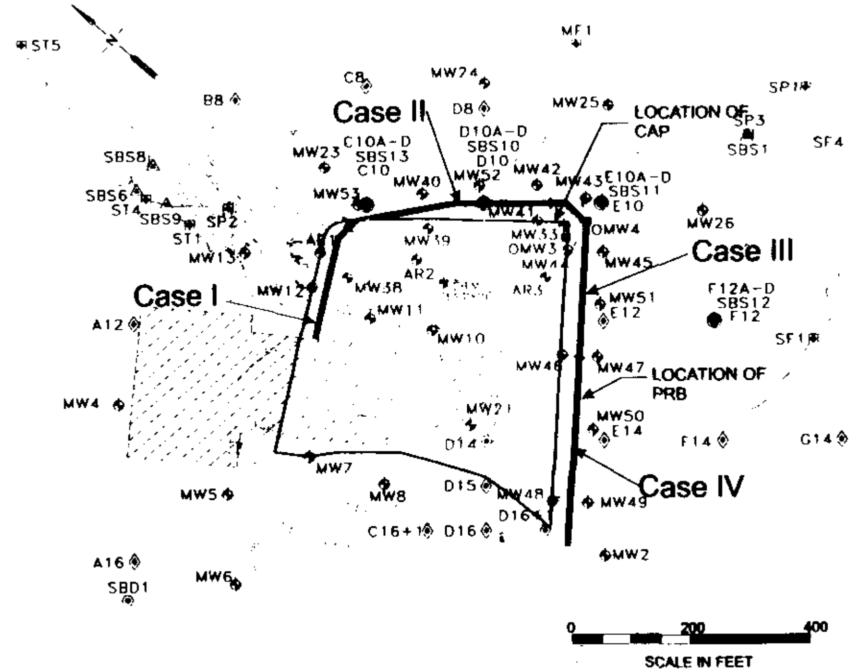
Plan View of PRB Design Cases

GOLDER SIERRA Atlanta, Georgia	DWG NO. 1100-D13 REV. NO. F DATE 2/2/01 SCALE FILE NO. 100-d13.cdr	JOB NO. 996-1100 DRAWN MAT CHECKED RIO REVIEWED	CLIENT/PROJECT SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA TITLE ASSUMPTIONS DESIGN CASES I and II FIGURE NO 40

AR301278

Prime Input Parameters	Parameter Distributions	Prime Input Parameters	Parameter Distributions
		Prime VOC Contaminants	
Formation Hydraulic Conductivity (cm/sec)		TCE (ppb)	
Hydraulic Gradient (ft/ft)		PCE (ppb)	
Design Case III		11-DCE (ppb)	

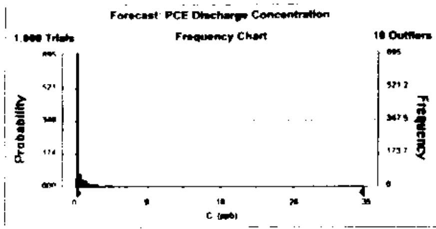
Prime Input Parameters	Parameter Distributions	Prime Input Parameters	Parameter Distributions
		Prime VOC Contaminants	
Formation Hydraulic Conductivity (cm/sec)		TCE (ppb)	
Hydraulic Gradient (ft/ft)		PCE (ppb)	
Design Case IV		11-DCE (ppb)	

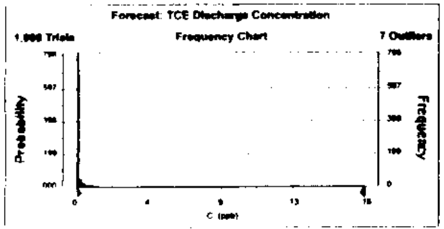


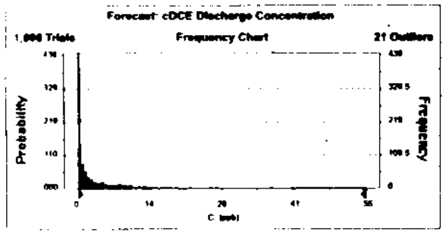
Plan View of PRB Design Cases

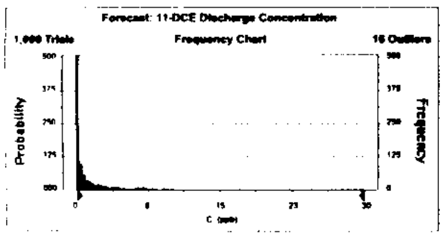
GOLDER SIERRA Atlanta, Georgia	DWG NO. 1100-D37 REV. NO. B / JOB NO. 996-1100 DATE 1/24/01 / DRAWN MAT SCALE / CHECKED RIO FILE NO. 100-d37.cdr / REVIEWED	CLIENT/PROJECT SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA TITLE ASSUMPTIONS DESIGN CASES III and IV	FIGURE NO. 41

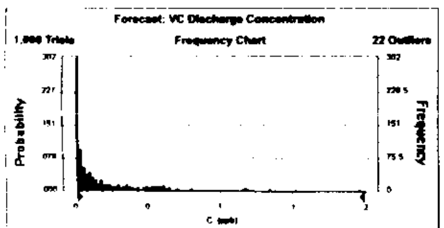
AR301279

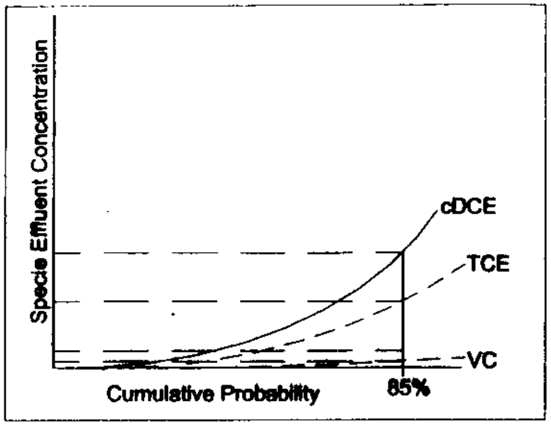






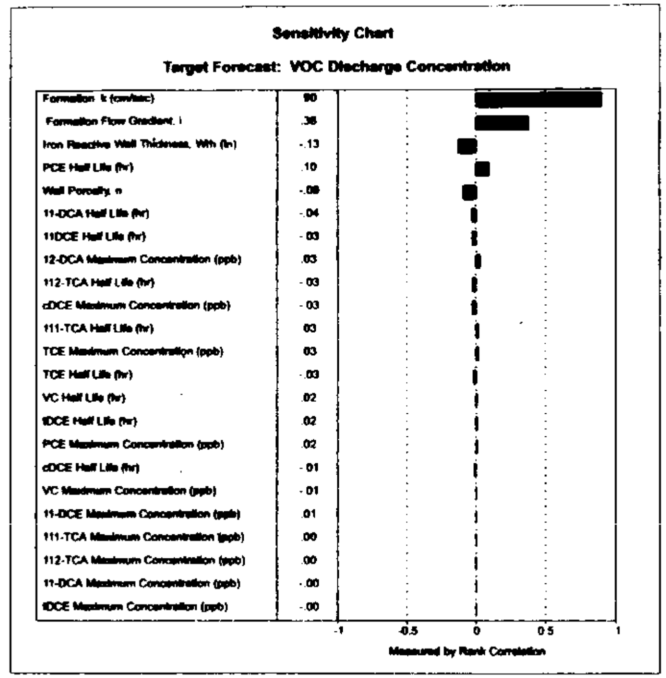






Compound	PRB Effluent Design Concentration (ug/l)	PRB Effluent 85 Percentile (ug/l)	MCL (ug/l)
PCE	5	2	5
TCE	5	ND	5
cDCE	70	12	70
tDCE	70	ND	70
11-DCE	7	5	7
VC	2	1	2
111-TCA	200	ND	200
112-TCA	5	ND	5
11-DCA	NL	37	NL
12-DCA	NA	4	5

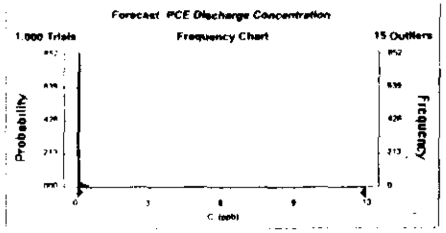
NL: No MCL for this Compound
NA: Not Applicable
ND: Non Detect

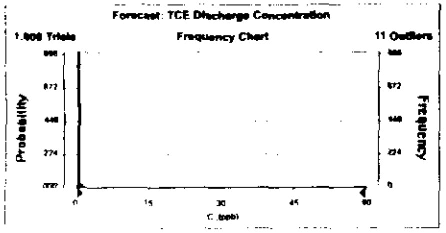


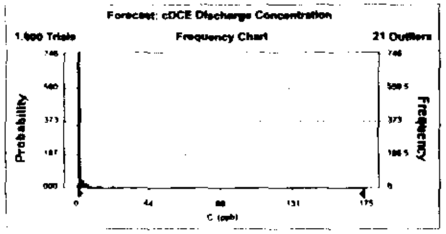
GOLDER SIERRA
Atlanta, Georgia

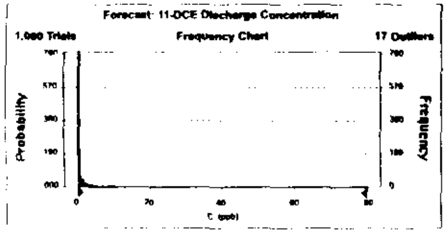
DWG NO. 1100-D11		CLIENT/PROJECT	SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
REV. NO. A	JOB NO. 998-1100		
DATE 1/25/01	DRAWN MAT	TITLE	PRB CASE I DESIGN OUTPUT DATA
SCALE	CHECKED RIO		
FILE NO. 1100-d11.cdr	REVIEWED	FIGURE NO.	42

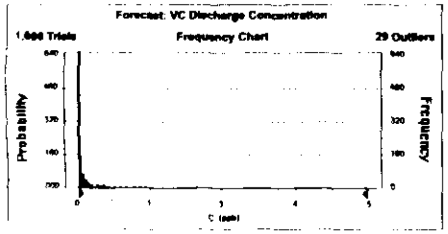
AR301280

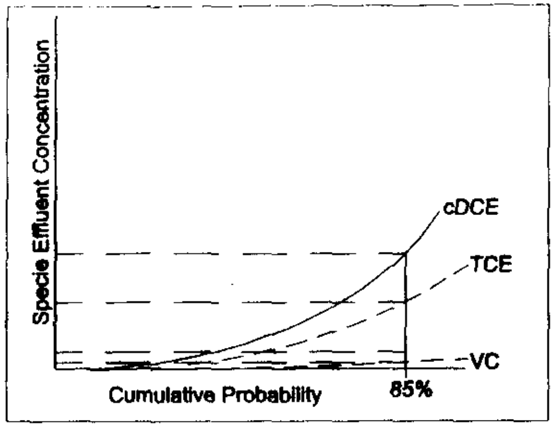


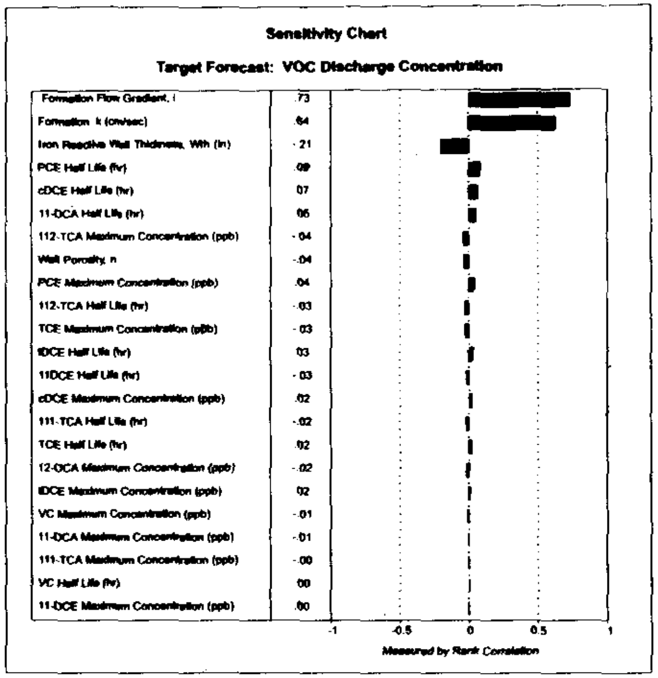












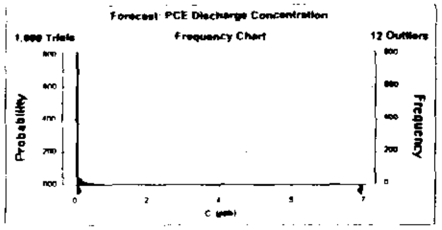
Compound	PRB Effluent Design Concentration (ug/l)	PRB Effluent 85 Percentile (ug/l)	MCL (ug/l)
PCE	5	ND	5
TCE	5	ND	5
cDCE	70	9	70
tDCE	70	ND	70
11-DCE	7	4	7
VC	2	1	2
111-TCA	200	ND	200
112-TCA	5	ND	5
11-DCA	NL	71	NL
12-DCA	NA	6	5

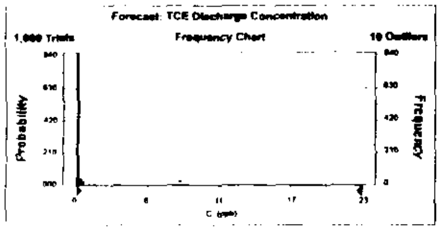
NL: No MCL for this Compound
NA: Not Applicable
ND: Non Detect

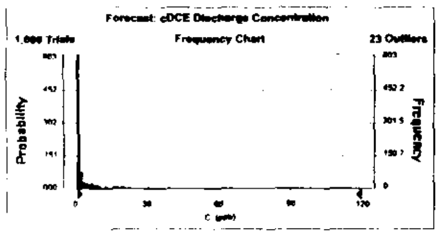
GOLDER SIERRA
Atlanta, Georgia

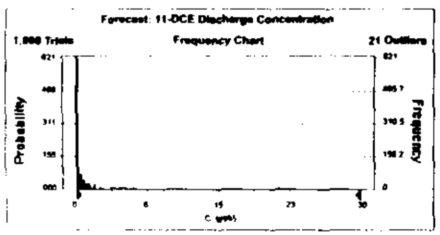
DWG NO. 1100-D15		CLIENT/PROJECT	SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
REV. NO. A	JOB NO. 996-1100	TITLE	PRB CASE II DESIGN OUTPUT DATA
DATE 7/26/00	DRAWN MAT		
SCALE	CHECKED RIO		
FILE NO. 1100-d15.cdr	REVIEWED		FIGURE NO 43

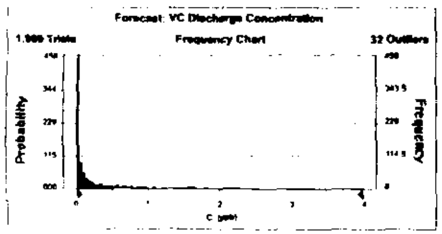
AR301281

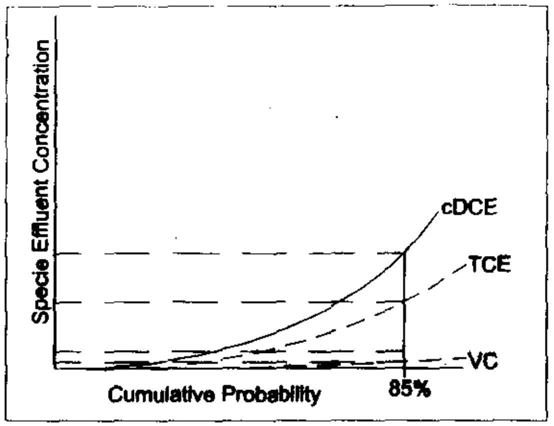






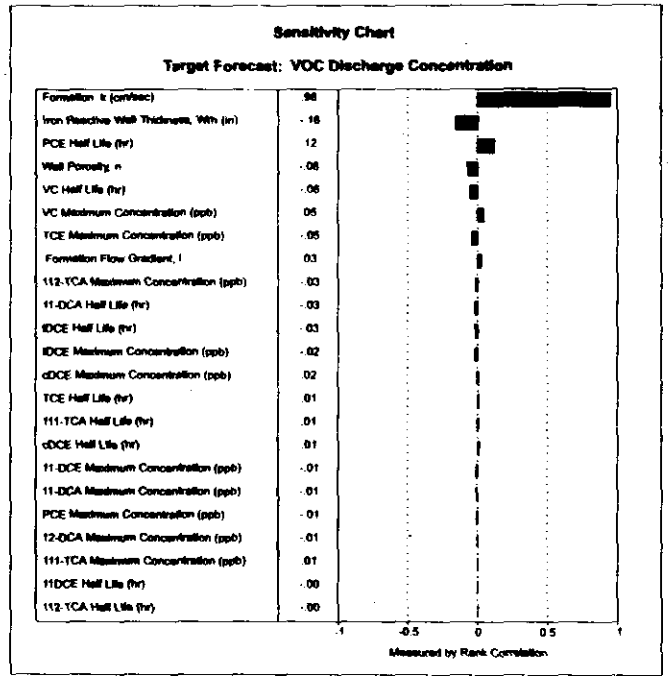






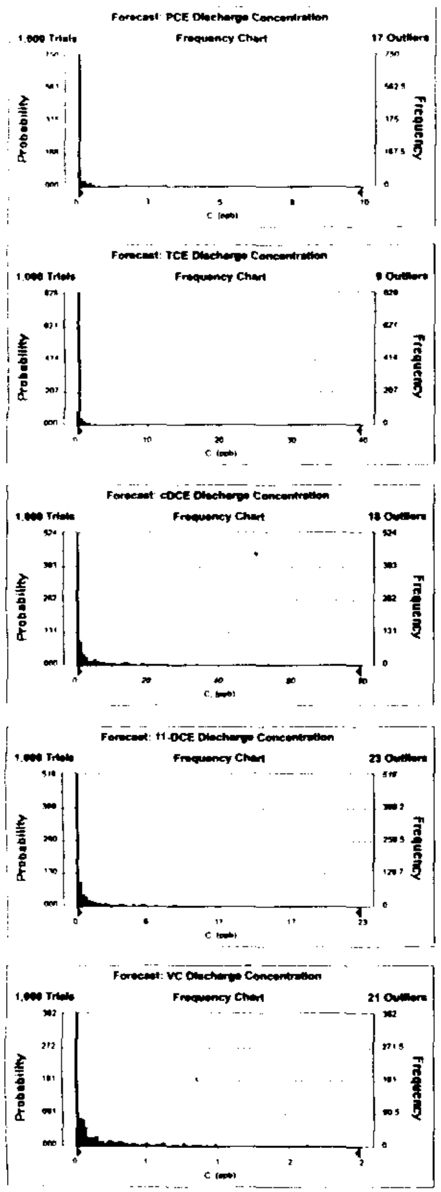
Compound	PRB Effluent Design Concentration (ug/l)	PRB Effluent 85 Percentile (ug/l)	MCL (ug/l)
PCE	5	ND	5
TCE	5	ND	5
cDCE	70	16	70
tDCE	70	ND	70
11-DCE	7	4	7
VC	2	1	2
111-TCA	200	ND	200
112-TCA	5	ND	5
11-DCA	NL	76	NL
12-DCA	NA	6	5

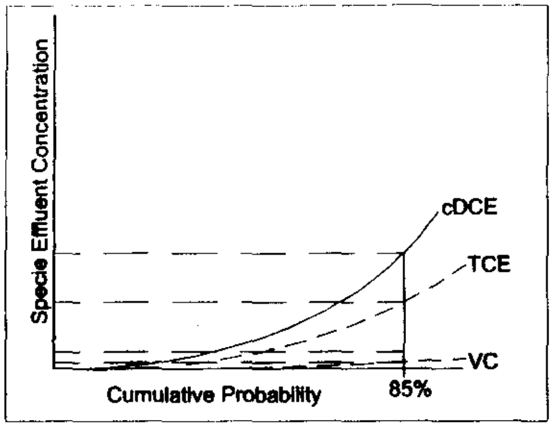
NL: No MCL for this Compound
NA: Not Applicable
ND: Non Detect



GOLDER SIERRA Atlanta, Georgia	DWG NO. 1100-D16 REV. NO. A / JOB NO. 996-1100 DATE 7/26/00 / DRAWN MAT SCALE / CHECKED RIO FILE NO. 1100-d16.cdr / REVIEWED	CLIENT/PROJECT SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA TITLE PRB CASE III DESIGN OUTPUT DATA FIGURE NO. 44

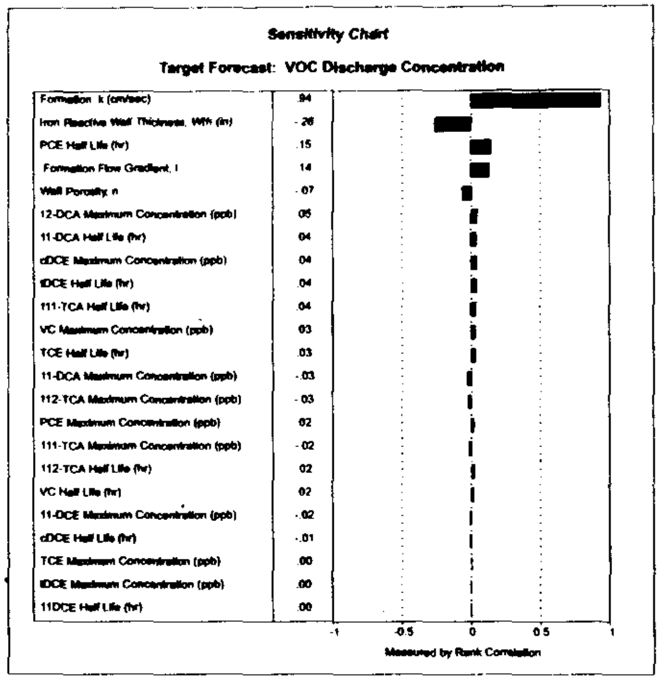
AR301282





Compound	PRB Effluent Design Concentration (ug/l)	PRB Effluent 85 Percentile (ug/l)	MCL (ug/l)
PCE	5	ND	5
TCE	5	1	5
cDCE	70	12	70
tDCE	70	ND	70
11-DCE	7	4	7
VC	2	1	2
111-TCA	200	ND	200
112-TCA	5	ND	5
11-DCA	NL	21	NL
12-DCA	NA	9	5

NL: No MCL for this Compound
NA: Not Applicable
ND: Non Detect



GOLDER SIERRA
Atlanta, Georgia

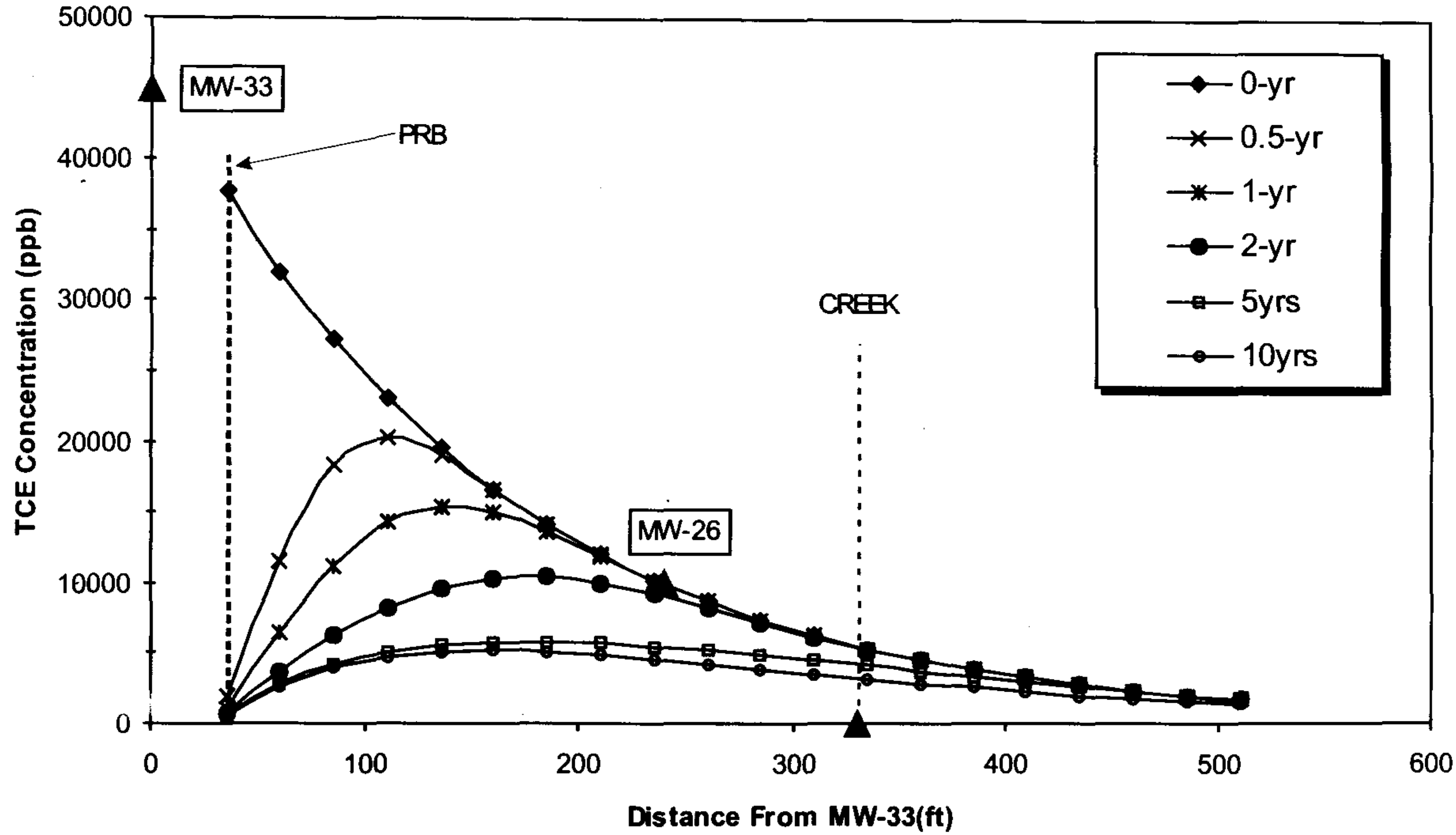
DWG NO. 1100-D39	
REV. NO.	JOB NO. 996-1100
DATE 1/25/01	DRAWN MAT
SCALE	CHECKED RIO
FILE NO. 1100-d39.cdr	REVIEWED

CLIENT/PROJECT
SALTIRE INDUSTRIAL, INC./
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

TITLE
PRB CASE IV DESIGN
OUTPUT DATA

FIGURE NO
45

AR301283



AR301284

CLIENT/PROJECT						TITLE		
SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA			GOLDER SIERRA Atlanta, Georgia			PRB DOWNGRADIENT TCE REMNANT PLUME DEGRADATION PROFILES		
DRAWN MAT	CHECKED RIO	REVIEWED	DATE 1/26/01	SCALE as shown	FILE NO. 1100-d14.cdr	JOB NO. 996-1100	DWG NO./REV NO. A	FIGURE 46

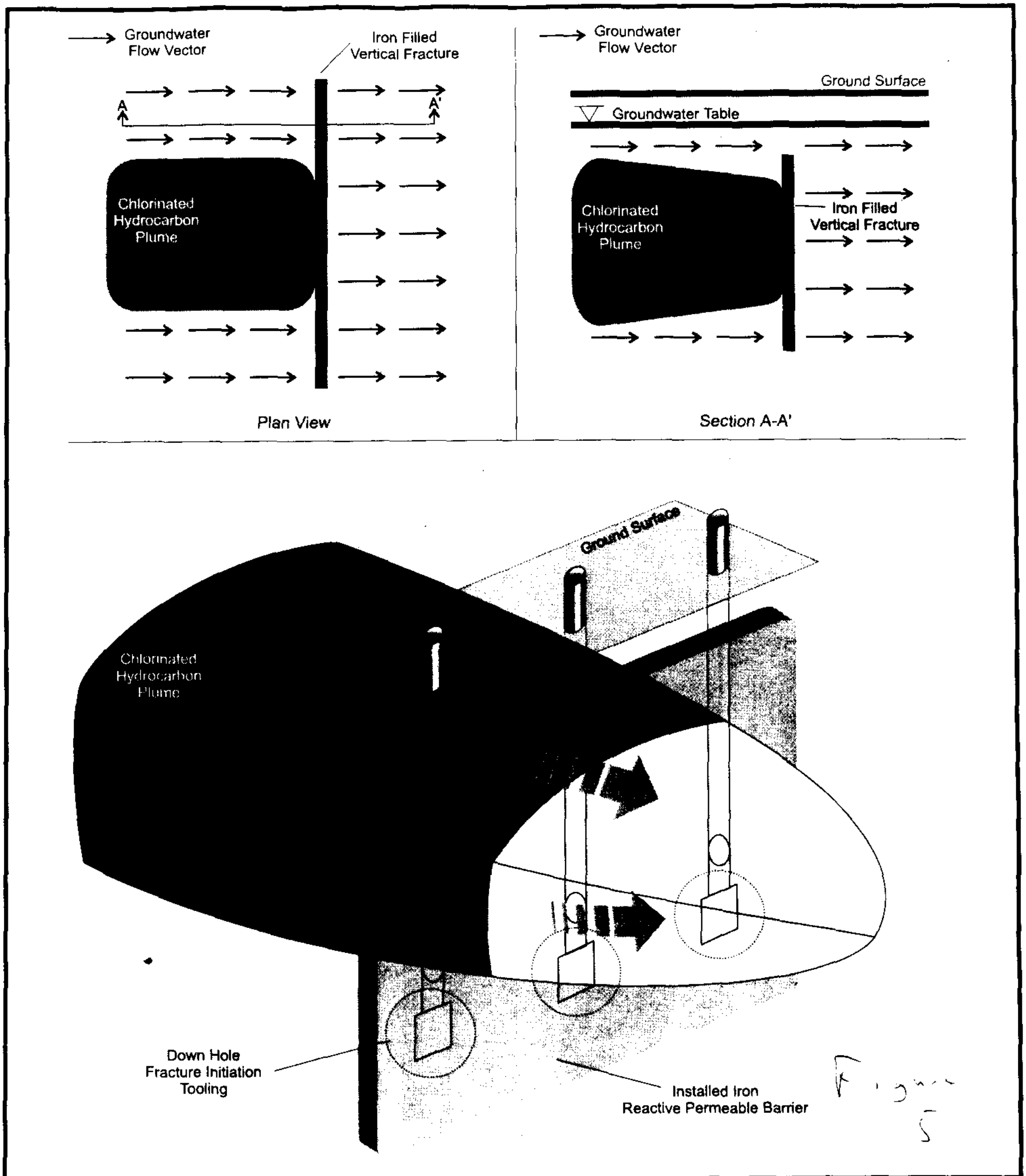


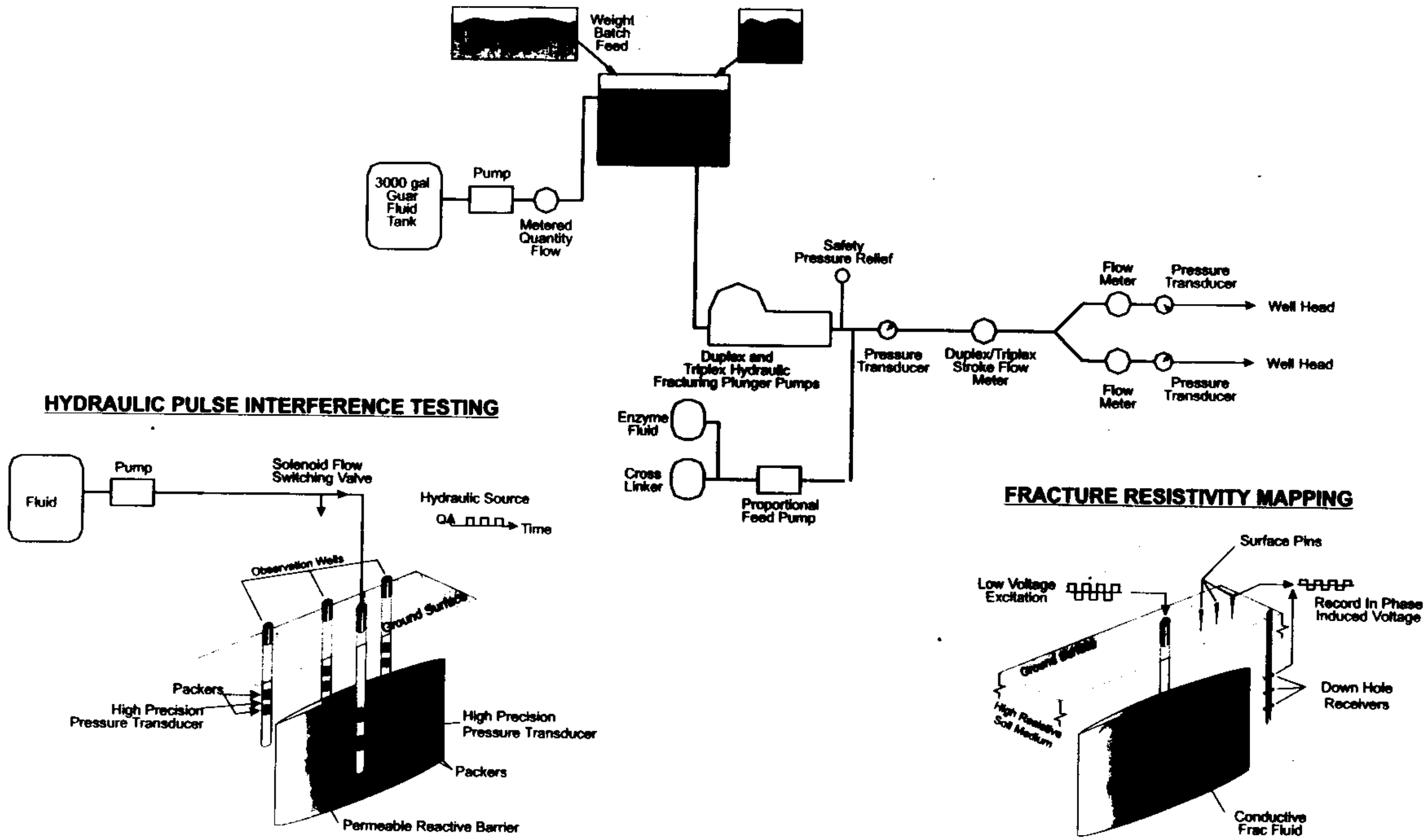
Figure 5

GOLDER SIERRA — Atlanta, Georgia

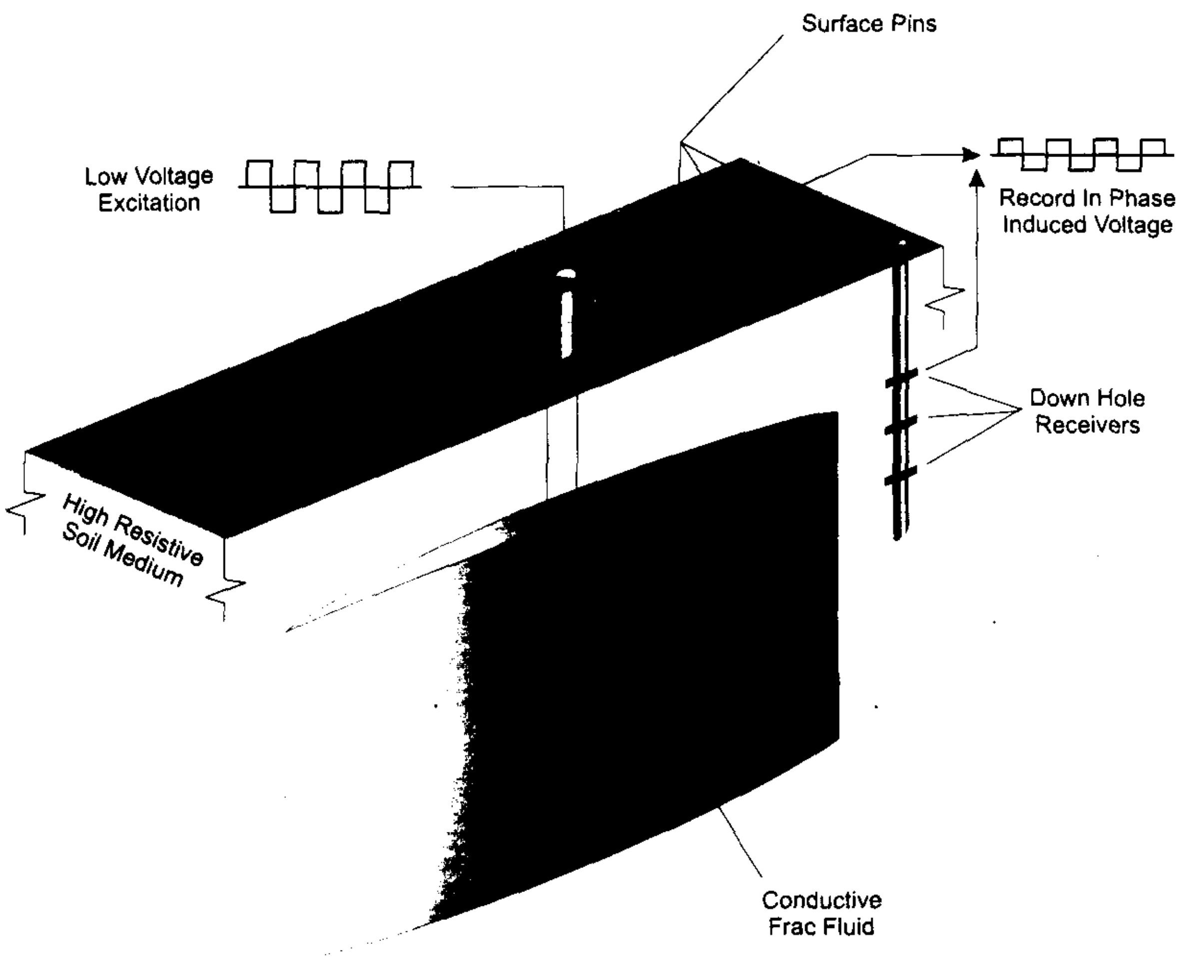
TITLE: VERTICALLY ORIENTATED HYDRAULIC FRACTURE PLACED IRON PERMEABLE REACTIVE BARRIER

CLIENT/PROJECT: SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA

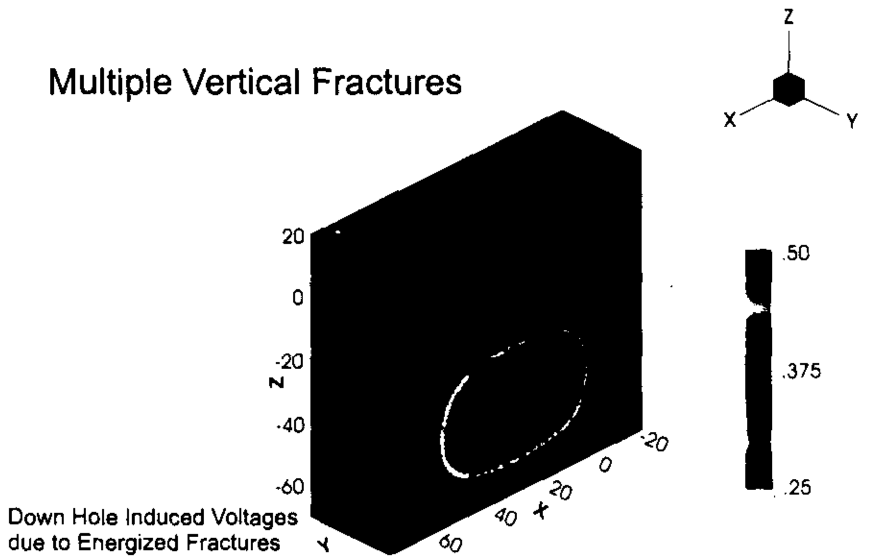
DRAWN	BSL	DATE	1/31/01	JOB NO.	996-1100
CHECKED	RIO	SCALE	NTS	DWG NO.	REV. NO.
REVIEWED	[illegible]	FILE NO.	1100-D44.cdr	SUBTITLE	FIGURE NO. 47



GOLDER SIERRA Atlanta, Georgia	DWG NO. 1100-D30F48		CLIENT/PROJECT: SALTIRE INDUSTRIAL, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
	REV. NO. B	JOB NO. 996-1100	
	DATE 1/20/01	DRAWN MAT	TITLE: FLOW DIAGRAM HYDROFRAC INSTRUMENTATION LAYOUT PLAN AND DETAILS
	SCALE NTS	CHECKED RIO	
	FILE NO. 1100-D30F48.cdr	REVIEWED	FIGURE NO. 48

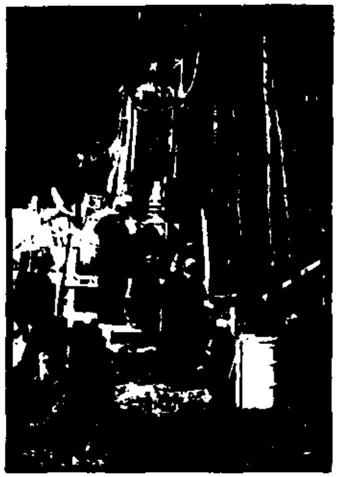


Multiple Vertical Fractures

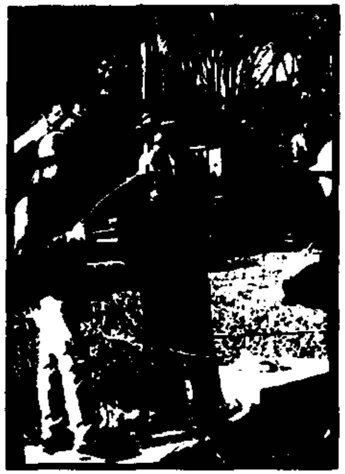


GOLDER SIERRA Atlanta, Georgia	TITLE HYDRAULIC FRACTURE MAPPING BY ELECTRICAL ACTIVE RESISTIVITY			
CLIENT/PROJECT SALTIRE INDUSTRIES, INC/ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA	DRAWN MAT	DATE 1/18/01	JOB NO. 996-1100	
	CHECKED RIO	SCALE NTS	DWG NO.	REV. NO.
	REVIEWED	FILE NO. 1100-D45.cdr	SUBTITLE	FIGURE NO. 49

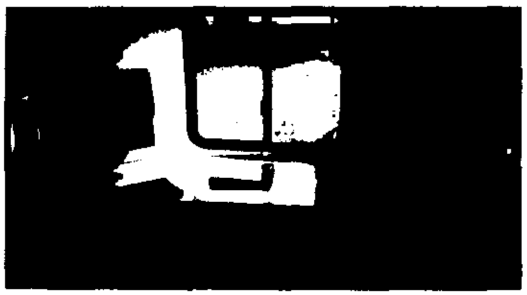
AR301287



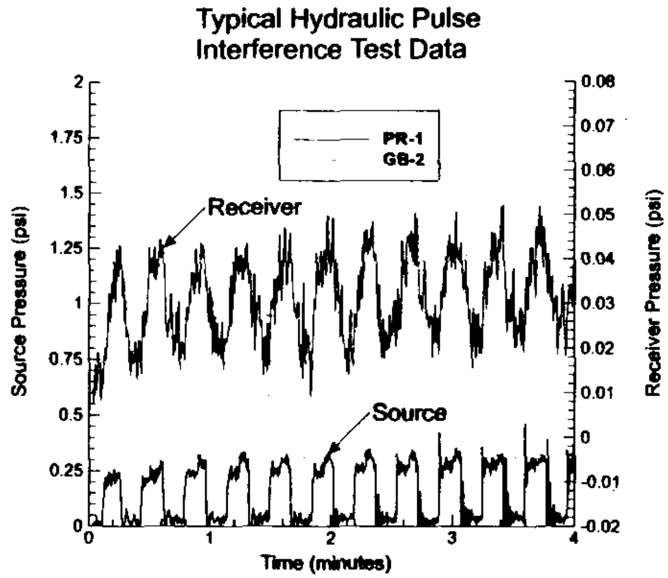
Pulse Well Assembly



Receiver Well Assembly

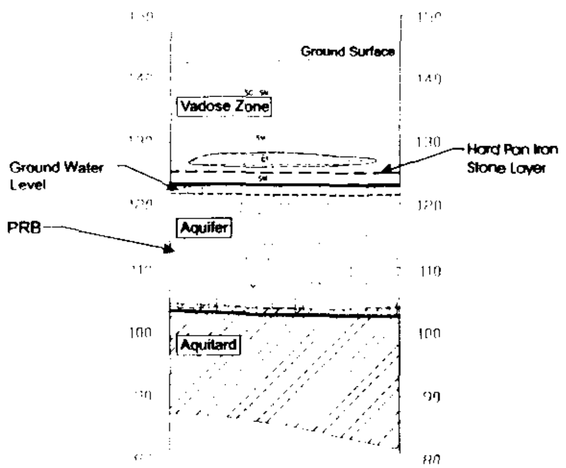


Real Time Data
Acquisition & Recording

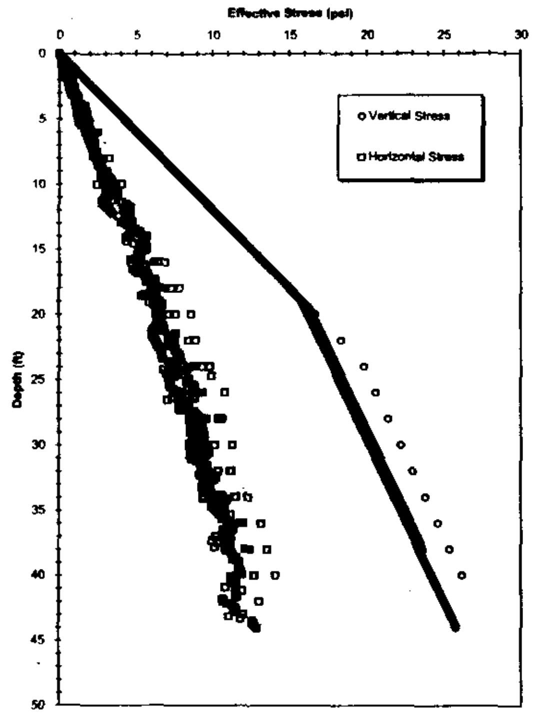


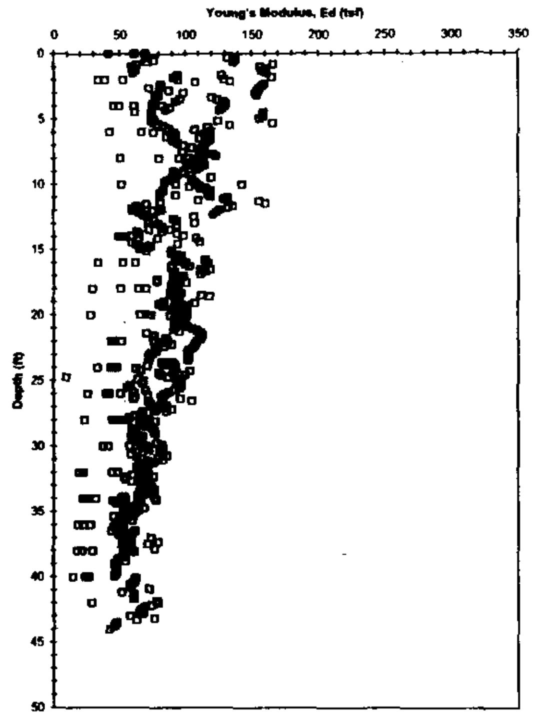
GOLDER SIERRA Atlanta, Georgia	DWG NO. 1100-D46		CLIENT/PROJECT SALTIRE INDUSTRIES, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA	
	REV. NO.	JOB NO. 996-1100		
	DATE 4/24/00	DRAWN MAT	TITLE TYPICAL HYDRAULIC PULSE INTERFERENCE TEST DATA FOR SITE CHARACTERIZATION	
	SCALE NTS	CHECKED RIO		
	FILE NO. 1100-d46.cdr	REVIEWED		FIGURE NO 50

AR301288



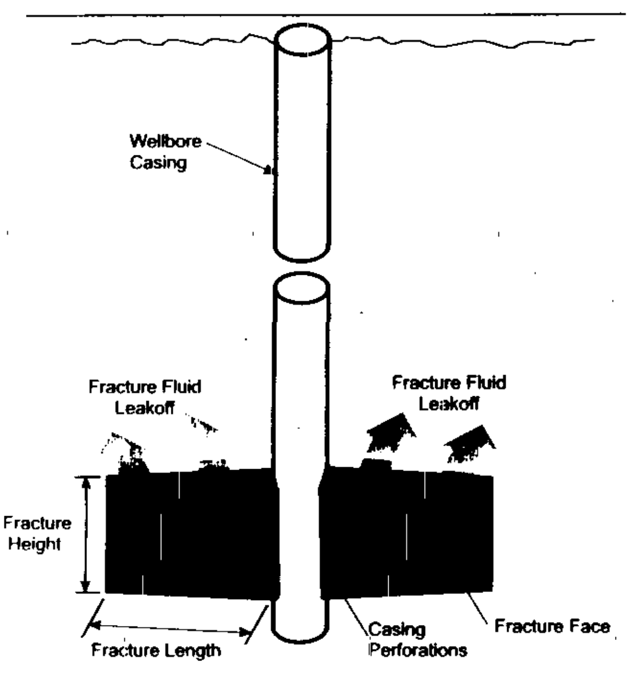
Typical Cross-Section
Along PRB



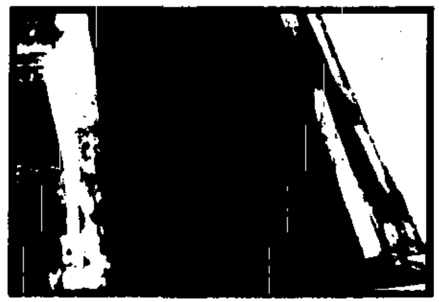


GOLDER SIERRA Atlanta, Georgia	DWG NO. 1100-D47		CLIENT/PROJECT SALTIRE INDUSTRIES, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
	REV. NO.	JOB NO. 996-1100	
	DATE 2/2/01	DRAWN MAT	TITLE IN-SITU EFFECTIVE STRESSES AND YOUNG'S MODULUS vs DEPTH PROFILE ALONG PRB ALIGNMENT
	SCALE NTS	CHECKED RIO	
	FILE NO. 1100-d47.cdr	REVIEWED	FIGURE NO 51

AR301289

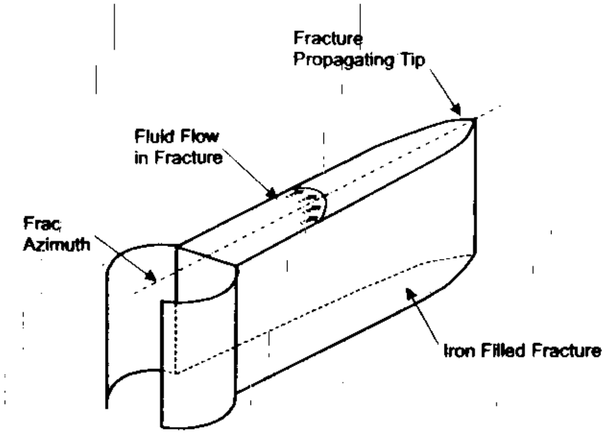


Hydraulic Fracture Propagating From
Wellbore Frac Casing

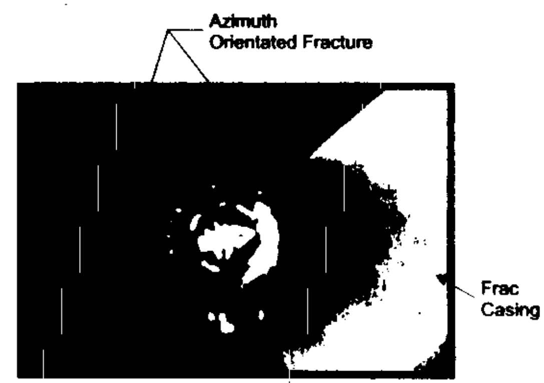


Uncrosslinked Fluid
(Mechanical Agitation Required for Iron Suspension)

Crosslinked Iron Gel Fluid



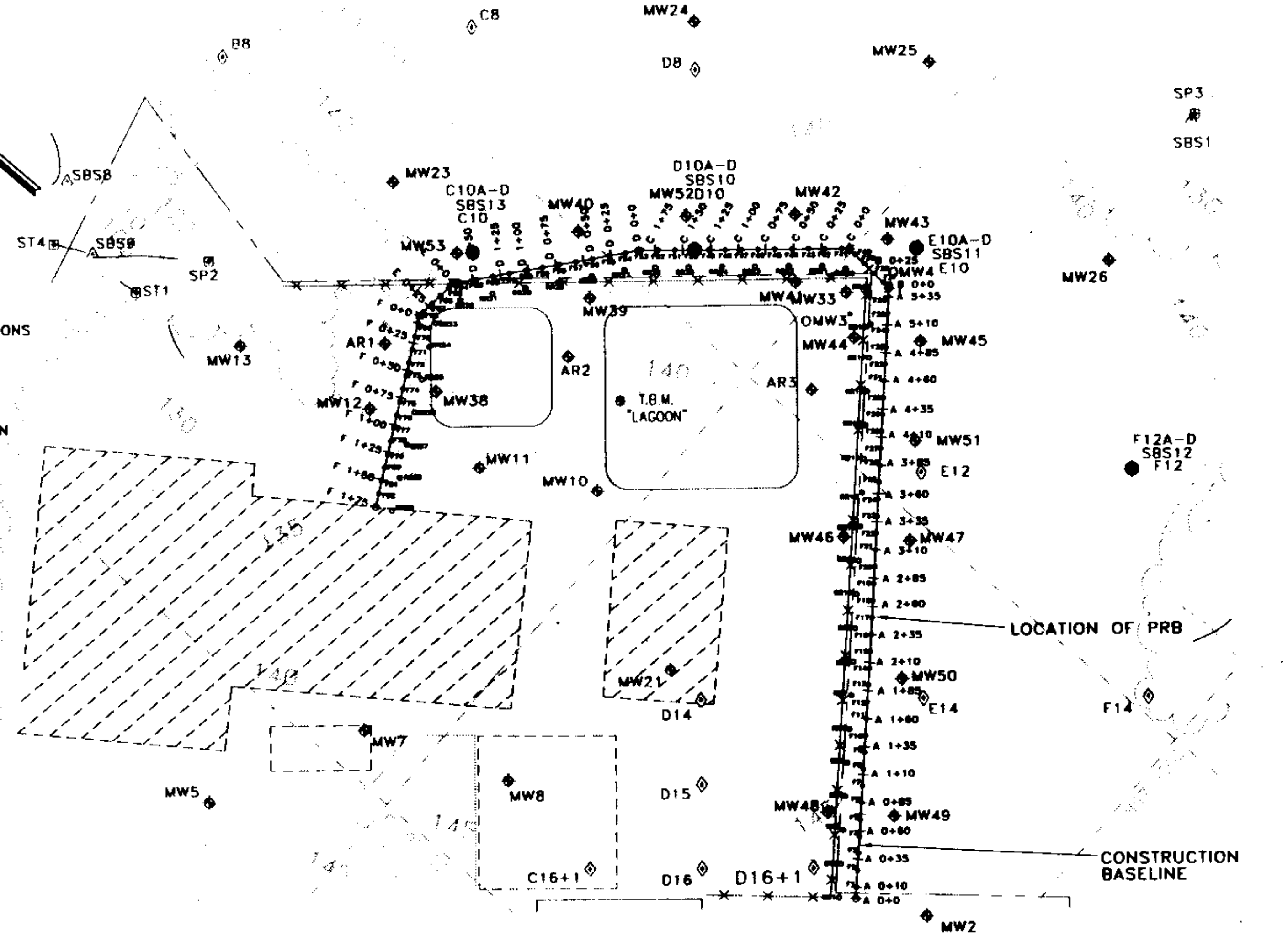
Fluid and Proppant Flow
In Vertical Hydraulic Fracture



Downhole Photograph of Azimuth
Orientated Vertical Fracture

GOLDER SIERRA Atlanta, Georgia	DWG NO. 1100-D48		CLIENT/PROJECT SALTIRE INDUSTRIES, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
	REV. NO.	JOB NO. 996-1100	
	DATE 1/30/01	DRAWN MAT	TITLE HYDRAULIC FRACTURE FLUID AND PROPPANT TRANSPORT
	SCALE NTS	CHECKED RIO	
	FILE NO. 1100-D48.cdr	REVIEWED	FIGURE NO. 52

AR301290



LEGEND

- PRB MONITORING WELLS (MW)
- EXISTING MONITORING WELL (MW)
- SHALLOW SOIL BORING (SBS)
- DIRECT PUSH GROUNDWATER SAMPLING LOCATIONS
- OBSERVATION MONTORING WELL (OMW)
- SPARGE MONITORING WELL (SMW)
- LOCATION OF DEEP BORING IN AQUITARD UNIT
- SURFACE WATER/SEDIMENT SAMPLING LOCATION
- AQUITARD LAYER POINT (SBS)
- PROPERTY LINE
- FENCE LINE
- TOPOGRAPHIC AQUIFER/AQUITARD INTERFACE
- STREAM
- INTERMITTENT DRAINAGE
- BURIED INTERMITTENT STREAM CHANNEL
- TREE LINE
- FORMER POND AREA
- FORMER DRUM STORAGE AREA
- HYDROFRACTURE WELL LOCATIONS
- RESISTIVITY STRING LOCATIONS

0 100 200

SCALE FEET

NOTE: TOPOGRAPHIC SURVEYING SERVICES PROVIDED BY: BALDWIN & GREGG, LTD NORFOLK, VA (DECEMBER 2000)

GOLDER SIERRA
Atlanta, Georgia

DWG. NO.	1100-C48F53
REV. NO.	B
JOB NO.	996-1100
DATE	1/18/01
DRAWN	MAT
SCALE	AS SHOWN
CHECKED	RJO
FILE NO.	1100-C48F53.dwg
REVIEWED	

CLIENT/PROJECT

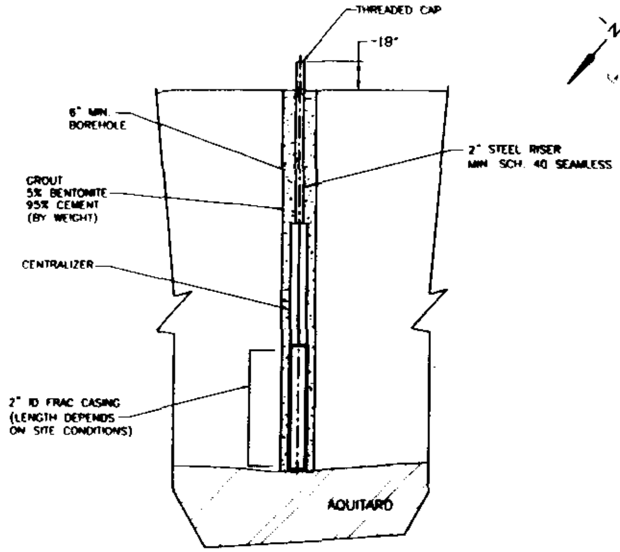
SALTIRE INDUSTRIAL, INC./
FORMER ARROWHEAD PLATING FACILITY
MONTROSS, VA

TITLE

PERMEABLE REACTIVE BARRIER (PRB)
LOCATION PLAN

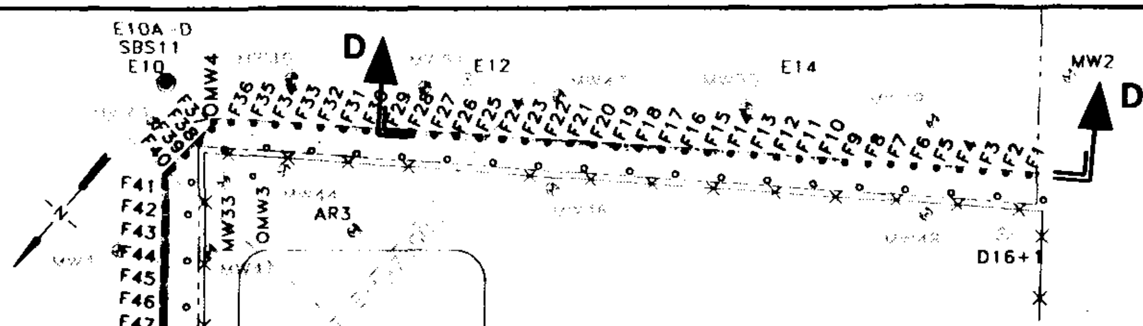
FIGURE NO. 53

AR301291

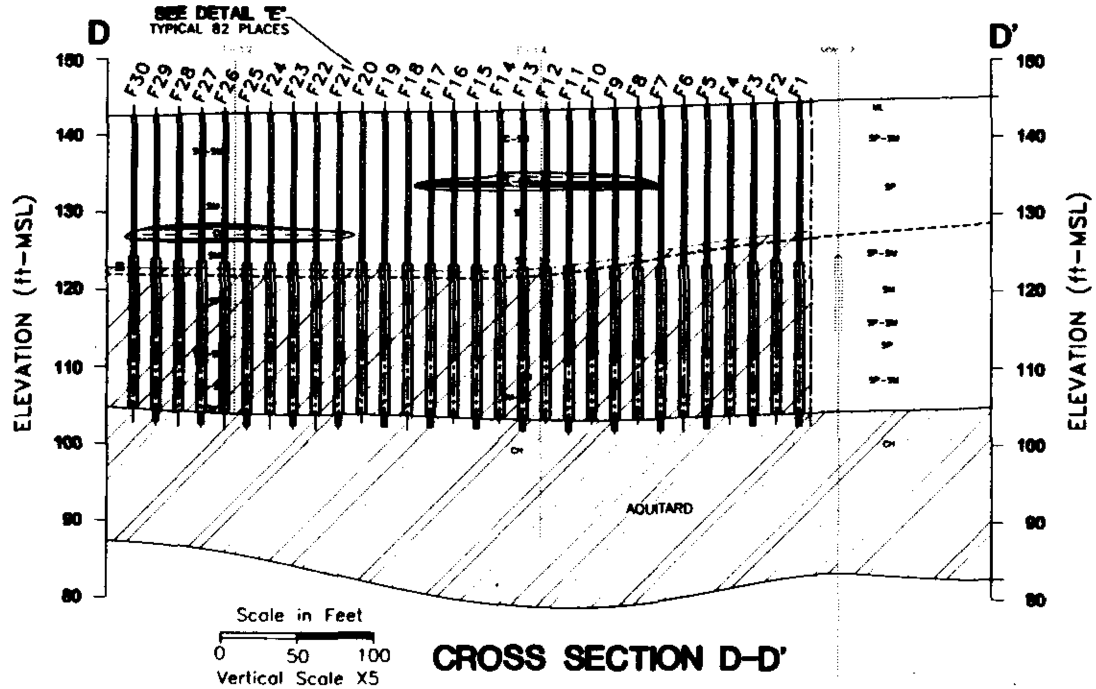


DETAIL "E" HYDROFRACTURE WELLS (F)

TYPICAL 82 PLACES
(NTS)



PLAN VIEW



CROSS SECTION D-D'

LEGEND

- GROUNDWATER LEVEL DATA (JUNE 1999)
- F1 HYDROFRACTURE WELLS
- RR10 RESISTIVITY RECEIVER STRINGS
- MW46 MONITORING WELLS
- SPLIT SPOON SAMPLING
- FRAC CASING
- LOCATION OF PRB

GOLDER SIERRA Atlanta, Georgia	DWG. NO. 1100-C51F54 REV. NO. A JOB NO. 998-1100 DATE 1/22/01 DRAWN MAT SCALE AS SHOWN CHECKED RO FILE NO. 1100-C51F54.DWG	CLIENT/PROJECT SALTIRE INDUSTRIES, INC. FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA TITLE HYDROFRACTURING WELL PLAN AND INSTALLATION DETAIL FIGURE NO. 54

AR301292

ACTIVITY	PERFORMANCE MONITORING	ACTION
Mixing, Blending and Injection of Iron Filings	Mix consistency, density, volumes, weights, pressures and flow rates to be monitored and recorded for QA purposes.	Mix consistency, density, volumes, weights, pressures and flow rates to be within technical specifications as detailed in CQAP. If outside specifications, corrective actions to be implemented and in certain cases batch mixes discarded or injection terminated.
Reactive Barrier Construction	Geometrical coverage of the reactive barrier quantified and recorded for QA purposes. Placement quantities monitored and recorded for QA purposes.	Geometrical coverage determined from active resistivity and placed quantities must meet or exceed technical specifications as detailed in CQAP. If not, additional volumes must be injected to remove deficiency.
Reactive Barrier Hydraulic Effectiveness	Hydraulic effectiveness of reactive barrier quantified by pulse interference test.	Hydraulic effectiveness of reactive barrier must pass pulse interference test as detailed in technical specifications included in CQAP.
Effectiveness of Groundwater Remediation	Upgradient and downgradient reactive barrier monitoring wells sampled and analyzed for VOC, metals and other parameters. Site wide monitoring wells sampled and analyzed for selected VOCs and field parameters.	VOCs concentration in groundwater downgradient of reactive barrier must be less than performance expectations as detailed in the PSVP. If not, additional sampling and/or contingency actions must be implemented as specified in the PSVP and CP. Degradation rate of VOC's concentration in site wide monitoring wells must be greater than performance expectations as detailed in the PSVP. If not, additional sampling and/or contingency actions must be implemented as specified in the PSVP.

GOLDER SIERRA
Atlanta, Georgia

DWG NO. 1100-d17		CLIENT/PROJECT	SALTIRE INDUSTRIAL, INC FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA
REV. NO. B	JOB NO. 996-1100	TITLE	PERFORMANCE MONITORING AND ACTION PLAN FOR THE PRB GROUNDWATER REMEDY
DATE 8/02/00	DRAWN MAT		
SCALE	CHECKED RIO		
FILE NO. 1100-d17.cdr	REVIEWED [signature]	FIGURE NO.	55

AR301293

APPENDIX A

Iron Permeable Reactive Barrier Laboratory Tests

SALTIRE/ARROWHEAD PLATING/VA
SUMMARY OF LABORATORY DATA

Sample Identification	Sample Type	Sample Depth	Soil Classification	Natural Moisture %	Atterberg Limits				Grain Size Distribution			Compaction		Gs	Unit Weight		Permeability (cm/sec)	Resistivity		Additional Tests Conducted (See Notes)
					L.L.	P.L.	P.I.	L.I.	% Finer No. 4 Sieve	% Finer No. 200 Sieve	% Finer .005 mm	Maximum Dry Density (lb/cuft)	Optimum Moisture %		Moisture %	Dry (lb/cuft)		(ohms-cm)	Moisture %	
ATL 80 20/30	Bag	-	SP	-	-	-	-	-	100.0	0.5	-	-	-	2.65	0.1	98.9	1.2E-02	-	-	-
CC-1115	Bag	-	SP	0.0	-	-	-	-	100.0	0.2	-	-	-	-	-	-	-	-	-	-
CC-1021	Bag	-	SM	0.3	-	-	-	-	100.0	40.1	-	-	-	5.69	0.3	168.1	3.9E-04	-	-	-
CC-1022	Bag	-	SP	0.0	-	-	-	-	100.0	0.1	-	-	-	5.93	0.0	172.0	1.2E-01	-	-	-
CC-1115/1021 (2:1)	Bag	-	(SP-SM)	0.0	-	-	-	-	-	-	-	-	-	-	0.0	178.2	2.2E-02	-	-	-
CC-1115/1021 (1:1)	Bag	-	(SM)	0.0	-	-	-	-	-	-	-	-	-	-	0.0	191.7	1.1E-03	-	-	-
CC-1022/ATL 80	Bag	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	PL,TOC
SBS - 11	Bulk	0.0 - 15.0'	(SM)	16.8					99.8	38.1	-	120.0	12.5	2.68	-	-	-	-	-	-
SBS - 10	Bag	16.0-18.0'	CH	36.3	80	29	51	0.14	100.0	93.0	75.0	-	-	2.75	-	-	-	4,673	123.2	-
SBS - 10	Bag	22.0-24.0'	(SP-SM)	-	-	-	-	-	100.0	11.7	-	-	-	2.68	-	-	-	8,010	35.5	-
SBS - 11	Bag	26.0-28.0'	(SP-SM)	-	-	-	-	-	99.0	11.1	-	-	-	2.67	-	-	-	8,121	33.9	-
SBS - 11	Bag	32.0-34.0'	(SP-SM)	-	-	-	-	-	99.9	11.2	-	-	-	2.73	-	-	-	3,449	37.3	-
SBS - 11	Bag	42.0-44.0'	CH	59.9	56	25	31	1.13	100.0	85.5	49.0	-	-	2.73	-	-	-	605	62.0	-
SBS - 12	Bag	30.0-32.0'	(SP-SM)	-	-	-	-	-	99.5	11.3	-	-	-	2.73	-	-	-	11,125	43.1	-
SBS - 12	Bag	34.0-36.0'	(SP-SM)	-	-	-	-	-	100.0	10.5	-	-	-	2.69	-	-	-	1,115	34.4	
SBS - 13	Bag	24.0-26.0'	(SM)	-	-	-	-	-	100.0	23.4	-	-	-	2.67	-	-	-	5,655	54.6	
SBS - 13	Bag	28.0-30.0'	(SM)	-	-	-	-	-	100.0	22.4	-	-	-	2.68	-	-	-	3,763	47.4	
SBS - 13	Bag	32.0-34.0'	(SM)	-	-	-	-	-	100.0	33.0	-	-	-	2.68	-	-	-	2,936	47.3	
SBD - 2	Bag	57.0-59.0'	SM	38.1	NP	NP	NP	NP	100.0	24.5	7.5	-	-	-	-	-	-	-	-	-
SBD - 2	Bag	59.0-61.0'	(SM)	36.0	-	-	-	-	-	28.6	-	-	-	-	36.0	83.7	7.5E-03	-	-	-
SBD - 2	Bag	83.0-85.0'	SC	34.1	37	19	18	0.83	100.0	43.4	28.0	-	-	-	-	-	-	-	-	-
SBD - 3	Bag	71.0-73.0'	CH	48.1	53	18	35	0.86	100.0	70.7	46.5	-	-	-	-	-	-	-	-	-
SBD - 3	Bag	105.7-107.0	(CL-ML)	29.3	-	-	-	-	-	66.8	-	-	-	-	29.3	91.1	1.7E-07	-	-	-
SBD - 3	Bag	107.0-109.0'	SC-SM	28.2	25	21	4	1.85	100.0	35.3	14.5	-	-	-	-	-	-	-	-	-
Gel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R,V
Iron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	pH,SA

ABBREVIATIONS: LIQUID LIMIT (LL)
PLASTIC LIMIT (PL)
PLASTICITY INDEX (PI)
LIQUIDITY INDEX (LI)
SPECIFIC GRAVITY (Gs)
MOISTURE (Mc)

NOTES: pH = pH ACTIVITY TEST
PL = PERM-LEAK-OFF TEST
R = RESISTIVITY TEST - SPECS DEVELOPMENT
SA = SIEVE ANALYSIS - SPECS DEVELOPMENT
TOC = TOTAL ORGANIC CARBON
V = VISCOCITY TEST - SPECS DEVELOPMENT

APPENDIX A-1

Soil Grain Size, Atterberg Limits, Specific Gravity and Resistivity Tests

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME:	**GSL/IC6-3831 GAI/FL**		
PROJECT NUMBER:	***IC3-3822***		
SAMPLE ID:	**SBS-10**	**SAMPLE DEPTH:**	**16.0 - 18.0'**
SAMPLE TYPE:	**Bag**		

SAMPLE PREPARATION

Wet or Dry: **Wet**

Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION		NATURAL MOISTURE
Number of Blows				22	22	
Weight of Wet Soil & Tare (gm	20.48	20.98	19.67	16.79	18.31	328.78
Weight of Dry Soil & Tare (gm)	18.54	18.78	17.80	11.20	13.06	255.06
Weight of Tare (gm)	11.81	11.24	11.31	4.30	6.62	51.90
Weight of Water (gm)	1.94	2.20	1.87	5.59	5.25	73.72
Weight of Dry Soil (gm)	6.73	7.54	6.49	6.90	6.44	203.16
Water Content %	28.83	29.18	28.81	81.01	81.52	36.29

	TRIAL 1	TRIAL 2
BLOWS:	**22**	**22**
K VALUE:	**0.985**	**0.985**

PLASTIC LIMIT (PL): 29

LIQUID LIMIT (LL): 80

PLASTICITY INDEX (PI): 51

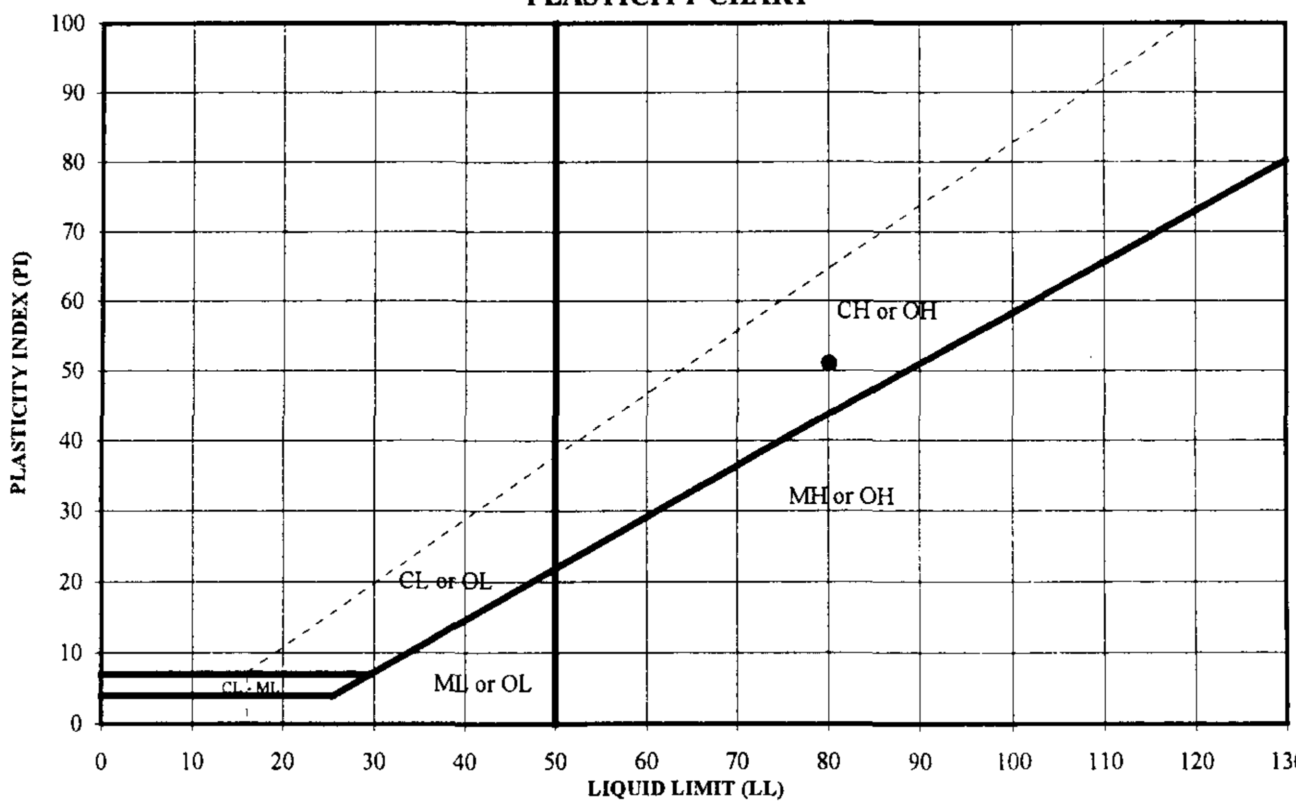
LIQUIDITY INDEX (LI): 0.14

NOTE:

DESCRIPTION: Yellowish Brown and Gray, SILTY CLAY, little coarse to fine sand.

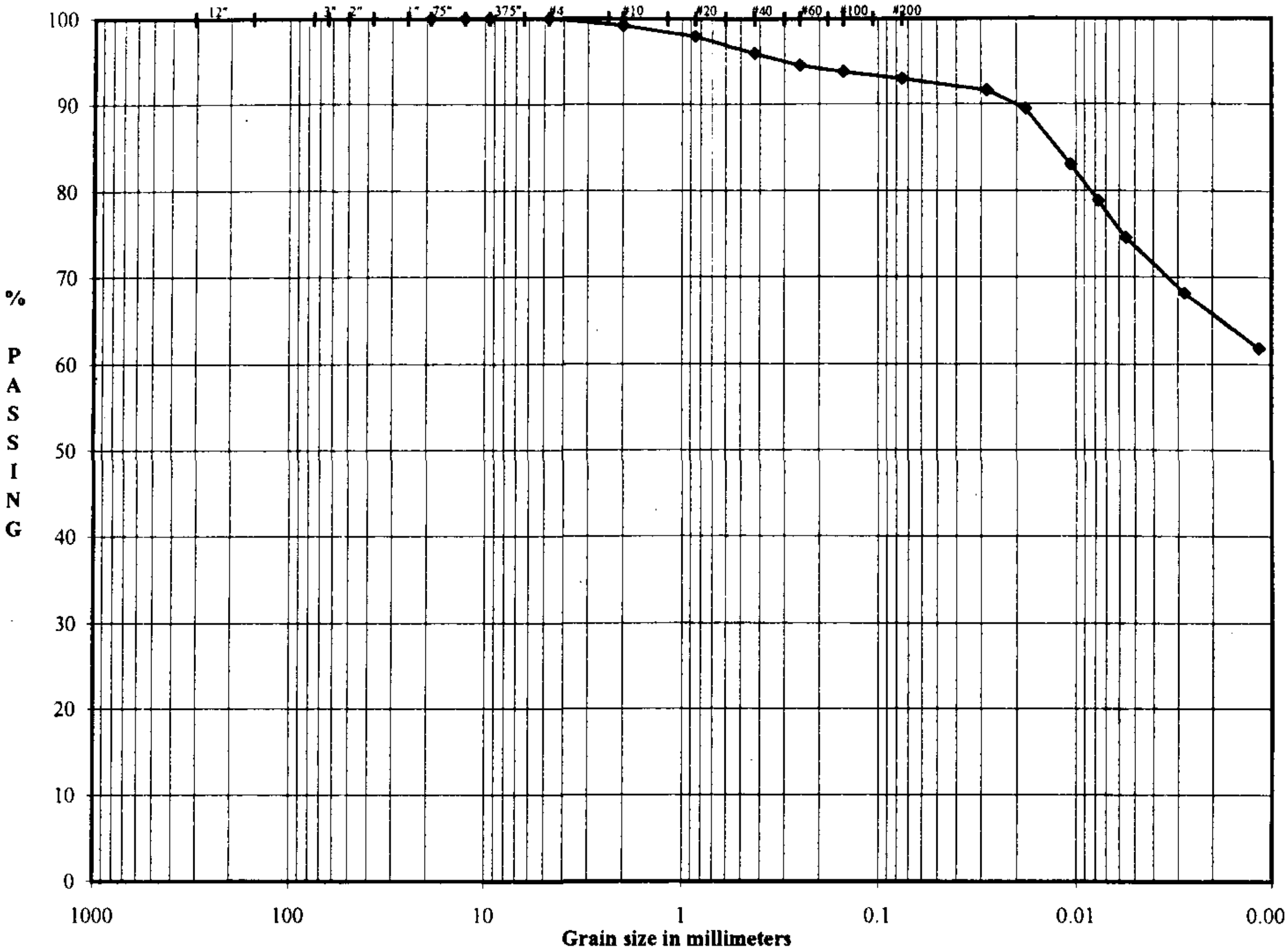
USCS: CH

PLASTICITY CHART



TECH	DH
DATE	6/1/00
CHECK	jh
REVIEW	jh

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	SBS-10
SAMPLE TYPE	Bag
SAMPLE DEPTH	16.0 - 18.0'

LL	80
PL	29
PI	51

DESCRIPTION	Yellowish Brown and Gray, SILTY CLAY, little coarse to fine sand.
USCS	CH

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	TJ
DATE	5/31/00
CHECK	
REVIEW	

GOLDER SIERRA

AR301298

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS-10 | -
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
		SAMPLE DEPTH	16.0 - 18.0'

AS RECEIVED WATER CONTENT

Tare No.		-
Wt. Wet Soil & Tare (gm)	(W1)	328.78
Wt. Dry Soil & Tare (gm)	(W2)	255.06
Weight of Tare (gm)	(W3)	51.90
Weight of Water (gm)	(W4=W1-W2)	73.72
Weight of Dry Soil (gm)	(W5=W2-W3)	203.16
Moisture Content (%)	(W4/W5)*100	36.29

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	25.62
Dry Soil & Tare (gm)	24.69
Tare Weight (gm)	3.25
Moisture Content (%)	4.34

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	294.11	
Tare Weight (gm)	114.48	
Total Weight (gm)	172.16	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"				12.0"	cobbles
3.0"				3.0"	coarse gravel
2.5"				2.5"	coarse gravel
2.0"				2.0"	coarse gravel
1.5"				1.5"	coarse gravel
1.0"				1.0"	coarse gravel
0.75"				0.75"	fine gravel
0.50"				0.50"	fine gravel
0.375"				0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	
Specific Gravity	(tested)	2.754
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	48.00
Calculated Dry Wt. used in test (gm)	46.00
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 0.00 **HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)**

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	0.37	0.37	99.2	#10	medium sand
#20	0.94	0.94	98.0	#20	medium sand
#40	1.87	1.87	95.9	#40	fine sand
#60	2.52	2.52	94.5	#60	fine sand
#100	2.87	2.87	93.8	#100	fine sand
#200	3.24	3.24	93.0	#200	fines

HYDROMETER CALCULATIONS

DATE 5/31/00	TIME 10:56	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
5/31/00	10:58	2.00	49.0	21.50	0.013	6.00	43.00	9.2	0.98
5/31/00	11:01	5.00	48.0	21.50	0.013	6.00	42.00	9.4	0.98
5/31/00	11:11	15.00	45.0	21.50	0.013	6.00	39.00	9.9	0.98
5/31/00	11:26	30.00	43.0	21.50	0.013	6.00	37.00	10.2	0.98
5/31/00	11:56	60.00	41.0	21.50	0.013	6.00	35.00	10.6	0.98
5/31/00	15:06	250.00	38.0	21.50	0.013	6.00	32.00	11.1	0.98
6/1/00	10:56	1440.00	35.0	22.00	0.013	6.00	29.00	11.5	0.98

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING		
		% COBBLES	0.00
0.0281	91.6	% COARSE GRAVEL	0.00
0.0180	89.5	% FINE GRAVEL	0.00
0.0106	83.1	% COARSE SAND	0.80
0.0076	78.8	% MEDIUM SAND	3.26
0.0055	74.6	% FINE SAND	2.98
0.0028	68.2	% FINES	92.96
0.0012	61.8	% TOTAL SAMPLE	100.00

Description Yellowish Brown and Gray, SILTY CLAY, little coarse to fine sand.

USCS CH

80	LL
29	PL
51	PI

TECH	TJ
DATE	5/31/00
CHECK	[illegible]
REVIEW	[illegible]

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	1C3-3822	**SAMPLE ID**	SBS - 10 / -
		SAMPLE TYPE	Bag
TESTED FOR	GS	**SAMPLE DEPTH**	16.0 - 18.0'

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	172.12
Weight Soil and Tare, Final (gm)	(W2)	171.45
Weight Of Tare (gm)	(W3)	51.92
Weight Of Moisture (gm)	(W4=W1-W2)	0.67
Weight Of Dry Soil (gm)	(W5=W2-W3)	119.53
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.6%

AIR REMOVAL METHOD: VACUUM

Trial		1	2	3
Pycnometer Number		1		
Weight Pycnometer Empty (gm)	(Mf)	189.07		
Weight of Soil & Pycnometer (gm)		289.08		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	750.64		
Observed Temperature (Tb), for (Mb) In Degrees C		23.0		
Observed Temperature (Ta), for (Ma) In Degrees C		22.00		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	687.39		
Relative Density of Water @ (Ta)		0.99780		
Relative Density of Water @ (Tx)		0.99757		
Correction Factor due to Temperature @Tx	(K)	0.9993		
Weight of Soil (gm)		100.01		
Weight of Dry Soil (gm)	(Mo)	99.45		
Weight of Pycnometer & Water (gm)	(Ma)	687.28		

SPECIFIC GRAVITY

	1	2	3	Gs Average
G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	2.754			2.754

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	RJ
DATE	5/31/00
CHECK	[illegible]
REVIEW	[illegible]

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS - 10	-
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag	
REMARKS		SAMPLE DEPT	16.0 - 18.0'	

SAMPLE PREPARATION	Sieved through the #8 Sieve	No
TEST APPARATUS	Miller Soilbox and Nilsson 400 Soil Resistance Meter.	

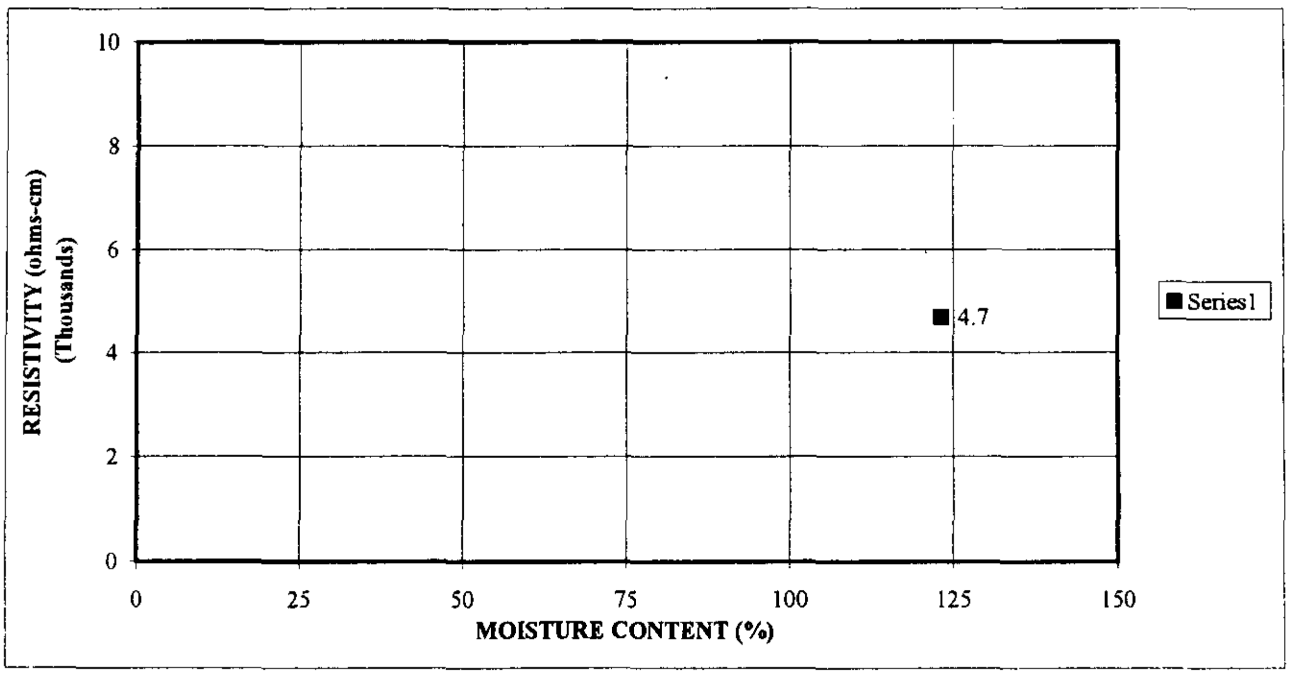
Identification:

Resisivity of the Site H_2O

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	4,200			1,400
TEMP DEGREES (C)	20.0			22.0
RESISTIVITY @ 15.5 C (ohms-cm)	4,673			1,628

MOISTURE CONTENT

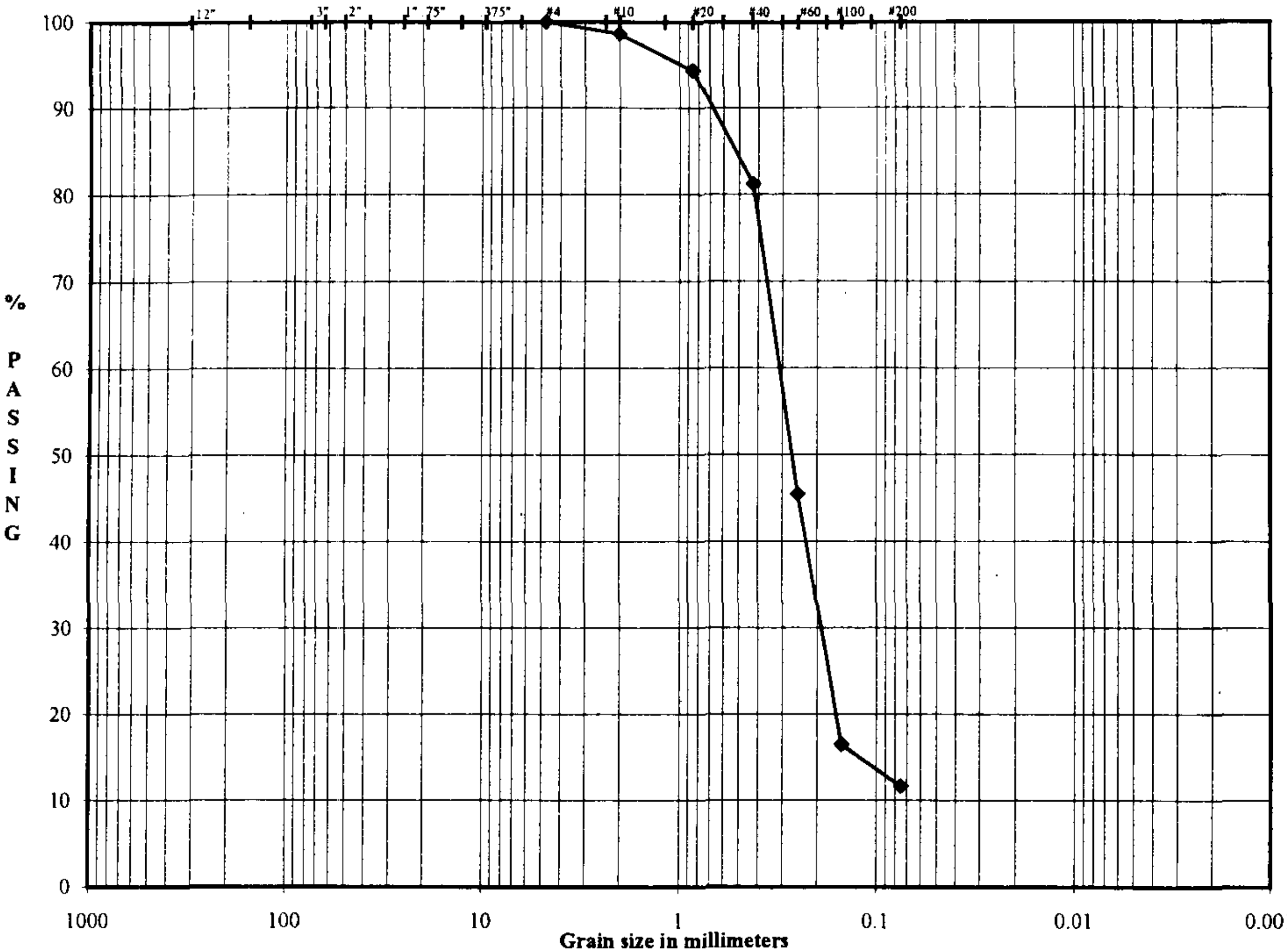
WET WEIGHT & TARE	121.99			
DRY WEIGHT & TARE	82.90			
TARE WEIGHT	51.16			
WEIGHT OF MOISTURE (gm)	39.09			
WEIGHT OF DRY SOIL (gm)	31.74			
MOISTURE CONTENT (%)	123.16			



Description	Yellowish Brown and Gray, SILTY CLAY, little coarse to fine sand.
USCS	CH

TECH	PWM
DATE	5/30/00
CHECK	CJM
REVIEW	CJM

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



<table>
<tr><td rowspan="2">Boulders</td><td rowspan="2">Cobbles</td><td>Coarse</td><td>Fine</td><td>Cor</td><td>Med</td><td>Fine</td><td>SILT OR CLAY</td></tr>
<tr><td colspan="2">Gravel</td><td colspan="3">SAND</td><td>FINES</td></tr>
</table>

SAMPLE ID	SBS - 10
SAMPLE TYPE	Bag
SAMPLE DEPTH	22.0 - 24.0'

LL	-
PL	-
PI	-

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS (SP-SM)

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	PWM/RJ
DATE	5/30/00
CHECK	[illegible]
REVIEW	[illegible]

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	SBS - 10 -
PROJECT NO.	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPTH**	22.0 - 24.0'

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1-w2)	
Weight of Dry Soil (gm)	(w5=w2-w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Mois

Weight Of Sample (gm)	193.62
Tare Weight (gm)	42.91
(W6) Total Dry Weight (gm)	150.71

SIEVE ANALYSIS

Tare Weight: 0.00

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	0.00	0.00	0.00	100.00	0.375"	fine gravel
#4	0.03	0.03	0.02	99.98	#4	coarse sand
#10	2.06	2.06	1.37	98.63	#10	medium sand
#20	8.48	8.48	5.63	94.37	#20	medium sand
#40	28.29	28.29	18.77	81.23	#40	fine sand
#60	82.14	82.14	54.50	45.50	#60	fine sand
#100	125.90	125.90	83.54	16.46	#100	fine sand
#200	133.12	133.12	88.33	11.67	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.02
% C SAND	1.35
% M SAND	17.40
% F SAND	69.56
% FINES	11.67
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	2.676

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS (SP-SM)

TECH	PWM/RJ
DATE	5/30/00
CHECK	CPM
REVIEW	CPM

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	IC3-3822	**SAMPLE ID**	SBS - 10 / -
		SAMPLE TYPE	Bag
TESTED FOR	GS	**SAMPLE DEPTH**	22.0 - 24.0'

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	203.85
Weight Soil and Tare, Final (gm)	(W2)	203.50
Weight Of Tare (gm)	(W3)	51.72
Weight Of Moisture (gm)	(W4=W1-W2)	0.35
Weight Of Dry Soil (gm)	(W5=W2-W3)	151.78
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.2%

AIR REMOVAL METHOD
VACUUM

Trial		1	2	3
Pycnometer Number		11		
Weight Pycnometer Empty (gm)	(Mf)	178.11		
Weight of Soil & Pycnometer (gm)		278.10		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	739.13		
Observed Temperature (Tb), for (Mb) In Degrees C		23.0		
Observed Temperature (Ta), for (Ma) In Degrees C		22.00		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	676.74		
Relative Density of Water @ (Ta)		0.99780		
Relative Density of Water @ (Tx)		0.99757		
Correction Factor due to Temperature @Tx	(K)	0.9993		
Weight of Soil (gm)		99.99		
Weight of Dry Soil (gm)	(Mo)	99.76		
Weight of Pycnometer & Water (gm)	(Ma)	676.63		

SPECIFIC GRAVITY

G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	2.676			**Gs Average** 2.676

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	RJ
DATE	5/31/00
CHECK	Gm
REVIEW	Gm

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS - 10	-
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag	
REMARKS		SAMPLE DEPT	22.0 - 24.0'	

SAMPLE PREPARATION	Sieved through the #8 Sieve	No
TEST APPARATUS	Miller Soilbox and Nilsson 400 Soil Resistance Meter.	

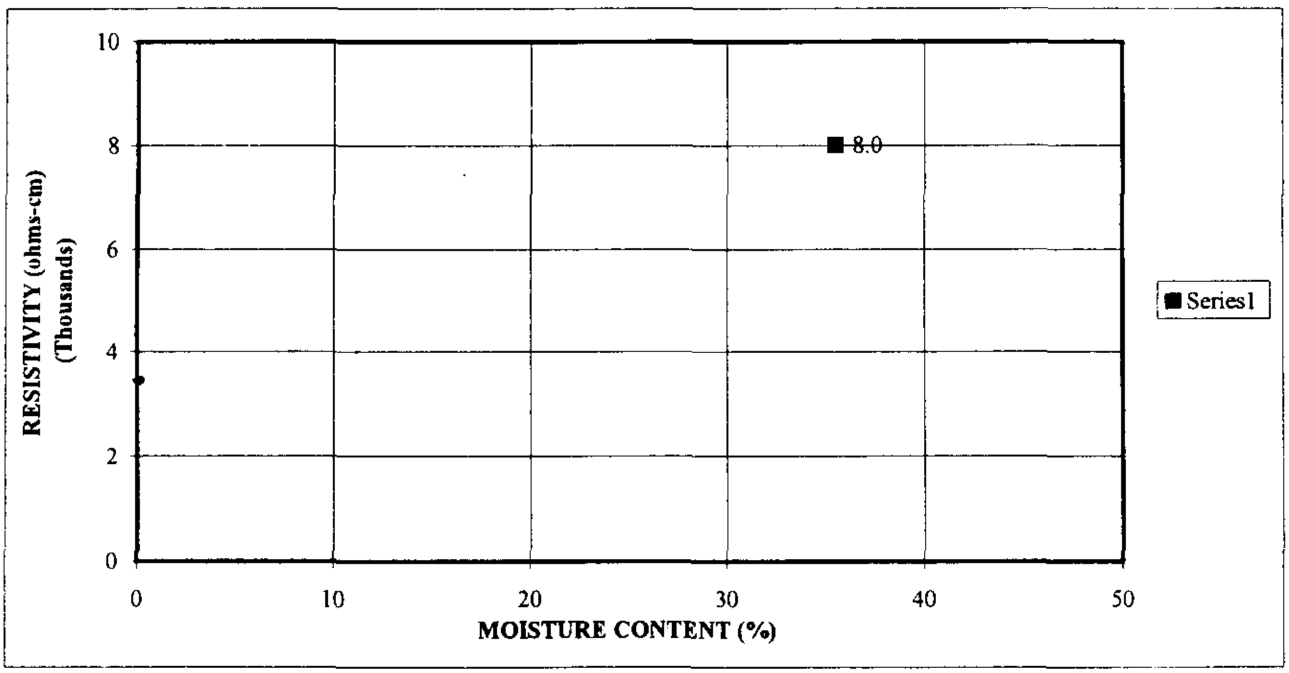
Identification:

Resisivity of the *Site H_2O*

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	7,200			1,400
TEMP DEGREES (C)	20.0			22.0
RESISTIVITY @ 15.5 C (ohms-cm)	8,010			1,628

MOISTURE CONTENT

WET WEIGHT & TARE	247.07			
DRY WEIGHT & TARE	193.62			
TARE WEIGHT	42.91			
WEIGHT OF MOISTURE (gm)	53.45			
WEIGHT OF DRY SOIL (gm)	150.71			
MOISTURE CONTENT (%)	35.47			



Description	Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.
USCS	(SP-SM)

TECH	PWM
DATE	5/30/00
CHECK	[illegible]
REVIEW	[illegible]

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS - 10	-
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag	
REMARKS		SAMPLE DEPT	22.0 - 24.0'	

SAMPLE PREPARATION — Sieved through the #8 Sieve: No

TEST APPARATUS — Miller Soilbox and Nilsson 400 Soil Resistance Meter.

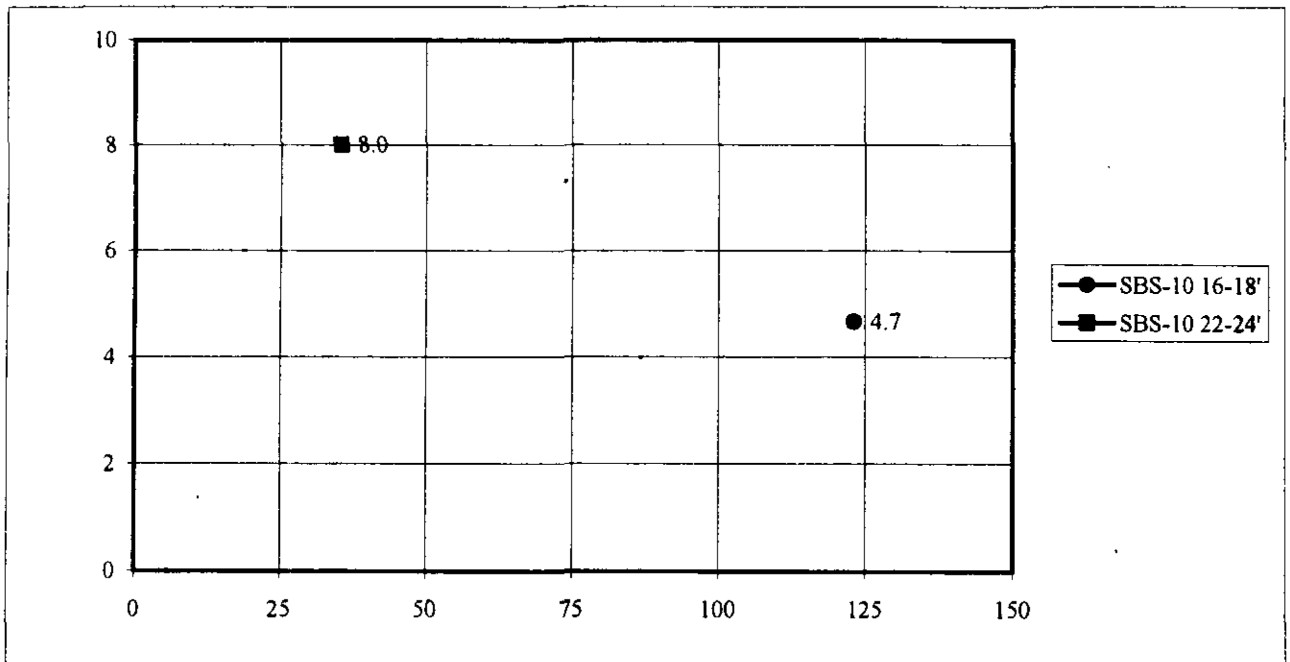
Identification:

Resisivity of the Site H_2O

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	4,200	7,200		1,400
TEMP DEGREES (C)	20.0	20.0		22.0
RESISTIVITY @ 15.5 C (ohms-cm)	4,673	8,010		1,628

MOISTURE CONTENT

WET WEIGHT & TARE	121.99	247.07		
DRY WEIGHT & TARE	82.90	193.62		
TARE WEIGHT	51.16	42.91		
WEIGHT OF MOISTURE (gm)	39.09	53.45		
WEIGHT OF DRY SOIL (gm)	31.74	150.71		
MOISTURE CONTENT (%)	123.16	35.47		

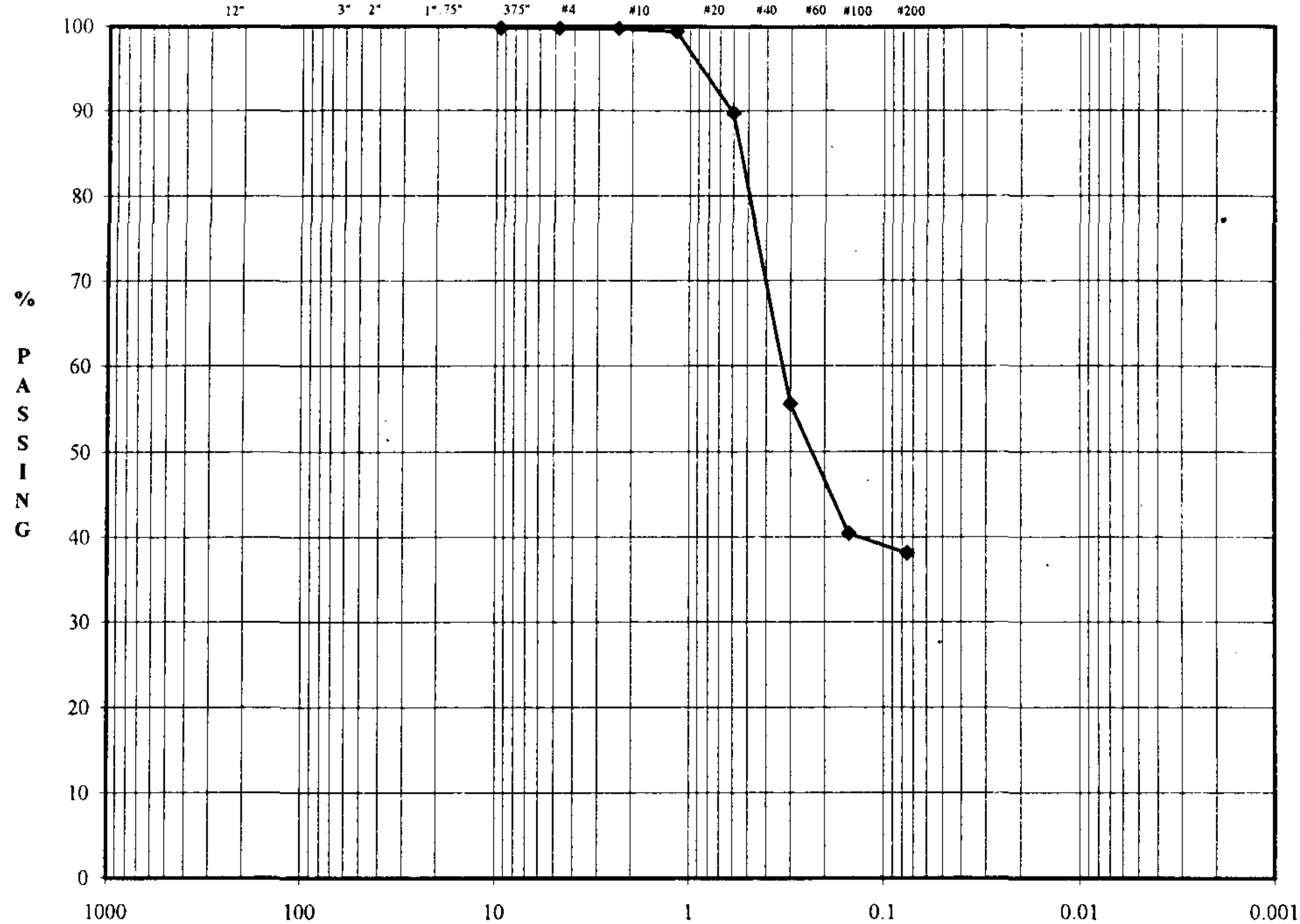


Description: Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS: (SP-SM)

TECH	PWM
DATE	5/30/00
CHECK	Gm
REVIEW	Jm

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	SBS-11
SAMPLE TYPE	Bulk
SAMPLE DEPTH	0.0 -15.0'

LL	-
PL	-
PI	-

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, and clayey silt, trace coarse to fine gravel.

USCS (SM)

SALTIRE/996-1100 IRON REACT WALL/VA
IC3-3822

TECH	SS
DATE	6/1/00
CHECK	JLL
REVIEW	JLL

GOLDER SIERRA

AR301307

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACT WALL/VA	**SAMPLE ID**	SBS-11 / -
PROJECT NO.	IC3-3822	**SAMPLE TYPE**	Bulk
REMARKS		**SAMPLE DEPTH**	0.0 -15.0'

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	713.68
Wt Dry Soil & Tare (gm)	(w2)	623.41
Weight of Tare (gm)	(w3)	86.32
Weight of Water (gm)	(w4=w1-w2)	90.27
Weight of Dry Soil (gm)	(w5=w2-w3)	537.09
Moisture Content (%)	(w4/w5)*100	16.81

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moist

Weight Of Sample (gm)	20044.13
Tare Weight (gm)	0.00
(W6) Total Dry Weight (gm)	20044.13

SIEVE ANALYSIS

Tare Weight: 0.00

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"	0.00	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	18.40	18.40	0.09	99.91	0.75"	fine gravel
0.50"	27.40	27.40	0.14	99.86	0.50"	fine gravel
0.375"	36.70	36.70	0.18	99.82	0.375"	fine gravel
#4	47.80	47.80	0.24	99.76	#4	coarse sand

SPLITTING INFORMATION

Weight in pan, from coarse sieve stack	20044.13
Weight split for fine sieve stack	509.64
Percent of original weight in pan	2.54%

#8	0.15	0.15	0.03	99.73	#8	coarse sand
#16	1.79	1.79	0.35	99.41	#16	medium sand
#30	51.27	51.27	10.06	89.73	#30	medium sand
#50	225.92	225.92	44.33	55.54	#50	fine sand
#100	303.41	303.41	59.53	40.37	#100	fine sand
#200	315.24	315.24	61.86	38.05	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.09
% F GRAVEL	0.15
% C SAND	0.11
% M SAND	26.94
% F SAND	34.66
% FINES	38.05
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

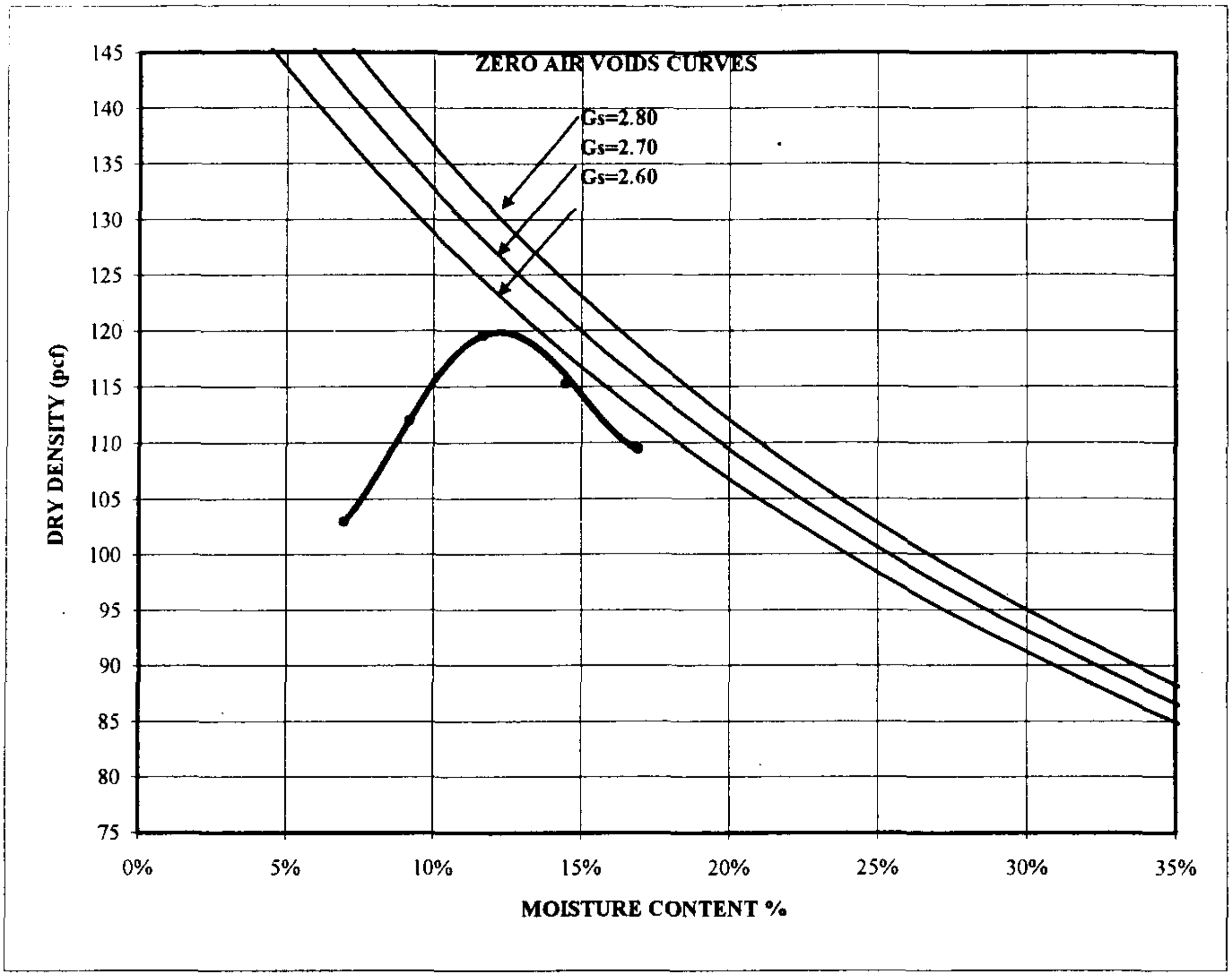
LL	-
PL	-
PI	-
Gs	2.676

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, and clayey silt, trace coarse to fine gravel.

USCS (SM)

TECH	SS
DATE	6/1/00
CHECK	GM
REVIEW	GM

MOISTURE / DRY DENSITY CURVE
D 698 METHOD A



MAXIMUM DRY DENSITY (pcf)	120.0	
OPTIMUM MOISTURE (%)	12.5	NO CORRECTION REQUIRED

SAMPLE ID	SBS-11	**LL**	-
SAMPLE TYPE	Bulk	**PL**	-
SAMPLE DEPTH	0.0 - 15.0'	**PI**	-

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, and clayey silt, trace coarse to fine gravel.

USCS (SM)

SALTIRE/996-100 IRON REACT WALL/VA
IC3-3822

TECH	SS
DATE	5/31/00
CHECK	[signature]
REVIEW	[signature]

MOISTURE DENSITY CURVES
ASTM D 698 & 1557

PROJECT TITLE	SALTIRE/996-100 IRON REACT WALL/VA			TEST TYPE	D 698
PROJECT NUMBER	IC3-3822			PROCEDURE	METHOD A
SAMPLE IDENTITY	SBS-11	-	0.0 - 15.0'		
SAMPLE TYPE	Bulk				

MOLD NUMBER	4	TYPE COMPACTOR: Mechanical	PREPARATION: Wet Method	METHOD A:	20% OR LESS RETAINED ON #4
MOLD WEIGHT (gm)	2027.00			METHOD B:	> 20% RETAINED ON #4 AND 20% OR LESS RETAINED ON 3/8"
MOLD DIAMETER (in)	4.001	TYPE PROCTOR: STANDARD			
MOLD HEIGHT (in)	4.569				
MOLD VOLUME (cu.ft)	0.0332			METHOD C:	> 20% RETAINED ON 3/8" AND < 30% RETAINED ON 3/4"

5.5 -lbf. RAMMER WITH 12 INCH DROP

WATER CONTENT		COARSE FRACTION	TOTAL SAMPLE
Wt Tare & Soil	(W1)		713.68
Wt Tare & Soil	(W2)		623.41
Wt Tare	(W3)		86.32
Wt Moisture	(W4=W1-W2)	0.00	90.27
Wt Dry Soil	(W5=W2-W3)	0.00	537.09
Water Content (dec)	(wc=W4/W5)		0.1681
Water Content (%)	(W4/W5)*100		16.81%

TOTAL WEIGHT BEFORE PROCESSING AND PERCENT RETAINED	
TOTAL WEIGHT, WET (COARSE & FINE)	23413.00
TOTAL WEIGHT, DRY (COARSE & FINE)	20044.13
WEIGHT RETAINED ON #4 SIEVE (WET)	47.80
WEIGHT RETAINED ON 3/8" SIEVE (WET)	36.70
WEIGHT RETAINED ON 3/4" SIEVE (WET)	18.40
PERCENT RETAINED ON #4 SIEVE (DRY)	0.24%
PERCENT RETAINED ON 3/8" SIEVE (DRY)	0.18%
PERCENT RETAINED ON 3/4" SIEVE (DRY)	0.09%

POINT RESULTS (FINE)		1	2	3	4	5	6	7
Wt. Soil & Mold	(W1)	3688.00	3872.00	4041.00	4017.00	3956.00		
Weight of Mold	(W2)	2027.00	2027.00	2027.00	2027.00	2027.00		
Wt. Of Wet Soil	(W3=W1-W2)	1661.00	1845.00	2014.00	1990.00	1929.00		
Wet Density, wd (pcf)	(W3/453.6*Vm)	110.15	122.35	133.56	131.97	127.92		
WATER CONTENTS								
Wt Tare & Soil	(W4)	283.19	317.96	250.89	337.04	266.73		
Wt Tare & Soil	(W5)	268.07	295.61	229.15	299.93	234.30		
Wt Tare	(W6)	50.99	52.03	43.15	43.28	42.73		
Wt Moisture	(W7=W4-W5)	15.12	22.35	21.74	37.11	32.43		
Wt Dry Soil	(W8=W5-W6)	217.08	243.58	186.00	256.65	191.57		
Water Content (%)	(W7/W8)*100	6.97%	9.18%	11.69%	14.46%	16.93%		
Dry Density (pcf)	(wd/(1+wc))	103.0	112.1	119.6	115.3	109.4		

MAXIMUM DRY DENSITY (pcf)	120.0
OPTIMUM MOISTURE CONTENT (%)	12.5
Corrected Maximum Dry Density (pcf)	
Corrected Optimum Moisture (%)	

DESCRIPTION: Reddish Brown, MEDIUM TO FINE SAND, and clayey silt, trace coarse to fine gravel.

USCS: (SM)

Specific Gravity And Absorption of Coarse Aggregate - ASTM C 127-88

Weight of Oven Dry Sample (gm)	A			
Weight of Saturated-Surface-Dry (gm)	B			
Weight of Saturated Sample in Water (gm)	C			
Absorption of Oversize Particles (%)	[(B-A)/A]*100			
Bulk Specific Gravity	A/(B-C)			

LL	-
PL	-
PI	-
MC	16.81%

AVERAGE ABSORPTION

AVERAGE BULK SPECIFIC GRAVITY

TECH	SS
DATE	5/31/00
CHECK	GW
REVIEW	GW

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA			
PROJECT NUMBER	IC3-3822	SAMPLE ID	SBS - 11	-
		SAMPLE TYPE	Bulk	
TESTED FOR	GS	SAMPLE DEPTH	0 - 15.0'	

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	40.36
Weight Soil and Tare, Final (gm)	(W2)	40.23
Weight Of Tare (gm)	(W3)	3.25
Weight Of Moisture (gm)	(W4=W1-W2)	0.13
Weight Of Dry Soil (gm)	(W5=W2-W3)	36.98
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.4%

AIR REMOVAL METHOD

VACUUM

Trial		1	2	3
Pycnometer Number		15		
Weight Pycnometer Empty (gm)	(Mf)	218.43		
Weight of Soil & Pycnometer (gm)		320.18		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	780.19		
Observed Temperature (Tb), for (Mb) In Degrees C		24.0		
Observed Temperature (Ta), for (Ma) In Degrees C		21.50		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	716.94		
Relative Density of Water @ (Ta)		0.99791		
Relative Density of Water @ (Tx)		0.99732		
Correction Factor due to Temperature @Tx	(K)	0.9991		
Weight of Soil (gm)		101.75		
Weight of Dry Soil (gm)	(Mo)	101.39		
Weight of Pycnometer & Water (gm)	(Ma)	716.65		

SPECIFIC GRAVITY

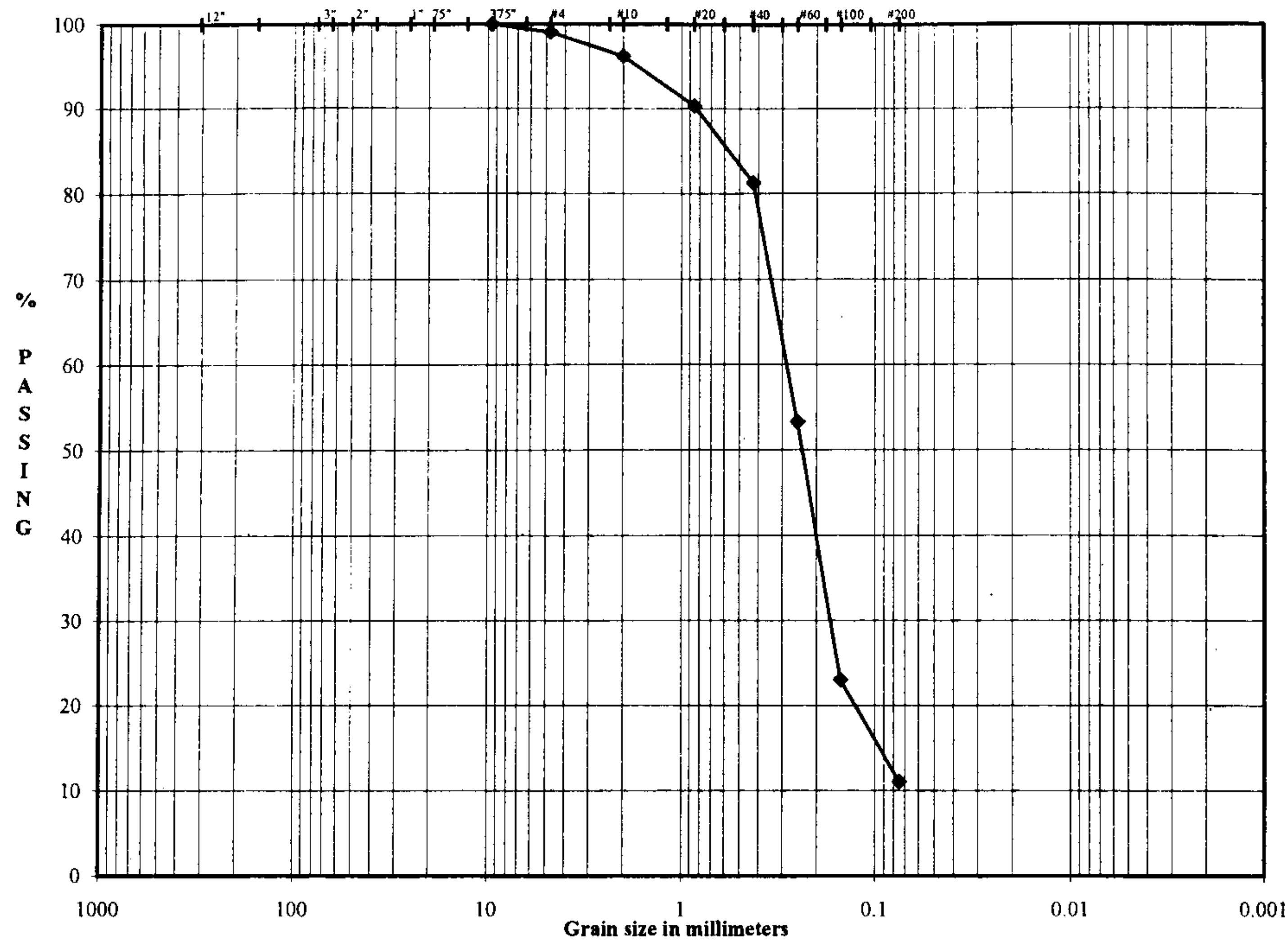
G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	1	2	3	Gs Average
	2.676			2.676

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	DH
DATE	6/2/00
CHECK	Gm
REVIEW	Bjm

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Gravel		SAND			FINES
		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY

SAMPLE ID	SBS - 11
SAMPLE TYPE	Bag
SAMPLE DEPTH	26.0 - 28.0'

LL	-
PL	-
PI	-

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS (SP-SM)

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	PWM/RJ
DATE	5/30/00
CHECK	QW
REVIEW	QW

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**SALTIRE/996-1100 IRON REACTIVE WALL/VA**	**SAMPLE ID**	**SBS - 11** / **-**
PROJECT NO.	**IC3-3822**	**SAMPLE TYPE**	**Bag**
REMARKS		**SAMPLE DEPTH**	**26.0 - 28.0'**

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1-w2)	
Weight of Dry Soil (gm)	(w5=w2-w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Mois

Weight Of Sample (gm)	207.85
Tare Weight (gm)	51.58
(W6) Total Dry Weight (gm)	156.27

SIEVE ANALYSIS

Tare Weight: 0.00

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	0.00	0.00	0.00	100.00	0.375"	fine gravel
#4	1.60	1.60	1.02	98.98	#4	coarse sand
#10	5.90	5.90	3.78	96.22	#10	medium sand
#20	15.09	15.09	9.66	90.34	#20	medium sand
#40	29.23	29.23	18.70	81.30	#40	fine sand
#60	72.99	72.99	46.71	53.29	#60	fine sand
#100	120.35	120.35	77.01	22.99	#100	fine sand
#200	138.95	138.95	88.92	11.08	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	1.02
% C SAND	2.75
% M SAND	14.93
% F SAND	70.21
% FINES	11.08
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	2.665

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS (SP-SM)

TECH	PWM/RJ
DATE	5/30/00
CHECK	Gu
REVIEW	Gu

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	IC3-3822	**SAMPLE ID**	SBS - 11 | -
		SAMPLE TYPE	Bag
TESTED FOR	GS	**SAMPLE DEPTH**	26.0 - 28.0'

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	200.65
Weight Soil and Tare, Final (gm)	(W2)	200.32
Weight Of Tare (gm)	(W3)	42.96
Weight Of Moisture (gm)	(W4=W1-W2)	0.33
Weight Of Dry Soil (gm)	(W5=W2-W3)	157.36
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.2%

AIR REMOVAL METHOD: VACUUM

Trial		1	2	3
Pycnometer Number		17		
Weight Pycnometer Empty (gm)	(Mf)	190.67		
Weight of Soil & Pycnometer (gm)		290.70		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	751.51		
Observed Temperature (Tb), for (Mb) In Degrees C		23.0		
Observed Temperature (Ta), for (Ma) In Degrees C		22.00		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	689.24		
Relative Density of Water @ (Ta)		0.99780		
Relative Density of Water @ (Tx)		0.99757		
Correction Factor due to Temperature @Tx	(K)	0.9993		
Weight of Soil (gm)		100.03		
Weight of Dry Soil (gm)	(Mo)	99.82		
Weight of Pycnometer & Water (gm)	(Ma)	689.13		

SPECIFIC GRAVITY

G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	2.665			**Gs Average** 2.665

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	RJ
DATE	5/31/00
CHECK	Qw
REVIEW	Qw

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS - 11	-
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag	
REMARKS		SAMPLE DEPT	26.0 - 28.0'	

SAMPLE PREPARATION Sieved through the #8 Sieve No

TEST APPARATUS Miller Soilbox and Nilsson 400 Soil Resistance Meter.

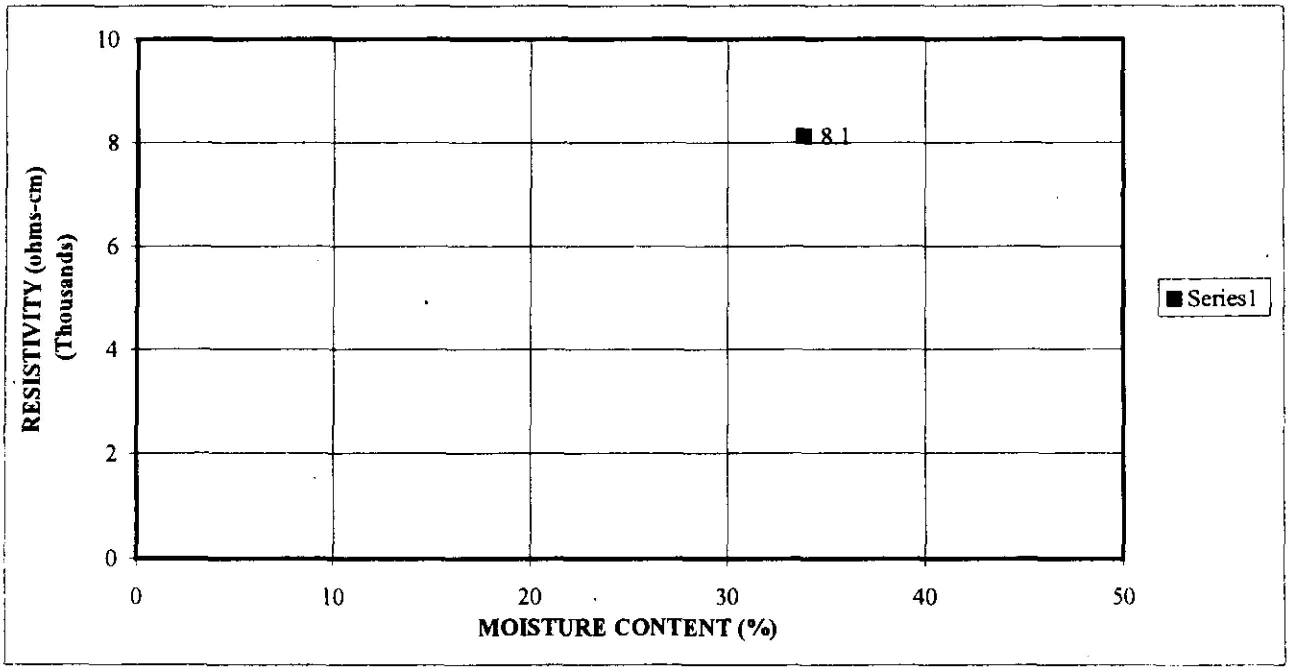
Identification:

Resisivity of the Site H_2O

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	7,300			1,400
TEMP DEGREES (C)	20.0			22.0
RESISTIVITY @ 15.5 C (ohms-cm)	8,121			1,628

MOISTURE CONTENT

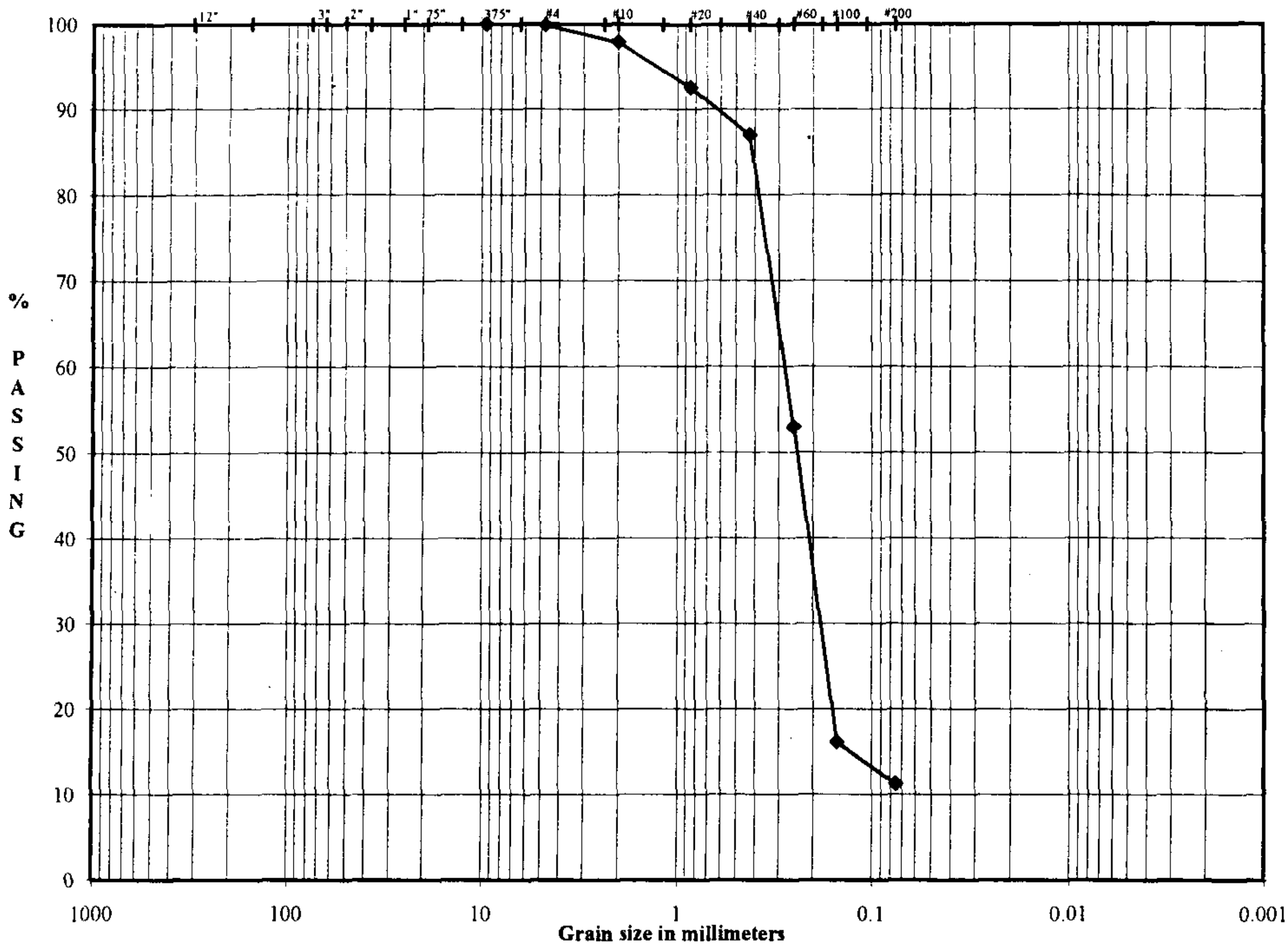
WET WEIGHT & TARE	260.77			
DRY WEIGHT & TARE	207.85			
TARE WEIGHT	51.58			
WEIGHT OF MOISTURE (gm)	52.92			
WEIGHT OF DRY SOIL (gm)	156.27			
MOISTURE CONTENT (%)	33.86			



Description	Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.
USCS	(SP-SM)

TECH	PWM
DATE	5/30/00
CHECK	GM
REVIEW	GM

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	SBS - 11	**LL**	-
SAMPLE TYPE	Bag	**PL**	-
SAMPLE DEPTH	32.0 - 34.0'	**PI**	-

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS (SP-SM)

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	PWM/RJ
DATE	5/30/00
CHECK	GM
REVIEW	GM

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**SALTIRE/996-1100 IRON REACTIVE WALL/VA**	**SAMPLE ID**	**SBS - 11** / -
PROJECT NO.	**IC3-3822**	**SAMPLE TYPE**	**Bag**
REMARKS		**SAMPLE DEPTH**	**32.0 - 34.0'**

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1-w2)	
Weight of Dry Soil (gm)	(w5=w2-w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Mois

Weight Of Sample (gm)	209.92
Tare Weight (gm)	51.90
(W6) Total Dry Weight (gm)	158.02

SIEVE ANALYSIS

Tare Weight: 0.00

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	0.00	0.00	0.00	100.00	0.375"	fine gravel
#4	0.24	0.24	0.15	99.85	#4	coarse sand
#10	3.32	3.32	2.10	97.90	#10	medium sand
#20	11.77	11.77	7.45	92.55	#20	medium sand
#40	20.54	20.54	13.00	87.00	#40	fine sand
#60	74.37	74.37	47.06	52.94	#60	fine sand
#100	132.59	132.59	83.91	16.09	#100	fine sand
#200	140.26	140.26	88.76	11.24	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.15
% C SAND	1.95
% M SAND	10.90
% F SAND	75.76
% FINES	11.24
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	2.731

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS (SP-SM)

TECH	PWM/RJ
DATE	5/30/00
CHECK	[signature]
REVIEW	[signature]

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	IC3-3822	**SAMPLE ID**	SBS - 11 / -
		SAMPLE TYPE	Bag
TESTED FOR	GS	**SAMPLE DEPTH**	32.0 - 34.0'

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	203.08
Weight Soil and Tare, Final (gm)	(W2)	202.51
Weight Of Tare (gm)	(W3)	51.30
Weight Of Moisture (gm)	(W4=W1-W2)	0.57
Weight Of Dry Soil (gm)	(W5=W2-W3)	151.21
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.4%

AIR REMOVAL METHOD

VACUUM

Trial		1	2	3
Pycnometer Number		8		
Weight Pycnometer Empty (gm)	(Mf)	183.60		
Weight of Soil & Pycnometer (gm)		283.60		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	745.01		
Observed Temperature (Tb), for (Mb) In Degrees C		23.0		
Observed Temperature (Ta), for (Ma) In Degrees C		22.00		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	681.96		
Relative Density of Water @ (Ta)		0.99780		
Relative Density of Water @ (Tx)		0.99757		
Correction Factor due to Temperature @Tx	(K)	0.9993		
Weight of Soil (gm)		100.00		
Weight of Dry Soil (gm)	(Mo)	99.62		
Weight of Pycnometer & Water (gm)	(Ma)	681.85		

SPECIFIC GRAVITY

				Gs Average
G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	2.731			2.731

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	RJ
DATE	5/31/00
CHECK	GNU
REVIEW	GNU

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS - 11 / -
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
REMARKS		SAMPLE DEPT	32.0 - 34.0'

SAMPLE PREPARATION — Sieved through the #8 Sieve: No

TEST APPARATUS — Miller Soilbox and Nilsson 400 Soil Resistance Meter.

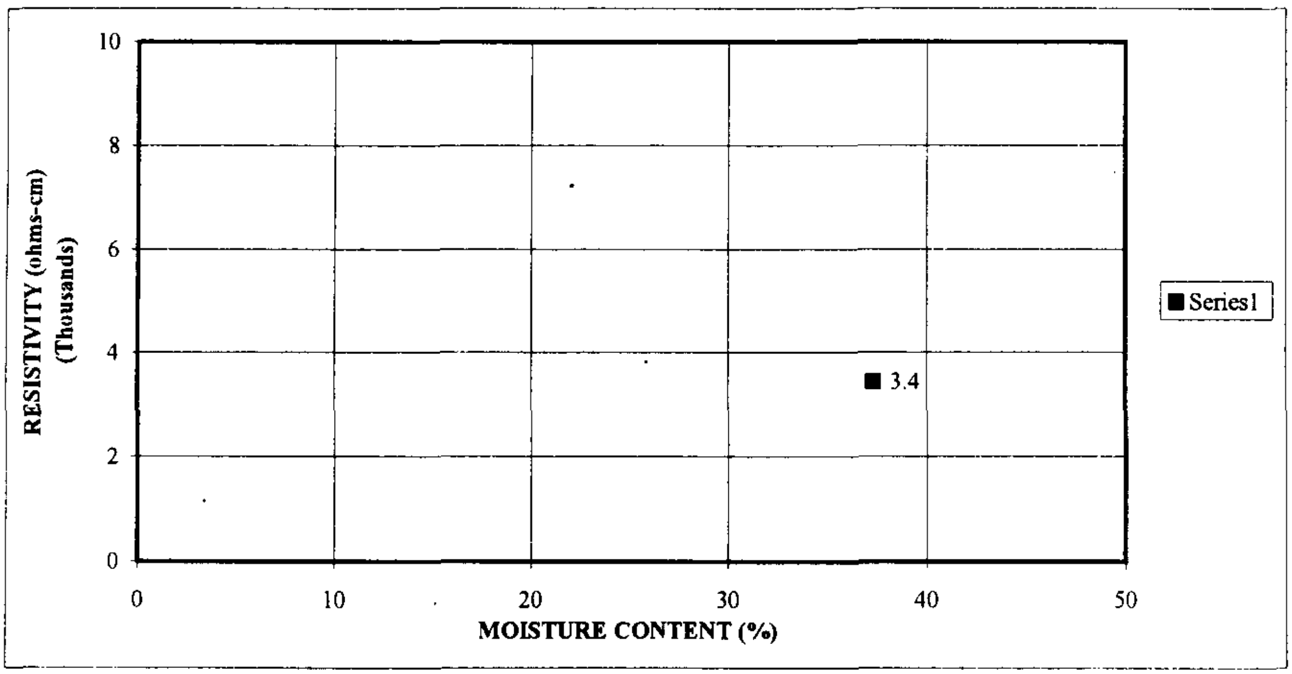
Identification:

Resisivity of the Site H_2O

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	3,100			1,400
TEMP DEGREES (C)	20.0			22.0
RESISTIVITY @ 15.5 C (ohms-cm)	3,449			1,628

MOISTURE CONTENT

WET WEIGHT & TARE	268.90			
DRY WEIGHT & TARE	209.92			
TARE WEIGHT	51.90			
WEIGHT OF MOISTURE (gm)	58.98			
WEIGHT OF DRY SOIL (gm)	158.02			
MOISTURE CONTENT (%)	37.32			



Description Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS (SP-SM)

TECH	PWM
DATE	5/30/00
CHECK	CAW
REVIEW	CAW

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME:	GSL/IC6-3831 GAI/FL	
PROJECT NUMBER:	IC3-3822	
SAMPLE ID:	SBS-11	MPLE DEPT 42.0 - 44.0'
SAMPLE TYPE:	Bag	

SAMPLE PREPARATION

Wet or Dry: Dry

Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION	
Number of Blows				25	25
Weight of Wet Soil & Tare (gm	23.11	22.60	20.41	15.94	17.15
Weight of Dry Soil & Tare (gm)	20.80	20.39	18.58	11.74	12.53
Weight of Tare (gm)	11.40	11.43	11.12	4.29	4.27
Weight of Water (gm)	2.31	2.21	1.83	4.20	4.62
Weight of Dry Soil (gm)	9.40	8.96	7.46	7.45	8.26
Water Content %	24.57	24.67	24.53	56.38	55.93

	TRIAL 1	TRIAL 2
BLOWS:	25	25
K VALUE:	1	1

NATURAL MOISTURE
258.70
181.43
52.44
77.27
128.99
59.90

PLASTIC LIMIT (PL): 25

LIQUID LIMIT (LL): 56

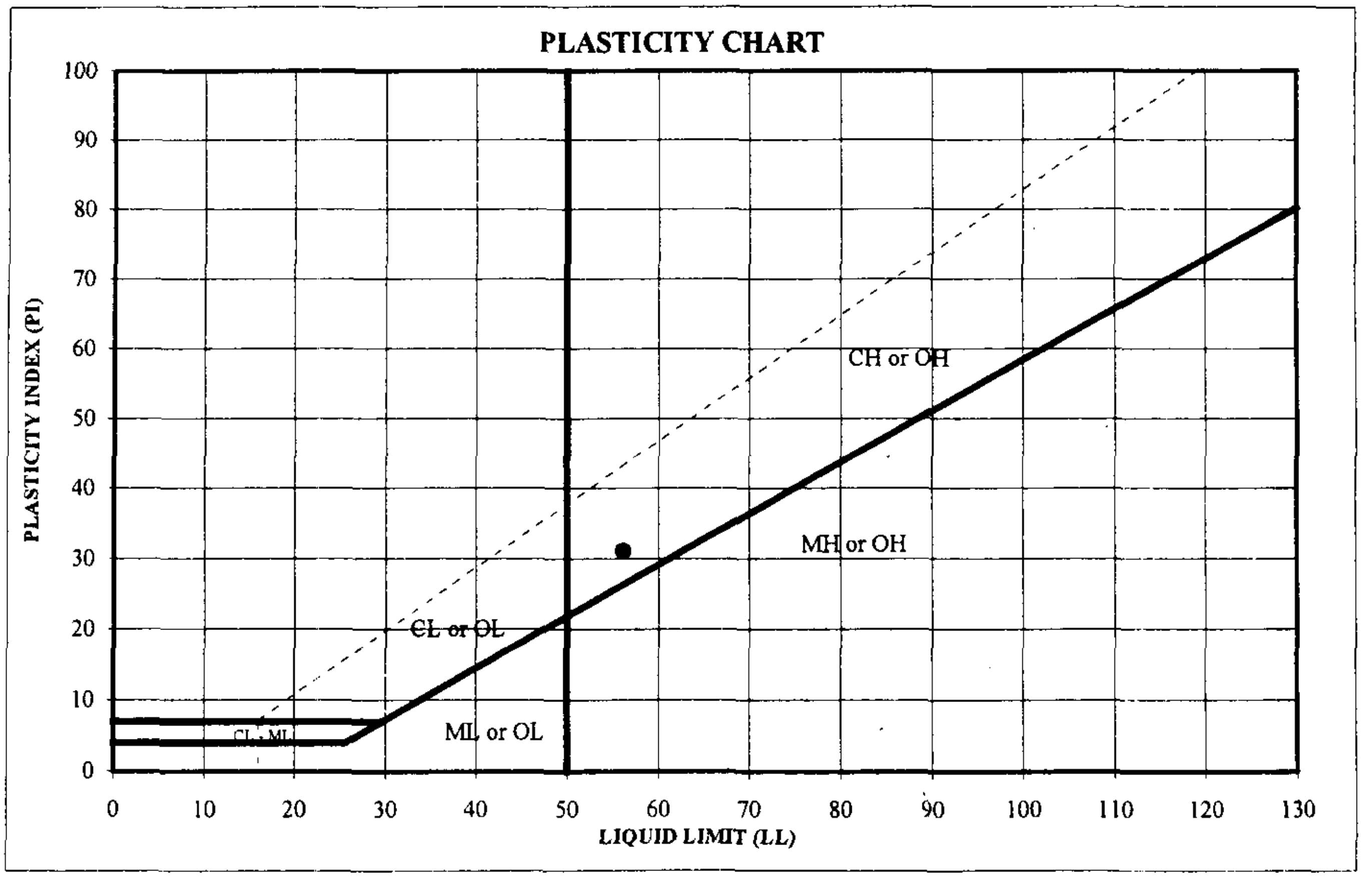
PLASTICITY INDEX (PI): 31

LIQUIDITY INDEX (LI): 1.13

NOTE:

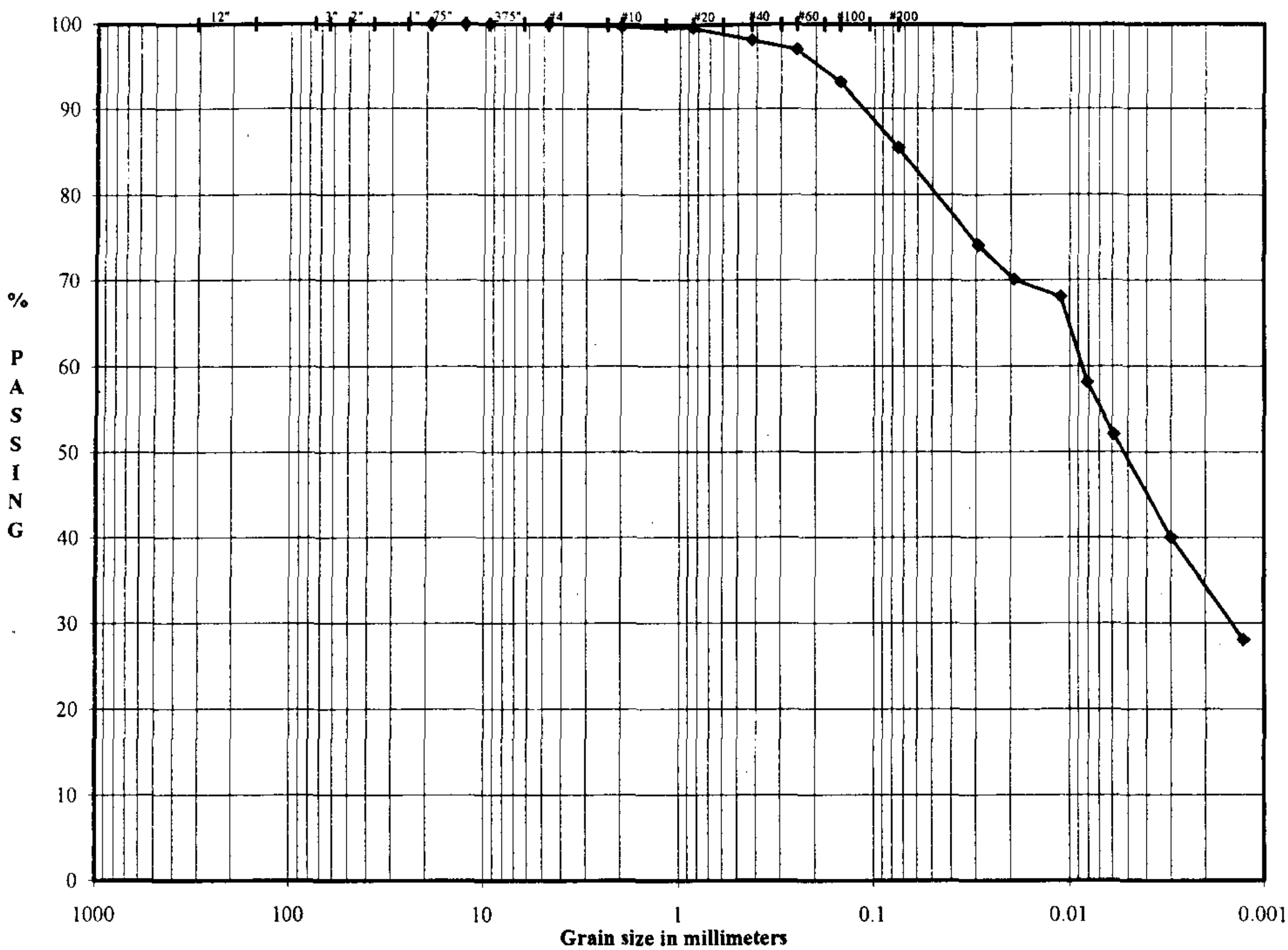
DESCRIPTION: *Gray, SILTY CLAY, some medium to fine sand.*

USCS: CH



TECH	DH
DATE	6/2/00
CHECK	[illegible]
REVIEW	[illegible]

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	SBS-11
SAMPLE TYPE	Bag
SAMPLE DEPTH	42.0 - 44.0'

LL	56
PL	25
PI	31

DESCRIPTION	Gray, SILTY CLAY, some medium to fine sand.
USCS	CH

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	TJ
DATE	5/30/00
CHECK	Cju
REVIEW	Cju

AR301321

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS-11 -
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
		SAMPLE DEPTH	42.0 - 44.0'

AS RECEIVED WATER CONTENT

Tare No.		-
Wt. Wet Soil & Tare (gm)	(W1)	258.70
Wt. Dry Soil & Tare (gm)	(W2)	181.43
Weight of Tare (gm)	(W3)	52.44
Weight of Water (gm)	(W4=W1-W2)	77.27
Weight of Dry Soil (gm)	(W5=W2-W3)	128.99
Moisture Content (%)	(W4/W5)*100	59.90

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	25.13
Dry Soil & Tare (gm)	24.68
Tare Weight (gm)	3.19
Moisture Content (%)	2.09

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	339.03
Tare Weight (gm)	0.00
Total Weight (gm)	332.08 (W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"				12.0"	cobbles
3.0"				3.0"	coarse gravel
2.5"				2.5"	coarse gravel
2.0"				2.0"	coarse gravel
1.5"				1.5"	coarse gravel
1.0"				1.0"	coarse gravel
0.75"				0.75"	fine gravel
0.50"				0.50"	fine gravel
0.375"				0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	
Specific Gravity	(tested)	2.734
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.47
Calculated Dry Wt. used in test (gm)	49.43
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 0.00

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	0.12	0.12	99.8	#10	medium sand
#20	0.19	0.19	99.6	#20	medium sand
#40	0.93	0.93	98.1	#40	fine sand
#60	1.48	1.48	97.0	#60	fine sand
#100	3.39	3.39	93.1	#100	fine sand
#200	7.19	7.19	85.5	#200	fines

HYDROMETER CALCULATIONS

DATE	TIME	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
5/31/00	10:54								
5/31/00	10:56	2.00	43.0	21.50	0.013	6.00	37.00	10.2	0.99
5/31/00	10:59	5.00	41.0	21.50	0.013	6.00	35.00	10.6	0.99
5/31/00	11:09	15.00	40.0	21.50	0.013	6.00	34.00	10.7	0.99
5/31/00	11:24	30.00	35.0	21.50	0.013	6.00	29.00	11.5	0.99
5/31/00	11:54	60.00	32.0	21.50	0.013	6.00	26.00	12.0	0.99
5/31/00	15:04	250.00	26.0	21.50	0.013	6.00	20.00	13.0	0.99
6/1/00	10:54	1440.00	20.0	22.00	0.013	6.00	14.00	14.0	0.99

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING		
		% COBBLES	0.00
0.0296	74.1	% COARSE GRAVEL	0.00
0.0191	70.1	% FINE GRAVEL	0.00
0.0111	68.1	% COARSE SAND	0.24
0.0081	58.1	% MEDIUM SAND	1.64
0.0059	52.1	% FINE SAND	12.66
0.0030	40.1	% FINES	85.46
0.0013	28.0	% TOTAL SAMPLE	100.00

Description Gray, SILTY CLAY, some medium to fine sand.

USCS CH

56	LL
25	PL
31	PI

TECH	TJ
DATE	5/30/00
CHECK	Cgu
REVIEW	Cgu

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	IC3-3822	**SAMPLE ID**	SBS - 11 | -
		SAMPLE TYPE	Bag
TESTED FOR	GS	**SAMPLE DEPTH**	42.0 - 44.0'

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	81.30
Weight Soil and Tare, Final (gm)	(W2)	81.25
Weight Of Tare (gm)	(W3)	52.54
Weight Of Moisture (gm)	(W4=W1-W2)	0.05
Weight Of Dry Soil (gm)	(W5=W2-W3)	28.71
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.2%

AIR REMOVAL METHOD

VACUUM

Trial		1	2	3
Pycnometer Number		25		
Weight Pycnometer Empty (gm)	(Mf)	177.66		
Weight of Soil & Pycnometer (gm)		277.67		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	739.39		
Observed Temperature (Tb), for (Mb) In Degrees C		23.0		
Observed Temperature (Ta), for (Ma) In Degrees C		21.50		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	676.22		
Relative Density of Water @ (Ta)		0.99791		
Relative Density of Water @ (Tx)		0.99757		
Correction Factor due to Temperature @Tx	(K)	0.9993		
Weight of Soil (gm)		100.01		
Weight of Dry Soil (gm)	(Mo)	99.84		
Weight of Pycnometer & Water (gm)	(Ma)	676.05		

SPECIFIC GRAVITY

G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)

	1	2	3	Gs Average
G @ 20 degrees C	2.734			2.734

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	RJ
DATE	5/31/00
CHECK	[illegible]
REVIEW	[illegible]

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	SBS - 11	-
PROJECT NO.	IC3-3822	**SAMPLE TYPE**	Bag	
REMARKS		**SAMPLE DEPT**	42.0 - 44.0'	

SAMPLE PREPARATION Sieved through the #8 Sieve: **No**

TEST APPARATUS Miller Soilbox and Nilsson 400 Soil Resistance Meter.

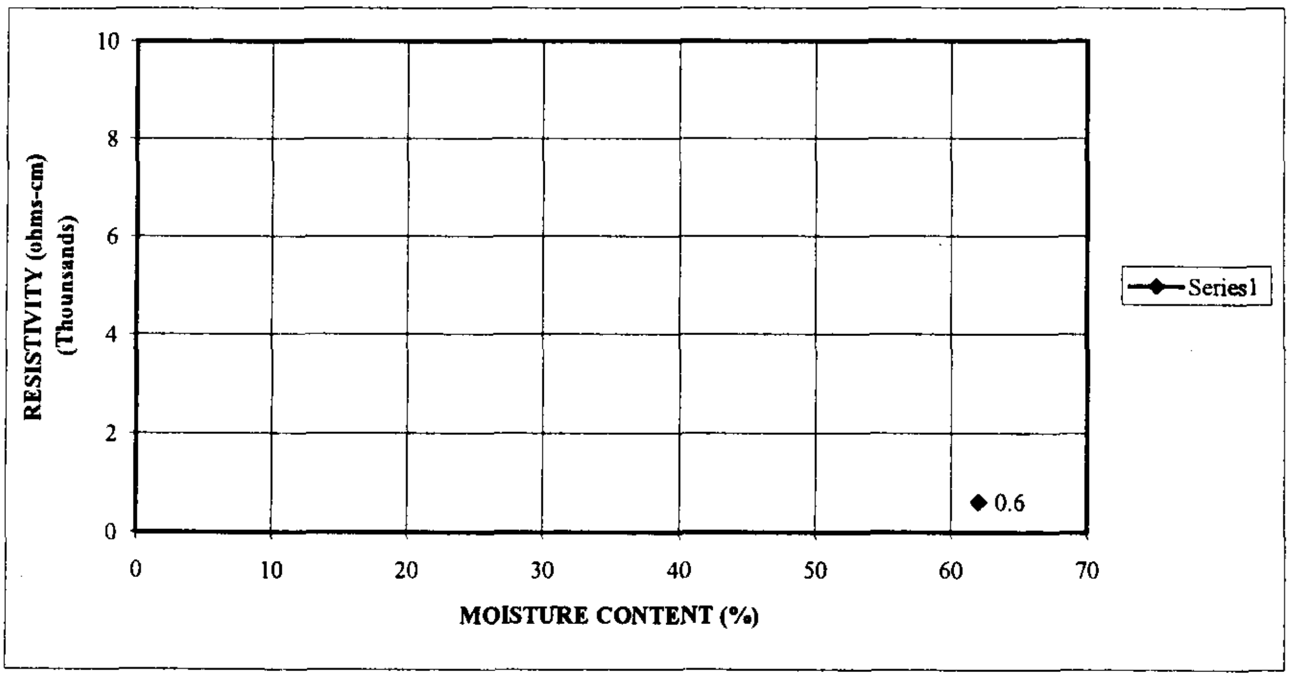
Identification:

Resisivity of the Site H_2O

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	520			1,400
TEMP DEGREES (C)	22.0			22.0
RESISTIVITY @ 15.5 C (ohms-cm)	605			1,628

MOISTURE CONTENT

WET WEIGHT & TARE	124.32			
DRY WEIGHT & TARE	93.30			
TARE WEIGHT	43.27			
WEIGHT OF MOISTURE (gm)	31.02			
WEIGHT OF DRY SOIL (gm)	50.03			
MOISTURE CONTENT (%)	62.00			



Description Gray, SILTY CLAY, some medium to fine sand.

USCS CH

TECH	PWM
DATE	5/30/00
CHECK	Cm
REVIEW	Cm

AR301324

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	SBS - 11
PROJECT NO.	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPT**	-

SAMPLE PREPARATION Sieved through the #8 Sieve — No

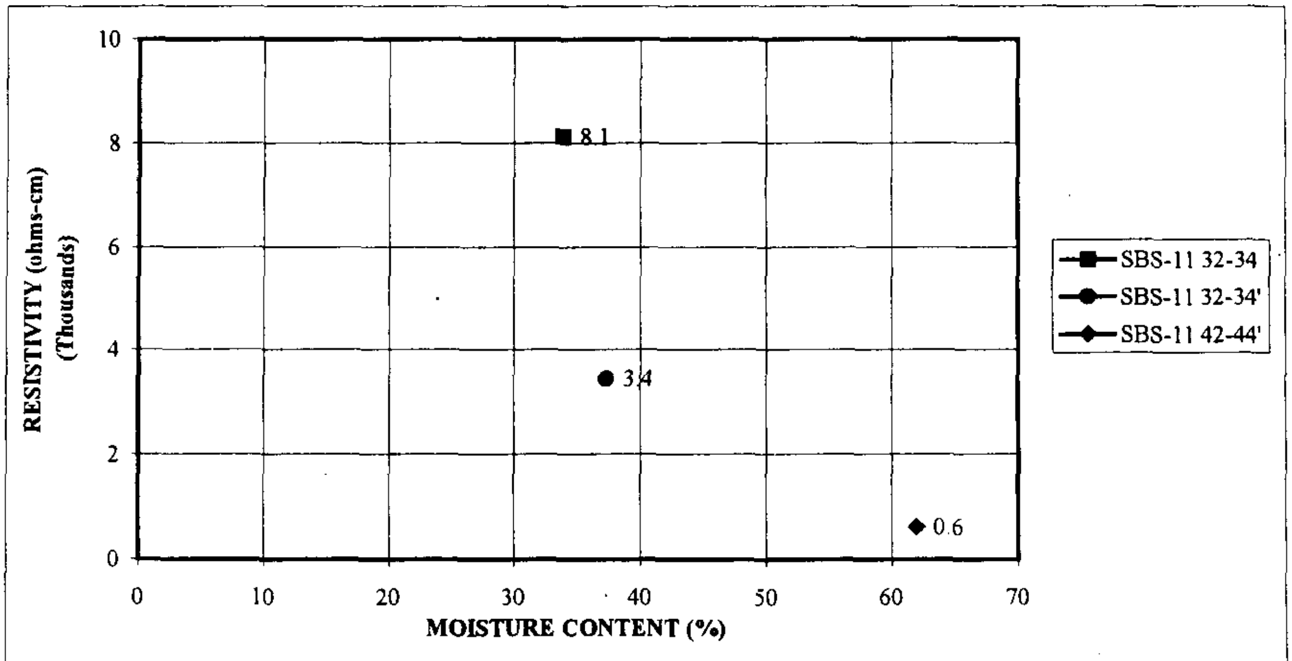
TEST APPARATUS Miller Soilbox and Nilsson 400 Soil Resistance Meter.

Identification:

				Resisivity of the Site H_2O
SAMPLE DEPTH	32.0 - 34.0'	32.0 - 34.0'	42.0 - 44.0'	
SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	7,300	3,100	520	1,400
TEMP DEGREES (C)	20.0	20.0	22.0	22.0
RESISTIVITY @ 15.5 C (ohms-cm)	8,121	3,449	605	1,628

MOISTURE CONTENT

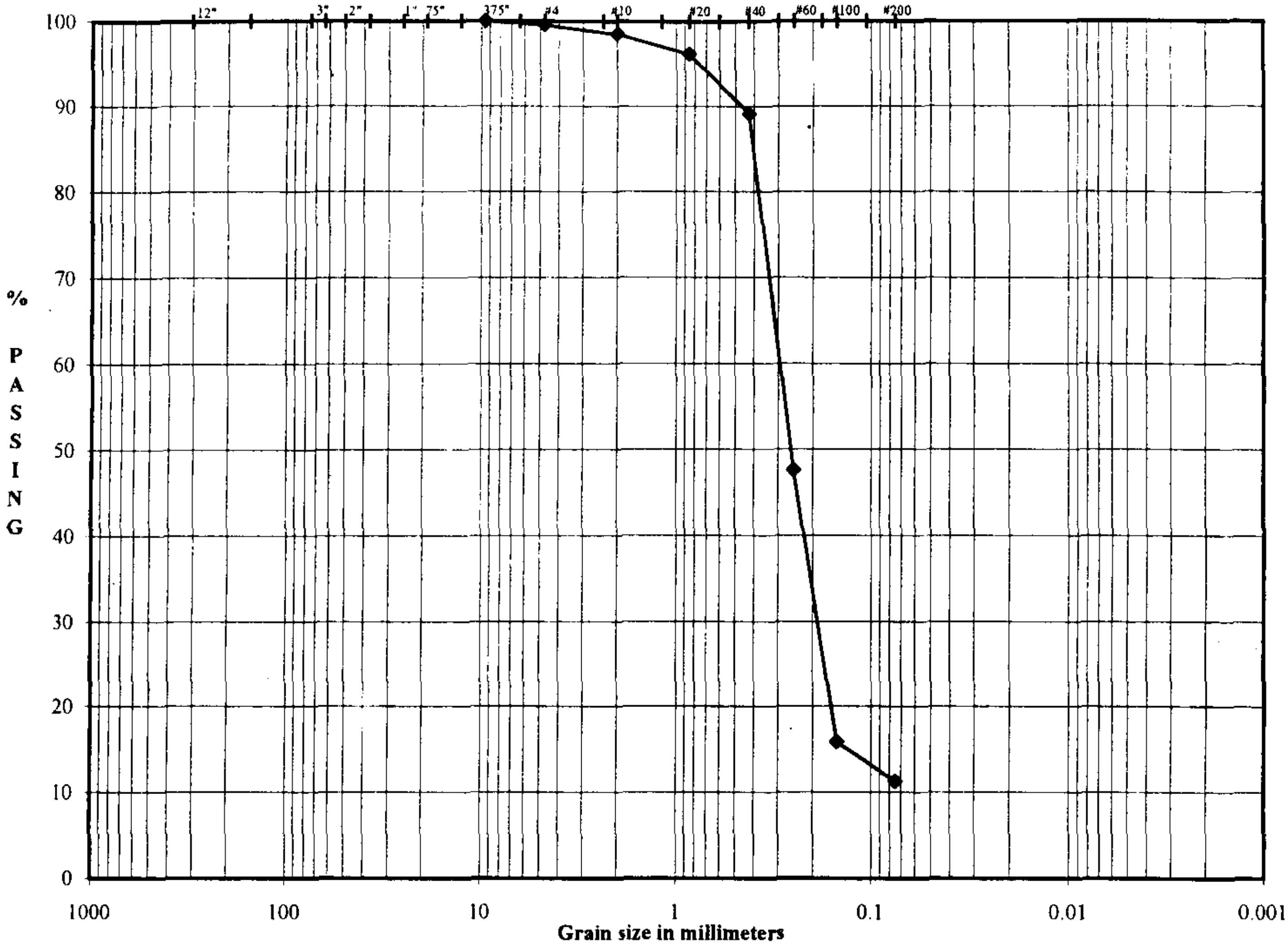
WET WEIGHT & TARE	260.77	268.90	124.32	
DRY WEIGHT & TARE	207.85	209.92	93.30	
TARE WEIGHT	51.58	51.90	43.27	
WEIGHT OF MOISTURE (gm)	52.92	58.98	31.02	
WEIGHT OF DRY SOIL (gm)	156.27	158.02	50.03	
MOISTURE CONTENT (%)	33.86	37.32	62.00	



Description	Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.
USCS	(SP-SM)

TECH	PWM
DATE	5/30/00
CHECK	QM
REVIEW	QM

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		**SAND**			**FINES**

SAMPLE ID	SBS - 12
SAMPLE TYPE	Bag
SAMPLE DEPTH	30.0 - 32.0'

LL	-
PL	-
PI	-

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS (SP-SM)

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	PWM/RJ
DATE	5/30/00
CHECK	Qu
REVIEW	Qu

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	SBS - 12 / -
PROJECT NO.	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPTH**	30.0 - 32.0'

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1-w2)	
Weight of Dry Soil (gm)	(w5=w2-w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Mois

Weight Of Sample (gm)	198.48
Tare Weight (gm)	51.78
(W6) Total Dry Weight (gm)	146.70

SIEVE ANALYSIS

Tare Weight: 0.00

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	0.00	0.00	0.00	100.00	0.375"	fine gravel
#4	0.70	0.70	0.48	99.52	#4	coarse sand
#10	2.24	2.24	1.53	98.47	#10	medium sand
#20	5.72	5.72	3.90	96.10	#20	medium sand
#40	15.96	15.96	10.88	89.12	#40	fine sand
#60	76.87	76.87	52.40	47.60	#60	fine sand
#100	123.39	123.39	84.11	15.89	#100	fine sand
#200	130.16	130.16	88.73	11.27	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.48
% C SAND	1.05
% M SAND	9.35
% F SAND	77.85
% FINES	11.27
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	2.728

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS (SP-SM)

TECH	PWM/RJ
DATE	5/30/00
CHECK	GW
REVIEW	GW

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA			
PROJECT NUMBER	IC3-3822	**SAMPLE ID**	SBS - 12	-
		SAMPLE TYPE	Bag	
TESTED FOR	GS	**SAMPLE DEPTH**	30.0 - 32.0'	

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	164.34
Weight Soil and Tare, Final (gm)	(W2)	163.75
Weight Of Tare (gm)	(W3)	42.10
Weight Of Moisture (gm)	(W4=W1-W2)	0.59
Weight Of Dry Soil (gm)	(W5=W2-W3)	121.65
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.5%

AIR REMOVAL METHOD
VACUUM

Trial		1	2	3
Pycnometer Number		16		
Weight Pycnometer Empty (gm)	(Mf)	171.51		
Weight of Soil & Pycnometer (gm)		271.52		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	732.22		
Observed Temperature (Tb), for (Mb) In Degrees C		23.0		
Observed Temperature (Ta), for (Ma) In Degrees C		22.50		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	669.20		
Relative Density of Water @ (Ta)		0.99768		
Relative Density of Water @ (Tx)		0.99757		
Correction Factor due to Temperature @Tx	(K)	0.9993		
Weight of Soil (gm)		100.01		
Weight of Dry Soil (gm)	(Mo)	99.53		
Weight of Pycnometer & Water (gm)	(Ma)	669.15		

SPECIFIC GRAVITY

				Gs Average
G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	2.728			2.728

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	RJ
DATE	5/31/00
CHECK	aw
REVIEW	[illegible]

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS - 12	-
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag	
REMARKS		SAMPLE DEPT	30.0 - 32.0'	

SAMPLE PREPARATION	Sieved through the #8 Sieve	No
TEST APPARATUS	Miller Soilbox and Nilsson 400 Soil Resistance Meter.	

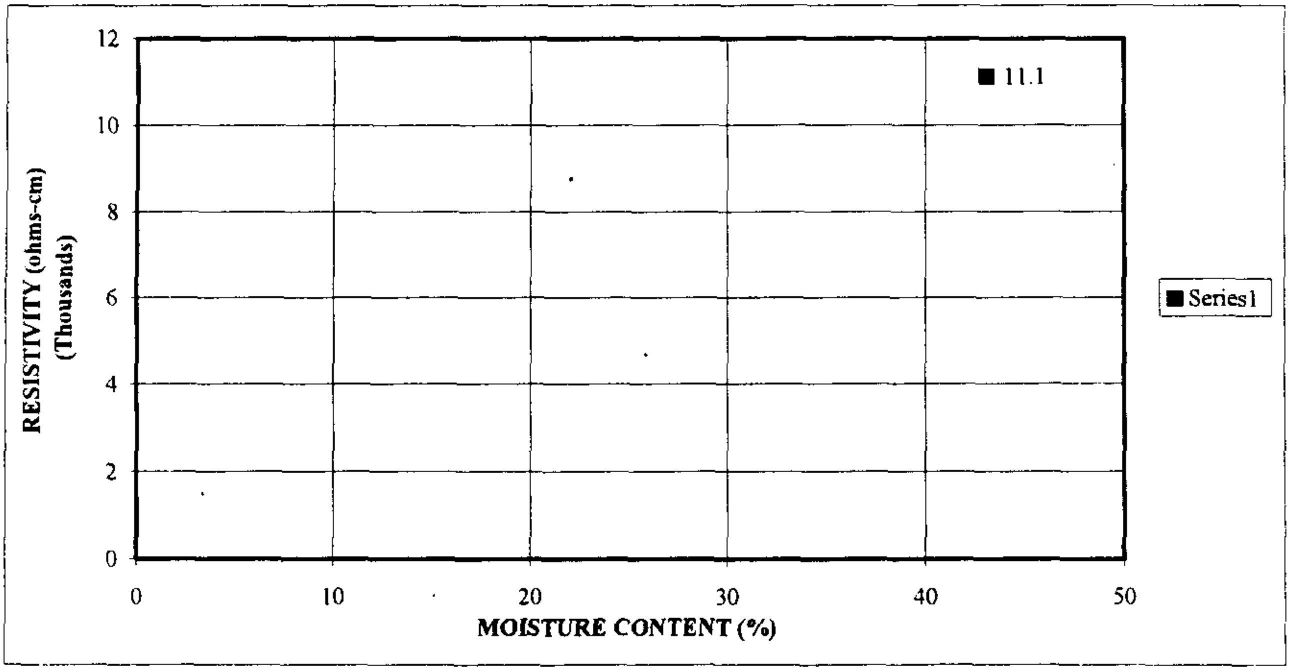
Identification:

Resisivity of the Site H_2O

SPECIMEN (Point)	1	2	3	4
RESISTIVITY *(ohms-cm)*	10,000			1,400
TEMP DEGREES (C)	20.0			22.0
RESISTIVITY @ 15.5 C (ohms-cm)	11,125			1,628

MOISTURE CONTENT

WET WEIGHT & TARE	258.77			
DRY WEIGHT & TARE	196.48			
TARE WEIGHT	51.78			
WEIGHT OF MOISTURE (gm)	62.29			
WEIGHT OF DRY SOIL (gm)	144.70			
MOISTURE CONTENT (%)	43.05			

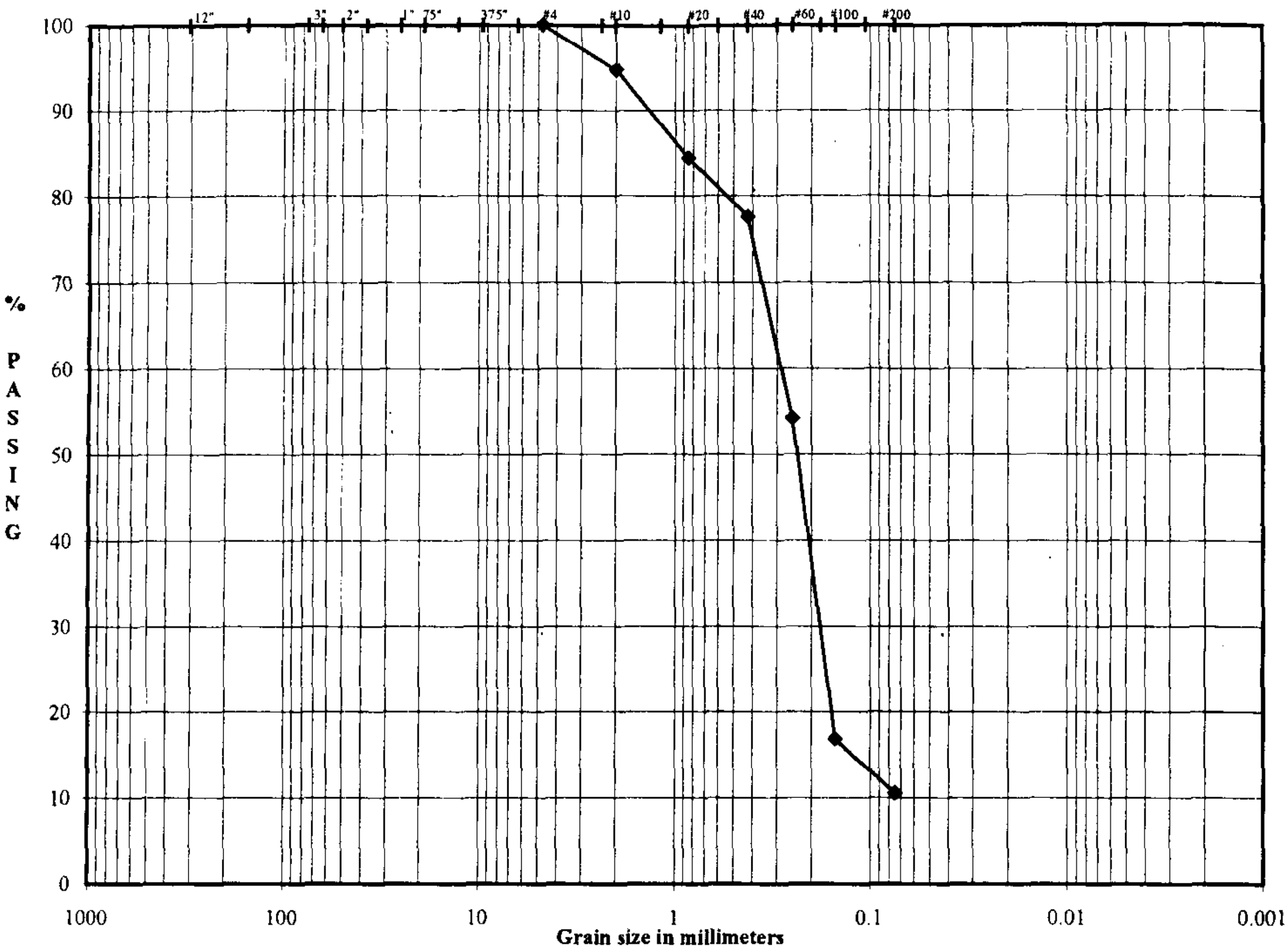


Description Reddish Brown, MEDIUM TO FINE SAND, little clayey silt, trace fine gravel.

USCS (SP-SM)

TECH	PWM
DATE	5/30/00
CHECK	(signature)
REVIEW	(signature)

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		**SAND**			**FINES**

SAMPLE ID	SBS - 12
SAMPLE TYPE	Bag
SAMPLE DEPTH	34.0 - 36.0'

LL	-
PL	-
PI	-

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, little clayey silt.

USCS (SP-SM)

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	PWM/RJ
DATE	5/30/00
CHECK	Cju
REVIEW	Cju

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	SBS - 12 / -
PROJECT NO.	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPTH**	34.0 - 36.0'

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1-w2)	
Weight of Dry Soil (gm)	(w5=w2-w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Mois

Weight Of Sample (gm)	229.90
Tare Weight (gm)	51.66
(W6) Total Dry Weight (gm)	178.24

SIEVE ANALYSIS

Tare Weight: 0.00

Sieve	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"					0.375"	fine gravel
#4	0.00	0.00	0.00	100.00	#4	coarse sand
#10	9.21	9.21	5.17	94.83	#10	medium sand
#20	27.70	27.70	15.54	84.46	#20	medium sand
#40	39.87	39.87	22.37	77.63	#40	fine sand
#60	81.63	81.63	45.80	54.20	#60	fine sand
#100	148.35	148.35	83.23	16.77	#100	fine sand
#200	159.45	159.45	89.46	10.54	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	5.17
% M SAND	17.20
% F SAND	67.09
% FINES	10.54
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	2.693

DESCRIPTION Reddish Brown, MEDIUM TO FINE SAND, little clayey silt.

USCS (SP-SM)

TECH	PWM/RJ
DATE	5/30/00
CHECK	[signature]
REVIEW	[signature]

AR301331

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS - 12	-
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
REMARKS		SAMPLE DEPT	34.0 - 36.0'

SAMPLE PREPARATION — Sieved through the #8 Sieve: No

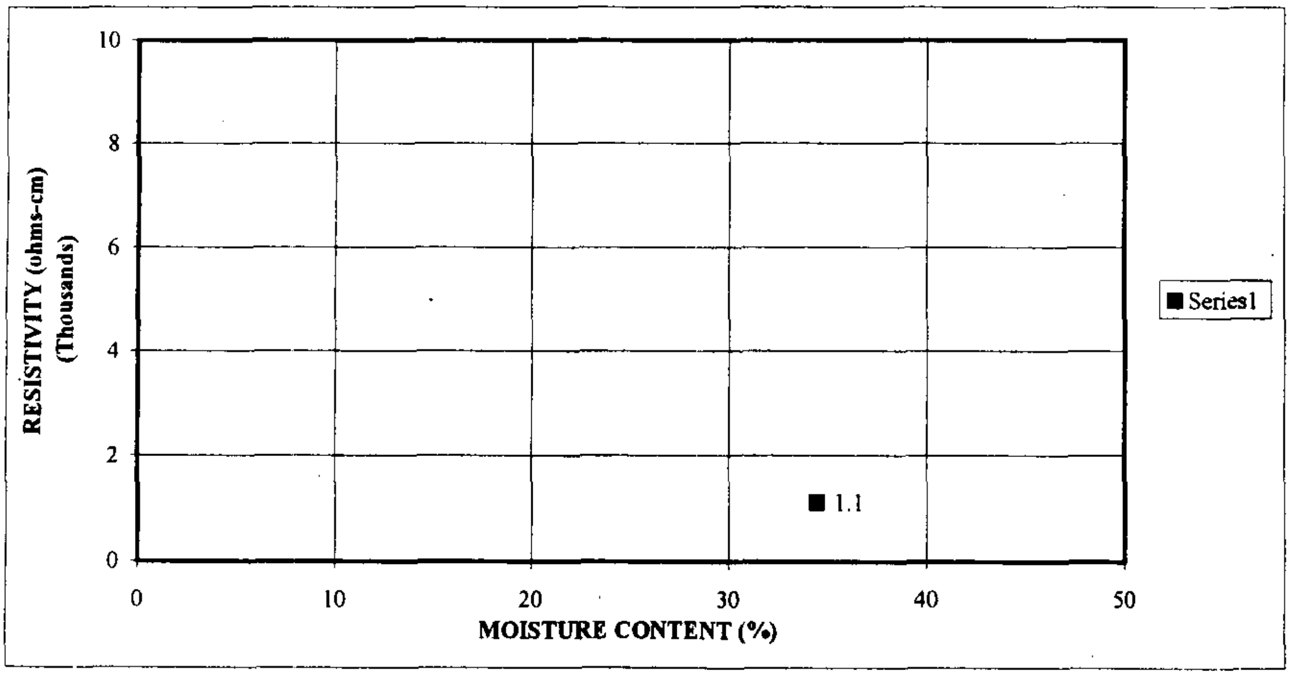
TEST APPARATUS — Miller Soilbox and Nilsson 400 Soil Resistance Meter.

Identification:

				Resisivity of the Site H_2O
SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	980			1,400
TEMP DEGREES (C)	21.0			22.0
RESISTIVITY @ 15.5 C (ohms-cm)	1,115			1,628

MOISTURE CONTENT

WET WEIGHT & TARE	291.27			
DRY WEIGHT & TARE	229.90			
TARE WEIGHT	51.66			
WEIGHT OF MOISTURE (gm)	61.37			
WEIGHT OF DRY SOIL (gm)	178.24			
MOISTURE CONTENT (%)	34.43			



Description: Reddish Brown, MEDIUM TO FINE SAND, little clayey silt.

USCS: (SP-SM)

TECH	PWM
DATE	5/30/00
CHECK	CAW
REVIEW	CAW

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS - 12
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
REMARKS		SAMPLE DEPT	-

SAMPLE PREPARATION — Sieved through the #8 Sieve: No

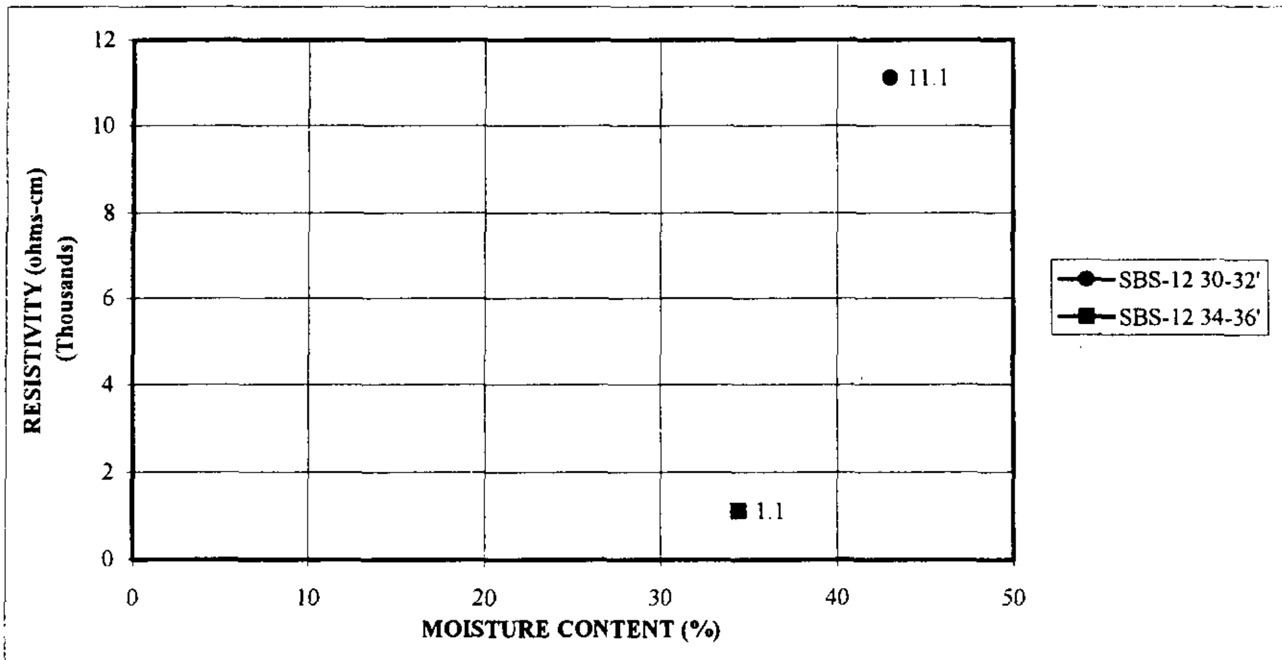
TEST APPARATUS — Miller Soilbox and Nilsson 400 Soil Resistance Meter.

Identification:

SAMPLE DEPTH	30.0 - 32.0'	34.0 - 36.0'		Resisivity of the Site H_2O
SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	10,000	980		1,400
TEMP DEGREES (C)	20.0	21.0		22.0
RESISTIVITY @ 15.5 C (ohms-cm)	11,125	1,115		1,628

MOISTURE CONTENT

WET WEIGHT & TARE	258.77	291.27		
DRY WEIGHT & TARE	196.48	229.90		
TARE WEIGHT	51.78	51.66		
WEIGHT OF MOISTURE (gm)	62.29	61.37		
WEIGHT OF DRY SOIL (gm)	144.70	178.24		
MOISTURE CONTENT (%)	43.05	34.43		

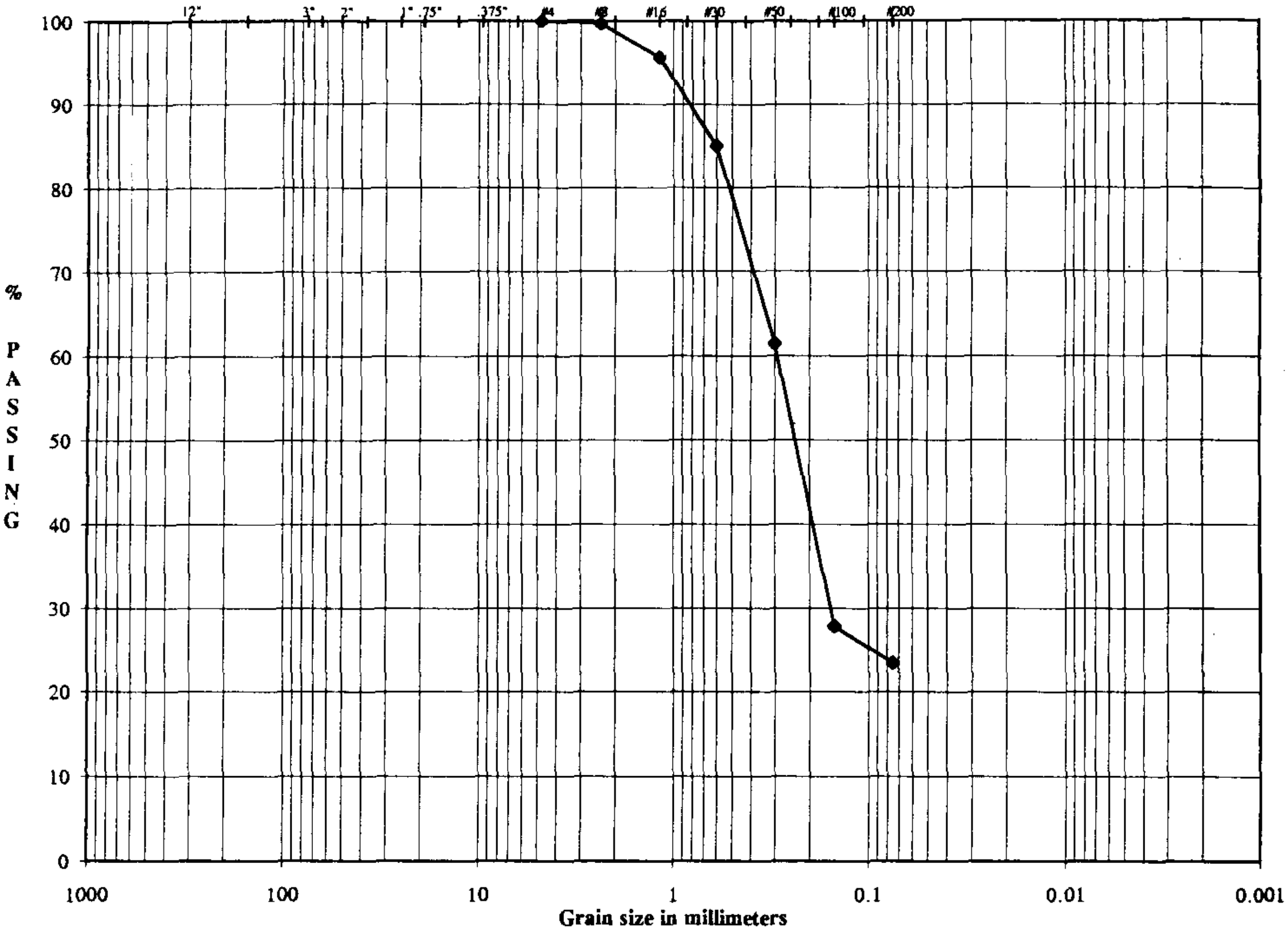


Description: Reddish Brown, MEDIUM TO FINE SAND, little clayey silt.

USCS: (SP-SM)

TECH	PWM
DATE	5/30/00
CHECK	Gm
REVIEW	Gm

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	SBS-13 -	LL	-
SAMPLE TYPE	Bag	PL	-
SAMPLE DEPTH	24.0 - 26.0'	PI	-

DESCRIPTION	Yellow Brown, MEDIUM TO FINE SAND, some clayey silt.
USCS	(SM)

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	RJ
DATE	7/27/00
CHECK	
REVIEW	

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS-13 -
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
REMARKS		SAMPLE DEPTH	24.0 - 26.0'

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1-w2)	
Weight of Dry Soil (gm)	(w5=w2-w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	182.13
	Tare Weight (gm)	43.13
(W6)	Total Dry Weight (gm)	139.00

SIEVE ANALYSIS

Tare Weight: 0.00

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"					0.375"	fine gravel
#4	0.00	0.00	0.00	100.00	#4	coarse sand
#8	0.50	0.50	0.36	99.64	#8	coarse sand
#16	6.07	6.07	4.37	95.63	#16	medium sand
#30	20.84	20.84	14.99	85.01	#30	medium sand
#50	53.57	53.57	38.54	61.46	#50	fine sand
#100	100.17	100.17	72.06	27.94	#100	fine sand
#200	106.42	106.42	76.56	23.44	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	1.32
% M SAND	25.39
% F SAND	49.85
% FINES	23.44
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	2.670

DESCRIPTION Yellow Brown, MEDIUM TO FINE SAND, some clayey silt.

USCS (SM)

TECH	RJ
DATE	7/27/00
CHECK	Cjw
REVIEW	Cjw

AR301335

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	IC3-3822	SAMPLE ID	SA - 13 / -
		SAMPLE TYPE	Bag
TESTED FOR	GS	SAMPLE DEPTH	24.0 - 26.0'

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	79.79
Weight Soil and Tare, Final (gm)	(W2)	79.78
Weight Of Tare (gm)	(W3)	51.82
Weight Of Moisture (gm)	(W4=W1-W2)	0.01
Weight Of Dry Soil (gm)	(W5=W2-W3)	27.96
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.0%

AIR REMOVAL METHOD

VACUUM

Trial		1	2	3
Pycnometer Number		19		
Weight Pycnometer Empty (gm)	(Mf)	177.09		
Weight of Soil & Pycnometer (gm)		277.09		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	738.18		
Observed Temperature (Tb), for (Mb) In Degrees C		22.0		
Observed Temperature (Ta), for (Ma) In Degrees C		21.50		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	675.69		
Relative Density of Water @ (Ta)		0.99791		
Relative Density of Water @ (Tx)		0.99780		
Correction Factor due to Temperature @Tx	(K)	0.9996		
Weight of Soil (gm)		100.00		
Weight of Dry Soil (gm)	(Mo)	99.96		
Weight of Pycnometer & Water (gm)	(Ma)	675.64		

SPECIFIC GRAVITY

G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	2.670			Gs Average: 2.670

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	RJ
DATE	7/26/00
CHECK	GW
REVIEW	GW

AR301336

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS-13
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
REMARKS		SAMPLE DEPT	24.0 - 26.0'

SAMPLE PREPARATION Sieved through the #8 Sieve: No

TEST APPARATUS Miller Soilbox and Nilsson 400 Soil Resistance Meter.

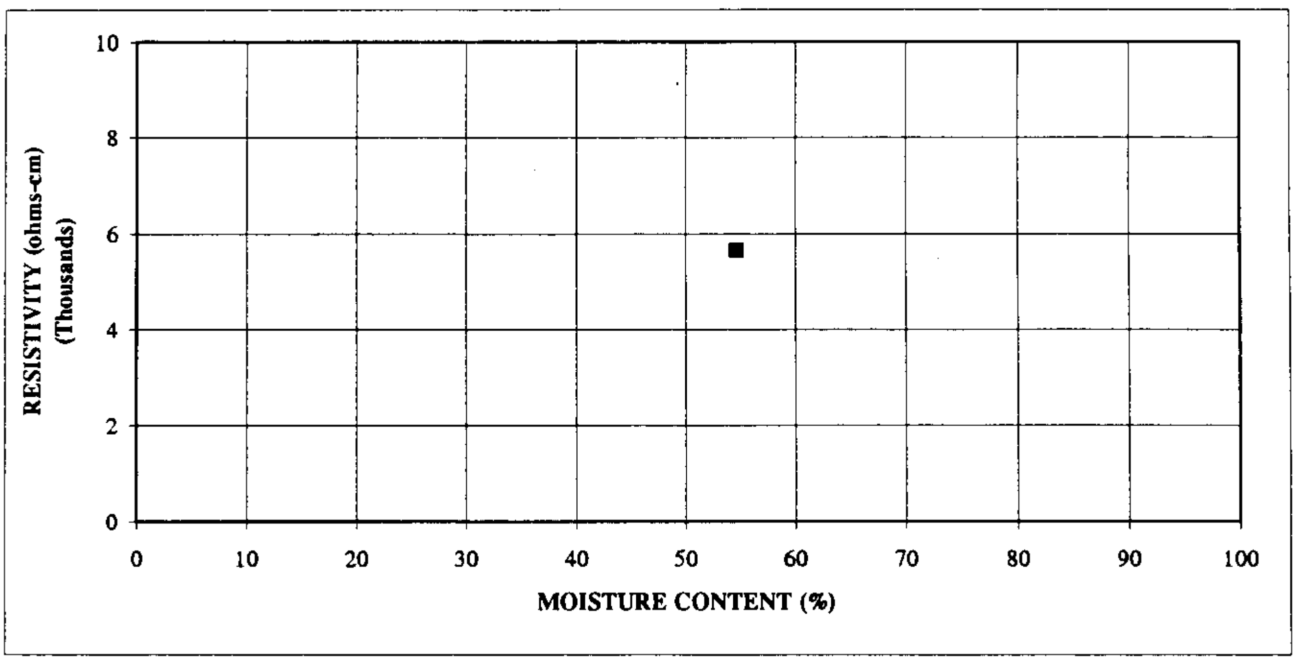
Identification:

Lowest resistivity

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	5,200			
TEMP DEGREES (C)	19.0			
RESISTIVITY @ 15.5 C (ohms-cm)	5,655			

MOISTURE CONTENT

WET WEIGHT & TARE	258.06			
DRY WEIGHT & TARE	182.13			
TARE WEIGHT	43.13			
WEIGHT OF MOISTURE (gm)	75.93			
WEIGHT OF DRY SOIL (gm)	139.00			
MOISTURE CONTENT (%)	54.63			

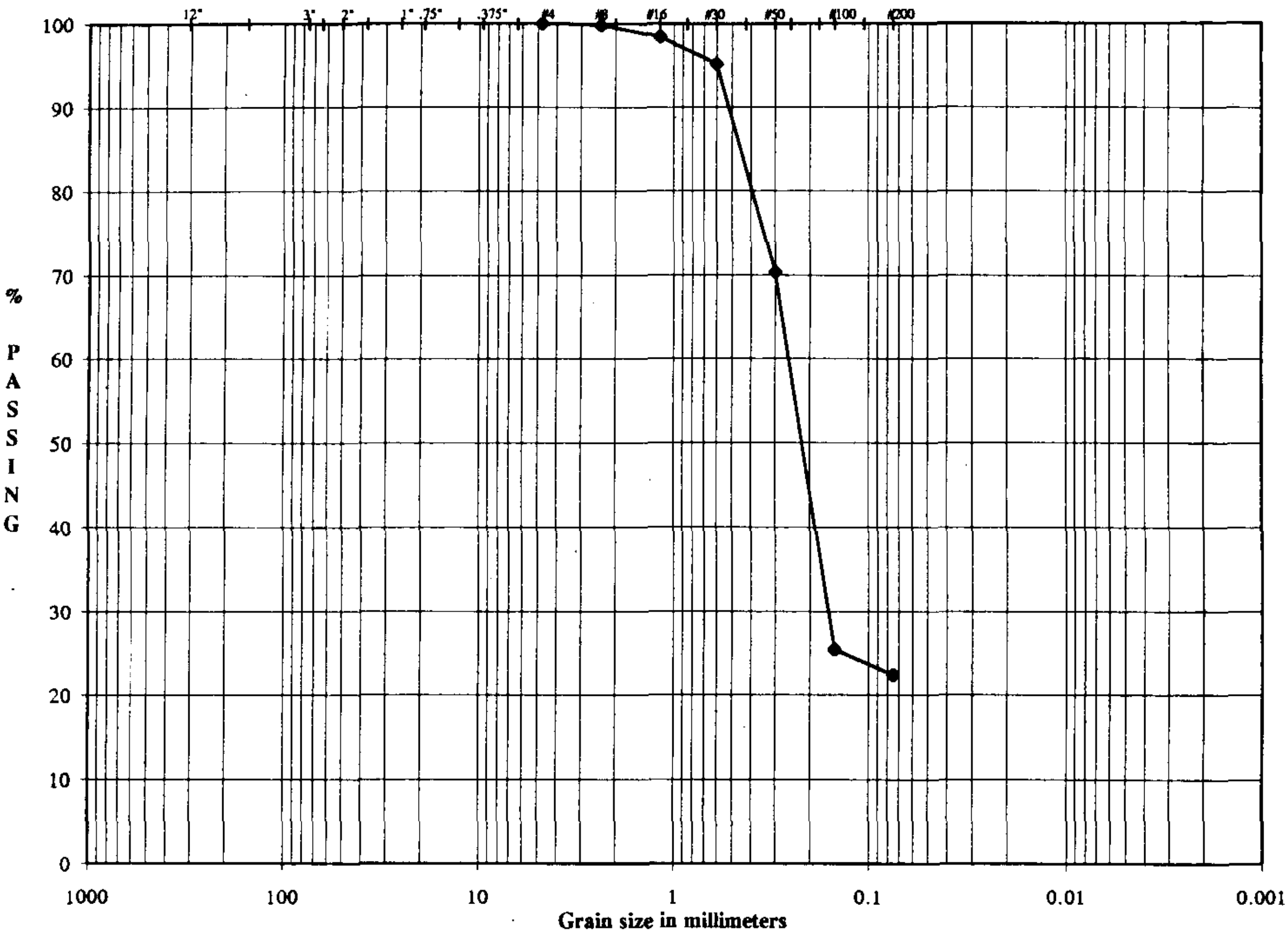


Description: Yellow Brown, MEDIUM TO FINE SAND, some clayey silt.

USCS: (SM)

TECH	RJ
DATE	7/25/00
CHECK	Gw
REVIEW	Gw

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Gravel		SAND			FINES
		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY

SAMPLE ID	SBS-13 -
SAMPLE TYPE	Bag
SAMPLE DEPTH	28.0 - 30.0'

LL	-
PL	-
PI	-

DESCRIPTION	Yellow Brown, MEDIUM TO FINE SAND, some clayey silt.
USCS	(SM)

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	RJ
DATE	7/27/00
CHECK	CAM
REVIEW	CAM

AR301338

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS-13 -
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
REMARKS		SAMPLE DEPTH	28.0 - 30.0'

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1-w2)	
Weight of Dry Soil (gm)	(w5=w2-w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	188.04
	Tare Weight (gm)	42.28
(W6)	Total Dry Weight (gm)	145.76

SIEVE ANALYSIS

Tare Weight: 0.00

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"					0.375"	fine gravel
#4	0.00	0.00	0.00	100.00	#4	coarse sand
#8	0.25	0.25	0.17	99.83	#8	coarse sand
#16	2.23	2.23	1.53	98.47	#16	medium sand
#30	7.03	7.03	4.82	95.18	#30	medium sand
#50	43.29	43.29	29.70	70.30	#50	fine sand
#100	108.73	108.73	74.60	25.40	#100	fine sand
#200	113.09	113.09	77.59	22.41	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.50
% M SAND	16.70
% F SAND	60.39
% FINES	22.41
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	2.678

DESCRIPTION: **Yellow Brown, MEDIUM TO FINE SAND, some clayey silt.**

USCS: (SM)

TECH	RJ
DATE	7/27/00
CHECK	
REVIEW	

AR301339

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	IC3-3822	SAMPLE ID	SA - 15 / -
		SAMPLE TYPE	Bag
TESTED FOR	GS	SAMPLE DEPTH	28.0 - 30.0'

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	76.80
Weight Soil and Tare, Final (gm)	(W2)	76.71
Weight Of Tare (gm)	(W3)	43.14
Weight Of Moisture (gm)	(W4=W1-W2)	0.09
Weight Of Dry Soil (gm)	(W5=W2-W3)	33.57
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.3%

AIR REMOVAL METHOD

VACUUM

Trial		1	2	3
Pycnometer Number		17		
Weight Pycnometer Empty (gm)	(Mf)	190.71		
Weight of Soil & Pycnometer (gm)		290.72		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	751.75		
Observed Temperature (Tb), for (Mb) In Degrees C		22.0		
Observed Temperature (Ta), for (Ma) In Degrees C		22.00		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	689.24		
Relative Density of Water @ (Ta)		0.99780		
Relative Density of Water @ (Tx)		0.99780		
Correction Factor due to Temperature @Tx	(K)	0.9996		
Weight of Soil (gm)		100.01		
Weight of Dry Soil (gm)	(Mo)	99.74		
Weight of Pycnometer & Water (gm)	(Ma)	689.24		

SPECIFIC GRAVITY

				Gs Average
G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	2.678			2.678

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	RJ
DATE	7/26/00
CHECK	[illegible]
REVIEW	[illegible]

AR301340

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS-13
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
REMARKS		SAMPLE DEPT	28.0 - 30.0'

SAMPLE PREPARATION Sieved through the #8 Sieve: No

TEST APPARATUS Miller Soilbox and Nilsson 400 Soil Resistance Meter.

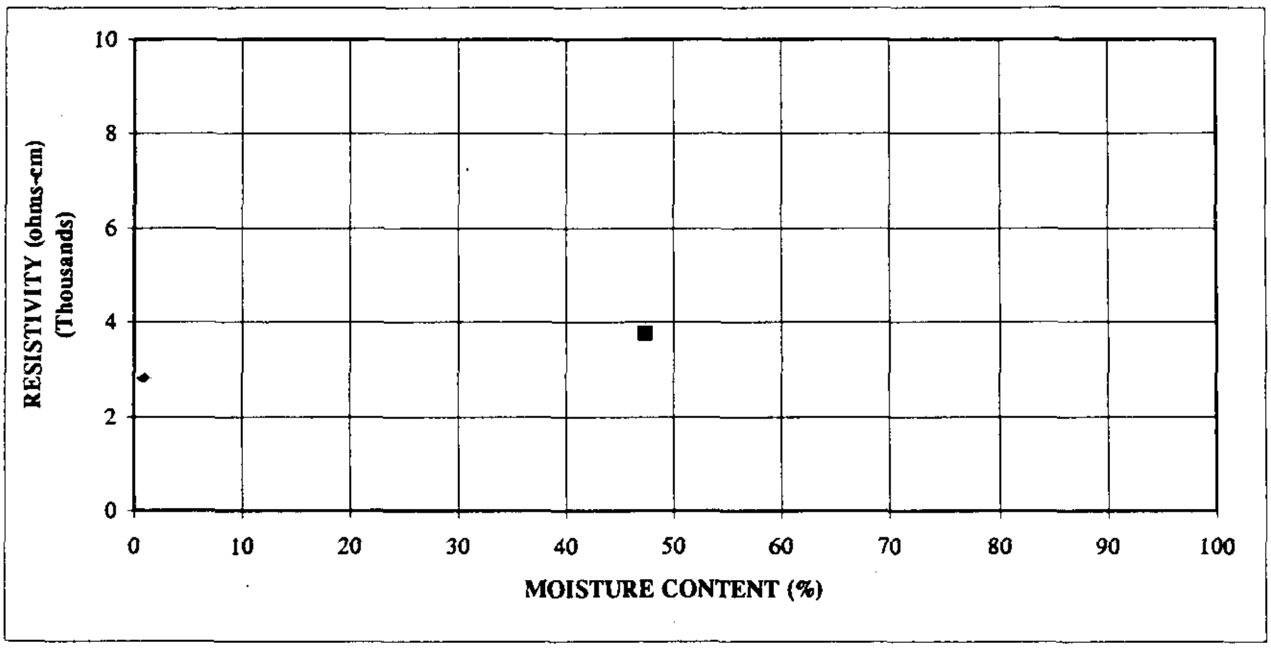
Identification:

Lowest resistivity

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	3,500			
TEMP DEGREES (C)	18.5			
RESISTIVITY @ 15.5 C (ohms-cm	3,763			

MOISTURE CONTENT

WET WEIGHT & TARE	257.07			
DRY WEIGHT & TARE	188.04			
TARE WEIGHT	42.28			
WEIGHT OF MOISTURE (gm)	69.03			
WEIGHT OF DRY SOIL (gm)	145.76			
MOISTURE CONTENT (%)	47.36			

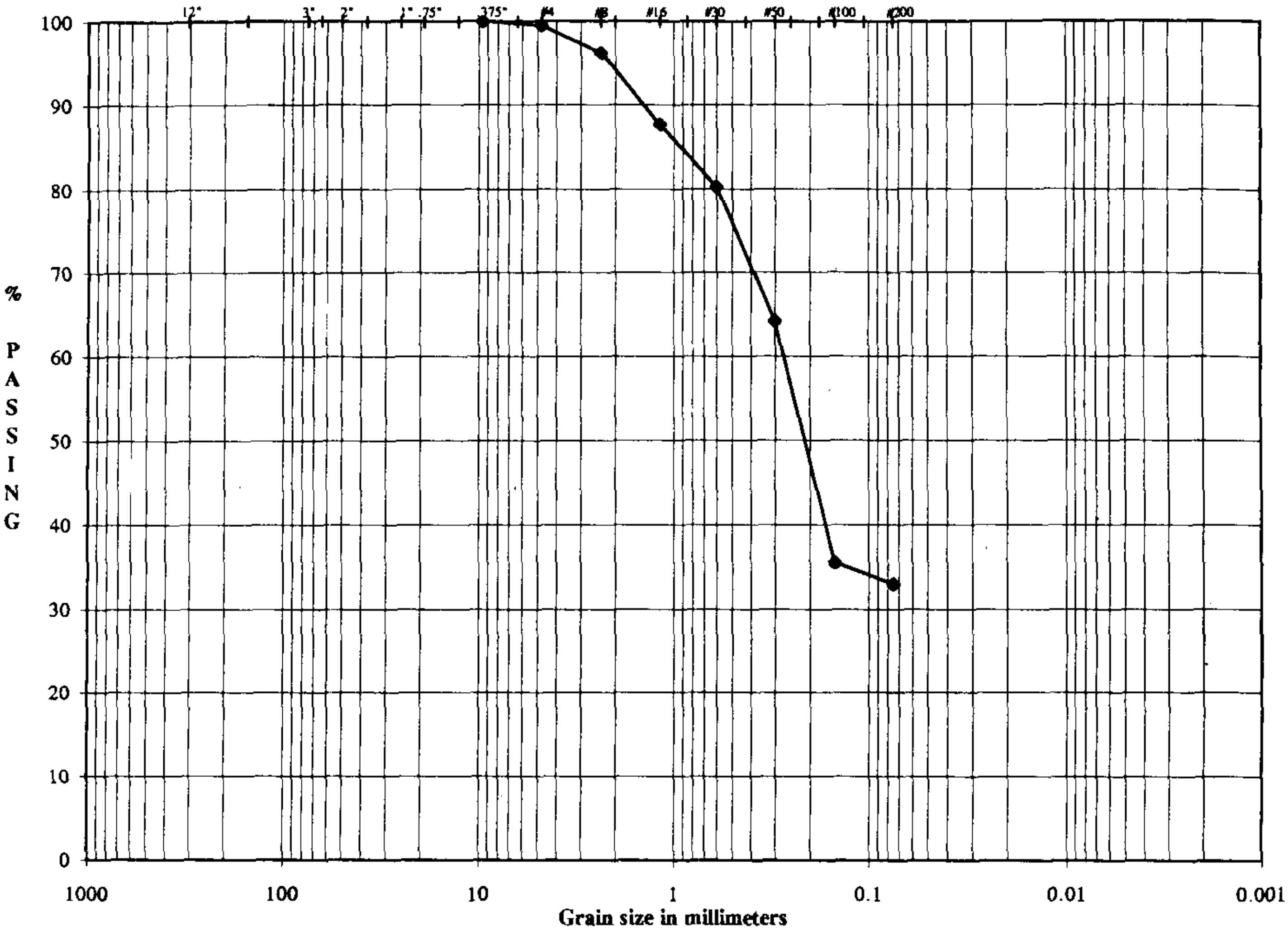


Description	Yellow Brown, MEDIUM TO FINE SAND, some clayey silt.
USCS	(SM)

TECH	RJ
DATE	7/25/00
CHECK	(initials)
REVIEW	(initials)

AR301341

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	SBS-13 -
SAMPLE TYPE	Bag
SAMPLE DEPTH	32.0 - 34.0'

LL	-
PL	-
PI	-

DESCRIPTION	Yellow Brown, MEDIUM TO FINE SAND, and clayey silt.
USCS	(SM)

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	RJ
DATE	7/27/00
CHECK	
REVIEW	

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	**SALTIRE/996-1100 IRON REACTIVE WALL/VA**	**SAMPLE ID**	**SBS-13** -
PROJECT NO.	**IC3-3822**	**SAMPLE TYPE**	**Bag**
REMARKS		**SAMPLE DEPTH**	**32.0 - 34.0'**

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1-w2)	
Weight of Dry Soil (gm)	(w5=w2-w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	180.20
	Tare Weight (gm)	50.69
(W6)	Total Dry Weight (gm)	129.51

SIEVE ANALYSIS

Tare Weight: 0.00

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"	0.00	0.00	0.00	100.00	0.375"	fine gravel
#4	0.72	0.72	0.56	99.44	#4	coarse sand
#8	4.92	4.92	3.80	96.20	#8	coarse sand
#16	15.96	15.96	12.32	87.68	#16	medium sand
#30	25.56	25.56	19.74	80.26	#30	medium sand
#50	46.44	46.44	35.86	64.14	#50	fine sand
#100	83.57	83.57	64.53	35.47	#100	fine sand
#200	86.80	86.80	67.02	32.98	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.56
% C SAND	5.28
% M SAND	21.92
% F SAND	39.27
% FINES	32.98
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	2.680

DESCRIPTION **Yellow Brown, MEDIUM TO FINE SAND, and clayey silt.**

USCS (SM)

TECH	RJ
DATE	7/27/00
CHECK	Cm
REVIEW	Cm

AR301343

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	IC3-3822	**SAMPLE ID**	SA - 17 | -
		SAMPLE TYPE	Bag
TESTED FOR	GS	**SAMPLE DEPTH**	32.0 - 34.0'

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	94.96
Weight Soil and Tare, Final (gm)	(W2)	94.88
Weight Of Tare (gm)	(W3)	51.23
Weight Of Moisture (gm)	(W4=W1-W2)	0.08
Weight Of Dry Soil (gm)	(W5=W2-W3)	43.65
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.2%

AIR REMOVAL METHOD

VACUUM

Trial		1	2	3
Pycnometer Number		29		
Weight Pycnometer Empty (gm)	(Mf)	187.75		
Weight of Soil & Pycnometer (gm)		287.75		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	748.78		
Observed Temperature (Tb), for (Mb) In Degrees C		22.0		
Observed Temperature (Ta), for (Ma) In Degrees C		22.00		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	686.19		
Relative Density of Water @ (Ta)		0.99780		
Relative Density of Water @ (Tx)		0.99780		
Correction Factor due to Temperature @Tx	(K)	0.9996		
Weight of Soil (gm)		100.00		
Weight of Dry Soil (gm)	(Mo)	99.82		
Weight of Pycnometer & Water (gm)	(Ma)	686.19		

SPECIFIC GRAVITY

				Gs Average
G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	2.680			2.680

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	RJ
DATE	7/26/00
CHECK	[illegible]
REVIEW	[illegible]

RESISTIVITY OF SOIL
ASTM G-57 AND U.S. DOT FP-85

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBS-13
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
REMARKS		SAMPLE DEPT	32.0 - 34.0'

SAMPLE PREPARATION — Sieved through the #8 Sieve: No

TEST APPARATUS — Miller Soilbox and Nilsson 400 Soil Resistance Meter.

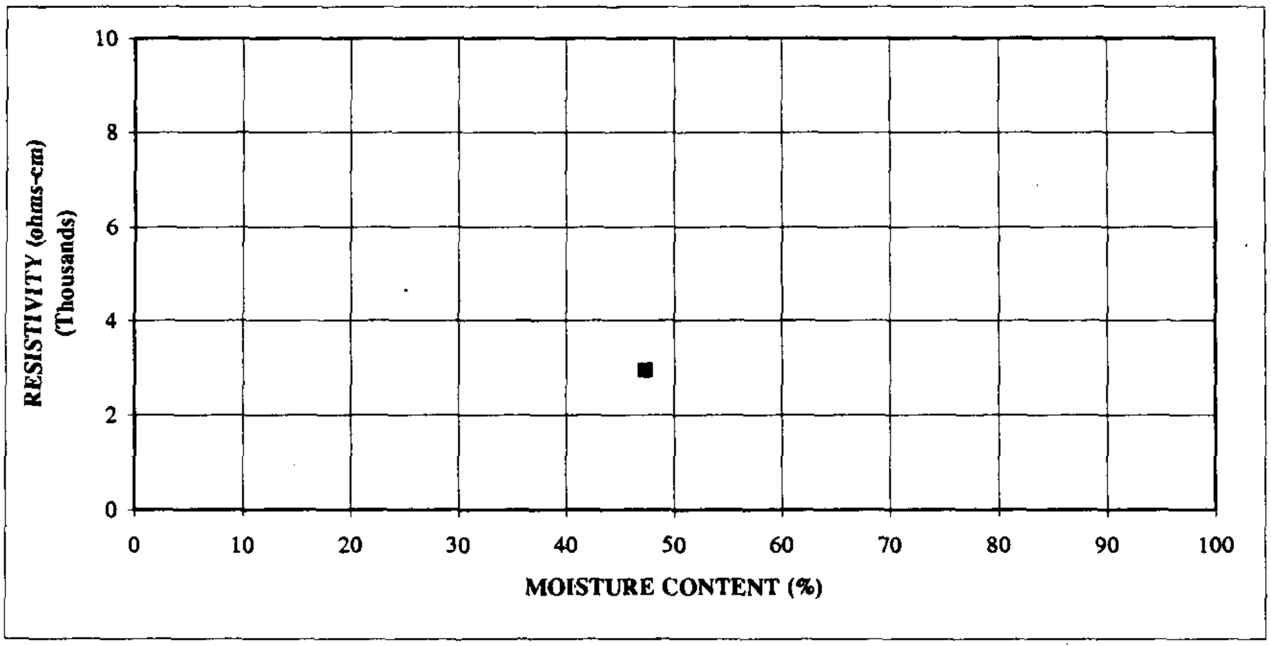
Identification:

Lowest resistivity

SPECIMEN (Point)	1	2	3	4
RESISTIVITY (ohms-cm)	2,700			
TEMP DEGREES (C)	19.0			
RESISTIVITY @ 15.5 C (ohms-cm	2,936			

MOISTURE CONTENT

WET WEIGHT & TARE	241.46			
DRY WEIGHT & TARE	180.20			
TARE WEIGHT	50.69			
WEIGHT OF MOISTURE (gm)	61.26			
WEIGHT OF DRY SOIL (gm)	129.51			
MOISTURE CONTENT (%)	47.30			



Description: Yellow Brown, MEDIUM TO FINE SAND, and clayey silt.

USCS: (SM)

TECH	RJ
DATE	7/25/00
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REVIEW	[signature]

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME: SALTIRE/996-1100 IRON REACTIVE WALL/VA
PROJECT NUMBER: IC3-3822
SAMPLE ID: SBD - 2 **SAMPLE DEPTH:** 57.0 - 59.0'
SAMPLE TYPE: Bag

SAMPLE PREPARATION

Wet or Dry: Dry

Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION		NATURAL MOISTURE
Number of Blows				6	8	
Weight of Wet Soil & Tare (gm)	25.85	22.18	22.43	28.02	26.50	199.94
Weight of Dry Soil & Tare (gm)	22.20	19.52	19.71	22.29	21.36	156.63
Weight of Tare (gm)	11.41	11.40	11.31	4.30	4.34	42.93
Weight of Water (gm)	3.65	2.66	2.72	5.73	5.14	43.31
Weight of Dry Soil (gm)	10.79	8.12	8.40	17.99	17.02	113.70
Water Content %	33.83	32.76	32.38	31.85	30.20	38.09

PLASTIC LIMIT (PL): NP

LIQUID LIMIT (LL): NP

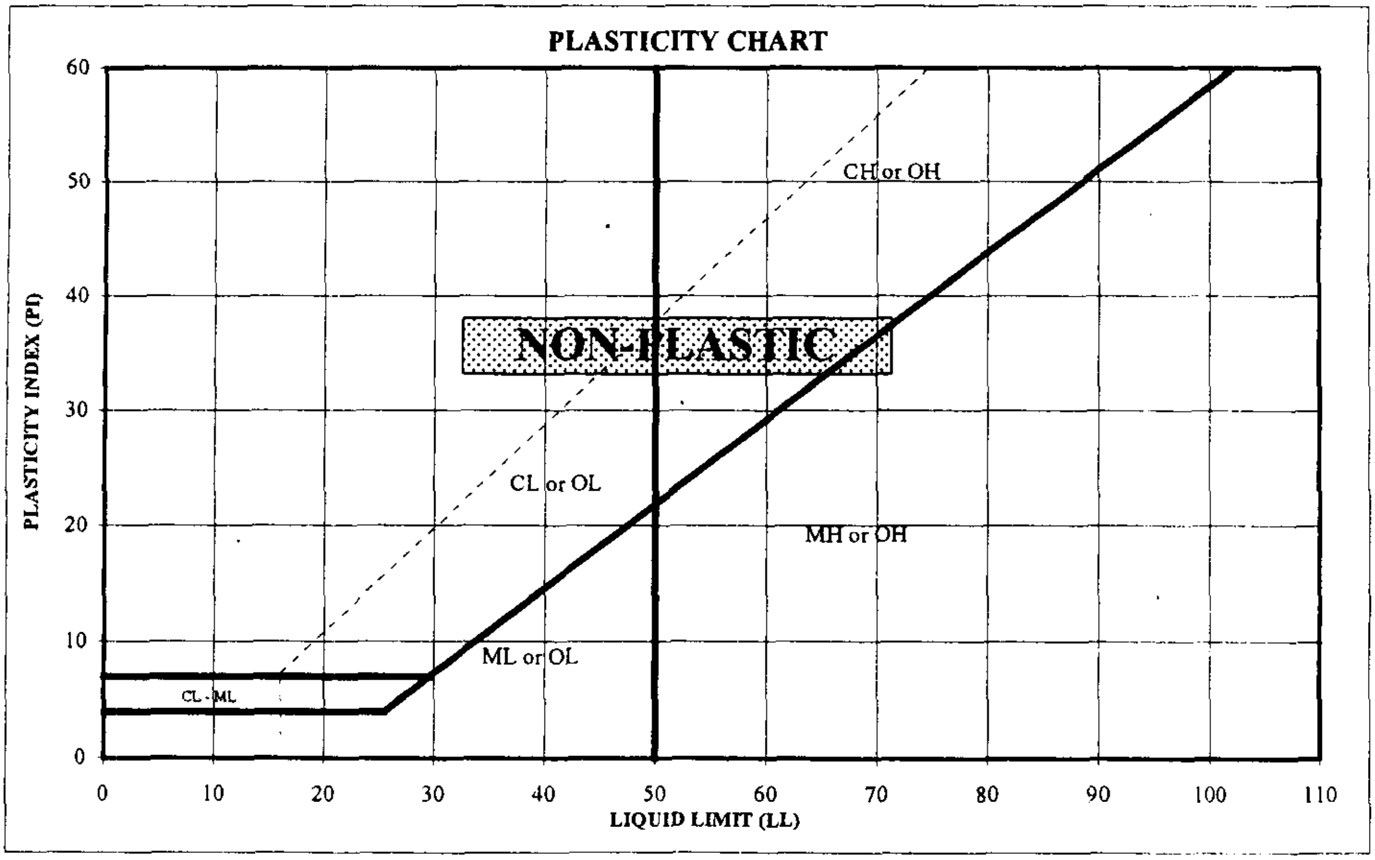
PLASTICITY INDEX (PI): NP

LIQUIDITY INDEX (LI): NP

NOTE:

DESCRIPTION: Gray, FINE SAND, some clayey silt.

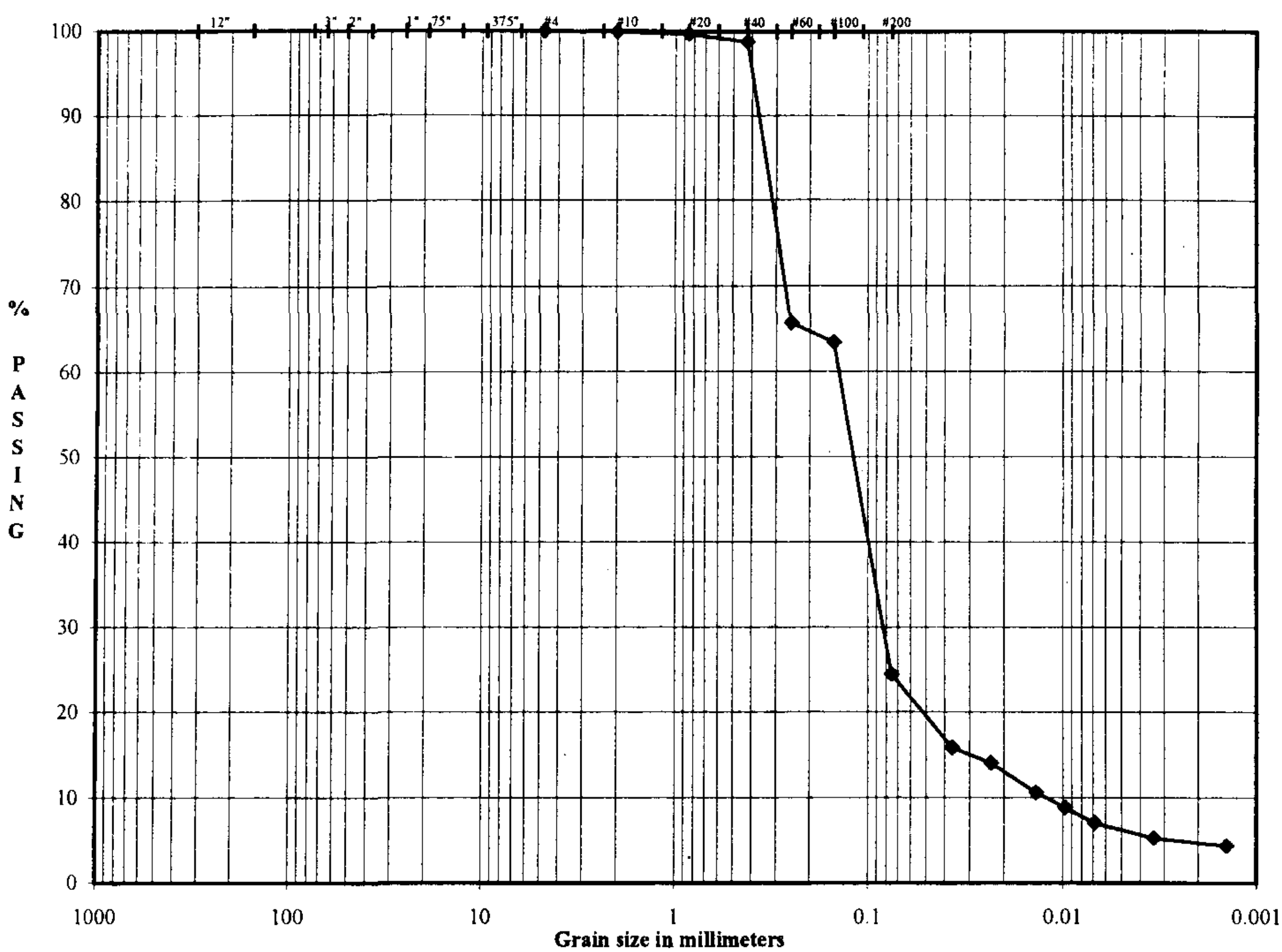
USCS: SM



TECH	DH
DATE	6/9/00
CHECK	CW
REVIEW	CW

AR301346

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		**SAND**			**FINES**

SAMPLE ID	SBD-2
SAMPLE TYPE	Bag
SAMPLE DEPTH	57.0 - 59.0'

LL	NP
PL	NP
PI	NP

DESCRIPTION Gray, FINE SAND, some clayey silt.

USCS SM

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	RJ/SW
DATE	6/8/00
CHECK	CJW
REVIEW	CJW

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBD-2 / -
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
		SAMPLE DEPTH	57.0 - 59.0'

AS RECEIVED WATER CONTENT

Tare No		-
Wt. Wet Soil & Tare (gm)	(W1)	199.94
Wt. Dry Soil & Tare (gm)	(W2)	156.63
Weight of Tare (gm)	(W3)	42.93
Weight of Water (gm)	(W4=W1-W2)	43.31
Weight of Dry Soil (gm)	(W5=W2-W3)	113.70
Moisture Content (%)	(W4/W5)*100	38.09

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	57.92
Dry Soil & Tare (gm)	57.21
Tare Weight (gm)	3.24
Moisture Content (%)	1.32

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	837.16	
Tare Weight (gm)	242.44	
Total Weight (gm)	587.00	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	% PASSING	Sieve	
12.0"				12.0"	cobbles
3.0"				3.0"	coarse gravel
2.5"				2.5"	coarse gravel
2.0"				2.0"	coarse gravel
1.5"				1.5"	coarse gravel
1.0"				1.0"	coarse gravel
0.75"				0.75"	fine gravel
0.50"				0.50"	fine gravel
0.375"				0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.650
Specific Gravity	(tested)	
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	57.56
Calculated Dry Wt. used in test (gm)	56.81
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 0.00

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	0.07	0.07	**99.9**	#10	medium sand
#20	0.18	0.18	**99.7**	#20	medium sand
#40	0.70	0.70	**98.8**	#40	fine sand
#60	19.51	19.51	**65.7**	#60	fine sand
#100	20.80	20.80	**63.4**	#100	fine sand
#200	42.92	42.92	**24.5**	#200	fines

HYDROMETER CALCULATIONS

DATE 6/9/00	TIME 9:16	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/9/00	9:18	2.00	15.0	21.50	0.014	6.00	9.00	14.8	1.00
6/9/00	9:21	5.00	14.0	21.50	0.014	6.00	8.00	15.0	1.00
6/9/00	9:31	15.00	12.0	21.50	0.014	6.00	6.00	15.3	1.00
6/9/00	9:46	30.00	11.0	21.50	0.014	6.00	5.00	15.5	1.00
6/9/00	10:16	60.00	10.0	21.50	0.014	6.00	4.00	15.6	1.00
6/9/00	13:26	250.00	9.0	21.50	0.014	6.00	3.00	15.8	1.00
6/10/00	9:16	1440.00	8.5	21.00	0.014	6.00	2.50	16.0	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING		
0.0367	15.8	% COBBLES	0.00
0.0234	14.1	% COARSE GRAVEL	0.00
0.0136	10.6	% FINE GRAVEL	0.00
0.0097	8.8	% COARSE SAND	0.12
0.0069	7.0	% MEDIUM SAND	1.11
0.0034	5.3	% FINE SAND	74.31
0.0014	4.4	% FINES	24.45
		% TOTAL SAMPLE	100.00

Description Gray, FINE SAND, some clayey silt.

USCS SM

NP	LL
NP	PL
NP	PI

TECH	RJ/SW
DATE	6/8/00
CHECK	[signature]
REVIEW	[signature]

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	SBD-2 / -
PROJECT NO.	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPTH**	59.0 - 61.0'

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	400.20
Wt Dry Soil & Tare (gm)	(w2)	294.20
Weight of Tare (gm)	(w3)	0.00
Weight of Water (gm)	(w4=w1-w2)	106.00
Weight of Dry Soil (gm)	(w5=w2-w3)	294.20
Moisture Content (%)	(w4/w5)*100	36.03

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Mois

Weight Of Sample (gm)	123.08
Tare Weight (gm)	51.35
(W6) Total Dry Weight (gm)	71.73

SIEVE ANALYSIS

Tare Weight: 51.35

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"					0.375"	fine gravel
#4					#4	coarse sand
#10					#10	medium sand
#20					#20	medium sand
#40					#40	fine sand
#60					#60	fine sand
#100					#100	fine sand
#200	102.54	51.19	71.36	28.64	#200	fines
PAN					PAN	

% COBBLES	
% C GRAVEL	
% F GRAVEL	
% C SAND	
% M SAND	
% F SAND	
% FINES	28.64
% TOTAL	

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	-

DESCRIPTION Gray, FINE SAND, some clayey silt.

USCS (SM)

TECH	JS/TJ
DATE	10/18/00
CHECK	[signature]
REVIEW	[signature]

FLOW PUMP #2A

FLEXIBLE WALL PERMEABILITY
ASTM D 5084
METHOD D, CONSTANT RATE OF FLOW

PROJECT TITLE	GSL/IC3-3822 SALTIRE/VA
PROJECT NUMBER	IC3-3822
SAMPLE ID	SBD-2 - 59.0 - 61.0'
SAMPLE TYPE	Bag

BOARD #	2
CELL #	2
Flow Pump Speed	9
Technician	SS/JS

COMMENTS: sample was remolded at in-situ moisture using standard effort sample was compacted until soil was pumping under compaction efforts in mold.

Sample Data, Initial			
Height, inches	2.190	B-Value, f	1.00
Diameter, inches	2.790	Cell Pres.	100.0
Area, cm²	39.44	Bot. Pres.	80.0
Volume, cm^3	219.40	Top Pres.	80.0
Mass, g	400.20	Tot. B.P.	80.0
Moisture Content, %	36.03	Head, max.	88.63
Dry Density, pcf	83.67	Head, min.	88.63
Spec. Gravity(assumed)	2.680	Max. Grad.	16.54
Volume Solids, cm^3	109.78	Min. Grad.	16.54
Volume Voids, cm^3	109.63		
Void Ratio	1.00		
Saturation, %	96.7%		

Sample Data, Final	
Height, inches	2.109
Diameter, inches	2.725
Area, cm²	37.63
Volume, cm^3	201.58
Mass, g	386.62
Moisture Content, %	31.41
Dry Density, pcf	91.07
Volume Solids, cm^3	109.78
Volume Voids, cm^3	91.80
Void Ratio	0.84
Saturation, %	100.7%

WATER CONTENTS		Trimmings Initial	Sample Final
Wt Soil & Tare, i	g	400.20	438.23
Wt Soil & Tare, f	g	294.20	345.85
Wt Tare	g	0.00	51.76
Wt Moisture Lost	g	106.00	92.38
Wt Dry Soil	g	294.20	294.09
Water Content	%	36.03%	31.41%

DESCRIPTION

Gray, FINE SAND, some clayey silt.

Flow Pump Rate 4.88E-05 cm^3/sec

USCS (SM)

TIME FUNCTIONS, SECONDS								dP				
DATE	DAY	HOUR	MIN	TEMP (°C)	dt (min)	dt,acc (min)	dt (sec)	dt,acc (sec)	Reading (psi)	Head (cm)	Gradient	Permeability (cm/sec)
10/19/00	36818	16	45	21.8	0	0	0	0	1.26	88.63	16.54	7.5E-08
10/19/00	36818	16	50	21.8	5	5	300	300	1.26	88.63	16.54	7.5E-08
10/19/00	36818	16	55	21.8	5	10	300	600	1.26	88.63	16.54	7.5E-08
10/19/00	36818	17	0	21.8	5	15	300	900	1.26	88.63	16.54	7.5E-08 *
10/19/00	36818	17	5	21.8	5	20	300	1200	1.26	88.63	16.54	7.5E-08 *
10/19/00	36818	17	10	21.8	5	25	300	1500	1.26	88.63	16.54	7.5E-08 *
10/19/00	36818	17	15	21.8	5	30	300	1800	1.26	88.63	16.54	7.5E-08 *

*TRANSCRIBED FROM ORIGINAL DATA SHEETS

PERMEABILITY REPORTED AS ** 7.5E-08 cm/sec **

DATE	10/19/00
CHECK	[initials]
REVIEW	[initials]

GOLDER SIERRA

AR301350

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME:	**SALTIRE/996-1100 IRON REACTIVE WALL/VA**		
PROJECT NUMBER:	**IC3-3822**		
SAMPLE ID:	**SBD - 2**	**SAMPLE DEPTH:**	**83.0 - 85.0'**
SAMPLE TYPE:	**Bag**		

SAMPLE PREPARATION

Wet or Dry: Dry

Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION				NATURAL MOISTURE
Number of Blows				32	28	21	16	
Weight of Wet Soil & Tare (gm)	26.15	24.27	22.78	17.82	19.79	17.02	21.12	199.94
Weight of Dry Soil & Tare (gm)	23.86	22.21	21.04	14.23	15.70	13.54	17.06	162.30
Weight of Tare (gm)	11.84	11.48	11.87	4.33	4.26	4.28	6.73	51.81
Weight of Water (gm)	2.29	2.06	1.74	3.59	4.09	3.48	4.06	37.64
Weight of Dry Soil (gm)	12.02	10.73	9.17	9.90	11.44	9.26	10.33	110.49
Water Content %	19.05	19.20	18.97	36.26	35.75	37.58	39.30	34.07

PLASTIC LIMIT (PL): 19

LIQUID LIMIT (LL): 37

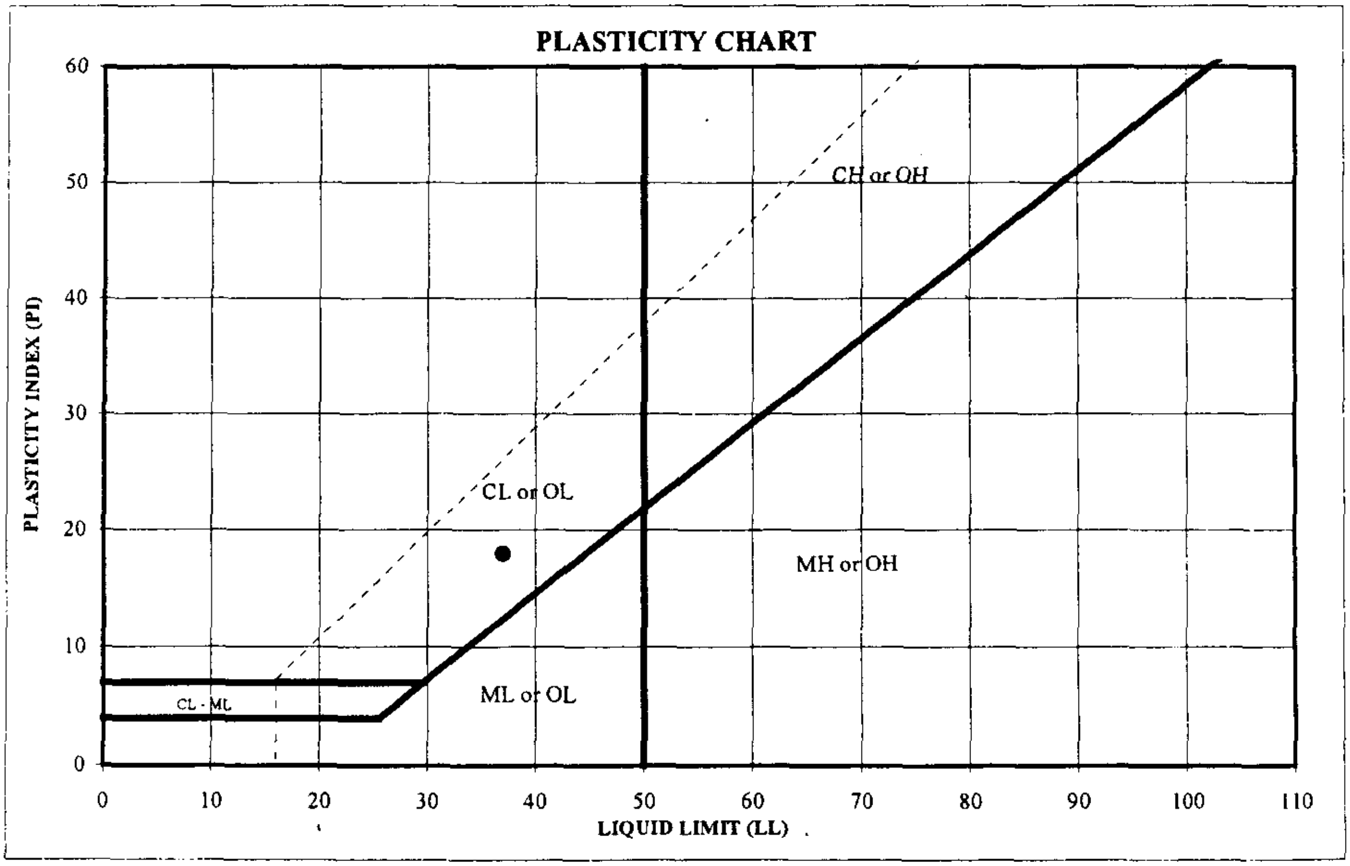
PLASTICITY INDEX (PI): 18

LIQUIDITY INDEX (LI): 0.83

NOTE:

DESCRIPTION: Gray, FINE SAND, and silty clay.

USCS: SC



TECH	DH
DATE	6/9/00
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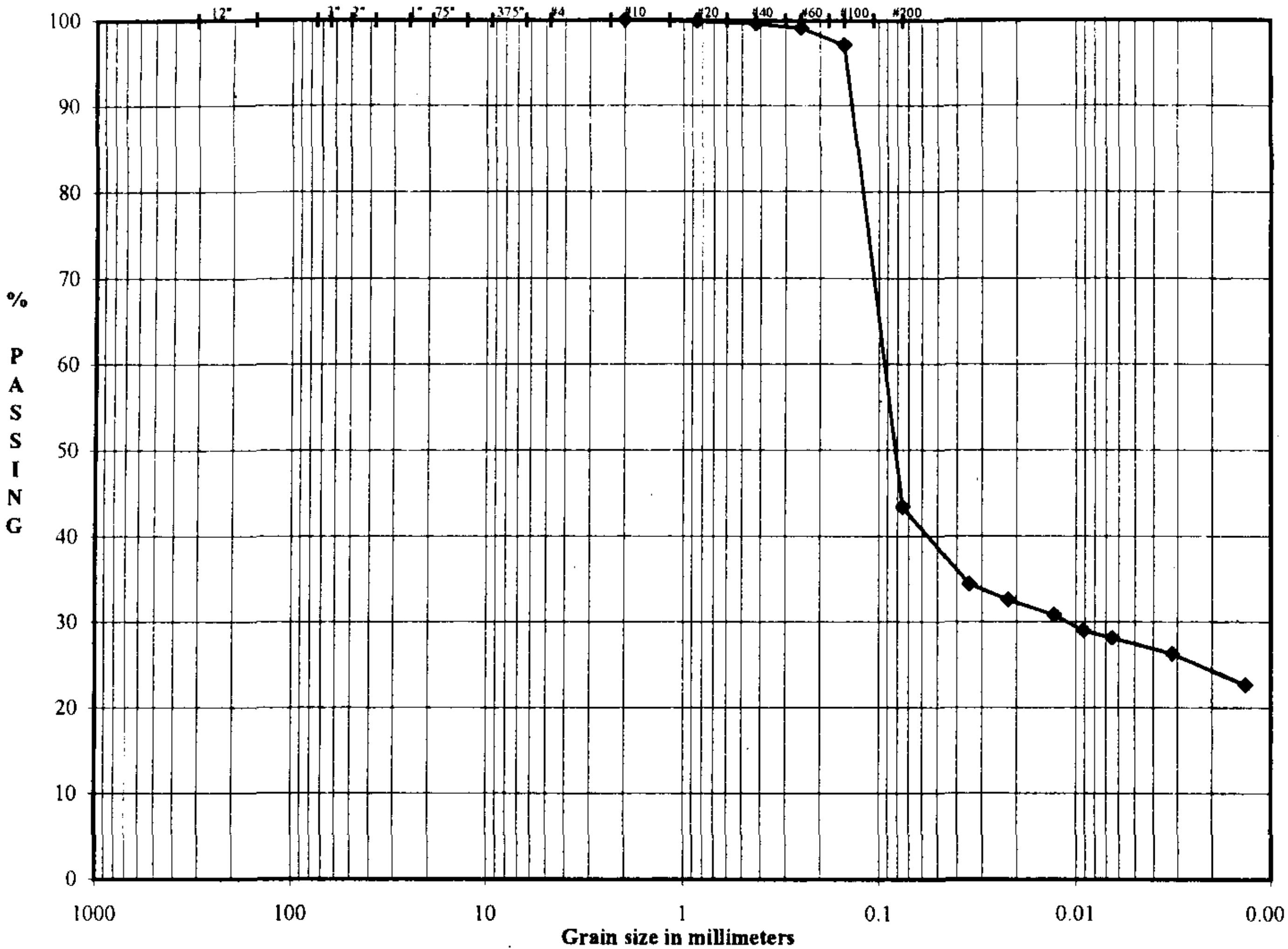
AR301351

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	SBD-2
SAMPLE TYPE	Bag
SAMPLE DEPTH	83.0 - 85.0'

LL	37
PL	19
PI	18

DESCRIPTION	Gray, FINE SAND, and silty clay.
USCS	SC

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	RJ/SW
DATE	6/8/00
CHECK	GM
REVIEW	GM

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBD-2 / -
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
		SAMPLE DEPTH	83.0 - 85.0'

AS RECEIVED WATER CONTENT

Tare No.		-
Wt. Wet Soil & Tare (gm)	(W1)	199.94
Wt. Dry Soil & Tare (gm)	(W2)	162.30
Weight of Tare (gm)	(W3)	51.81
Weight of Water (gm)	(W4=W1-W2)	37.64
Weight of Dry Soil (gm)	(W5=W2-W3)	110.49
Moisture Content (%)	(W4/W5)*100	34.07

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	56.39
Dry Soil & Tare (gm)	54.08
Tare Weight (gm)	3.16
Moisture Content (%)	4.54

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	953.51
Tare Weight (gm)	235.21
Total Weight (gm)	687.13 (W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	% PASSING	Sieve	
12.0"				12.0"	cobbles
3.0"				3.0"	coarse gravel
2.5"				2.5"	coarse gravel
2.0"				2.0"	coarse gravel
1.5"				1.5"	coarse gravel
1.0"				1.0"	coarse gravel
0.75"				0.75"	fine gravel
0.50"				0.50"	fine gravel
0.375"				0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.650
Specific Gravity	(tested)	
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	57.67
Calculated Dry Wt. used in test (gm)	55.17
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 0.00

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	0.00	0.00	**100.0**	#10	medium sand
#20	0.06	0.06	**99.9**	#20	medium sand
#40	0.22	0.22	**99.6**	#40	fine sand
#60	0.48	0.48	**99.1**	#60	fine sand
#100	1.58	1.58	**97.1**	#100	fine sand
#200	31.21	31.21	**43.4**	#200	fines

HYDROMETER CALCULATIONS

DATE 6/9/00	TIME 9:14	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/9/00	9:16	2.00	25.0	21.50	0.014	6.00	19.00	13.2	1.00
6/9/00	9:19	5.00	24.0	21.50	0.014	6.00	18.00	13.3	1.00
6/9/00	9:29	15.00	23.0	21.50	0.014	6.00	17.00	13.5	1.00
6/9/00	9:44	30.00	22.0	21.50	0.014	6.00	16.00	13.7	1.00
6/9/00	10:14	60.00	21.5	21.50	0.014	6.00	15.50	13.8	1.00
6/9/00	13:24	250.00	20.5	21.50	0.014	6.00	14.50	14.0	1.00
6/10/00	9:14	1440.00	18.5	21.00	0.014	6.00	12.50	14.3	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING		
0.0347	34.4	% COBBLES	0.00
0.0220	32.6	% COARSE GRAVEL	0.00
0.0128	30.8	% FINE GRAVEL	0.00
0.0091	29.0	% COARSE SAND	0.00
0.0065	28.1	% MEDIUM SAND	0.40
0.0032	26.3	% FINE SAND	56.17
0.0013	22.7	% FINES	43.43
		% TOTAL SAMPLE	100.00

Description Gray, FINE SAND, and silty clay.

USCS SC

37	LL
19	PL
18	PI

TECH	RJ/SW
DATE	6/8/00
CHECK	[signature]
REVIEW	[signature]

AR301353

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME:	**SALTIRE/996-1100 IRON REACTIVE WALL/VA**		
PROJECT NUMBER:	**IC3-3822**		
SAMPLE ID:	**SBD - 3**	**SAMPLE DEPTH:**	**71.0 - 73.0'**
SAMPLE TYPE:	**Bag**		

SAMPLE PREPARATION

Wet or Dry: Dry

Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION				NATURAL MOISTURE
Number of Blows				35	29	24	17	
Weight of Wet Soil & Tare (gm	25.18	21.63	19.18	17.16	17.64	15.93	18.10	168.43
Weight of Dry Soil & Tare (gm)	23.06	20.09	17.96	12.78	13.90	11.89	13.14	130.63
Weight of Tare (gm)	11.40	11.39	11.08	4.30	6.62	4.32	4.29	52.05
Weight of Water (gm)	2.12	1.54	1.22	4.38	3.74	4.04	4.96	37.80
Weight of Dry Soil (gm)	11.66	8.70	6.88	8.48	7.28	7.57	8.85	78.58
Water Content %	18.18	17.70	17.73	51.65	51.37	53.37	56.05	48.10

PLASTIC LIMIT (PL): 18

LIQUID LIMIT (LL): 53

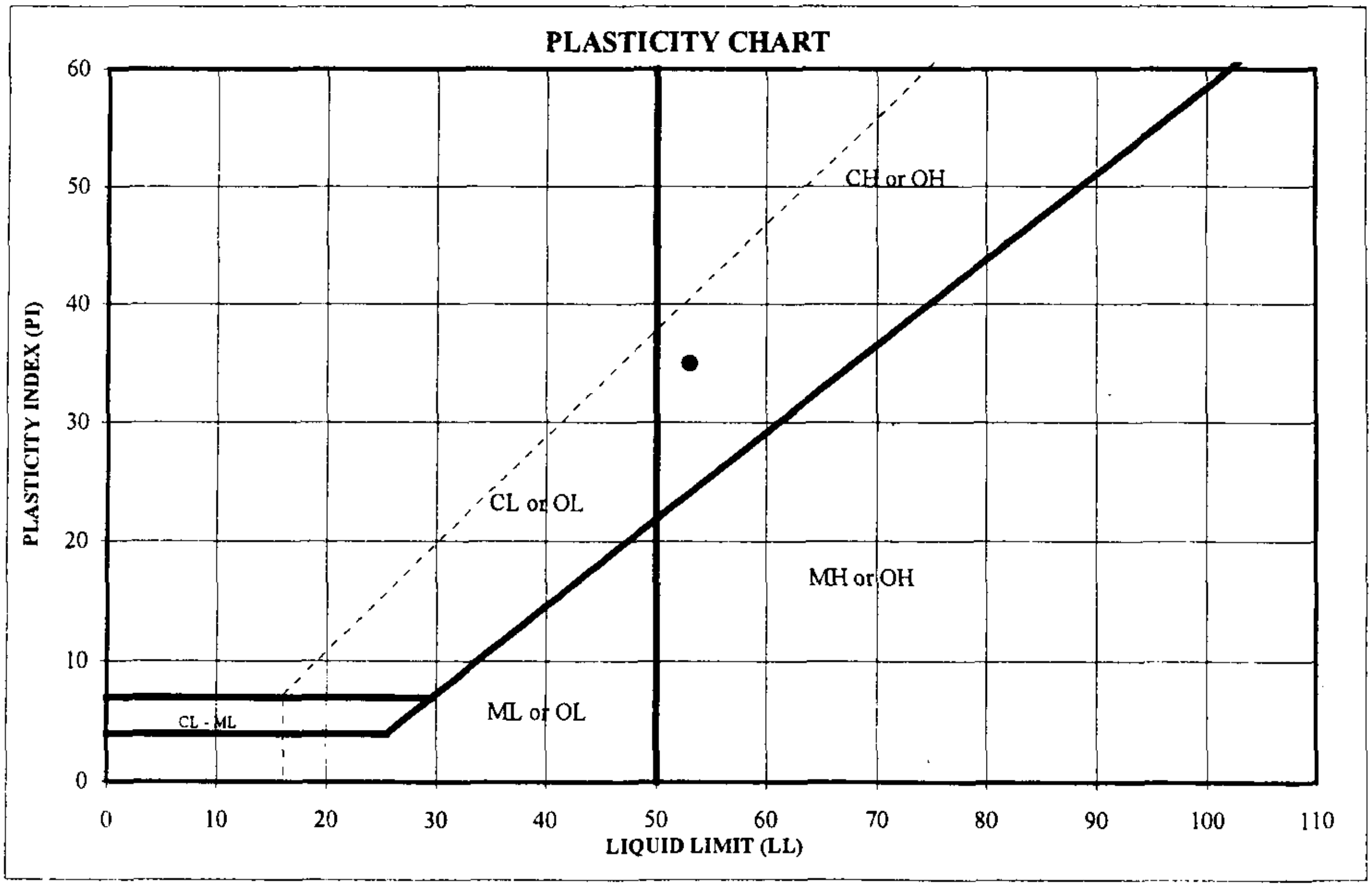
PLASTICITY INDEX (PI): 35

LIQUIDITY INDEX (LI): 0.86

NOTE:

DESCRIPTION: Gray, SILTY CLAY, some fine sand.

USCS: CH



TECH	DH
DATE	6/9/00
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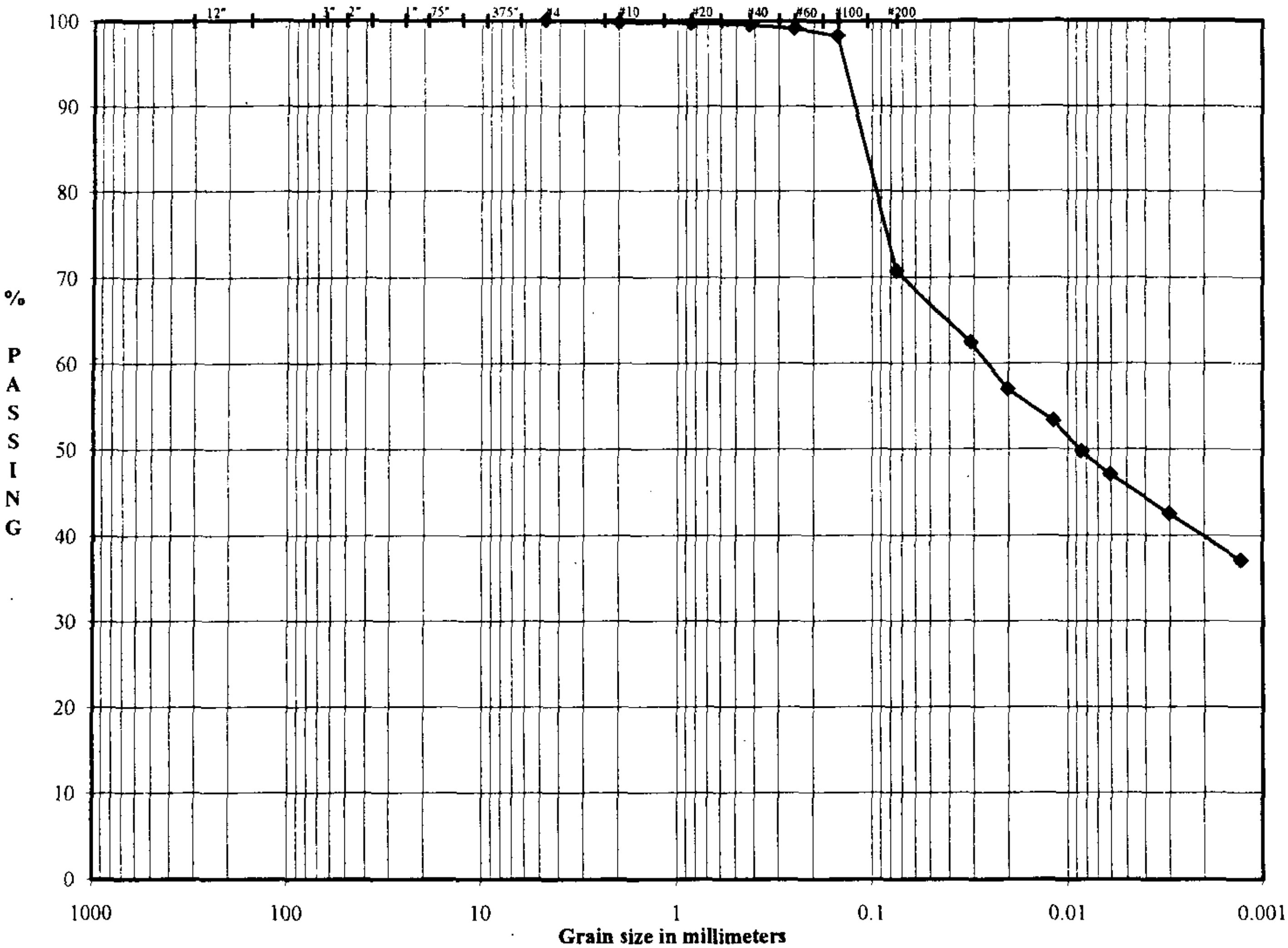
REVIEW	[illegible]

AR301354

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	SBD-3
SAMPLE TYPE	Bag
SAMPLE DEPTH	71.0 - 73.0'

LL	53
PL	18
PI	35

DESCRIPTION	Gray, SILTY CLAY, some fine sand.
USCS	CH

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	RJ/SW
DATE	6/8/00
CHECK	
REVIEW	

AR301355

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBD-3 / -
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
		SAMPLE DEPTH	71.0 - 73.0'

AS RECEIVED WATER CONTENT

Tare No		-
Wt. Wet Soil & Tare (gm)	(W1)	168.43
Wt. Dry Soil & Tare (gm)	(W2)	130.63
Weight of Tare (gm)	(W3)	52.05
Weight of Water (gm)	(W4=W1-W2)	37.80
Weight of Dry Soil (gm)	(W5=W2-W3)	78.58
Moisture Content (%)	(W4/W5)*100	48.10

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	59.83
Dry Soil & Tare (gm)	57.68
Tare Weight (gm)	3.23
Moisture Content (%)	3.95

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	684.75	
Tare Weight (gm)	218.95	
Total Weight (gm)	448.11	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"				12.0"	cobbles
3.0"				3.0"	coarse gravel
2.5"				2.5"	coarse gravel
2.0"				2.0"	coarse gravel
1.5"				1.5"	coarse gravel
1.0"				1.0"	coarse gravel
0.75"				0.75"	fine gravel
0.50"				0.50"	fine gravel
0.375"				0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.650
Specific Gravity	(tested)	
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	57.46
Calculated Dry Wt. used in test (gm)	55.28
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 0.00 **HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)**

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	0.14	0.14	99.7	#10	medium sand
#20	0.19	0.19	99.7	#20	medium sand
#40	0.25	0.25	99.5	#40	fine sand
#60	0.48	0.48	99.1	#60	fine sand
#100	0.96	0.96	98.3	#100	fine sand
#200	16.19	16.19	70.7	#200	fines

HYDROMETER CALCULATIONS

DATE 6/9/00	TIME 9:10	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/9/00	9:12	2.00	40.5	21.50	0.014	6.00	34.50	10.7	1.00
6/9/00	9:15	5.00	37.5	21.50	0.014	6.00	31.50	11.2	1.00
6/9/00	9:25	15.00	35.5	21.50	0.014	6.00	29.50	11.5	1.00
6/9/00	9:40	30.00	33.5	21.50	0.014	6.00	27.50	11.9	1.00
6/9/00	10:10	60.00	32.0	21.50	0.014	6.00	26.00	12.0	1.00
6/9/00	13:20	250.00	29.5	21.50	0.014	6.00	23.50	12.5	1.00
6/10/00	9:10	1440.00	26.5	21.00	0.014	6.00	20.50	13.0	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING		
		% COBBLES	0.00
0.0312	62.4	% COARSE GRAVEL	0.00
0.0202	57.0	% FINE GRAVEL	0.00
0.0118	53.4	% COARSE SAND	0.25
0.0085	49.7	% MEDIUM SAND	0.20
0.0060	47.0	% FINE SAND	28.84
0.0030	42.5	% FINES	70.71
0.0013	37.1	% TOTAL SAMPLE	100.00

Description Gray, SILTY CLAY, some fine sand.

USCS CH

53	LL
18	PL
35	PI

TECH	RJ/SW
DATE	6/8/00
CHECK	[illegible]
REVIEW	[illegible]

AR301356

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	SBD-3 / -
PROJECT NO.	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPTH**	105.7 - 107.0'

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	400.11
Wt Dry Soil & Tare (gm)	(w2)	309.48
Weight of Tare (gm)	(w3)	0.00
Weight of Water (gm)	(w4=w1-w2)	90.63
Weight of Dry Soil (gm)	(w5=w2-w3)	309.48
Moisture Content (%)	(w4/w5)*100	29.28

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Mois

Weight Of Sample (gm)	131.04
Tare Weight (gm)	42.92
(W6) Total Dry Weight (gm)	88.12

SIEVE ANALYSIS

Tare Weight: 42.92

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"					0.375"	fine gravel
#4					#4	coarse sand
#10					#10	medium sand
#20					#20	medium sand
#40					#40	fine sand
#60					#60	fine sand
#100					#100	fine sand
#200	72.20	29.28	33.23	66.77	#200	fines
PAN					PAN	

% COBBLES	
% C GRAVEL	
% F GRAVEL	
% C SAND	
% M SAND	
% F SAND	
% FINES	66.77
% TOTAL	

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	-

DESCRIPTION Gray, SILTY CLAY, and fine sand.

USCS (CL-ML)

TECH	JS/TJ
DATE	10/18/00
CHECK	[illegible]
REVIEW	[illegible]

FLOW PUMP #1

FLEXIBLE WALL PERMEABILITY
ASTM D 5084
METHOD D, CONSTANT RATE OF FLOW

PROJECT TITLE	GSL/IC3-3822 SALTIRE/VA		BOARD #	1
PROJECT NUMBER	IC3-3822		CELL #	1
SAMPLE ID	SBD-3 -	105.7 - 107.0'	Flow Pump Speed	8
SAMPLE TYPE	Bag		Technician	SS/JS

COMMENTS: sample was remolded at in-situ moisture using standard effort sample was compacted until soil was pumping under compaction efforts in mold.

Sample Data, Initial				Sample Data, Final	
Height, inches	2.116	B-Value, f	1.00	Height, inches	2.055
Diameter, inches	2.790	Cell Pres.	100.0	Diameter, inches	2.740
Area, cm^2	39.44	Bot. Pres.	80.0	Area, cm^2	38.04
Volume, cm^3	211.99	Top Pres.	80.0	Volume, cm^3	198.57
Mass, g	400.11	Tot. B.P.	80.0	Mass, g	392.00
Moisture Content, %	29.28	Head, max.	108.32	Moisture Content, %	26.66
Dry Density, pcf	91.10	Head, min.	108.32	Dry Density, pcf	97.26
Spec. Gravity(assumed)	2.680	Max. Grad.	20.75	Volume Solids, cm^3	115.48
Volume Solids, cm^3	115.48	Min. Grad.	20.75	Volume Voids, cm^3	83.09
Volume Voids, cm^3	96.51			Void Ratio	0.72
Void Ratio	0.84			Saturation, %	99.3%
Saturation, %	93.9%				

Flow Pump Rate 1.40E-04 cm^3/sec   USCS (CL-ML)

WATER CONTENTS		Trimmings Initial	Sample Final
Wt Soil & Tare, i	g	400.11	443.60
Wt Soil & Tare, f	g	309.48	361.14
Wt Tare	g	0.00	51.87
Wt Moisture Lost	g	90.63	82.46
Wt Dry Soil	g	309.48	309.27
Water Content	%	29.28%	26.66%

DESCRIPTION
Gray, SILTY CLAY, and fine sand.

TIME FUNCTIONS, SECONDS								dP				
DATE	DAY	HOUR	MIN	TEMP (°C)	dt (min)	dt,acc (min)	dt (sec)	dt,acc (sec)	Reading (psi)	Head (cm)	Gradient	Permeability (cm/sec)
10/19/00	36818	16	20	21.8	0	0	0	0	1.54	108.32	20.75	1.7E-07
10/19/00	36818	16	25	21.8	5	5	300	300	1.54	108.32	20.75	1.7E-07
10/19/00	36818	16	30	21.8	5	10	300	600	1.54	108.32	20.75	1.7E-07
10/19/00	36818	16	35	21.8	5	15	300	900	1.54	108.32	20.75	1.7E-07 *
10/19/00	36818	16	40	21.8	5	20	300	1200	1.54	108.32	20.75	1.7E-07 *
10/19/00	36818	16	45	21.8	5	25	300	1500	1.54	108.32	20.75	1.7E-07 *
10/19/00	36818	16	50	21.8	5	30	300	1800	1.54	108.32	20.75	1.7E-07 *

*TRANSCRIBED FROM ORIGINAL DATA SHEETS

PERMEABILITY REPORTED AS ** 1.7E-07 cm/sec **

DATE 10/19/00
CHECK GJL
REVIEW GJL

GOLDER SIERRA

AR301358

ATTERBERG LIMITS

ASTM D 4318

PROJECT NAME:	**SALTIRE/996-1100 IRON REACTIVE WALL/VA**		
PROJECT NUMBER:	**IC3-3822**		
SAMPLE ID:	**SBD - 3**	**SAMPLE DEPTH:**	**107.0 - 109.0'**
SAMPLE TYPE:	**Bag**		

SAMPLE PREPARATION

Wet or Dry: Dry — Minus #40 Sieve: Yes

	PLASTIC LIMIT DETERMINATION			LIQUID LIMIT DETERMINATION				NATURAL MOISTURE
Number of Blows				34	28	24	15	
Weight of Wet Soil & Tare (gm	20.04	20.05	21.38	27.72	22.52	25.04	33.18	245.46
Weight of Dry Soil & Tare (gm)	18.55	18.53	19.67	23.29	18.89	20.83	27.66	200.78
Weight of Tare (gm)	11.43	11.23	11.40	4.27	4.35	4.26	6.62	42.50
Weight of Water (gm)	1.49	1.52	1.71	4.43	3.63	4.21	5.52	44.68
Weight of Dry Soil (gm)	7.12	7.30	8.27	19.02	14.54	16.57	21.04	158.28
Water Content %	20.93	20.82	20.68	23.29	24.97	25.41	26.24	28.23

PLASTIC LIMIT (PL): 21

LIQUID LIMIT (LL): 25

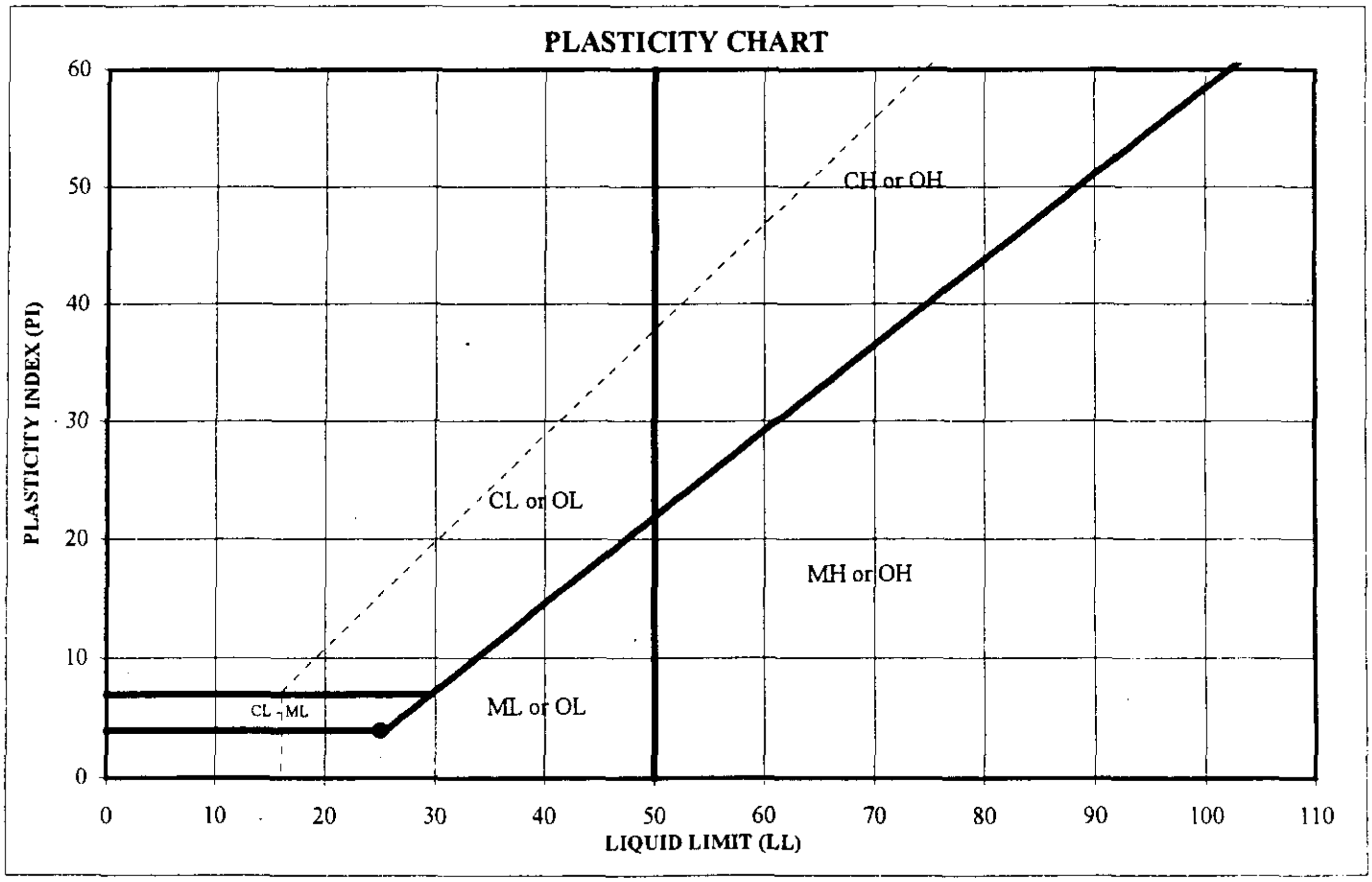
PLASTICITY INDEX (PI): 4

LIQUIDITY INDEX (LI): 1.85

NOTE:

DESCRIPTION: Gray, FINE SAND, and silty clay.

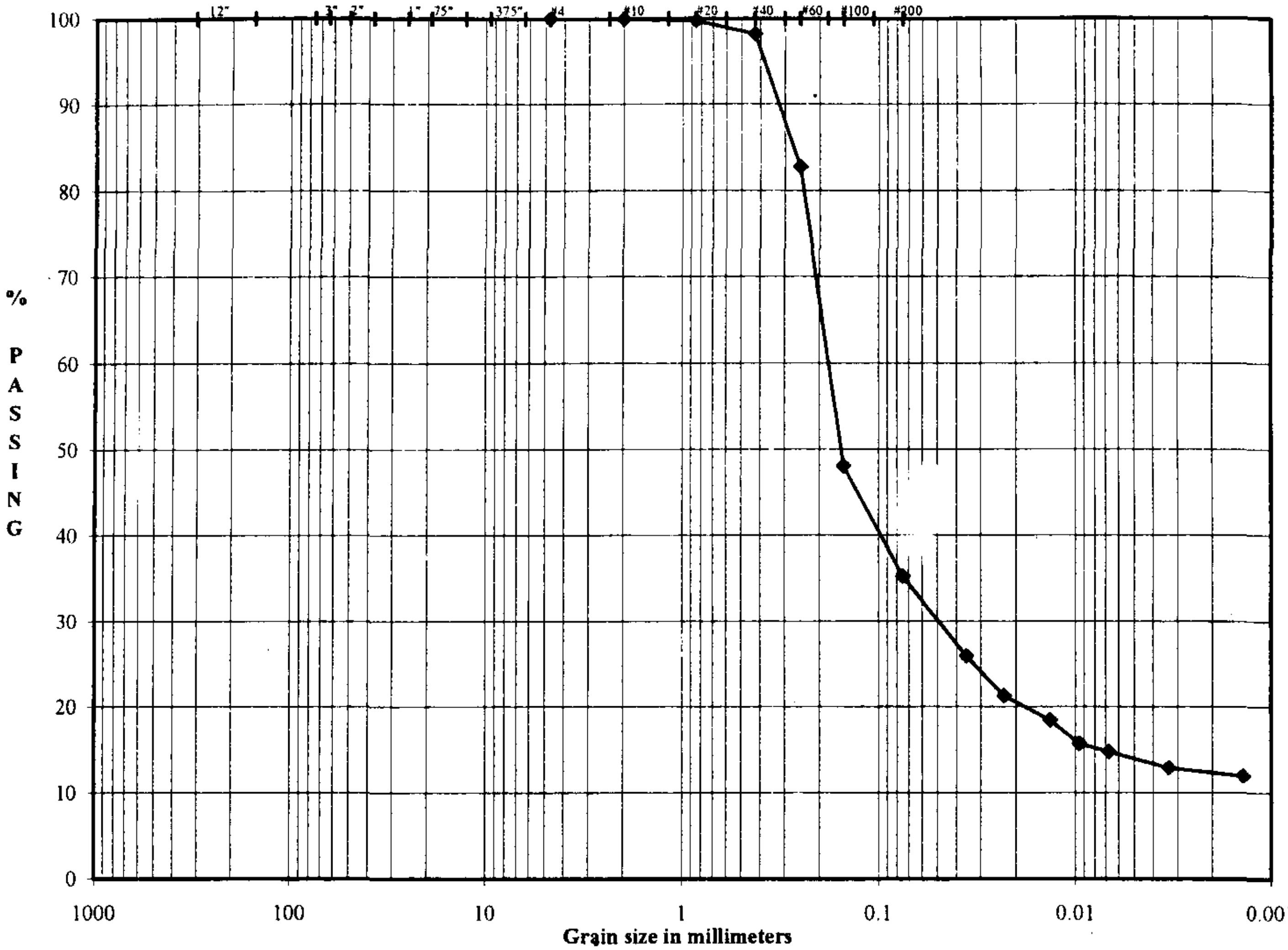
USCS: SC-SM



TECH	SW
DATE	6/9/00
CHECK	
REVIEW	

AR301359

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	SBD-3
SAMPLE TYPE	Bag
SAMPLE DEPTH	107.0 - 109.0'

LL	25
PL	21
PI	4

DESCRIPTION Gray, FINE SAND, and silty clay.

USCS SC-SM

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	RJ/SW
DATE	6/8/00
CHECK	GMW
REVIEW	GMW

AR301360

GOLDER SIERRA

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	SBD-3 / -
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
		SAMPLE DEPTH	107.0 - 109.0'

AS RECEIVED WATER CONTENT

Tare No		-
Wt. Wet Soil & Tare (gm)	(W1)	245.46
Wt. Dry Soil & Tare (gm)	(W2)	200.78
Weight of Tare (gm)	(W3)	42.50
Weight of Water (gm)	(W4=W1-W2)	44.68
Weight of Dry Soil (gm)	(W5=W2-W3)	158.28
Moisture Content (%)	(W4/W5)*100	28.23

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	54.31
Dry Soil & Tare (gm)	52.09
Tare Weight (gm)	3.21
Moisture Content (%)	4.54

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	987.53	
Tare Weight (gm)	236.16	
Total Weight (gm)	718.73	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"				12.0"	cobbles
3.0"				3.0"	coarse gravel
2.5"				2.5"	coarse gravel
2.0"				2.0"	coarse gravel
1.5"				1.5"	coarse gravel
1.0"				1.0"	coarse gravel
0.75"				0.75"	fine gravel
0.50"				0.50"	fine gravel
0.375"				0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.650
Specific Gravity	(tested)	
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	56.57
Calculated Dry Wt. used in test (gm)	54.11
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 0.00

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	0.03	0.03	99.9	#10	medium sand
#20	0.14	0.14	99.7	#20	medium sand
#40	0.97	0.97	98.2	#40	fine sand
#60	9.35	9.35	82.7	#60	fine sand
#100	28.09	28.09	48.1	#100	fine sand
#200	35.02	35.02	35.3	#200	fines

HYDROMETER CALCULATIONS

DATE	TIME	ET	READING	TEMP	TEMP.COR.	HYD.COR.	READING	EFFECTIVE	
6/9/00	9:12	(min)	R	T	K	Cc	C	LENGTH	A
6/9/00	9:14	2.00	20.0	21.50	0.014	6.00	14.00	14.0	1.00
6/9/00	9:17	5.00	17.5	21.50	0.014	6.00	11.50	14.5	1.00
6/9/00	9:27	15.00	16.0	21.50	0.014	6.00	10.00	14.7	1.00
6/9/00	9:42	30.00	14.5	21.50	0.014	6.00	8.50	15.0	1.00
6/9/00	10:12	60.00	14.0	21.50	0.014	6.00	8.00	15.0	1.00
6/9/00	13:22	250.00	13.0	21.50	0.014	6.00	7.00	15.2	1.00
6/10/00	9:12	1440.00	12.5	21.00	0.014	6.00	6.50	15.3	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING		
0.0357	25.9	% COBBLES	0.00
0.0230	21.3	% COARSE GRAVEL	0.00
0.0134	18.5	% FINE GRAVEL	0.00
0.0095	15.7	% COARSE SAND	0.06
0.0068	14.8	% MEDIUM SAND	1.74
0.0033	12.9	% FINE SAND	62.92
0.0014	12.0	% FINES	35.28
		% TOTAL SAMPLE	100.00

Description Gray, FINE SAND, and silty clay.

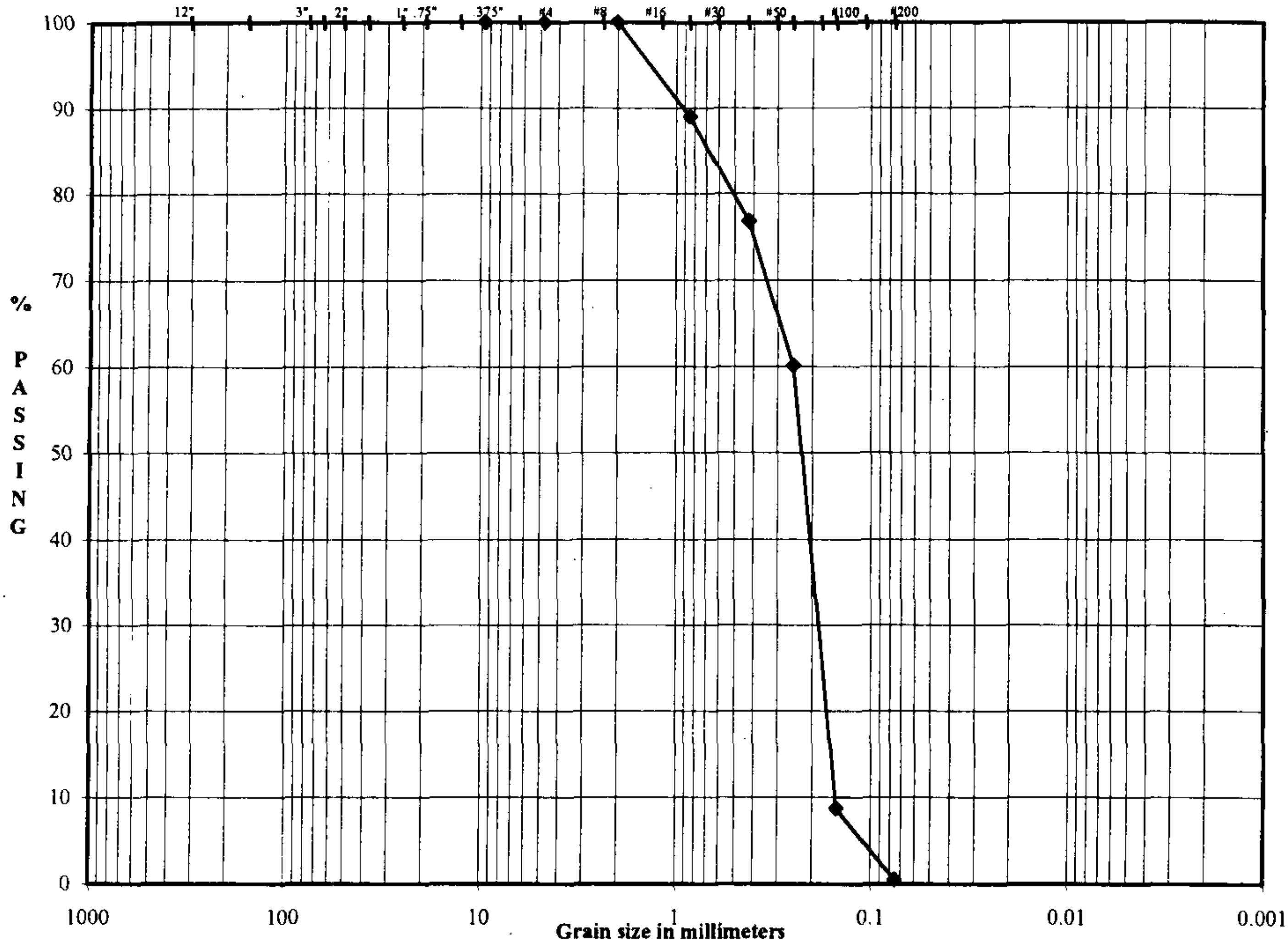
USCS SC-SM

25	LL
21	PL
4	PI

TECH	RJ/SW
DATE	6/8/00
CHECK	CMW
REVIEW	CMW

AR301361

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		Gravel		SAND			FINES

SAMPLE ID	ATL-80	20/30
SAMPLE TYPE	Bag	
SAMPLE DEPTH	-	

LL	-
PL	-
PI	-

DESCRIPTION White, MEDIUM TO FINE SAND, trace silt.

USCS SP

SALTIRE/996-1100 IRON REACTIVE WALL/VA
976-1060

TECH	RJ
DATE	7/6/00
CHECK	GK
REVIEW	GK

AR301362

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	ATL-80 / 20/30
PROJECT NO.	976-1060	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPTH**	-

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	
Wt Dry Soil & Tare (gm)	(w2)	
Weight of Tare (gm)	(w3)	
Weight of Water (gm)	(w4=w1-w2)	
Weight of Dry Soil (gm)	(w5=w2-w3)	
Moisture Content (%)	(w4/w5)*100	

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Mois

	Weight Of Sample (gm)	1191.47
	Tare Weight (gm)	0.00
(W6)	Total Dry Weight (gm)	1191.47

SIEVE ANALYSIS

Tare Weight: 0.00

Sieve	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"					0.375"	fine gravel
#4					#4	coarse sand
#10	0.00	0.00	0.00	100.00	#10	medium sand
#20	131.49	131.49	11.04	88.96	#20	medium sand
#40	275.94	275.94	23.16	76.84	#40	fine sand
#50	285.28	285.28	23.94	76.06	#50	fine sand
#60	475.05	475.05	39.87	60.13	#60	fine sand
#100	1087.49	1087.49	91.27	8.73	#100	fine sand
#200	1185.49	1185.49	99.50	0.50	#200	fines
PAN	1191.01	1191.01			PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	23.16
% F SAND	76.34
% FINES	0.50
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	2.650

DESCRIPTION White, MEDIUM TO FINE SAND, trace silt.

USCS SP

TECH	RJ
DATE	7/6/00
CHECK	[illegible]
REVIEW	[illegible]

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	IC3-3822	SAMPLE ID	ATL80 20/30
		SAMPLE TYPE	Bag
TESTED FOR	GS	SAMPLE DEPTH	-

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	67.17
Weight Soil and Tare, Final (gm)	(W2)	67.15
Weight Of Tare (gm)	(W3)	3.23
Weight Of Moisture (gm)	(W4=W1-W2)	0.02
Weight Of Dry Soil (gm)	(W5=W2-W3)	63.92
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.0%

AIR REMOVAL METHOD: VACUUM

Trial		1	2	3
Pycnometer Number		25		
Weight Pycnometer Empty (gm)	(Mf)	177.74		
Weight of Soil & Pycnometer (gm)		278.52		
Weight of Soil, Water & Pycnometer (gm)	(Mb)	738.80		
Observed Temperature (Tb), for (Mb) In Degrees C		23.0		
Observed Temperature (Ta), for (Ma) In Degrees C		21.50		
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	676.22		
Relative Density of Water @ (Ta)		0.99791		
Relative Density of Water @ (Tx)		0.99757		
Correction Factor due to Temperature @Tx	(K)	0.9993		
Weight of Soil (gm)		100.78		
Weight of Dry Soil (gm)	(Mo)	100.75		
Weight of Pycnometer & Water (gm)	(Ma)	676.05		

SPECIFIC GRAVITY

	1	2	3	Gs Average
G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	2.650			2.650

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	SW
DATE	7/6/00
CHECK	GAW
REVIEW	GAW

AR301364

CONSTANT HEAD PERMEABILITY TEST
ASTM D 2434

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	ATL 80-20/30
PROJECT NUMBER	IC3-3822	SAMPLE TYPE	Bag
REMARKS	-	SAMPLE DEPTH	-

	TIME (sec)	VOLUME (ml)	TEMP. (°C)	Q (ml/sec)	
1.	120	24	23.0	0.20	
2.	120	24	23.0	0.20	*
3.	120	24	23.0	0.20	*
4.	120	24	23.0	0.20	*
5.	120	24	23.0	0.20	*

UNIT WEIGHT DETERMINATION

APPARATUS & WET SAMPLE (g):	2332.8
APPARATUS WEIGHT (g):	1349.8
WET SAMPLE WEIGHT (g):	982.9
SAMPLE HEIGHT (in):	5.35
SAMPLE DIAMETER (in):	3.00
SAMPLE AREA (in^2):	7.07
SAMPLE AREA (cm^2):	45.60
SAMPLE VOLUME (in^3):	37.82
SAMPLE VOLUME (cm^3):	619.71
WET DENSITY (pcf):	99.0
DRY DENSITY (pcf):	98.9

MOISTURE CONTENT

WET SAMPLE & TARE (g):	143.78
DRY SAMPLE & TARE (g):	143.65
WEIGHT OF WATER (g):	0.13
WEIGHT OF TARE (g):	52.09
DRY SAMPLE WEIGHT (g):	91.56
MOISTURE CONTENT (%):	0.14
SPECIFIC GRAVITY:	2.65
VOLUME OF SOLIDS (cm^3):	370.40
VOLUME OF VOIDS (cm^3):	249.31

DISTANCE B/W MANOMETERS (cm):	7.62
AVERAGE Q VALUE:	0.20
AVERAGE TEMP:	23.0
TEMPERATURE CORRECTION:	0.93
HEAD OF WATER (cm):	2.70
HYDRAULIC GRADIENT (i):	0.354

K VALUE CORRECTED FOR 20 °C 1.2E-02 cm/sec

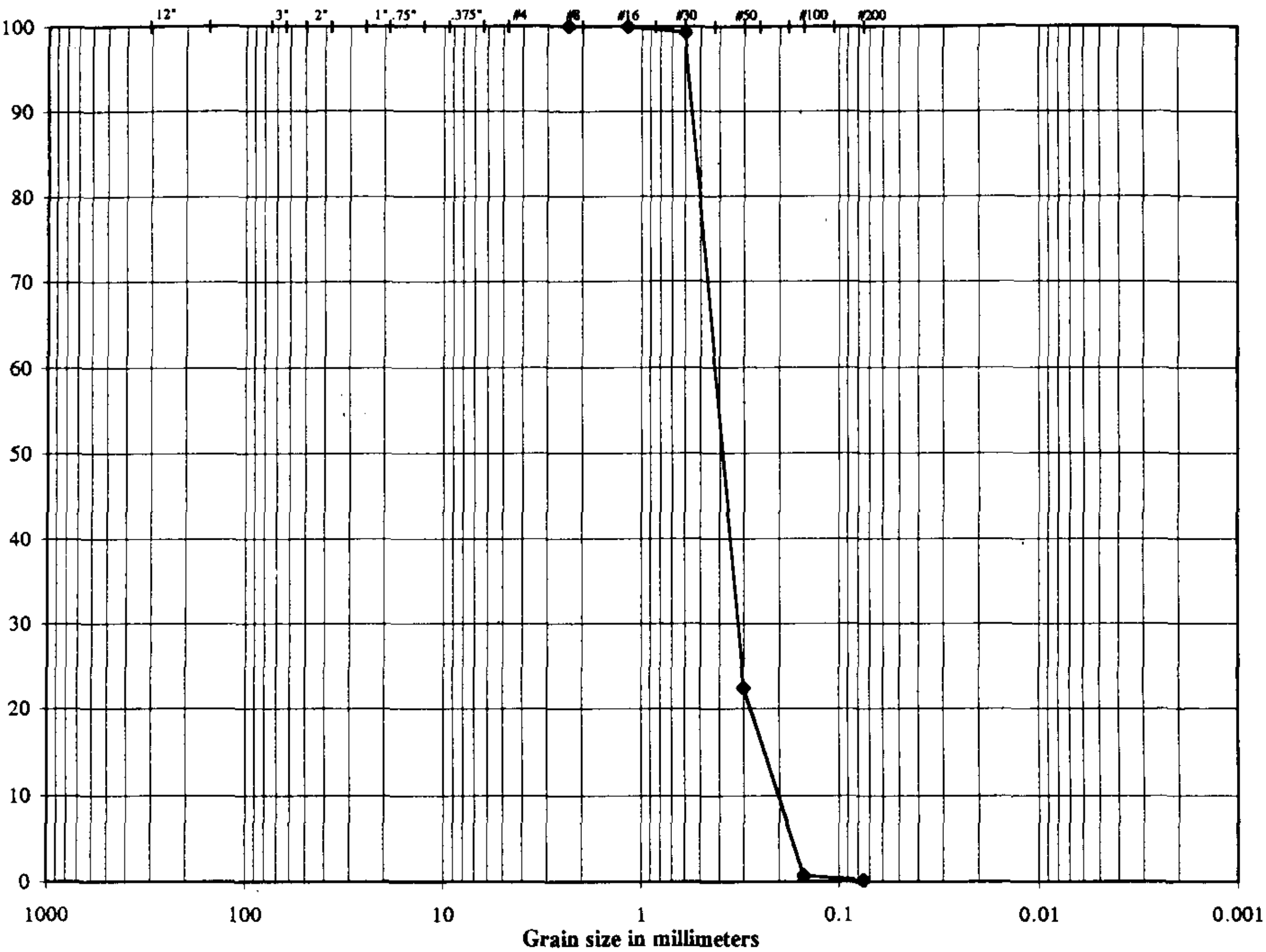
TECH	JS
DATE	7/6/00
CHECK	[illegible]
REVIEW	[illegible]

AR301365

APPENDIX A-2

Iron Filings Grain Size, Specific Gravity and Permeater Tests

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	CC-1115 -	**LL**	-
SAMPLE TYPE	Bag	**PL**	-
SAMPLE DEPTH	-	**PI**	-

DESCRIPTION Black, MEDIUM TO FINE IRON FILINGS.

USCS SP

Cu = D60/D10 = 0.41/0.2 = 2.05 < 6

Cc = D30^2/(D60*D10) = 0.31^2/(0.41*0.2) = 1.17 > 1

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	GM
DATE	Jun-00
CHECK	[signature]
REVIEW	[signature]

AR301367

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	CC-1115 / -
PROJECT NO.	IC3-3822	SAMPLE TYPE	Bag
REMARKS		SAMPLE DEPTH	-

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	55.00
Wt Dry Soil & Tare (gm)	(w2)	55.00
Weight of Tare (gm)	(w3)	3.24
Weight of Water (gm)	(w4=w1-w2)	0.00
Weight of Dry Soil (gm)	(w5=w2-w3)	51.76
Moisture Content (%)	(w4/w5)*100	0.00

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	256.77
Tare Weight (gm)	51.91
(W6) Total Dry Weight (gm)	204.86

SIEVE ANALYSIS

Tare Weight: 192.40

Sieve	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"					0.375"	fine gravel
#4					#4	coarse sand
#8					#8	coarse sand
#16	192.40	0.00	0.00	100.00	#16	medium sand
#30	193.82	1.42	0.69	99.31	#30	medium sand
#50	351.20	158.80	77.52	22.48	#50	fine sand
#100	395.78	203.38	99.28	0.72	#100	fine sand
#200	396.88	204.48	99.81	0.19	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.00
% M SAND	38.91
% F SAND	60.90
% FINES	0.19
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	-

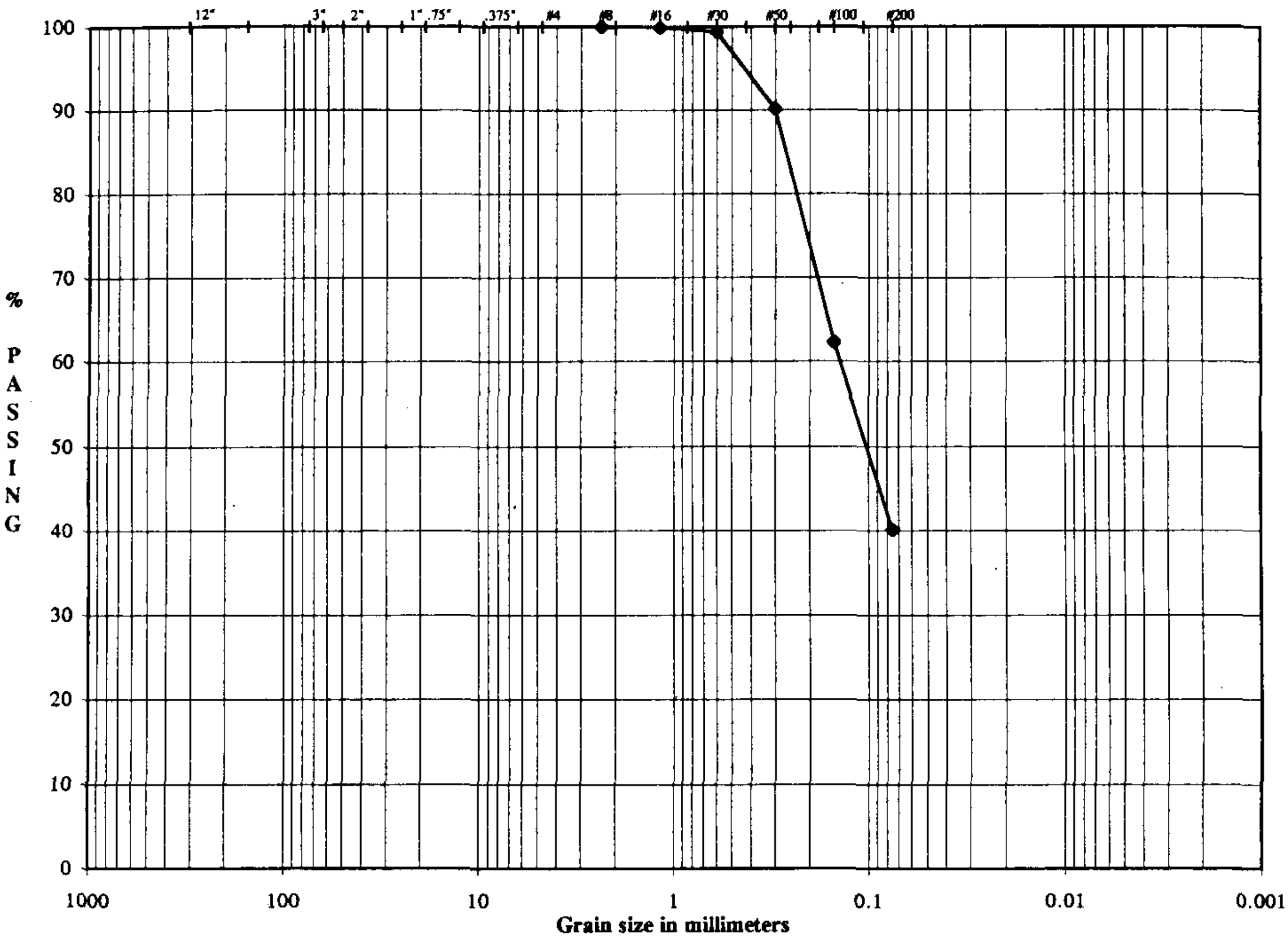
DESCRIPTION: Black, MEDIUM TO FINE IRON FILINGS.

USCS: SP

TECH	GM
DATE	Jun-00
CHECK	GM
REVIEW	GM

AR301368

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SAMPLE ID	CC-1021 -	**LL**	-
SAMPLE TYPE	Bag	**PL**	-
SAMPLE DEPTH	-	**PI**	-

DESCRIPTION	Black, FINE IRON FILINGS.
USCS	SM

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	GM
DATE	Jun-00
CHECK	Ju
REVIEW	Ju

AR301369

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	CC-1021 / -
PROJECT NO.	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPTH**	-

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	44.65
Wt Dry Soil & Tare (gm)	(w2)	44.53
Weight of Tare (gm)	(w3)	3.20
Weight of Water (gm)	(w4=w1-w2)	0.12
Weight of Dry Soil (gm)	(w5=w2-w3)	41.33
Moisture Content (%)	(w4/w5)*100	0.29

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	44.65
Dry Soil & Tare (gm)	44.53
Tare Weight (gm)	3.20
Moisture Content (%)	0.29

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

	Weight Of Sample (gm)	297.96
	Tare Weight (gm)	51.60
(W6)	Total Dry Weight (gm)	245.65

SIEVE ANALYSIS

Tare Weight: 192.41

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"					0.375"	fine gravel
#4					#4	coarse sand
#8	192.41	0.00	0.00	100.00	#8	coarse sand
#16	192.61	0.20	0.08	99.92	#16	medium sand
#30	194.01	1.60	0.65	99.35	#30	medium sand
#50	216.53	24.12	9.82	90.18	#50	fine sand
#100	284.95	92.54	37.67	62.33	#100	fine sand
#200	339.41	147.00	59.84	40.16	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.02
% M SAND	5.19
% F SAND	54.63
% FINES	40.16
% TOTAL	100.00

Descriptive Terms

trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	5.687

DESCRIPTION Black, FINE IRON FILINGS.

USCS SM

TECH	GM
DATE	Jun-00
CHECK	
REVIEW	

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	IC3-3822	SAMPLE ID	CC-1021 -
		SAMPLE TYPE	Bag
TESTED FOR	SPECIFIC GRAVITY	SAMPLE DEPTH	-

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	44.65
Weight Soil and Tare, Final (gm)	(W2)	44.53
Weight Of Tare (gm)	(W3)	3.20
Weight Of Moisture (gm)	(W4=W1-W2)	0.12
Weight Of Dry Soil (gm)	(W5=W2-W3)	41.33
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	0.3%

AIR REMOVAL METHOD: VACUUM

Trial		1	2	3
Pycnometer Number		5	4	
Weight Pycnometer Empty (gm)	(Mf)	185.13	211.93	
Weight of Soil & Pycnometer (gm)		282.19	285.54	
Weight of Soil, Water & Pycnometer (gm)	(Mb)	763.00	770.65	
Observed Temperature (Tb), for (Mb) In Degrees C		22.5	22.5	
Observed Temperature (Ta), for (Ma) In Degrees C		22.00	19.50	
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	683.30	710.47	
Relative Density of Water @ (Ta)		0.99780	0.99833	
Relative Density of Water @ (Tx)		0.99768	0.99768	
Correction Factor due to Temperature @Tx	(K)	0.9995	0.9995	
Weight of Soil (gm)		97.06	73.61	
Weight of Dry Soil (gm)	(Mo)	96.78	73.40	
Weight of Pycnometer & Water (gm)	(Ma)	683.24	710.15	

SPECIFIC GRAVITY

	1	2	3	Gs Average
G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	5.684	5.690		5.687

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	GM
DATE	Jun-00
CHECK	[illegible]
REVIEW	[illegible]

CONSTANT HEAD PERMEABILITY TEST
ASTM D 2434

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	CC-1021 -
PROJECT NUMBER	IC3-3822	SAMPLE TYPE	Bag
REMARKS	-	SAMPLE DEPTH	-

	TIME (sec)	VOLUME (ml)	TEMP. (°C)	Q (ml/sec)	
1.	120	7.1	20.5	0.06	*
2.	120	7.2	20.0	0.06	*
3.	120	7.1	20.5	0.06	*

UNIT WEIGHT DETERMINATION	
APPARATUS & WET SAMPLE (g):	3468.8
APPARATUS WEIGHT (g):	1826.5
WET SAMPLE WEIGHT (g):	1642.3
SAMPLE HEIGHT (in):	5.25
SAMPLE DIAMETER (in):	3.00
SAMPLE AREA (in^2):	7.07
SAMPLE AREA (cm^2):	45.60
SAMPLE VOLUME (in^3):	37.11
SAMPLE VOLUME (cm^3):	608.12
WET DENSITY (pcf):	168.6
DRY DENSITY (pcf):	168.1

MOISTURE CONTENT	
WET SAMPLE & TARE (g):	44.65
DRY SAMPLE & TARE (g):	44.53
WEIGHT OF WATER (g):	0.12
WEIGHT OF TARE (g):	3.20
DRY SAMPLE WEIGHT (g):	41.33
MOISTURE CONTENT (%):	0.29
SPECIFIC GRAVITY:	5.687
VOLUME OF SOLIDS (cm^3):	287.95
VOLUME OF VOIDS (cm^3):	320.18

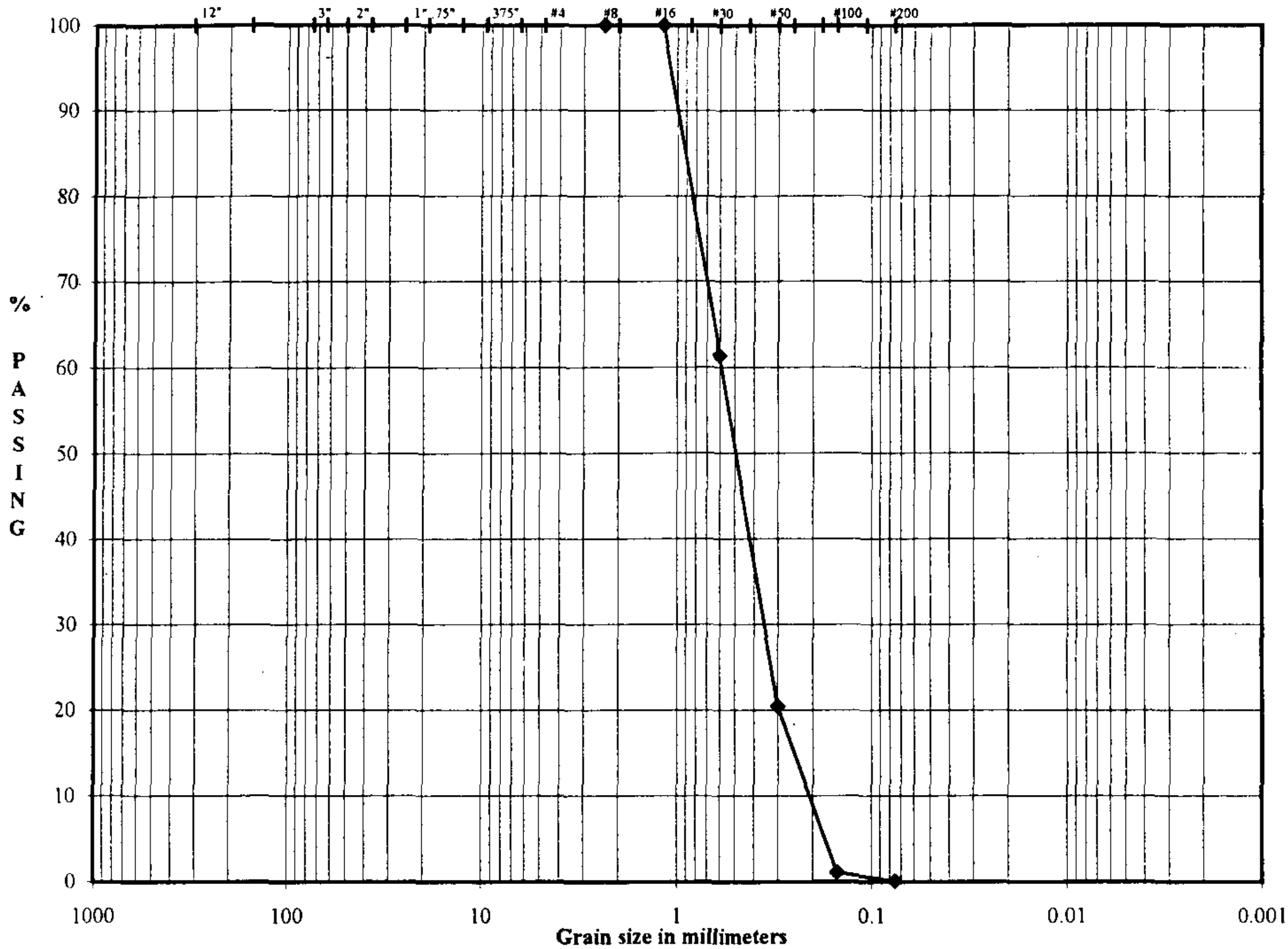
DISTANCE B/W MANOMETERS (cm):	7.62
AVERAGE Q VALUE:	0.06
AVERAGE TEMP:	20.3
TEMPERATURE CORRECTION:	0.99
HEAD OF WATER (cm):	25.50
HYDRAULIC GRADIENT (i):	3.346

K VALUE CORRECTED FOR 20 °C = 3.9E-04 cm/sec

TECH	GM
DATE	Jun-00
CHECK	C.J.
REVIEW	Ch

AR301372

PARTICLE SIZE DISTRIBUTION
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		**SAND**			**FINES**

SAMPLE ID	CC-1022 -		**LL**	-
SAMPLE TYPE	Bag		**PL**	-
SAMPLE DEPTH	-		**PI**	-

DESCRIPTION Black, MEDIUM TO FINE IRON FILINGS.

USCS SP

Cu = D60/D10 = 0.49/0.2 = 2.45 < 6

Cc = D30^2/(D60*D10) = 0.33^2/(0.49*0.2) = 1.11 > 1

SALTIRE/996-1100 IRON REACTIVE WALL/VA
IC3-3822

TECH	GM
DATE	Jun-00
CHECK	CAM
REVIEW	CAM

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	CC-1022 / -
PROJECT NO.	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS		**SAMPLE DEPTH**	-

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	37.17
Wt Dry Soil & Tare (gm)	(w2)	37.17
Weight of Tare (gm)	(w3)	3.22
Weight of Water (gm)	(w4=w1-w2)	0.00
Weight of Dry Soil (gm)	(w5=w2-w3)	33.95
Moisture Content (%)	(w4/w5)*100	0.00

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	
Dry Soil & Tare (gm)	
Tare Weight (gm)	
Moisture Content (%)	

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Mois

Weight Of Sample (gm)	320.25
Tare Weight (gm)	51.92
(W6) Total Dry Weight (gm)	268.33

SIEVE ANALYSIS

Tare Weight: 192.39

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) ((wt ret/w6)*100	% PASS (100-%ret)	SIEVE	
12.0"					12.0"	cobbles
3.0"					3.0"	coarse gravel
2.5"					2.5"	coarse gravel
2.0"					2.0"	coarse gravel
1.5"					1.5"	coarse gravel
1.0"					1.0"	coarse gravel
0.75"					0.75"	fine gravel
0.50"					0.50"	fine gravel
0.375"					0.375"	fine gravel
#4					#4	coarse sand
#8	192.39	0.00	0.00	100.00	#8	coarse sand
#16	192.46	0.07	0.03	99.97	#16	medium sand
#30	295.98	103.59	38.61	61.39	#30	medium sand
#50	405.70	213.31	79.50	20.50	#50	fine sand
#100	457.80	265.41	98.91	1.09	#100	fine sand
#200	460.55	268.16	99.94	0.06	#200	fines
PAN					PAN	

% COBBLES	0.00
% C GRAVEL	0.00
% F GRAVEL	0.00
% C SAND	0.01
% M SAND	58.94
% F SAND	40.99
% FINES	0.06
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

LL	-
PL	-
PI	-
Gs	6.927

DESCRIPTION Black, MEDIUM TO FINE IRON FILINGS.

USCS SP

TECH	GM
DATE	Jun-00
CHECK	Gw
REVIEW	Gw

SPECIFIC GRAVITY OF SOILS
ASTM D-854
PYCNOMETER METHOD

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA		
PROJECT NUMBER	IC3-3822	**SAMPLE ID**	CC-1022 -
		SAMPLE TYPE	Bag
TESTED FOR	SPECIFIC GRAVITY	**SAMPLE DEPTH**	-

HYGROSCOPIC MOISTURE OF MATERIAL PASSING THE #4 SIEVE

Weight Soil and Tare, Inital (gm)	(W1)	37.17
Weight Soil and Tare, Final (gm)	(W2)	37.17
Weight Of Tare (gm)	(W3)	3.22
Weight Of Moisture (gm)	(W4=W1-W2)	0.00
Weight Of Dry Soil (gm)	(W5=W2-W3)	33.95
Hygroscopic Moisture In (%)	(HM=(W4/W5)*100)	

AIR REMOVAL METHOD: VACUUM

Trial		1	2	3
Pycnometer Number		25	14	
Weight Pycnometer Empty (gm)	(Mf)	177.66	213.02	
Weight of Soil & Pycnometer (gm)		251.56	292.40	
Weight of Soil, Water & Pycnometer (gm)	(Mb)	739.24	779.53	
Observed Temperature (Tb), for (Mb) In Degrees C		22.5	21.5	
Observed Temperature (Ta), for (Ma) In Degrees C		21.50	21.50	
Weight of Pycnometer & Water (gm)	(Ma @ Ta)	676.22	711.50	
Relative Density of Water @ (Ta)		0.99791	0.99791	
Relative Density of Water @ (Tx)		0.99768	0.99791	
Correction Factor due to Temperature @Tx	(K)	0.9995	0.9997	
Weight of Soil (gm)		73.90	79.38	
Weight of Dry Soil (gm)	(Mo)	73.90	79.38	
Weight of Pycnometer & Water (gm)	(Ma)	676.11	711.50	

SPECIFIC GRAVITY

				Gs Average
G @ 20 degrees C = [Mo/(Mo+(Ma - Mb))]*(K)	6.861	6.992		6.927

Correction Values Due To Temperature

Temp. (C)	Rel. Density	Corr. (K)	Temp. (C)	Rel. Density	Corr. (K)
16.00	0.99897	1.0007	23.50	0.99745	0.9992
16.50	0.99889	1.0007	24.00	0.99732	0.9991
17.00	0.99880	1.0006	24.50	0.99720	0.9990
17.50	0.99871	1.0005	25.00	0.99707	0.9988
18.00	0.99862	1.0004	25.50	0.99694	0.9987
18.50	0.99853	1.0003	26.00	0.99681	0.9986
19.00	0.99843	1.0002	26.50	0.99668	0.9984
19.50	0.99833	1.0001	27.00	0.99654	0.9983
20.00	0.99823	1.0000	27.50	0.99640	0.9982
20.50	0.99812	0.9999	28.00	0.99626	0.9980
21.00	0.99802	0.9998	28.50	0.99612	0.9979
21.50	0.99791	0.9997	29.00	0.99597	0.9977
22.00	0.99780	0.9996	29.50	0.99582	0.9976
22.50	0.99768	0.9995	30.00	0.99567	0.9974
23.00	0.99757	0.9993			

TECH	GM
DATE	Jun-00
CHECK	[illegible]
REVIEW	[illegible]

CONSTANT HEAD PERMEABILITY TEST
ASTM D 2434

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	CC-1022 | -
PROJECT NUMBER	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS	-	**SAMPLE DEPTH**	-

	TIME (sec)	VOLUME (ml)	TEMP. (°C)	Q (ml/sec)	
1.	30	67	17.0	2.23	*
2.	30	67	17.0	2.23	*
3.	30	67	17.0	2.23	*

UNIT WEIGHT DETERMINATION

APPARATUS & WET SAMPLE (g):	3066.6
APPARATUS WEIGHT (g):	1356.3
WET SAMPLE WEIGHT (g):	1710.3
SAMPLE HEIGHT (in):	5.36
SAMPLE DIAMETER (in):	3.00
SAMPLE AREA (in	7.07
SAMPLE AREA (cm):	45.60
SAMPLE VOLUME (in^3):	37.89
SAMPLE VOLUME (cm^3):	620.86
WET DENSITY (pcf):	172.0
DRY DENSITY (pcf):	172.0

MOISTURE CONTENT

WET SAMPLE & TARE (g):	37.17
DRY SAMPLE & TARE (g):	37.17
WEIGHT OF WATER (g):	0.00
WEIGHT OF TARE (g):	0.00
DRY SAMPLE WEIGHT (g):	37.17
MOISTURE CONTENT (%):	0.00
SPECIFIC GRAVITY:	6.927
VOLUME OF SOLIDS (cm^3):	246.90
VOLUME OF VOIDS (cm^3):	373.96

DISTANCE B/W MANOMETERS (cm):	7.62
AVERAGE Q VALUE:	2.23
AVERAGE TEMP:	17.0
TEMPERATURE CORRECTION:	1.08
HEAD OF WATER (cm):	3.40
HYDRAULIC GRADIENT (i):	0.446

K VALUE CORRECTED FOR 20 °C = 1.2E-01 cm/sec

TECH	GM
DATE	Jun-00
CHECK	GM
REVIEW	GM

CONSTANT HEAD PERMEABILITY TEST
ASTM D 2434

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	CC-1022 / -
PROJECT NUMBER	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS	-	**SAMPLE DEPTH**	-

	TIME (sec)	VOLUME (ml)	TEMP. (°C)	Q (ml/sec)	
1.	15	96	15.5	6.40	*
2.	15	96	15.5	6.40	*
3.	15	96	15.5	6.40	*

UNIT WEIGHT DETERMINATION

APPARATUS & WET SAMPLE (g):	3066.6
APPARATUS WEIGHT (g):	1356.3
WET SAMPLE WEIGHT (g):	*1710.3*
SAMPLE HEIGHT (in):	5.36
SAMPLE DIAMETER (in):	3.00
SAMPLE AREA (in):	7.07
SAMPLE AREA (cm):	45.60
SAMPLE VOLUME (in^3):	37.89
SAMPLE VOLUME (cm^3):	620.86
WET DENSITY (pcf):	172.0
DRY DENSITY (pcf):	172.0

MOISTURE CONTENT

WET SAMPLE & TARE (g):	37.17
DRY SAMPLE & TARE (g):	37.17
WEIGHT OF WATER (g):	*0.00*
WEIGHT OF TARE (g):	0.00
DRY SAMPLE WEIGHT (g):	37.17
MOISTURE CONTENT (%):	0.00
SPECIFIC GRAVITY:	6.927
VOLUME OF SOLIDS (cm^3):	246.90
VOLUME OF VOIDS (cm^3):	373.96

DISTANCE B/W MANOMETERS (cm):	7.62
AVERAGE Q VALUE:	6.40
AVERAGE TEMP:	15.5
TEMPERATURE CORRECTION:	1.12
HEAD OF WATER (cm):	10.00
HYDRAULIC GRADIENT (i):	1.312

K VALUE CORRECTED FOR 20 °C = 1.2E-01 cm/sec

TECH	GM
DATE	Jun-00
CHECK	Gm
REVIEW	Gm

CONSTANT HEAD PERMEABILITY TEST
ASTM D 2434

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	CC-1115/1021 (2:1)
PROJECT NUMBER	IC3-3822	SAMPLE TYPE	Bag
REMARKS	-	SAMPLE DEPTH	-

	TIME (sec)	VOLUME (ml)	TEMP. (°C)	Q (ml/sec)	
1.	60	25.0	17.0	0.42	*
2.	60	25.0	17.0	0.42	*
3.	60	25.0	17.0	0.42	*

UNIT WEIGHT DETERMINATION

APPARATUS & WET SAMPLE (g):	3563.2
APPARATUS WEIGHT (g):	1827.2
WET SAMPLE WEIGHT (g):	1736.0
SAMPLE HEIGHT (in):	5.25
SAMPLE DIAMETER (in):	3.00
SAMPLE AREA (in²):	7.07
SAMPLE AREA (cm²):	45.60
SAMPLE VOLUME (in³):	37.11
SAMPLE VOLUME (cm³):	608.12
WET DENSITY (pcf):	178.2
DRY DENSITY (pcf):	178.2

MOISTURE CONTENT

WET SAMPLE & TARE (g):	50.00
DRY SAMPLE & TARE (g):	50.00
WEIGHT OF WATER (g):	0.00
WEIGHT OF TARE (g):	3.24
DRY SAMPLE WEIGHT (g):	46.76
MOISTURE CONTENT (%):	0.00
SPECIFIC GRAVITY (assumed):	5.8
VOLUME OF SOLIDS (cm³):	299.31
VOLUME OF VOIDS (cm³):	308.81

DISTANCE B/W MANOMETERS (cm):	7.62
AVERAGE Q VALUE:	0.42
AVERAGE TEMP:	17.0
TEMPERATURE CORRECTION:	1.08
HEAD OF WATER (cm):	3.40
HYDRAULIC GRADIENT (i):	0.446

K VALUE CORRECTED FOR 20 °C = 2.2E-02 cm/sec

TECH	GM
DATE	Jun-00
CHECK	Jm
REVIEW	Jm

CONSTANT HEAD PERMEABILITY TEST
ASTM D 2434

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	CC-1115/1021 (2:1)
PROJECT NUMBER	IC3-3822	SAMPLE TYPE	Bag
REMARKS	-	SAMPLE DEPTH	-

	TIME (sec)	VOLUME (ml)	TEMP. (°C)	Q (ml/sec)	
1.	30	37.0	17.5	1.23	*
2.	30	37.0	17.5	1.23	*
3.	30	37.0	17.5	1.23	*

UNIT WEIGHT DETERMINATION	
APPARATUS & WET SAMPLE (g):	3563.2
APPARATUS WEIGHT (g):	1827.2
WET SAMPLE WEIGHT (g):	1736.0
SAMPLE HEIGHT (in):	5.25
SAMPLE DIAMETER (in):	3.00
SAMPLE AREA (in^2):	7.07
SAMPLE AREA (cm^2):	45.60
SAMPLE VOLUME (in^3):	37.11
SAMPLE VOLUME (cm^3):	608.12
WET DENSITY (pcf):	178.2
DRY DENSITY (pcf):	178.2

MOISTURE CONTENT	
WET SAMPLE & TARE (g):	50.00
DRY SAMPLE & TARE (g):	50.00
WEIGHT OF WATER (g):	0.00
WEIGHT OF TARE (g):	3.24
DRY SAMPLE WEIGHT (g):	46.76
MOISTURE CONTENT (%):	0.00
SPECIFIC GRAVITY (assumed):	5.8
VOLUME OF SOLIDS (cm^3):	299.31
VOLUME OF VOIDS (cm^3):	308.81

DISTANCE B/W MANOMETERS (cm):	7.62
AVERAGE Q VALUE:	1.23
AVERAGE TEMP:	17.5
TEMPERATURE CORRECTION:	1.06
HEAD OF WATER (cm):	8.80
HYDRAULIC GRADIENT (i):	1.155

K VALUE CORRECTED FOR 20 °C = 2.5E-02 cm/sec

TECH	GM
DATE	Jun-00
CHECK	GM
REVIEW	GM

AR301379

CONSTANT HEAD PERMEABILITY TEST
ASTM D 2434

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	**SAMPLE ID**	CC-1115/1021 (1:1)
PROJECT NUMBER	IC3-3822	**SAMPLE TYPE**	Bag
REMARKS	-	**SAMPLE DEPTH**	-

	TIME (sec)	VOLUME (ml)	TEMP. (°C)	Q (ml/sec)	
1.	120	2.8	21.0	0.02	*
2.	120	2.9	21.0	0.02	*
3.	120	2.8	21.0	0.02	*

UNIT WEIGHT DETERMINATION	
APPARATUS & WET SAMPLE (g):	3694.8
APPARATUS WEIGHT (g):	1827.3
WET SAMPLE WEIGHT (g):	1867.5
SAMPLE HEIGHT (in):	5.25
SAMPLE DIAMETER (in):	3.00
SAMPLE AREA (in^2):	7.07
SAMPLE AREA (cm^2):	45.60
SAMPLE VOLUME (in^3):	37.11
SAMPLE VOLUME (cm^3):	608.12
WET DENSITY (pcf):	191.7
DRY DENSITY (pcf):	191.7

MOISTURE CONTENT	
WET SAMPLE & TARE (g):	50.00
DRY SAMPLE & TARE (g):	50.00
WEIGHT OF WATER (g):	0.00
WEIGHT OF TARE (g):	3.24
DRY SAMPLE WEIGHT (g):	46.76
MOISTURE CONTENT (%):	0.00
SPECIFIC GRAVITY (assumed):	5.8
VOLUME OF SOLIDS (cm^3):	321.98
VOLUME OF VOIDS (cm^3):	286.14

DISTANCE B/W MANOMETERS (cm):	7.62
AVERAGE Q VALUE:	0.02
AVERAGE TEMP:	21.0
TEMPERATURE CORRECTION:	0.98
HEAD OF WATER (cm):	3.40
HYDRAULIC GRADIENT (i):	0.446

K VALUE CORRECTED FOR 20 °C = 1.1E-03 cm/sec

TECH	GM
DATE	Jun-00
CHECK	GM
REVIEW	GM

AR301380

CONSTANT HEAD PERMEABILITY TEST
ASTM D 2434

PROJECT TITLE	SALTIRE/996-1100 IRON REACTIVE WALL/VA	SAMPLE ID	CC-1115/1021 (1:1)
PROJECT NUMBER	IC3-3822	SAMPLE TYPE	Bag
REMARKS	-	SAMPLE DEPTH	-

	TIME (sec)	VOLUME (ml)	TEMP. (°C)	Q (ml/sec)	
1.	120	13.5	21.0	0.11	*
2.	120	14.0	21.0	0.12	*
3.	120	13.5	21.0	0.11	*

UNIT WEIGHT DETERMINATION	
APPARATUS & WET SAMPLE (g):	3694.8
APPARATUS WEIGHT (g):	1827.3
WET SAMPLE WEIGHT (g):	1867.5
SAMPLE HEIGHT (in):	5.25
SAMPLE DIAMETER (in):	3.00
SAMPLE AREA (in^2):	7.07
SAMPLE AREA (cm^2):	45.60
SAMPLE VOLUME (in^3):	37.11
SAMPLE VOLUME (cm^3):	608.12
WET DENSITY (pcf):	191.7
DRY DENSITY (pcf):	191.7

MOISTURE CONTENT	
WET SAMPLE & TARE (g):	50.00
DRY SAMPLE & TARE (g):	50.00
WEIGHT OF WATER (g):	0.00
WEIGHT OF TARE (g):	3.24
DRY SAMPLE WEIGHT (g):	46.76
MOISTURE CONTENT (%):	0.00
SPECIFIC GRAVITY (assumed):	5.8
VOLUME OF SOLIDS (cm^3):	321.98
VOLUME OF VOIDS (cm^3):	286.14

DISTANCE B/W MANOMETERS (cm):	7.62
AVERAGE Q VALUE:	0.11
AVERAGE TEMP:	21.0
TEMPERATURE CORRECTION:	0.98
HEAD OF WATER (cm):	9.80
HYDRAULIC GRADIENT (i):	1.286

K VALUE CORRECTED FOR 20 °C = 1.9E-03 cm/sec

TECH	GM
DATE	Jun-00
CHECK	*[signature]*
REVIEW	*[signature]*

AR301381

APPENDIX A-3

Leak Off Tests

IRON-GEL-SAND LEAK-OFF TEST RESULTS

PROJECT NAME: SALTIRE/ARROWHEAD PLATING/VA
PROJECT NUMBER: 996-1100
SAMPLE ID: CC-1022/ATL SAND 80-20/30

TESTING CONDITIONS

Column Preparation (Time)	7/14/00 11:26 AM	Time (min):	0
Leak-Off Test Start Since Initial Gel Cross Link	7/14/00 11:33 AM	Time (min):	7
Leak-Off Test End Since Initial Gel Cross Link	7/14/00 12:33 PM	Time (min):	67
Leak-Off Test Duration (min)	60		
Leak-Off Test Pressure (psi)	49		
Leak-Off Test Locking Pressure (psi)	19		
Gel Volume (ml)	1368		
Weight of Iron (gm)	1634		

IRON/IRON-GEL-SAND/LEAK-OFF PERM. TEST

SOIL DESCRIPTION: White, MEDIUM TO FINE SAND, trace silt.
(ATL SAND 80-20/30)
USCS: SP
IRON DESCRIPTION: Black, MEDIUM TO FINE CONNELLY CC-1022 IRON FILINGS.
USCS: SP
FLUID DESCRIPTION: 48 lb/1000 gal cross linked gel

SOIL SAMPLE PREPARATION

Height, cm	30.48
Diameter, cm	10.16
Area, cm	81.07
Volume, cm3	2471.11
Dry Sand Weight, g	3764.00
Saturated Sand Weight, g	4798.00
Weight of Water, g	1034.00
Dry Density, pcf	95.05
Spec. Gravity	2.65
Volume Solids, cm3	1420.38
Volume Voids, cm3	1050.73
Saturation, %	98.4%
Void Ratio %	74.0%
Porosity, %	42.5%

TIME (min)	TIME ROOT (min)	VOLUME OF WATER DISPLACED FROM SAMPLE (ml)	TEST PRESSURE (psi)
0.0	0.00	0.0	49
0.1	0.29	19.0	49
3.8	1.96	37.0	49
7.5	2.74	47.0	49
13.2	3.63	60.0	49
20.2	4.50	73.0	49
27.8	5.28	85.0	49
35.8	5.98	96.0	49
44.2	6.65	107.5	49
50.4	7.10	117.0	49
55.8	7.47	125.0	49
60.0	7.75	132.5	49
121.0	11.00	224.5	19
197.0	14.04	504.5	19
251.0	15.84	699.5	19
302.0	17.38	849.5	19
4202.0	64.82	1089.5	19

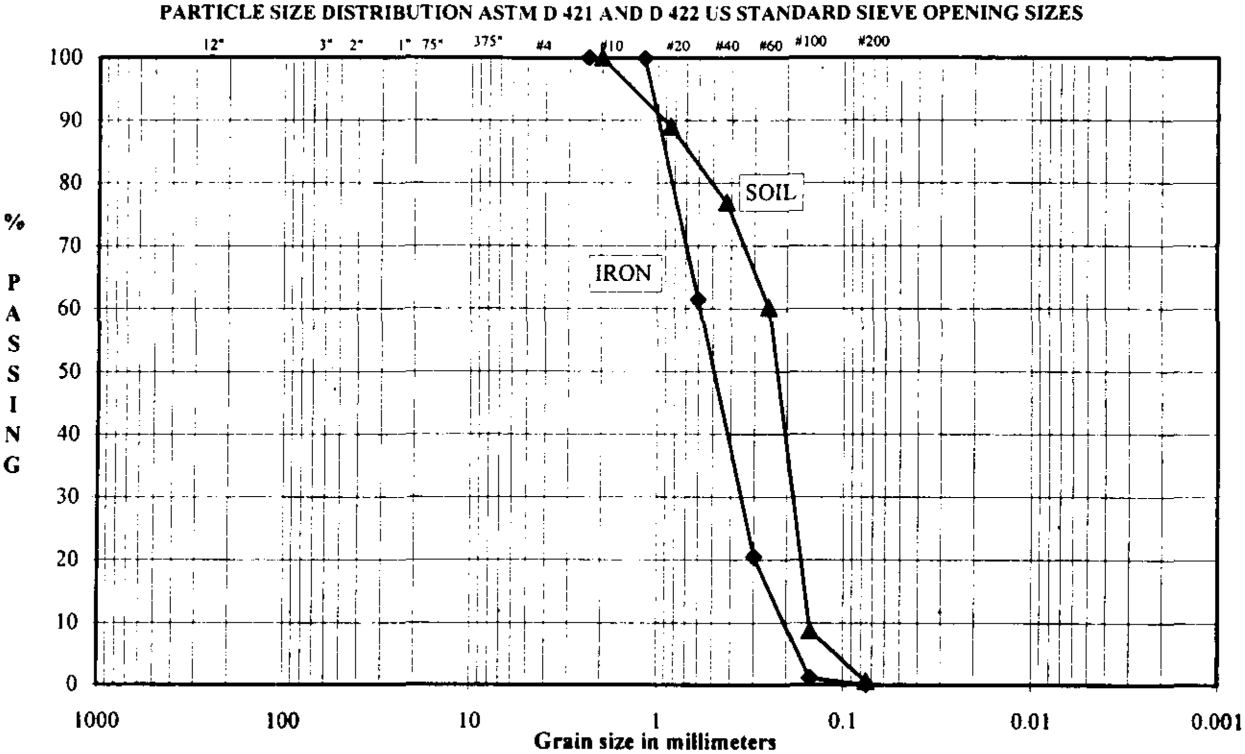
FILTER CAKE THICKNESS (cm): 0.5

TECH	SW
DATE	7/17/00
CHECK	GM
REVIEW	RIO

JANUARY 2001 | 996-1100

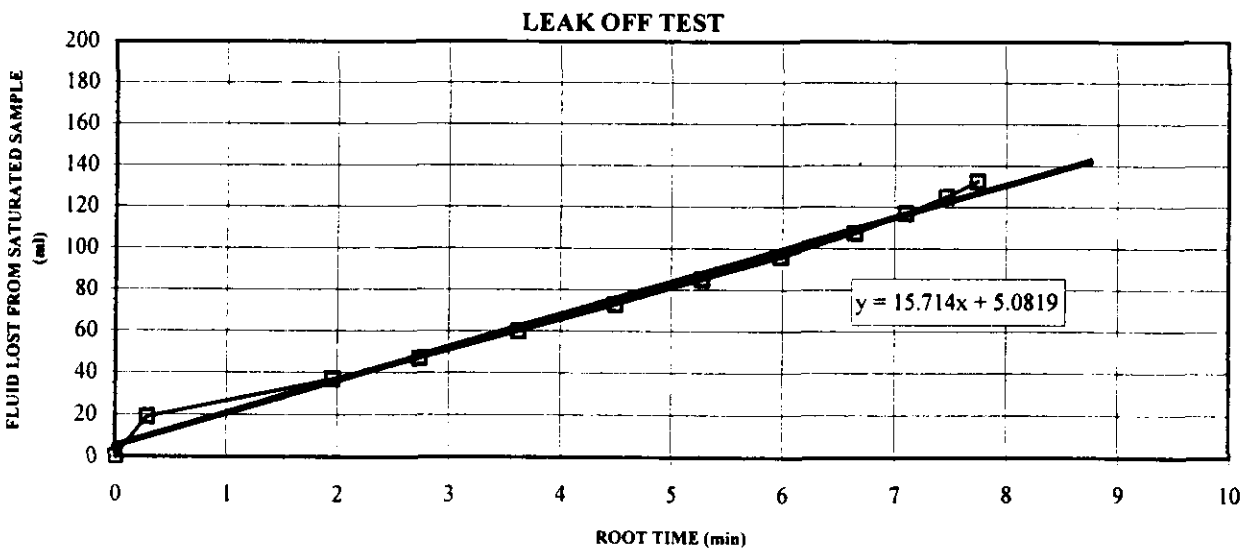
IRON-GEL-SAND LEAK-OFF TEST RESULTS

PROJECT NAME: SALTIRE/ARROWHEAD PLATING/VA
PROJECT NUMBER: 996-1100
SAMPLE ID: CC-1022/ATL SAND 80-20/30



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES

SOIL DESCRIPTION: White, MEDIUM TO FINE SAND, trace silt.
(ATL SAND 80-20/30)
USCS: SP-SM
IRON DESCRIPTION: Black, MEDIUM TO FINE CONNELLY CC-1022 IRON FILINGS.
USCS: SP
FLUID DESCRIPTION: 48 lb/1000 gal cross linked gel



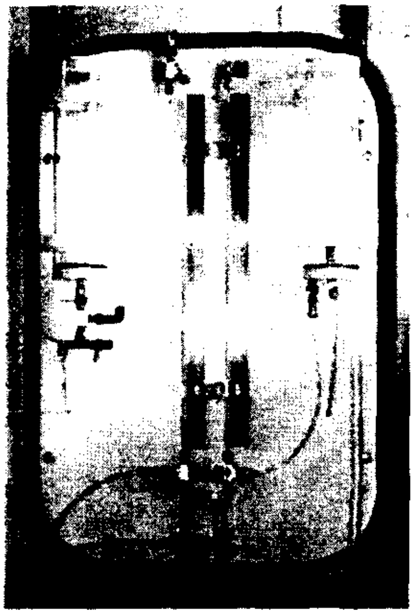
LEAK OFF COEFFICIENT Cw (cm/min$^{1/2}$) = 0.10
(Tested under 60 psi)
SPURT VALUE SV (cm) = 0.03

y = mx + b where m = slope
Cw = m / (2 Ac) b = y-intercept
SV = b / 2 Ac Ac = sample area

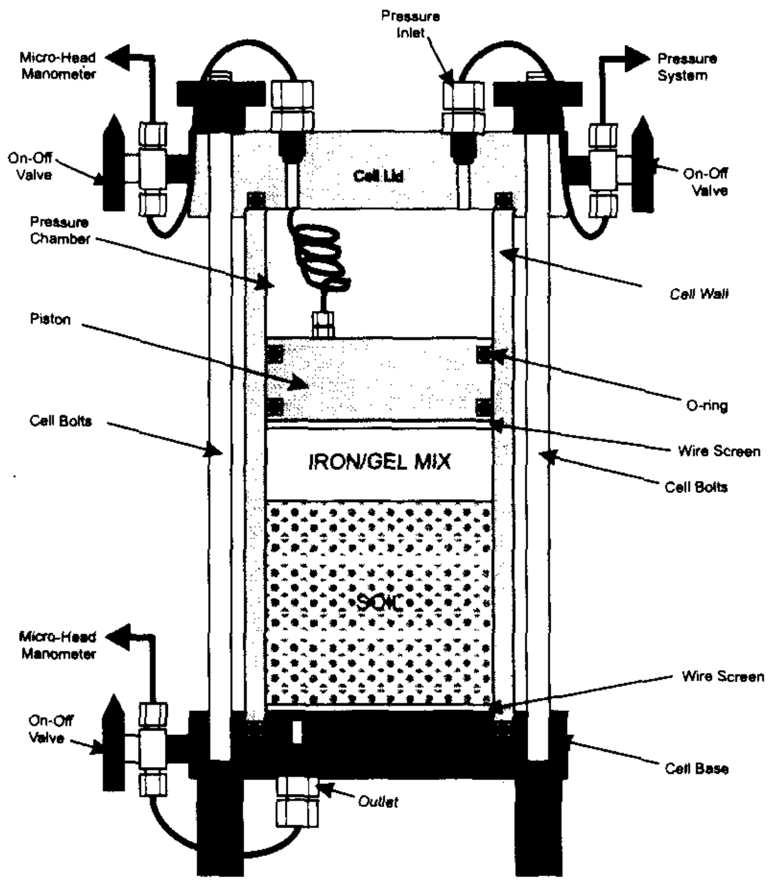
TECH	SW
DATE	7/17/00
CHECK	GM
REVIEW	RIO

AR301384

GOLDER SIERRA 1100-20_30-80.xls: IRON-GEL-SAND LEAK-OFF CHART



Micro-Head Manometer



Perm-Leak-Off Apparatus

GOLDER SIERRA — Atlanta, Georgia		TITLE: Golder Micro-Head Perm-Leak-Off Test Apparatus			
CLIENT/PROJECT: SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA	DRAWN: MAT	DATE: 3/13/00	JOB NO.: 996-1100		
	CHECKED: RIO	SCALE: N/A	DWG NO.	REV. NO.	
	REVIEWED: [illegible]	FILE NO.: 1100-D38.cdr	SUBTITLE	FIGURE NO.: 1	

AR301385

APPENDIX A-4

Micro-Head Permeameter and TOC Tests

IRON-GEL-SAND PERMEABILITY

ASTM D2434 - MODIFIED

PROJECT NAME: SALTIRE/ARROWHEAD PLATING/VA

PROJECT NUMBER: 996-1100

SAMPLE ID: IRON-GEL-SAND **IRON/SAND TYPE:** CC-1022/ATL SAND 80-20/30

Iron-Gel-Sand Column Preparation	7/14/00 11:26 AM	0
Iron-Gel-Sand Permeability Test Start	7/17/00 2:05 PM	3.1
Iron-Gel-Sand Permeability Test End	7/28/00 2:00 PM	14.1

Sand Sample Data

Height, cm	30.48	Dry Density, pcf	95.05
Diameter, cm	10.16	Spec. Gravity (*)	2.65
Area, cm²	81.07	Volume Solids, cm³	1420.38
Volume, cm3	2471.11	Volume Voids, cm³	1050.73
Dry Sand Weight (Dry), g	3764.00	Saturation, %	98.4%
Saturated Sand Weight, g	4798.00	Void Ratio %	74.0%
Weight of Water, g	1034.00	Porosity, %	42.5%
Moisture Content, %	27.5%		

Iron Sample Data - Final

Height, cm	7.47	Dry Density, pcf	168.41
Diameter, cm	10.16	Spec. Gravity (*)	6.93
Area, cm²	81.07	Volume Solids, cm³	235.89
Volume, cm³	605.42	Volume Voids, cm³	369.53
Dry Iron Weight, g	1634.00	Porosity, %	61.0%
Iron-Sand Column Pore Volume, ml	1420		

TECH	SW
DATE	7/28/00
CHECK	GM
REVIEW	RIO

(*) Assumed Value

Pore Volume	Manometer		Head	Flow	Time	Gradient	Temp	Iron/Sand Permeability	Time Since Cross Link	TOC (composite)	O.R.P.	Dissolved	pH
	$H_{1(Top)}$	$H_{2(Bottom)}$	(cm)	Q, cm³	t_{sec}	(i)	°C	@ 20°C (cm/sec)	(day)	(ppm)	mV (eh)	O_2(ppm)	
INTIAL RUN OFF	--	--	--	--		--	--	--	3.1	--	--	--	--
0.03	54.8	50.9	3.9	41	8580	0.103	25.0	5.10E-04	3.2	--	--	--	--
0.26	54.8	51.2	3.6	325	66120	0.095	25.0	5.68E-04	4.0	3260	--	--	--
0.33	54.7	51.0	3.7	100	9300	0.098	25.0	1.21E-03	4.1	--	--	--	--
0.42	54.7	51.3	3.4	125	10140	0.090	25.0	1.51E-03	4.2	--	--	--	--
0.98	54.5	51.3	3.2	805	56880	0.084	25.0	1.84E-03	4.9	1080	--	--	--
1.27	54.4	51.2	3.2	410	24660	0.084	25.0	2.16E-03	5.1	--	--	--	--
2.47	54.2	51.1	3.1	1700	65340	0.082	25.0	3.49E-03	5.9	--	--	--	--
2.68	54.3	50.8	3.5	295	13740	0.092	25.0	2.55E-03	6.1	156	--	--	--
2.85	54.3	50.5	3.8	245	4560	0.100	25.0	5.88E-03	6.1	--	--	--	--
3.68	54.3	50.5	3.8	1180	67740	0.100	25.0	1.91E-03	6.9	--	--	--	--
3.93	54.2	50.5	3.7	350	14520	0.098	25.0	2.71E-03	7.1	--	--	--	--
3.93	53.1	50.5	2.6		720	0.069	25.0	0.00E+00	7.1	--	--	--	--
4.55	51.9	43.6	8.3	890	8400	0.219	25.0	5.31E-03	7.2	--	--	--	--
4.75	52.3	42.2	10.1	275	4500	0.266	25.0	2.52E-03	7.2	39	--	--	--
7.63	51.4	42.5	8.9	4100	61980	0.235	25.0	3.09E-03	7.9	---	--	--	--
7.82	51.4	42.2	9.2	270	232	0.242	25.0	5.27E-02	8.0	15	--	--	--
11.55	50.4	42.2	8.2	5300	7335	0.216	25.0	3.67E-02	9.1	--	--	--	--
11.74	49.4	39.5	9.9	270	297	0.261	25.0	3.82E-02	9.1	9	--	--	--
12.50	54.8	39.5	15.3	1075	4780	0.403	25.0	6.12E-03	9.8	--	--	--	--
12.80	47.9	15.1	32.8	420	561	0.864	25.0	9.50E-03	9.9	--	--	--	--
13.15	46.2	15.1	31.1	500	199	0.820	25.0	3.36E-02	9.9	--	--	--	--
14.33	49.5	14.8	34.7	1675	1581	0.914	25.0	1.27E-02	10.2	--	--	--	--
14.54	47.6	15.4	32.2	300	176	0.849	25.0	2.20E-02	10.2	7	--	--	--
18.62	50.5	15.3	35.2	5800	4159	0.928	25.0	1.65E-02	10.8	7	--	--	--

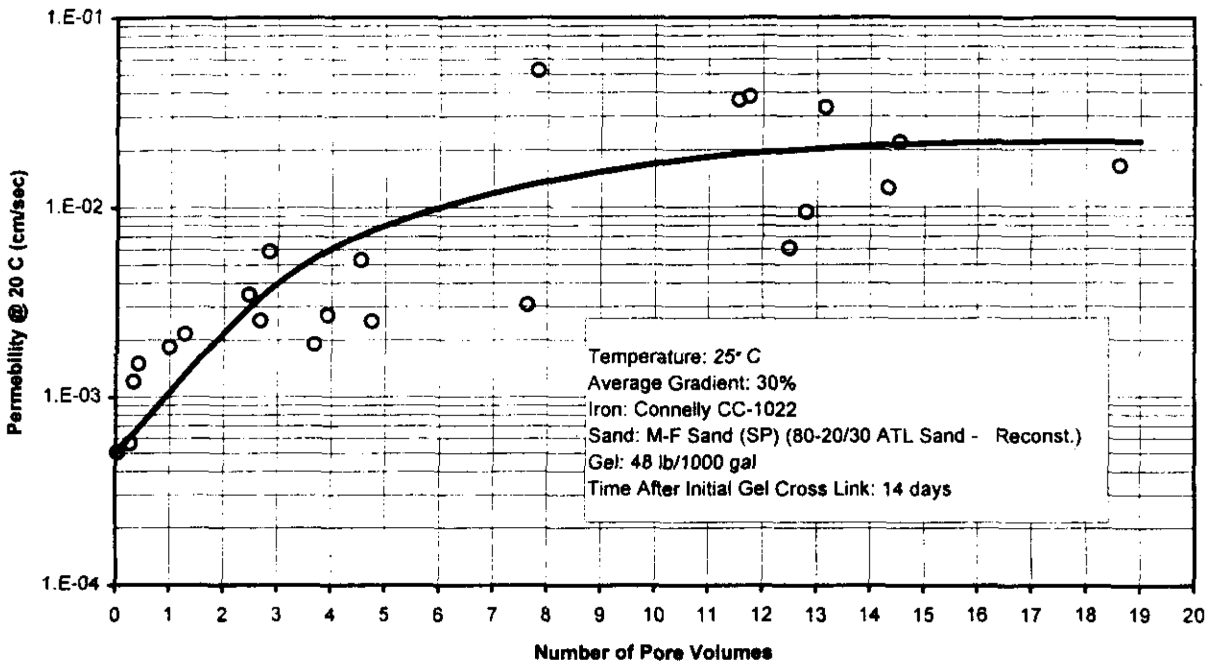
AR301387

JANUARY 2001 | 996-1100

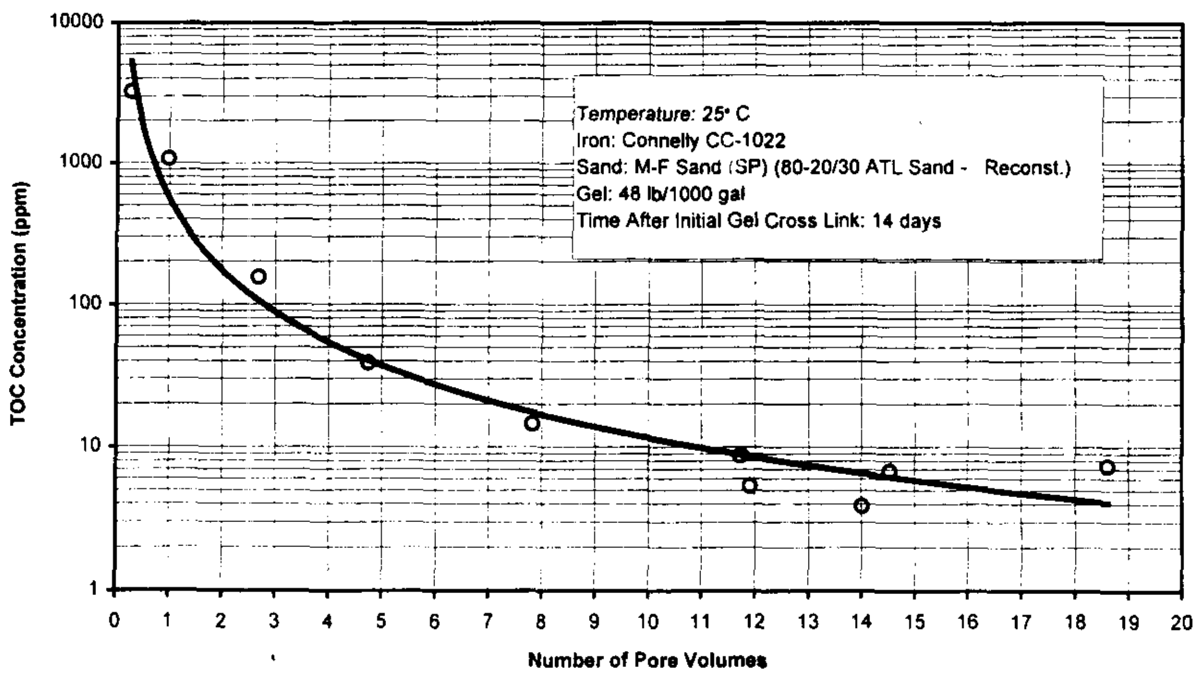
IRON-GEL-SAND LEAK-OFF TEST RESULTS

PROJECT NAME: SALTIRE/ARROWHEAD PLATING/VA
PROJECT NUMBER: 996-1100
SAMPLE ID: CC-1022/ATL SAND 80-20/30

IRON-GEL-SAND PERMEABILITY TEST



IRON-GEL-SAND GEL-BREAKDOWN TEST



TECH	SW
DATE	7/17/00
CHECK	RJO
REVIEW	RJO

ACL

ADVANCED CHEMISTRY LABS, INC.

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Fax: (770) 409-1844
Outside GA: (800) 277-0520
e-mail: acl@mindspring.com

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P.O. Box 88610 • Atlanta, GA 30356
www.advancedchemistrylabs.com

Client: Golder Sierra LLC
3730 Chamblee Tucker Road
Atlanta, GA 30341

Client Project No: 4-202/Saltire
ACL Project No: 32978
Date Received: 07-25-00
Date Reported: 07-28-00

Contact: Mr. Rafael Ospina

Sample ID	ACL #	Matrix	TOC (EPA 415.1) (mg/liter) Result	Det. Limit	Date Analyzed
1	157643	Water	3260	1.0	07-28-00
2	157644	Water	1080	1.0	07-28-00
3	157645	Water	156	1.0	07-28-00
4	157646	Water	38.9	1.0	07-28-00
5	157647	Water	14.6	1.0	07-28-00
6	157648	Water	8.8	1.0	07-28-00
7	157649	Water	6.8	1.0	07-28-00
8	157650	Water	7.4	1.0	07-28-00

John Andros

John Andros, Lab Manager

BDL = Below Detection Limit

APPENDIX A-5

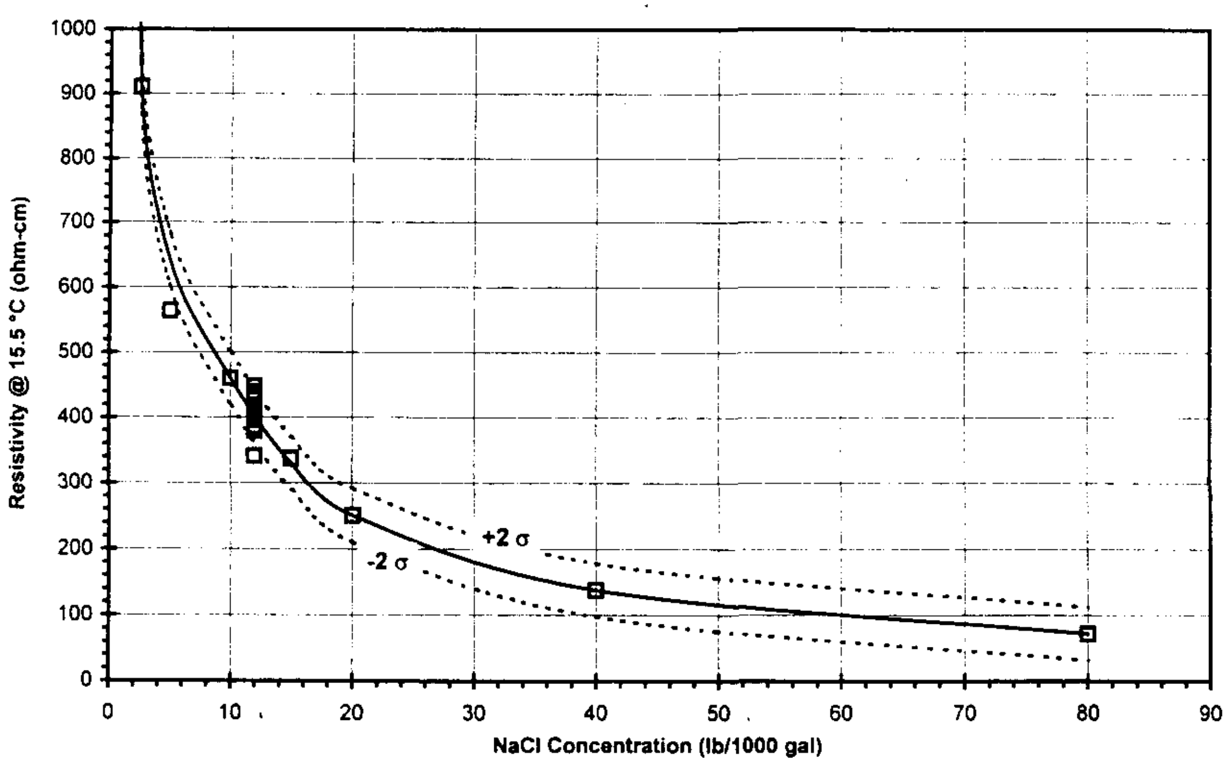
Fracture Fluid Resistivity Tests

GEL RESISTIVITY TESTING

Project: SALTIRE/ARROWHEAD PLATING/VA
Job No.: 996-1100
Meter Type: Nilsson 400 Soil Resistance Meter.
Miller Soilbox

Date: Jun-00
Tested By: RIO
Checked By: RIO

NaCl Concentration (lb/1000 gal)	Resistivity @ 15.5 °C (ohm-cm)		
	mean	min	max
0	4438	4398	4478
2.5	911	871	951
5	640	600	680
10	460	420	500
15	330	290	370
20	251	211	291
40	138	98	178
80	72	32	112



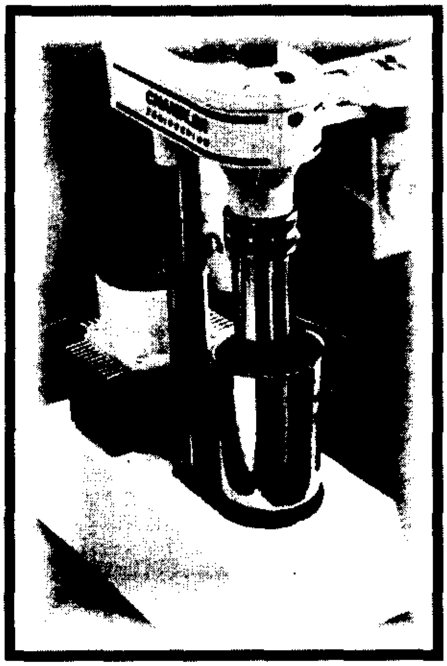
GOLDER SIERRA

Cqabatch.xls: Resistivity Spec Lab

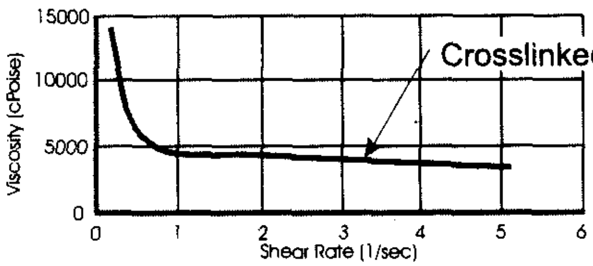
AR301391

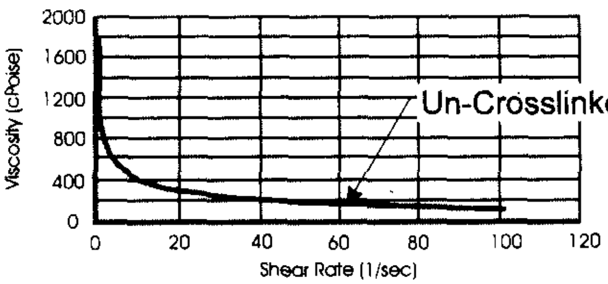
APPENDIX A-6

Fracture Fluid Viscosity Tests



Rotating Cylinder
Viscometer





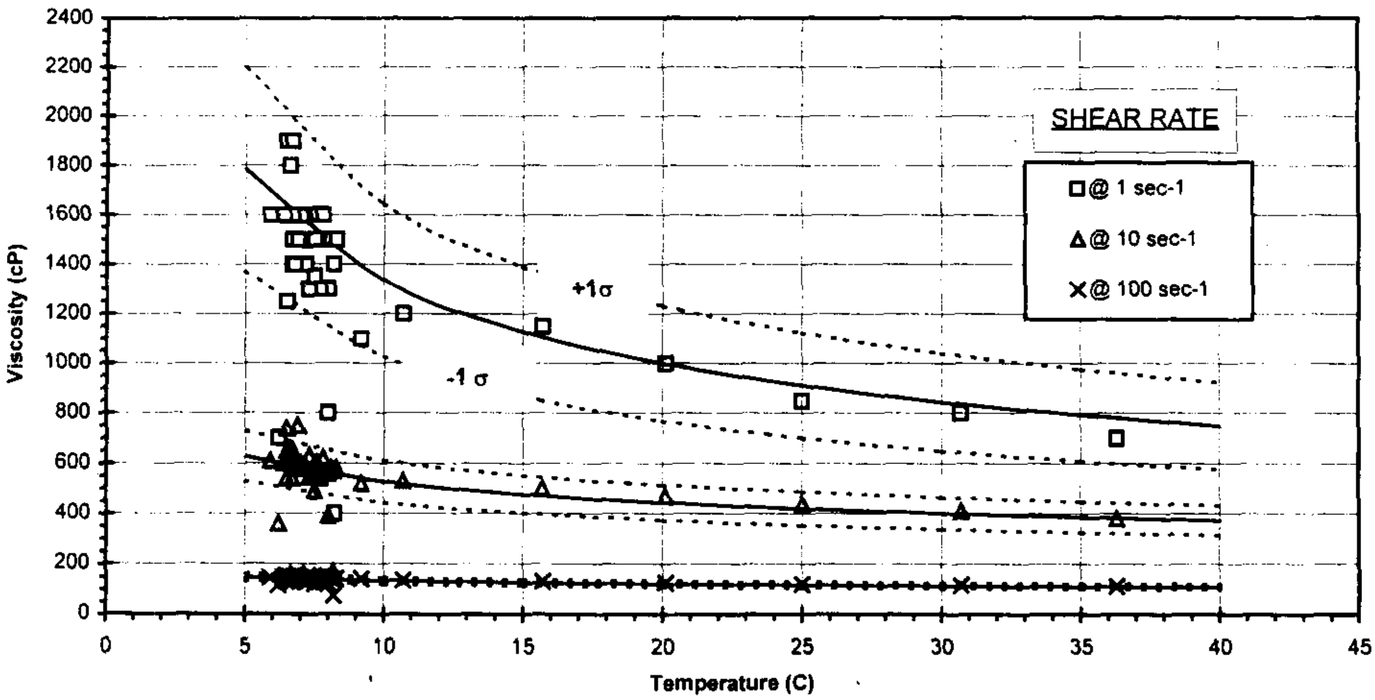
GOLDER SIERRA Atlanta, Georgia	TITLE ROTATING CYLINDER VISCOMETER					
CLIENT/PROJECT SALTIRE INDUSTRIAL, INC./ FORMER ARROWHEAD PLATING FACILITY MONTROSS, VA	DRAWN MAT	DATE 2/2/01	JOB NO. 996-1100			
	CHECKED RIO	SCALE N/A	DWG NO.	REV. NO.		
	REVIEWED [signature]	FILE NO. 1100-d49.cdr	SUBTITLE	FIGURE NO. 1		

AR301393

GEL VISCOSITY TESTING

Project:	SALTIRE/ARROWHEAD PLATING/VA	Date:	Jun-00
Job No.:	996-1100	Tested By:	RIO
Meter Type	EG&G Chandler Model 35	Checked By:	RIO
	Bob-B1, Rotor-R-1, Spring-F0.2		

Temperature (C)	Viscosity (cP) @ 1 sec-1 mean	min	max	@ 10 sec-1 mean	min	max	@ 100 sec-1 mean	min	max
5	1783	1370	2195	627	527	726	146	132	161
10	1335	1026	1645	527	443	611	132	119	145
15	1128	867	1389	476	400	552	125	112	137
20	1000	769	1232	443	373	513	120	108	131
25	911	700	1123	419	352	485	116	104	127
30	845	649	1040	400	337	464	113	101	124
35	792	609	976	385	324	446	110	99	121
40	749	576	923	372	313	432	108	97	119



CROSSLINKED HPG GEL VISCOSITY TEST RESULTS

Project:	SALTIRE/ARROWHEAD PLATING/VA	Date:	Aug-00
Job No.:	996-1100	Tested By:	RIO
Meter Typ	EG&G Chandler Model 35	Checked By:	RIO
	Bob-B1, Rotor-R-1, Spring-F0.2		

Shear Rate 1 sec-1	Viscosity (cP)
0.17	14,100
0.34	7,950
0.51	6,100
1.02	4,400
1.7	4,500
3.4	3,720
5.11	3,240

Fluid Description:
G1 - Frac Fluid - 48 lb HPG Gel / 1000 gal water

Power Law Viscosity Model

$\mu = a \dot{\gamma}^{b}$

μ is viscosity (cP)

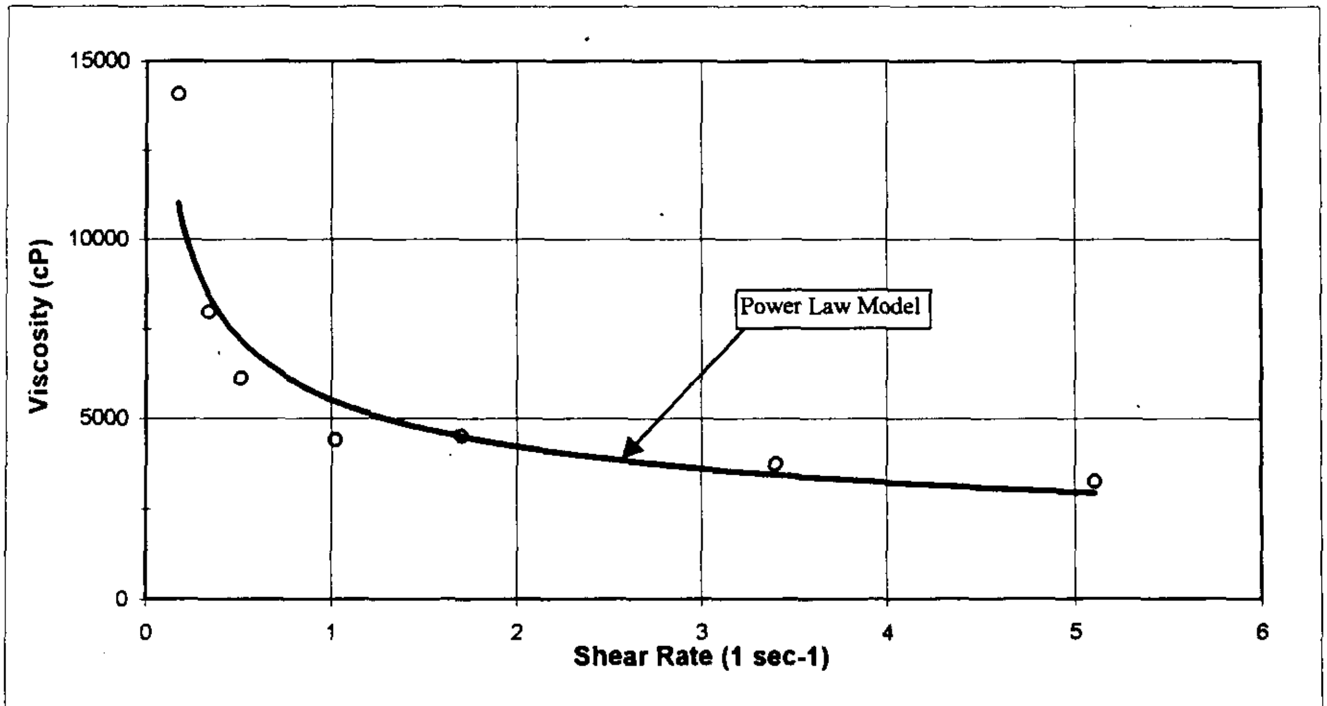
γ is shear rate (1/sec)

a = 5518.2

b = -0.39

$R^2 = 0.9$

Viscosity Versus Shear Rate at 25°C of Crosslinked HPG Gel



APPENDIX A-7

Iron Filings Grain Size Specification and Mineralogical Analysis

IRON FILINGS SPECIFICATION DEVELOPMENT GRAIN SIZE ANALYSIS

ASTM GRAIN SIZE ANALYSIS ASTM D421, D2217, D1140, C117, D422, C136

Project:	SALTIRE/ARROWHEAD PLATING/VA	Date:	Jun-00
Job No.:	996-1100	Tested By:	GM
Iron Type:	Connelly CC-1022	Checked By:	RIO

Sample Load No.	Load Weight (ton)	% Passing Sieve (ASTM D422)						
		#4	#8	#16	#30	#50	#100	#200
1	22	100.0	100.0	100.0	68.8	15.0	1.0	0.0
2	22	100.0	100.0	100.0	73.1	19.8	1.8	0.1
3	22	100.0	100.0	100.0	70.6	19.3	2.1	0.3
4	22	100.0	100.0	100.0	65.0	20.6	1.3	0.0
5	22	100.0	100.0	100.0	74.3	22.1	2.3	0.2
6	22	100.0	100.0	100.0	64.9	15.4	1.0	0.0
7	22	100.0	100.0	100.0	68.5	18.5	1.6	0.1
Average		**100.0**	**100.0**	**100.0**	**69.3**	**18.7**	**1.6**	**0.1**
Project Specification		**100**	**100**	**95 - 100**	**55 - 95**	**15 - 45**	**0 - 15**	**< 5**

CONNELLY - GPM, INC.
ESTABLISHED 1875
3154 SOUTH CALIFORNIA AVENUE · CHICAGO, ILLINOIS 60608-5176
PHONE: (773) 247-7231 FAX: (773) 247-7239

SCREEN SPECIFICATION
CC-1022
PROPRIETARY BLEND FOR GOLDER SIERRA
(-14+84 Mesh)

U.S. SCREEN NUMBER	
8	100% PASSING
16	95 - 100% PASSING
30	60 - 90
50	15 - 40
100	0 - 10
200	0 - 3

MATERIAL WEIGHS APPROXIMATELY 170 - 190 POUNDS PER CUBIC FOOT

TYPICAL ANALYSIS OF IRON AGGREGATE

Metallic Iron	89.82
Total Carbon	2.85
Manganese	0.60
Sulphur	0.107
Phosphorous	0.132
Silicon	1.85
Nickel	0.05 - 0.21
Chromium	0.03 - 0.17
Vanadium	Nil
Molybdenum	0.15
Titanium	0.004
Copper	0.15 - 0.20
Aluminum	Trace
Cobalt	0.003

CURTIS A. REVELL
Technical Director

D:\WORD\CI-CUSTO\1022SPECGOLDER.DOC

AR301398

APPENDIX A-8

Iron Filings pH Activity Tests

IRON pH ACTIVITY TEST RESULTS
ASTM D1293, D4972 MODIFIED

Project:	SALTIRE/ARROWHEAD PLATING/VA	Date:	Jun-00
Job No.:	996-1100	Tested By:	RIO
Iron Type:	Connelly	Checked By:	RIO

SAMPLE ID Day	Time	pH
1	10:50	6.58
1	10:59	6.31
1	11:04	6.20
1	11:09	6.32
1	11:16	6.06
1	11:18	6.33
1	stirred sample	
1	11:22	6.95
1	11:27	6.63
1	11:32	6.62
1	11:37	6.71
1	11:42	6.63
1	11:47	6.60
1	11:52	6.53
1	11:57	6.37
1	12:02	6.42
1	stirred sample	
1	12:07	6.97
1	12:22	6.72
1	12:37	6.40
1	12:52	6.44
1	13:07	6.38
1	13:22	6.23
1	13:37	6.28
1	13:52	6.39
1	14:07	6.50
1	14:22	5.92
1	14:37	6.55
1	14:52	6.31
1	stirred sample	
1	15:00	7.44
1	15:07	6.51
1	15:22	6.47
1	poured samples from cups to jars w/ lids	
1	15:34	7.57
2	06:37	7.21

Sample Preparation: 143.4 grams of iron per 100 mL distilled deionized water

APPENDIX B

Boring and Well Installation Logs and Monitoring Well Sampling Data

APPENDIX B-1	Boring Logs
APPENDIX B-2	Well Installation Log
APPENDIX B-3	Monitoring Well Water Level and Sampling Data
APPENDIX B-4	Soil Boring and CPT Soil Interpretation Data Correlation
APPENDIX B-5	Investigation Derived Waste Characterization Laboratory Data

APPENDIX B-1

Boring Logs

SOIL LOG OF BOREHOLE SBS-10

PROJECT NO: 996-1100

DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA

COORDINATES: N 6719608.83, E 11975554.76

CLIENT: SALTIRE INDUSTRIAL, INC.

SITE LOCATION: ARROWHEAD FACILITY

GSL INSPECTOR: SLW

BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE						
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
		Ground Surface		0							
0		0-6' Loose to compact, reddish brown, MEDIUM to FINE SAND, some silty clay.	(SC-SM)	140.84							
1					1	DO	5	12/24	N/A	●	
3					2	DO	5	19/24	N/A	●	
5					3	DO	11	17/24	0.3	●	
6		6-14' Compact, reddish brown, MEDIUM to FINE SAND, some clayey silt.	(SM)	6 134.84							
7					4	DO	17	20/24	0.2	●	
9					5	DO	29	20/24	N/A	●	
11					6	DO	27	17/24	0.1	●	
12											@ 12' Iron sand lense.
13					7	DO	21	19/24	N/A	●	
14			(CH)	14 126.84							
15										●	

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/8/00

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SHEET: 1 of 3

SOIL LOG OF BOREHOLE SBS-10

PROJECT NO: 996-1100
DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA
COORDINATES: N 6719608.83, E 11975554.76

CLIENT: SALTIRE INDUSTRIAL, INC.
SITE LOCATION: ARROWHEAD FACILITY

GSL INSPECTOR: SLW
BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE						
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft 'N'	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
16, 17		14-18' Firm to stiff, mottled gray and yellowish brown, SILTY CLAY, little coarse to fine sand.	(CH)	18	8	DO	13	23/24	N/A		16-18' Performed sieve analysis and Atterberg limits. USCS: (CH)
					9	DO	14	20/24	N/A		
18, 19, 20, 21, 22, 23		18-24' Compact, reddish brown, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	122.84 24	10	DO	23	19/24	N/A		
					11	DO	25	19/24	N/A		
					12	DO	12	19/24	N/A		22-24' Performed sieve analysis. USCS: (SP-SM)
24, 25, 26, 27		24-28' Compact, mottled yellowish brown and reddish yellow, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	116.84 28	13	DO	14	18/24	N/A		@ 25' 3" clay lense.
					14	DO	11	15/24	N/A		@ 27' 4" clay lense.
28, 29, 30		28-31' Compact, mottled yellowish gray, brown and red, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	112.84	15	DO	18	18/24	N/A		@ 30' Iron sand lense.

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/8/00

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SOIL LOG OF BOREHOLE SBS-10

PROJECT NO: 996-1100

DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA

COORDINATES: N 6719608.83, E 11975554.76

CLIENT: SALTIRE INDUSTRIAL, INC.

SITE LOCATION: ARROWHEAD FACILITY

GSL INSPECTOR: SLW

BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE						
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
			(SP-SM)	31							
31		31-34' Loose , gray, MEDIUM to FINE SAND, some silty clay.	(SC)	109.84	16	DO	12	20/24	N/A	●	
32–33					17	DO	4	23/24	N/A	●	
				34							
34		34-44' Soft, dark gray, SILTY CLAY, some medium to fine sand.	(CH)	106.84	18	DO	5	24/24	N/A	●	
36–37					19	DO	7	24/24	N/A	●	
38–39					20	DO	8	24/24	N/A	●	
40–41					21	DO	6	24/24	N/A	●	
				42							
42		Borehole Terminated @ 42' BGS.		98.84							
43–45											

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/8/00

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SHEET: 3 of 3

AR301405

SOIL LOG OF BOREHOLE SBS-11

PROJECT NO: 996-1100 **DATUM:** MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA **COORDINATES:** N 6719456.82, E 11975684.52

CLIENT: SALTIRE INDUSTRIAL, INC. **SITE LOCATION:** ARROWHEAD FACILITY

GSL INSPECTOR: SLW **BORING LOCATION:** -

Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
		Ground Surface		0							
0–2		0-2' Loose, brown, MEDIUM to FINE SAND, some clayey silt.	(SM)	142.41 / 2	1	DO	9	12/24	N/A		
2–6		2-6' Loose, reddish brown, MEDIUM to FINE SAND and SILTY CLAY.	(SC-SM)	140.41 / 6	2	DO	4	17/24	N/A		
					3	DO	7	12/24	0.4		
6–14		6-14' Loose to dense, reddish brown, MEDIUM to FINE SAND, some clayey silt.	(SM)	136.41	4	DO	7	16/24	N/A		
					5	DO	20	18/24	0.1		
					6	DO	52	19/24	N/A		@ 11.5' Iron sand lense.
					7	DO	15	16/24	N/A		

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/5/00

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SHEET: 1 of 3

SOIL LOG OF BOREHOLE SBS-11

PROJECT NO: 996-1100

DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA

COORDINATES: N 6719456.82, E 11975684.52

CLIENT: SALTIRE INDUSTRIAL, INC.

SITE LOCATION: ARROWHEAD FACILITY

GSL INSPECTOR: SLW

BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE						
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
16, 17, 18		6-14' Loose to dense, reddish brown, MEDIUM to FINE SAND, some clayey silt.	(SM)	18	8	DO	14	14/24	N/A		
					9	DO	18	16/24	N/A		
18, 19, 20, 21, 22		18-22' Compact, reddish brown, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	124.41 / 22	10	DO	20	20/24	N/A		
					11	DO	26	20/24	N/A		
22, 23, 24, 25, 26, 27, 28		22-28' Compact, mottled *yellowish brown and* reddish yellow, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	120.41 / 28	12	DO	13	15/24	N/A		
					13	DO	12	21/24	0.0		
					14	DO	12	18/24	N/A		26-28' Performed sieve analysis. USCS: (SP-SM)
28, 29, 30		28-35' Compact, mottled *yellowish brown, red and* black, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	114.41	15	DO	14	17/24	N/A		

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/5/00

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SHEET: 2 of 3

SOIL LOG OF BOREHOLE SBS-11

PROJECT NO: 996-1100
DATUM: MSL
PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA
COORDINATES: N 6719456.82, E 11975684.52
CLIENT: SALTIRE INDUSTRIAL, INC.
SITE LOCATION: ARROWHEAD FACILITY
GSL INSPECTOR: SLW
BORING LOCATION: -

Depth (FT)	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Remarks
31	28-35' Compact, mottled yellowish brown, red and black, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)		16	DO	20	15/24	N/A	
33				17	DO	14	18/24	0.0	32-34' Performed sieve analysis. USCS: (SP-SM)
35	35-36' Loose, dark gray, MEDIUM to FINE SAND, some silty clay.	(SC)	35 107.41 36 106.41	18	DO	6	22/24	N/A	
37	36-44' Firm, dark gray, SILTY CLAY, some medium to fine sand.	(CH)		19	DO	5	23/24	N/A	
39				20	DO	5	24/24	0.0	
41				21	DO	7	24/24	N/A	
43			44 98.41	22	DO	8	24/24	N/A	Performed sieve analysis and Atterberg limits. USCS: (CH)
45	Boring Terminated @ 44' BGS.								

Standard Pentration Test — blows/ft 20 40 60 80

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/5/00

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00
SHEET: 3 of 3

AR301408

SOIL LOG OF BOREHOLE SBS-12

PROJECT NO: 996-1100 | **DATUM:** MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA | **COORDINATES:** N 6719183.85 E 11975657.99

CLIENT: SALTIRE INDUSTRIAL, INC. | **SITE LOCATION:** ARROWHEAD FACILITY

GSL INSPECTOR: SLW | **BORING LOCATION:** -

SUBSURFACE PROFILE					SAMPLE					Standard Pentration Test	Remarks
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	blows/ft 20 40 60 80	
		Ground Surface		0							
0–2		0-2' Compact, brown, MEDIUM to FINE SAND, some clayey silt.	(SM)	142.03 / 2	1	DO	11	6/24	3.8	●	
2–10		2-10' Loose to compact, reddish brown, MEDIUM to FINE SAND, some silty clay.	(SC-SM)	140.03 / 10	2	DO	8	12/24	0.9	●	
					3	DO	8	12/24	0.8	●	
					4	DO	14	18/24	0.5	●	
					5	DO	10	12/24	0.2	●	
10–11		10-11' Firm, reddish brown, SILTY CLAY and FINE SAND.	(CL)	132.03 / 11	6	DO	11	18/24	0.3	●	
11–12		11-12' Compact, reddish brown, FINE SAND, some silty clay.	(SC)	131.03 / 12							
12–15		12-16.5' Compact, reddish brown, MEDIUM to FINE SAND, some clayey silt.	(SM)	130.03	7	DO	23	19/24	0.4	●	@ 13-13.2' Iron sand lense. 13.3-13.6' Light gray silty clay (CH) lense. 14.2-14.3' Light gray silty clay (CH) lense.
										●	

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/8/00

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SHEET: 1 of 3

SOIL LOG OF BOREHOLE SBS-12

PROJECT NO: 996-1100
DATUM: MSL
PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA
COORDINATES: N 6719183.85 E 11975657.99
CLIENT: SALTIRE INDUSTRIAL, INC.
SITE LOCATION: ARROWHEAD FACILITY
GSL INSPECTOR: SLW
BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE					Standard Pentration Test	Remarks
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	blows/ft 20 40 60 80	
16		12-16.5' Compact, reddish brown, MEDIUM to FINE SAND, some clayey silt.	(SM)	16.5	8	DO	12	18/24	0.9		
17–18		16.5-18.3' Soft, light gray, SILTY CLAY, trace fine sand.	(CH)	125.53 18.3	9	DO	7	18/24	0.9		
19–20		18.3-28' Compact to loose, white and yellowish mottled, MEDIUM to FINE SAND, little clayey silt.		123.73	10	DO	14	18/24	0.2		
21–22					11	DO	22	24/24	0.3		
23–24			(SP-SM) ▽		12	DO	16	14/24	0.2		
25–26					13	DO	14	18/24	0.3		
27–28				28	14	DO	6	24/24	0.2		27-27.2' Light gray silty clay (CH) lense.
29–30		28-34.5' Compact, mottled gray, brown and red, MEDIUM to FINE SAND, little clayey silt, trace iron fragments.	(SP-SM)	114.03	15	DO	14	18/24	0.3		28.5-28.8' Light gray silty clay (CH) lense.

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/8/00

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SHEET: 2 of 3

AR301410

SOIL LOG OF BOREHOLE SBS-12

PROJECT NO: 996-1100 | **DATUM:** MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA | **COORDINATES:** N 6719183.85 E 11975657.99

CLIENT: SALTIRE INDUSTRIAL, INC. | **SITE LOCATION:** ARROWHEAD FACILITY

GSL INSPECTOR: SLW | **BORING LOCATION:** -

SUBSURFACE PROFILE					SAMPLE					Standard Pentration Test	Remarks
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	blows/ft 20 40 60 80	
31		28-34.5' Compact, mottled gray, brown and red, MEDIUM to FINE SAND, little clayey silt, trace iron fragments.	(SP-SM)		16	DO	11	18/24	0.1	●	30-32' Performed sieve analysis. USCS: (SP-SM)
32-33					17	DO	17	24/24	0.2	●	
34				34.5							34-36' Performed sieve analysis. USCS: (SP-SM)
35		34.5-36.3' Loose, dark gray, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	107.53	18	DO	9	24/24	0.5	●	
36				36.3							
37		36.3-42' Firm to stiff, dark gray, SILTY CLAY, some medium to fine sand.	(CH)	105.73	19	DO	4	24/24	0.0	●	
38-39					20	DO	4	24/24	0.1	●	
40-41					21	DO	3	24/24	N/A	●	
42				42							
43		Boring Terminated @ 42' BGS.		100.03							
44											
45											

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/8/00

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SHEET: 3 of 3

SOIL LOG OF BOREHOLE SBS-13

PROJECT NO: 996-1100
DATUM: MSL
PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA
COORDINATES: (APPROX.) N 6719758, E 11975425
CLIENT: SALTIRE INDUSTRIAL, INC.
SITE LOCATION: ARROWHEAD FACILITY
GSL INSPECTOR: GM
BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE						
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
0		Ground Surface		0							
0-2		0-2' Brown, MEDIUM to FINE SAND, some clayey silt.	(SM)	141 / 2	1	DO	NA	N/A	0.0	●	
2-4		2-12' Loose to dense, reddish brown, MEDIUM to FINE SAND, trace silt.	(SP)	139	2	DO	5	18/24	N/A	●	
4-6					3	DO	15	13/24	N/A	●	
6-8					4	DO	17	20/24	0.7	●	
8-10					5	DO	26	15/24	N/A	●	
10-12				12	6	DO	34	16/24	0.0	●	
12-14		12-18.2' Compact to loose, reddish brown, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	129	7	DO	24	8/24	N/A	●	
14-15											

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: 4-1/4" HSA
DRILL RIG: MOBILE DRILL
DRILLER: AARON EICHELBERGER
DRILL DATE: 7/19/00

LOGGED: GM
CHECKED: RIO
DATE: 7/26/00

SHEET: 1 of 3

AR301412

SOIL LOG OF BOREHOLE SBS-13

PROJECT NO: 996-1100 **DATUM:** MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA **COORDINATES:** (APPROX.) N 6719758, E 11975425

CLIENT: SALTIRE INDUSTRIAL, INC. **SITE LOCATION:** ARROWHEAD FACILITY

GSL INSPECTOR: GM **BORING LOCATION:** -

Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
16, 17, 18		12-18.2' *Compact to loose, reddish brown, MEDIUM to FINE SAND, little clayey silt.*	(SP-SM)	18.2							
19		18.2-22.4' Firm to soft, mottled gray and yellowish brown, SILTY CLAY, some fine sand.	▽ (CH)	122.8	8	DO	6	20/24	N/A	●	
20, 21, 22				22.4	9	DO	6	23/24	0.3	●	
23		22.4-27' Dense to loose, mottled gray and yellowish brown, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	118.6	12	DO	34	24/24	N/A	●	
24, 25, 26					13	DO	8	24/24	0.0	●	24-26' *Performed sieve* analysis. USCS: (SM)
27				27	14	DO	16	24/24	N/A	●	
28, 29, 30		27-30.7' Compact to loose brown, MEDIUM TO FINE SAND, some clayey silt.	(SM)	114	15	DO	5	12/24	N/A	●	28-30' Performed sieve analysis. USCS: (SM)

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: 4-1/4" HSA
DRILL RIG: MOBILE DRILL
DRILLER: AARON EICHELBERGER
DRILL DATE: 7/19/00

LOGGED: GM
CHECKED: RIO
DATE: 7/26/00

SHEET: 2 of 3

SOIL LOG OF BOREHOLE SBS-13

PROJECT NO: 996-1100

DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA

COORDINATES: (APPROX.) N 6719758, E 11975425

CLIENT: SALTIRE INDUSTRIAL, INC.

SITE LOCATION: ARROWHEAD FACILITY

GSL INSPECTOR: GM

BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE					Standard Pentration Test blows/ft 20 40 60 80	Remarks
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)		
			(SM)	30.7							
31		30.7-32.9' Compact to loose, mottled red, gray and brown, MEDIUM to FINE SAND, little clayey silt, trace fine gravel (iron fragments).	(SP-SM)	110.3	16	DO	28	24/24	0.0		
32				32.9							32-34' Performed sieve analysis. USCS: (SM)
33		32.9-34.5' Loose to compact, gray, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	108.1	17	DO	5	12/24	N/A		
34				34.5							
35		34.5-38' Firm to stiff, gray, SILTY CLAY, some medium to fine sand.	(CH)	106.5	18	DO	18	18/24	0.1		
36											
37					19	DO	7	24/24	N/A		
38				38							
		Boring Terminated @ 38' BGS.		103							
39											
40											
41											
42											
43											
44											
45											

DRILLING COMPANY: CHESAPEAKE GEOSYSTEMS INC.
DRILL METHOD: 4-1/4" HSA
DRILL RIG: MOBILE DRILL
DRILLER: AARON EICHELBERGER
DRILL DATE: 7/19/00

LOGGED: GM
CHECKED: RIO
DATE: 7/26/00

SHEET: 3 of 3

SOIL LOG OF BOREHOLE SBD-2

PROJECT NO: 996-1100

DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA

COORDINATES: N 6719635.32, E 11974652.29

CLIENT: *SALTIRE INDUSTRIAL, INC.*

SITE LOCATION: *ARROWHEAD FACILITY*

GSL INSPECTOR: SLW

BORING LOCATION: -

Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	*Remarks*
51–55		No samples taken above 55' BGS.		55							0-55' Installed (grouted) 8" Dia. steel casing.
55–63		*55-63' Loose to compact,* dark gray, FINE SAND, some clayey silt.	(SM)	92.23	1	DO	14	24/24	0.0	●	
					2	DO	13	24/24	0.0	●	57-59' Performed sieve analysis and Atterberg limits USCS: (SM)
					3	DO	12	24/24	0.0	●	
				63	4	DO	9	24/24	0.0	●	
63–65		63-75' Loose to compact, dark gray, FINE SAND and SILTY CLAY.		84.23	5	DO	7	24/24	0.0	●	

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 12" MUD ROTARY/ 3-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/17/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SOIL LOG OF BOREHOLE SBD-2

PROJECT NO: 996-1100

DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA

COORDINATES: N 6719635.32, E 11974652.29

CLIENT: SALTIRE INDUSTRIAL, INC.

SITE LOCATION: ARROWHEAD FACILITY

GSL INSPECTOR: SLW

BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE					Standard Pentration Test	Remarks
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	blows/ft 20 40 60 80	
66		63-75' Loose to compact, dark gray, FINE SAND and SILTY CLAY.			6	DO	12	24/24	0.0	●	
67											
68					7	DO	6	24/24	0.0	●	
69			(SC)								
70					8	DO	7	24/24	0.0	●	
71											
72					9	DO	12	24/24	0.0	●	
73											
74					10	DO	11	24/24	0.0	●	
75				75 72.23							
76		75-83' Firm to stiff, dark gray, SILTY CLAY, some fine sand.			11	DO	12	24/24	0.0	●	
77											
78					12	DO	11	24/24	0.0	●	
79			(CH)								
80										●	

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 12" MUD ROTARY/ 3-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/17/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00
SHEET: 2 of 5

SOIL LOG OF BOREHOLE SBD-2

PROJECT NO: 996-1100 | **DATUM:** MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA | **COORDINATES:** N 6719635.32, E 11974652.29

CLIENT: SALTIRE INDUSTRIAL, INC. | **SITE LOCATION:** ARROWHEAD FACILITY

GSL INSPECTOR: SLW | **BORING LOCATION:** -

SUBSURFACE PROFILE					SAMPLE					Standard Pentration Test	Remarks
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	blows/ft 20 40 60 80	
81		75-83' Firm to stiff, dark gray, SILTY CLAY, some fine sand.			13	DO	12	24/24	0.0	●	
82				83	14	DO	11	24/24	0.0	●	
83		83-93' Loose to compact, dark gray, FINE SAND and SILTY CLAY.		64.23							83-85' Performed sieve analysis and Atterberg limits. USCS: (SC)
84					15	DO	13	24/24	0.0	●	
85											
86			(SC)		16	DO	11	24/24	0.0	●	
87											
88					17	DO	11	24/24	0.0	●	
89											
90					18	DO	8	24/24	0.0	●	
91											
92				93	19	DO	10	24/24	0.0	●	
93		93-105' Stiff to very stiff, dark gray, SILTY CLAY, some fine sand.		54.23							
94					20	DO	9	24/24	0.0	●	
95											

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 12" MUD ROTARY/ 3-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/17/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SOIL LOG OF BOREHOLE SBD-2

PROJECT NO: 996-1100

DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA

COORDINATES: N 6719635.32, E 11974652.29

CLIENT: SALTIRE INDUSTRIAL, INC.

SITE LOCATION: ARROWHEAD FACILITY

GSL INSPECTOR: SLW

BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE						
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft 'N'	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
96		93-105' Stiff to very stiff, dark gray, SILTY CLAY, some fine sand.			21	DO	13	24/24	0.0	●	
98					22	DO	13	24/24	0.0	●	
99			(CH)								
100					23	DO	9	24/24	1.1	●	
102					24	DO	13	24/24	0.0	●	
104					25	DO	11	24/24	0.2	●	
105		105-111' Compact, dark gray, FINE SAND and SILTY CLAY.		105 42.23							
106					26	DO	12	24/24	0.0	●	
108			(SC)		27	DO	24	24/24	0.2	●	
110										●	

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 12" MUD ROTARY/ 3-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/17/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SHEET: 4 of 5

AR301418

SOIL LOG OF BOREHOLE SBD-2

PROJECT NO: 996-1100

DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA

COORDINATES: N 6719635.32, E 11974652.29

CLIENT: SALTIRE INDUSTRIAL, INC.

SITE LOCATION: ARROWHEAD FACILITY

GSL INSPECTOR: SLW

BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE					Standard Pentration Test	Remarks
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	blows/ft 20 40 60 80	
				111	28	DO	26	24/24	0.3		
111		Boring Terminated @ 111' BGS.		36.23							
112											
113											
114											
115											
116											
117											
118											
119											
120											
121											
122											
123											
124											
125											

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 12" MUD ROTARY/ 3-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/17/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00
SHEET: 5 of 5

SOIL LOG OF BOREHOLE SBD-3

PROJECT NO: 996-1100
DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA
COORDINATES: N 6720020.57, E 11975728.45

CLIENT: SALTIRE INDUSTRIAL, INC.
SITE LOCATION: ARROWHEAD FACILITY

GSL INSPECTOR: SLW
BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE						
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
51–54		No samples taken above 55' BGS.		55							0-55' Installed (grouted) 8" Dia. steel casing.
55		Loose, dark gray, FINE SAND and SILTY CLAY.		84.33							
56					1	DO	7	24/24	0.8	●	
58					2	DO	7	24/24	0.9	●	
59			(SC-SM)								
60					3	DO	7	24/24	0.3	●	
62					4	DO	8	24/24	1.2	●	
64					5	DO	6	24/24	0.0	●	
65											

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 12" MUD ROTARY/ 3-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/19/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SHEET: 1 of 5

SOIL LOG OF BOREHOLE SBD-3

PROJECT NO: 996-1100 **DATUM:** MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA **COORDINATES:** N 6720020.57, E 11975728.45

CLIENT: SALTIRE INDUSTRIAL, INC. **SITE LOCATION:** ARROWHEAD FACILITY

GSL INSPECTOR: SLW **BORING LOCATION:** -

SUBSURFACE PROFILE					SAMPLE						
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
66		Loose, dark gray, FINE SAND and SILTY CLAY.		67	6	DO	8	24/24	0.0	●	
67–76		67-76' Firm to stiff, dark gray, SILTY CLAY, some fine sand.	(CH)	72.33	7	DO	10	24/24	0.0	●	
					8	DO	12	24/24	0.0	●	
					9	DO	13	24/24	0.0	●	71-73' Performed sieve analysis and Atterberg limits USCS: (CH)
				76	10	DO	10	24/24	0.0	●	
76–80		76-86' Loose to compact, dark gray, FINE SAND and SILTY CLAY.		63.33	11	DO	7	24/24	0.0	●	
					12	DO	7	24/24	0.0	●	
80										●	

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 12" MUD ROTARY/ 3-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/19/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00
SHEET: 2 of 5

SOIL LOG OF BOREHOLE SBD-3

PROJECT NO: 996-1100

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA

CLIENT: SALTIRE INDUSTRIAL, INC.

GSL INSPECTOR: SLW

DATUM: MSL

COORDINATES: N 6720020.57, E 11975728.45

SITE LOCATION: ARROWHEAD FACILITY

BORING LOCATION: -

Depth (FT)	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test (blows/ft 20 40 60 80)	Remarks
81	76-86' Loose to compact, dark gray, FINE SAND and SILTY CLAY.	(SC)		13	DO	5	24/24	0.0		
82				14	DO	8	24/24	0.0		
83–84				15	DO	10	24/24	0.0		
85–86			86	16	DO	7	24/24	0.0		
86–87	*86-103' Stiff to very stiff,* dark gray, SILTY CLAY, some fine sand.	(CH)	53.33							
88				17	DO	10	24/24	0.0		
89–90				18	DO	10	24/24	0.0		
91–92				19	DO	12	24/24	0.0		
93–94				20	DO	11	24/24	0.9		
95										

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 12" MUD ROTARY/ 3-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/19/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00
SHEET: 3 of 5

SOIL LOG OF BOREHOLE SBD-3

PROJECT NO: 996-1100
DATUM: MSL
PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA
COORDINATES: N 6720020.57, E 11975728.45
CLIENT: SALTIRE INDUSTRIAL, INC.
SITE LOCATION: ARROWHEAD FACILITY
GSL INSPECTOR: SLW
BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE					Standard Pentration Test	Remarks
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	blows/ft 20 40 60 80	
96		86-103' Stiff to very stiff, dark gray, SILTY CLAY, some fine sand.	(CH)		21	DO	9	24/24	0.6		
98					22	DO	10	24/24	0.0		
100					23	DO	15	24/24	0.0		
102				103	24	DO	26	24/24	0.3		
104		103-111' Loose to compact, dark gray, FINE SAND and SILTY CLAY.	(SC-SM)	36.33	25	DO	10	24/24	0.2		
106					26	DO	14	24/24	0.0		
108					27	DO	9	24/24	0.0		107-109' Performed sieve analysis and Atterberg limits. USCS: (SC-SM)
110											

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 12" MUD ROTARY/ 3-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/19/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SOIL LOG OF BOREHOLE SBD-3

PROJECT NO: 996-1100
DATUM: MSL
PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA
COORDINATES: N 6720020.57, E 11975728.45
CLIENT: SALTIRE INDUSTRIAL, INC.
SITE LOCATION: ARROWHEAD FACILITY
GSL INSPECTOR: SLW
BORING LOCATION: -

SUBSURFACE PROFILE					SAMPLE					Standard Pentration Test	Remarks
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	blows/ft 20 40 60 80	
				111	28	DO	12	24/24	0.0		
111		Boring Terminated @ 111' BGS.		28.33							
112											
113											
114											
115											
116											
117											
118											
119											
120											
121											
122											
123											
124											
125											

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 12" MUD ROTARY/ 3-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/19/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00
SHEET: 5 of 5

AR301424

SOIL LOG OF BOREHOLE MW-37

PROJECT NO: 996-1100
DATUM: MSL
PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA
COORDINATES: N 6719573.00, E 11975408.86
CLIENT: SALTIRE INDUSTRIAL, INC.
SITE LOCATION: ARROWHEAD FACILITY
GSL INSPECTOR: SLW
BORING LOCATION: ROUT 3 ROW

Depth (FT)	Symbol	Description (SUBSURFACE PROFILE)	USCS	Depth/Elev. (FT)	Number (SAMPLE)	Type	Blows/ft 'N'	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
0		Ground Surface		0							
0–2		0-2' Compact, brown, MEDIUM to FINE SAND, some clayey silt.	(SM)	148 / 2	1	DO	15	16/24	1.5	●	
2–10		2-10' Firm, red and yellowish brown, SILTY CLAY and MEDIUM to FINE SAND.	(CL-ML)	146 / 10	2	DO	6	20/24	0.3	●	
					3	DO	14	21/24	0.8	●	
					4	DO	11	21/24	0.9	●	
					5	DO	9	15/24	0.9	●	
10–15		10-20' Compact to dense, reddish brown, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	138	6	DO	17	20/24	0.3	●	
					7	DO	20	22/24	0.9	●	
15										●	

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 4-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/11/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00
SHEET: 1 of 3

SOIL LOG OF BOREHOLE MW-37

PROJECT NO: 996-1100

DATUM: MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA

COORDINATES: N 6719573.00, E 11975408.86

CLIENT: SALTIRE INDUSTRIAL, INC.

SITE LOCATION: ARROWHEAD FACILITY

GSL INSPECTOR: SLW

BORING LOCATION: ROUT 3 ROW

Depth (FT)	Symbol	Description (SUBSURFACE PROFILE)	USCS	Depth/Elev. (FT)	Number (SAMPLE)	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)	Standard Pentration Test blows/ft 20 40 60 80	Remarks
15–16		10-20' Compact to dense, reddish brown, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)		8	DO	38	21/24	0.3		
16–18					9	DO	28	20/24	0.0		
18–20				20	10	DO	16	18/24	0.0		18.1-18.3' Iron sand lense.
20–22		20-28' Compact to loose, yellowish brown, MEDIUM to FINE SAND, little clayey silt, trace fine gravel.	(SP-SM)	128	11	DO	14	18/24	1.3		
22–24					12	DO	3	22/24	0.0		
24–26					13	DO	6	20/24	0.0		25.1-25.3' Iron sand lense.
26–28				28	14	DO	8	17/24	0.2		27.5-27.7' Clay lense.
28–30		28-34' Loose to compact, mottled yellowish, brown and gray, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)	120	15	DO	9	23/24	0.0		

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 4-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/11/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SOIL LOG OF BOREHOLE MW-37

PROJECT NO: 996-1100 | **DATUM:** MSL

PROJECT: SALTIRE/ ARROWHEAD PLATING/ VA | **COORDINATES:** N 6719573.00, E 11975408.86

CLIENT: SALTIRE INDUSTRIAL, INC. | **SITE LOCATION:** ARROWHEAD FACILITY

GSL INSPECTOR: SLW | **BORING LOCATION:** ROUT 3 ROW

SUBSURFACE PROFILE					SAMPLE					Standard Pentration Test blows/ft 20 40 60 80	Remarks
Depth (FT)	Symbol	Description	USCS	Depth/Elev. (FT)	Number	Type	Blows/ft "N"	Recovery (IN/IN)	PID Reading (ppm)		
31		28-34' Loose to compact, mottled yellowish, brown and gray, MEDIUM to FINE SAND, little clayey silt.	(SP-SM)		16	DO	12	16/24	0.1	●	
33				34	17	DO	26	19/24	1.2	●	
34-35		34-35' Soft to firm, dark gray, SILTY CLAY, some medium to fine sand.	(CH)	114 35	18	DO	11	20/24	0.0	●	
35-40		35-40' Compact, dark gray, MEDIUM to FINE SAND, some silty clay.	(SC)	113							
37					19	DO	12	18/24	0.0	●	
39				40	20	DO	9	24/24	0.0	●	
40-44		40-44' Soft to firm, dark gray, SILTY CLAY, some medium to fine sand.	(CH)	108	21	DO	9	24/24	0.0	●	
43				44	22	DO	10	24/24	0.0	●	
44-45		Boring Terminated @ 44' BGS.		104							

DRILLING COMPANY: CHESAPEAKE GEOSYST
DRILL METHOD: 4-1/4" HSA
DRILL RIG: MOBILE B-80
DRILLER: BRIAN VAN DURAN
DRILL DATE: 5/11/00

GOLDER SIERRA

LOGGED: SLW
CHECKED: RIO
DATE: 7/10/00

SHEET: 3 of 3

APPENDIX B-2

Well Installation Log

MONITORING WELL INSTALLATION LOG

JOB NO. 996-1100 PROJECT SALTIRE/ARROWHEAD PLATING/VA WELL NO. MW-37 SHEET 1 of 1

CA INSP. SW DRILLING METHOD 4-1/4" ID HOLLOW STEM AUGERS GROUND ELEV. 148.00 WATER DEPTH 129.22

WEATHER PARTLY CLOUDY DRILLING COMPANY CHESAPEAKE GEOSYSTEMS INC TOP PVC ELEV. 150.06 TIME/DATE MAY 2000

TEMP. 90"s F DRILL RIG MOBIL B-80 DRILLER BRIAN VAN DOREN STARTED - (TIME / DATE) COMPLETED - (TIME / DATE)

LOCATION / COORDINATES 6718821.57 N; 11974637.02 E

MATERIALS INVENTORY

WELL CASING 2 in. dia. 35' l.f. WELL SCREEN 2 in. dia. 10' l.f. BENTONITE SEAL 3/8" BENTONITE CHIPS

CASING TYPE SCH. 40 PVC SCREEN TYPE SCH 40 PVC INSTALLATION METHOD -

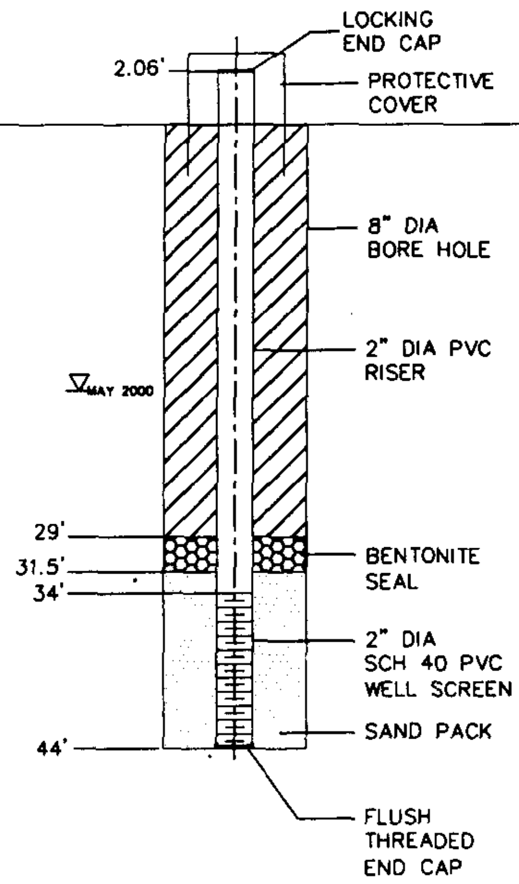
JOINT TYPE FLUSH THREADED SLOT SIZE 0.010" MACHINE SLOTTED FILTER PACK QTY. 380 lbs

GROUT QUANTITY 74 GALLONS CENTRALIZERS NONE USED FILTER PACK TYPE SILICA 20-40

GROUT TYPE 95% CEMENT/5% BENTONITE DRILLING MUD TYPE NA INSTALLATION METHOD WASHED

ELEV./DEPTH	DESCRIPTION
148.00	GROUND SURFACE
0.0	SEE BORING LOG MW-37 FOR LITHOLOGIC DESCRIPTION
10.0	
20.0	
30.0	
40.0	
50.0	
60.0	
70.0	
80.0	

WELL SKETCH



INSTALLATION NOTES

WELL DEVELOPMENT NOTES

5/12/00 GSL PURGED 60 GALLONS OF GROUNDWATER.

5/15/00 GSL PURGED 3 GALLONS OF GROUNDWATER W/FIELD MEASUREMENTS (SAMPLED SIMULTANEOUSLY)

LEGEND

CEMENT/BENTONITE GROUT

3/8" BENTONITE CHIPS

20-40 SAND PACK

DRILLER: BRIAN VAN DOREN

STATE LIC. DRILLER: BRIAN VAN DOREN

GSL APPROVAL: RIO

DATE: 7/31/00

File 1100MW-37

Golder Sierra

AR301429

APPENDIX B-3

Monitoring Well Water Level and Sampling Data

TABLE B-1

WATER LEVEL DATA SUMMARY
MAY 2000 BASELINE SAMPLING EVENT
ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	COORDINATES (ft)		WATER LEVEL DATA							
	EASTING	NORTHING	Top of Casing Elevation (ft-MSL)	Ground Surface Elevation (ft-MSL)	Top of Screen Depth (ft-BTOC)	Bottom of Screen Depth (ft-BTOC)	Sampling Pump Depth (ft-BTOC)	Date Water Level Measured	Water Level (ft-BTOC)	Water Level (ft-MSL)
MW1	11974959.02	6718745.40	149.99	147.81	35.18	25.18	30.2	May-00	21.58	128.41
	See Note 1		149.85	147.88	34.97	24.97	30.0	-	-	-
MW2	11975237.52	6719067.34	146.74	144.83	31.91	21.91	26.9	May-00	19.47	127.27
MW3	11974409.18	6719493.68	151.30	149.38	36.92	26.92	31.9	May-00	20.54	130.76
MW4	11974891.39	6719862.21	141.45	139.46	21.99	11.99	17.0	May-00	11.21	130.24
MW5	11974897.78	6719622.67	143.49	143.72	29.77	19.77	24.8	May-00	13.59	129.90
MW6	11974791.02	6719514.24	148.76	147.06	36.70	26.70	31.7	May-00	19.29	129.47
MW7	11975036.79	6719558.47	142.30	142.60	29.70	19.70	24.7	May-00	14.43	127.87
MW8	11975086.22	6719430.72	142.62	142.92	29.70	19.70	24.7	May-00	15.03	127.59
MW9	11974603.64	6719354.70	148.46	146.70	31.76	21.76	26.8	May-00	18.28	130.18
MW10	11975334.30	6719537.10	139.92	138.12	31.80	21.80	26.8	May-00	15.89	124.03
MW11	11975282.07	6719630.42	134.87	132.46	27.41	17.41	22.4	May-00	11.95	122.92
MW12	11975258.18	6719739.94	128.12	126.29	21.83	11.83	16.8	May-00	7.52	120.60
MW13	11975226.15	6719865.09	119.93	118.14	15.79	5.79	12.4	May-00	9.10	110.83

AR301431

TABLE B-1

WATER LEVEL DATA SUMMARY
MAY 2000 BASELINE SAMPLING EVENT
ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	COORDINATES (ft)		WATER LEVEL DATA							
	EASTING	NORTHING	Top of Casing Elevation (ft-MSL)	Ground Surface Elevation (ft-MSL)	Top of Screen Depth (ft-BTOC)	Bottom of Screen Depth (ft-BTOC)	Sampling Pump Depth (ft-BTOC)	Date Water Level Measured	Water Level (ft-BTOC)	Water Level (ft-MSL)
MW21	11975255.28	6719384.19	144.19	142.12	37.07	27.07	32.1	May-00	17.61	126.58
MW22	11974513.30	6719251.11	148.70	146.69	27.01	17.01	22.3	May-00	17.67	131.03
MW23	11975425.54	6719854.47	141.14	139.32	34.82	24.82	29.8	May-00	20.79	120.35
MW24	11975707.91	6719739.94	137.79	136.38	33.41	23.41	28.4	May-00	17.49	120.30
MW25	11975817.14	6719554.06	140.99	138.73	36.76	26.76	31.8	May-00	22.52	118.47
MW26	11975785.70	6719318.84	143.25	141.25	38.50	28.50	33.5	May-00	23.67	119.58
MW31	11974655.37	6719299.59	147.28	147.78	43.00	33.00	38.0	May-00	17.44	129.84
MW32	11974933.55	6719285.19	147.39	147.89	43.50	33.50	38.5	May-00	18.85	128.54
MW33	11975613.44	6719480.19	143.74	141.74	40.00	30.00	35.0	May-00	21.23	122.51
MW34	11974416.23	6719068.92	149.34	147.34	42.00	32.00	37.0	May-00	19.02	130.32
MW35	11975607.24	6720432.51	143.98	141.98	36.00	26.00	31.6	May-00	27.28	116.70
MW36	11976177.18	6720125.21	138.90	136.90	32.00	22.00	27.0	May-00	21.99	116.91
MW37	11974637.02	6718821.57	150.06	148.00	46.06	36.06	41.1	May-00	20.84	129.22

NOTES:
(1) Monitoring well MW-1 was resurveyed after the completion of the May 2000 sampling event.

AR301432

TABLE B-2

WELL SAMPLING DATA
MAY 2000 BASELINE SAMPLING EVENT
ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	WELL SAMPLING DATA						
		Water Level Before Purging (ft-BTOC)	Purging Flow Rate (ml/min)	Total Purging Time (hrs)	Volume Purged (gal)	Water Level Before Sampling (ft-BTOC)	Water Level After Sampling (ft-BTOC)	Sampling Flow Rate (ml/min)
MW1	May-00	21.63	180	0.83	2.0	21.78	21.78	180
MW2	May-00	19.40	250-150	0.83	4.0	19.57	19.57	250
MW3	May-00	20.44	150-125	0.83	1.5	20.64	20.63	125
MW4	May-00	11.22	400	0.92	3.5	11.38	11.40	400
MW5	May-00	13.26	72-60	2.17	2.0	14.28	14.36	66
MW6	May-00	19.14	275-250	0.58	3.3	19.25	19.25	250
MW7	May-00	14.25	150-125	0.83	2.0	14.35	14.40	125
MW8	May-00	14.90	250-200	1.50	5.0	15.30	15.35	220
MW9	May-00	18.15	400-350	0.83	5.3	18.30	18.30	375
MW10	May-00	15.58	150-100	1.00	2.0	15.70	15.69	100
MW11	May-00	11.60	500	0.58	5.0	11.90	12.00	500
MW12	May-00	8.21	100-50	0.83	1.0	8.35	8.35	75
MW13	May-00	9.11	1000	1.08	14.0	9.34	9.35	500

AR301433

TABLE B-2

WELL SAMPLING DATA
MAY 2000 BASELINE SAMPLING EVENT
ARROWHEAD PLATING FACILITY
MONTROSS, VA

WELL No.	Date	WELL SAMPLING DATA						
		Water Level Before Purging (ft-BTOC)	Purging Flow Rate (ml/min)	Total Purging Time (hrs)	Volume Purged (gal)	Water Level Before Sampling (ft-BTOC)	Water Level After Sampling (ft-BTOC)	Sampling Flow Rate (ml/min)
MW21	May-00	17.58	500-450	0.83	4.0	17.94	17.92	500
MW22	May-00	17.72	400-375	0.67	4.5	17.80	17.82	400
MW23	May-00	20.57	50-25	1.08	2.0	21.31	21.50	25
MW24	May-00	17.16	64	2.00	1.5	17.30	17.30	64
MW25	May-00	22.35	150	0.75	1.0	22.46	22.46	150
MW26	May-00	23.47	200-150	0.67	1.5	23.78	23.82	150
MW31	May-00	17.52	175-100	0.83	2.0	17.75	17.75	150
MW32	May-00	18.91	200-150	1.42	4.3	19.06	19.04	200
MW33	May-00	21.36	200	0.83	2.0	21.50	21.50	200
MW34	May-00	18.95	30	2.17	1.3	19.45	19.45	30
MW35	May-00	26.97	350-250	0.58	4.0	27.18	27.18	350
MW36	May-00	21.85	180	1.17	3.5	21.94	21.93	180
MW-37	May-00	19.98	120-50	1.08	3.0	21.00	21.00	50

AR301434

APPENDIX B-4

Soil Boring and CPT Soil Interpretation Data Correlation

TABLE B-3

SOIL BORING AND CPT SOIL DATA CORRELATION
MAY 2000 BASELINE SAMPLING EVENT
ARROWHEAD PLATING FACILITY
MONTROSS, VA

Depth (ft)	Standard CPT Soil Type (CPT D10)	Boring Soil Classification (SBS-10)
1.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Some Silty Clay (SC-SM)
2.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Some Silty Clay (SC-SM)
2.9	SILTY CLAY TO CLAY (CL)	M-F SAND, Some Silty Clay (SC-SM)
3.1	CLAY (CH)	M-F SAND, Some Silty Clay (SC-SM)
3.9	CLAY (CH)	M-F SAND, Some Silty Clay (SC-SM)
4.1	SILTY CLAY TO CLAY (CL)	M-F SAND, Some Silty Clay (SC-SM)
4.9	CLAY (CH)	M-F SAND, Some Silty Clay (SC-SM)
5.1	CLAY (CH)	M-F SAND, Some Silty Clay (SC-SM)
6.0	ORGANIC MATERIAL	M-F SAND, Some Silty Clay (SC-SM)
6.1	ORGANIC MATERIAL	M-F SAND, Some Clayey Silt (SM)
7.0	CLAYEY SILT TO SILTY CLAY (MH-CL)	M-F SAND, Some Clayey Silt (SM)
7.9	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Clayey Silt (SM)
8.1	SAND TO SILTY SAND (SP-SM)	M-F SAND, Some Clayey Silt (SM)
8.9	SAND (SP)	M-F SAND, Some Clayey Silt (SM)
9.1	SAND (SP)	M-F SAND, Some Clayey Silt (SM)
10.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Some Clayey Silt (SM)
12.1	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Some Clayey Silt (SM)
13.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Clayey Silt (SM)
13.9	CLAYEY SILT TO SILTY CLAY (MH-CL)	M-F SAND, Some Clayey Silt (SM)
14.1	SILTY SAND TO SANDY SILT (SM)	SILTY CLAY, Little C-F Sand (CH)
14.9	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Little C-F Sand (CH)
15.1	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Little C-F Sand (CH)
16.0	SILTY CLAY TO CLAY (CL)	SILTY CLAY, Little C-F Sand (CH)
17.0	SILTY CLAY TO CLAY (CL)	SILTY CLAY, Little C-F Sand (CH)
17.9	SILTY CLAY TO CLAY (CL)	SILTY CLAY, Little C-F Sand (CH)
18.1	SILTY CLAY TO CLAY (CL)	M-F SAND, Little Clayey Silt (SP-SM)
18.9	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
19.1	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Little Clayey Silt (SP-SM)
19.9	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
20.1	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
20.9	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
21.1	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
22.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
23.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
24.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
25.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Little Clayey Silt (SP-SM)
25.9	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Little Clayey Silt (SP-SM)
26.1	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Little Clayey Silt (SP-SM)
26.9	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
27.1	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
28.0	SILTY CLAY TO CLAY (CL)	M-F SAND, Little Clayey Silt (SP-SM)
29.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
30.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
30.9	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
31.1	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Silty Clay (SC)
32.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Silty Clay (SC)
33.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Silty Clay (SC)
34.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Silty Clay (SC)
35.0	SAND TO SILTY SAND (SP-SM)	SILTY CLAY, Some M-F Sand (CH)
35.9	CLAYEY SILT TO SILTY CLAY (MH-CL)	SILTY CLAY, Some M-F Sand (CH)
36.9	SAND TO SILTY SAND (SP-SM)	SILTY CLAY, Some M-F Sand (CH)
37.1	SAND TO SILTY SAND (SP-SM)	SILTY CLAY, Some M-F Sand (CH)
38.0	SAND TO SILTY SAND (SP-SM)	SILTY CLAY, Some M-F Sand (CH)
39.0	SAND TO SILTY SAND (SP-SM)	SILTY CLAY, Some M-F Sand (CH)
40.0	SAND TO SILTY SAND (SP-SM)	SILTY CLAY, Some M-F Sand (CH)
41.0	SAND TO SILTY SAND (SP-SM)	SILTY CLAY, Some M-F Sand (CH)
42.0	SAND TO SILTY SAND (SP-SM)	SILTY CLAY, Some M-F Sand (CH)

AR301436

TABLE B-4

SOIL BORING AND CPT SOIL DATA CORRELATION
MAY 2000 BASELINE SAMPLING EVENT
ARROWHEAD PLATING FACILITY
MONTROSS, VA

Depth (ft)	Standard CPT Soil Type (CPT C10)	Boring Soil Classification (SBS-13)
1.0	CLAY (CH)	M-F SAND, Some Clayey Silt (SC-SM)
2.0	SILTY CLAY TO CLAY (CL)	M-F SAND, Trace Silt (SP)
3.0	CLAY (CH)	M-F SAND, Trace Silt (SP)
4.0	SILTY CLAY TO CLAY (CL)	M-F SAND, Trace Silt (SP)
5.0	CLAY (CH)	M-F SAND, Trace Silt (SP)
6.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Trace Silt (SP)
7.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Trace Silt (SP)
7.9	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Trace Silt (SP)
8.1	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Trace Silt (SP)
9.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Trace Silt (SP)
10.1	SAND TO SILTY SAND (SP-SM)	M-F SAND, Trace Silt (SP)
11.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Trace Silt (SP)
12.0	SAND (SP)	M-F SAND, Little Silt (SP-SM)
13.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Silt (SP-SM)
13.9	SAND (SP)	M-F SAND, Little Silt (SP-SM)
14.1	SAND (SP)	M-F SAND, Little Silt (SP-SM)
14.9	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Little Silt (SP-SM)
15.1	SILTY CLAY TO CLAY (CL)	M-F SAND, Little Silt (SP-SM)
16.0	CLAY (CH)	M-F SAND, Little Silt (SP-SM)
17.0	SILTY CLAY TO CLAY (CL)	M-F SAND, Little Silt (SP-SM)
17.9	SILTY CLAY TO CLAY (CL)	M-F SAND, Little Silt (SP-SM)
18.1	SILTY CLAY TO CLAY (CL)	SILTY CLAY, Some Fine Sand (CH)
18.9	SILTY CLAY TO CLAY (CL)	SILTY CLAY, Some Fine Sand (CH)
19.1	CLAY (CH)	SILTY CLAY, Some Fine Sand (CH)
19.9	CLAY (CH)	SILTY CLAY, Some Fine Sand (CH)
20.1	CLAY (CH)	SILTY CLAY, Some Fine Sand (CH)
20.9	CLAY (CH)	SILTY CLAY, Some Fine Sand (CH)
21.1	CLAY (CH)	SILTY CLAY, Some Fine Sand (CH)
21.9	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Some Fine Sand (CH)
22.1	SILTY SAND TO SANDY SILT (SM)	SILTY CLAY, Some Fine Sand (CH)
22.9	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
23.1	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
23.9	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Little Clayey Silt (SP-SM)
24.1	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Little Clayey Silt (SP-SM)
24.9	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
25.1	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
25.9	SILTY CLAY TO CLAY (CL)	M-F SAND, Little Clayey Silt (SP-SM)
26.1	CLAY (CH)	M-F SAND, Little Clayey Silt (SP-SM)
26.9	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
27.1	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Clayey Silt (SM)
27.9	SAND TO SILTY SAND (SP-SM)	M-F SAND, Some Clayey Silt (SM)
28.1	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Clayey Silt (SM)
29.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND, Some Clayey Silt (SM)
30.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Clayey Silt (SM)
31.0	SAND (SP)	M-F SAND, Litle Clayey Silt, Trace F Gravel (SP-SM)
32.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Litle Clayey Silt, Trace F Gravel (SP-SM)
33.0	CLAY (CH)	M-F SAND, Litle Clayey Silt (SP-SM)
34.0	SILTY CLAY TO CLAY (CL)	M-F SAND, Litle Clayey Silt (SP-SM)
35.0	SILTY CLAY TO CLAY (CL)	SILTY CLAY, Some M-F Sand (CH)
36.0	CLAYEY SILT TO SILTY CLAY (MH-CL)	SILTY CLAY, Some M-F Sand (CH)
37.0	CLAY (CH)	SILTY CLAY, Some M-F Sand (CH)
38.0	SILTY CLAY TO CLAY (CL)	SILTY CLAY, Some M-F Sand (CH)

TABLE B-5

SOIL BORING AND CPT SOIL DATA CORRELATION
MAY 2000 BASELINE SAMPLING EVENT
ARROWHEAD PLATING FACILITY
MONTROSS, VA

Depth (ft)	Standard CPT Soil Type (CPT F12)	Boring Soil Classification (SBS-12)
1.0	SANDY SILT TO CLAYEY SILT (ML-MH)	FINE SAND, Some Silty Clay, Some Organics (SC)
2.0	CLAYEY SILT TO SILTY CLAY (MH-ML)	FINE SAND, Some Silty Clay, Some Organics (SC)
2.9	CLAY (CH)	M-F SAND and SILTY CLAY (SC)
3.1	SILTY CLAY TO CLAYEY SILT (CL)	M-F SAND and SILTY CLAY (SC)
4.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND and SILTY CLAY (SC)
5.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND and SILTY CLAY (SC)
6.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND and SILTY CLAY (SC)
7.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND and SILTY CLAY (SC)
8.0	VERY STIFF FINE GRAINED	M-F SAND and SILTY CLAY (SC)
9.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND and SILTY CLAY (SC)
10.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND and SILTY CLAY (SC)
11.0	CLAY (CH)	SILTY CLAY and FINE SAND (CL)
12.1	SAND (SP)	FINE SAND, Some Silty Clay (SC)
13.0	SAND (SP)	FINE SAND, Trace Clayey Silt (SP)
13.9	SILTY CLAY TO CLAY (CL)	SILTY CLAY, Trace Fine Sand (CH)
14.1	CLAY (CH)	SILTY CLAY, Trace Fine Sand (CH)
14.9	GRAVELLY SAND TO SAND (SP)	FINE SAND, Trace Clayey Silt, Trace Fine Gravel (SP)
15.1	GRAVELLY SAND TO SAND (SP)	SILTY CLAY, Trace Fine Sand (CH)
16.0	SAND (SP)	FINE SAND, Trace Clayey Silt, Trace Fine Gravel (SP)
17.0	SILTY SAND TO SANDY SILT (SM)	SILTY CLAY, Trace Fine Sand (CH)
17.9	CLAY (CH)	SILTY CLAY, Trace Fine Sand (CH)
18.1	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Trace Fine Sand (CH)
19.1	SILTY SAND TO SANDY SILT (SM)	FINE SAND, Trace Clayey Silt (SP)
19.3	SAND TO SILTY SAND (SP-SM)	FINE SAND, Trace Clayey Silt (SP)
19.9	SAND (SP)	FINE SAND, Trace Clayey Silt (SP)
20.1	SAND (SP)	FINE SAND, Trace Clayey Silt (SP)
20.9	SAND (SP)	FINE SAND, Trace Clayey Silt (SP)
21.1	SAND (SP)	FINE SAND, Trace Clayey Silt (SP)
22.0	SAND (SP)	FINE SAND, Trace Clayey Silt (SP)
23.0	SAND (SP)	FINE SAND, Trace Clayey Silt (SP)
23.9	SAND (SP)	FINE SAND, Trace Clayey Silt (SP)
24.1	SAND TO SILTY SAND (SP-SM)	FINE SAND, Trace Clayey Silt (SP)
24.9	SAND (SP)	FINE SAND, Trace Clayey Silt (SP)
25.1	SAND (SP)	FINE SAND, Trace Clayey Silt (SP)
25.9	SILTY SAND TO SANDY SILT (SM)	FINE SAND, Trace Clayey Silt (SP)
26.1	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Trace Clayey Silt (SP)
26.9	SAND TO SILTY SAND (SP-SM)	M-F SAND, Trace Clayey Silt (SP)
27.1	SAND (SP)	M-F SAND, Trace Clayey Silt (SP)
28.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Trace Clayey Silt (SP)
29.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Silty Clay (SP-SC)
30.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Silty Clay (SP-SC)
30.9	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Silty Clay (SP-SC)
31.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Silty Clay (SP-SC)
32.0	SAND (SP)	M-F SAND, Little Silty Clay (SP-SC)
33.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Silty Clay (SP-SC)
34.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Silty Clay (SP-SC)
35.0	SILTY SAND TO SANDY SILT (SM)	FINE SAND, Trace Clayey Silt (SP)
36.0	SILTY SAND TO SANDY SILT (SM)	FINE SAND, Trace Clayey Silt (SP)
37.0	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Some Fine Sand, Trace Fine Gravel (CH)
38.0	CLAY (CH)	SILTY CLAY, Trace Fine Sand, Trace Fine Gravel (CH)
39.0	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Trace Fine Sand, Trace Fine Gravel (CH)
40.0	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Trace Fine Sand, Trace Fine Gravel (CH)
40.9	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Trace Fine Sand (CH)
41.1	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Trace Fine Sand (CH)
42.0	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Trace Fine Sand (CH)

TABLE B-6

SOIL BORING AND CPT SOIL DATA CORRELATION
MAY 2000 BASELINE SAMPLING EVENT
ARROWHEAD PLATING FACILITY
MONTROSS, VA

Depth (ft)	Standard CPT Soil Type (CPT E10)	Boring Soil Classification (SBS-11)
1.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Some Clayey Silt (SM)
2.0	CLAYEY SILT TO SILTY CLAY (MH-CL)	M-F SAND, Some Clayey Silt (SM)
3.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND and SILTY CLAY (SC-SM)
4.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND and SILTY CLAY (SC-SM)
4.8	SILTY SAND TO SANDY SILT (SM)	M-F SAND and SILTY CLAY (SC-SM)
5.1	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND and SILTY CLAY (SC-SM)
6.0	SANDY SILT TO CLAYEY SILT (ML-MH)	M-F SAND and SILTY CLAY (SC-SM)
7.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Clayey Silt (SM)
8.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Some Clayey Silt (SM)
9.0	SAND (SP)	M-F SAND, Some Clayey Silt (SM)
10.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Some Clayey Silt (SM)
10.8	SAND (SP)	M-F SAND, Some Clayey Silt (SM)
11.1	GRAVELLY SAND TO SAND (SP)	M-F SAND, Some Clayey Silt (SM)
12.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Some Clayey Silt (SM)
13.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Some Clayey Silt (SM)
14.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Some Clayey Silt (SM)
15.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Clayey Silt (SM)
15.9	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Clayey Silt (SM)
16.1	SAND TO SILTY SAND (SP-SM)	M-F SAND, Some Clayey Silt (SM)
17.0	GRAVELLY SAND TO SAND (SP)	M-F SAND, Some Clayey Silt (SM)
18.0	SAND (SP)	M-F SAND, Some Clayey Silt (SM)
19.0	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
20.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
21.0	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
22.0	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
22.8	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
23.1	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
23.9	GRAVELLY SAND TO SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
24.1	GRAVELLY SAND TO SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
24.9	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
25.1	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
26.0	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
27.0	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
28.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
29.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
29.9	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
30.1	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
30.9	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
31.1	SAND (SP)	M-F SAND, Little Clayey Silt (SP-SM)
32.0	SAND TO SILTY SAND (SP-SM)	M-F SAND, Little Clayey Silt (SP-SM)
33.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
33.9	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
34.1	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
34.9	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
35.1	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Little Clayey Silt (SP-SM)
36.0	SILTY SAND TO SANDY SILT (SM)	M-F SAND, Some Silty Clay (SC)
37.0	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Some M-F Sand (CH)
38.0	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Some M-F Sand (CH)
39.0	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Some M-F Sand (CH)
40.0	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Some M-F Sand (CH)
40.9	CLAY (CH)	SILTY CLAY, Some M-F Sand (CH)
41.2	CLAYEY SILT TO SILTY CLAY (MH-CL)	SILTY CLAY, Some M-F Sand (CH)
42.0	CLAY (CH)	SILTY CLAY, Some M-F Sand (CH)
43.0	SILTY CLAY TO CLAY (CL)	SILTY CLAY, Some M-F Sand (CH)
43.8	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Some M-F Sand (CH)
44.1	SANDY SILT TO CLAYEY SILT (ML-MH)	SILTY CLAY, Some M-F Sand (CH)

APPENDIX B-5

Investigation Derived Waste Characterization Laboratory Data

TABLE B-7

INVESTIGATION DERIVED WASTE CHARACTERIZATION LABORATORY DATA
ARROWHEAD PLATING FACILITY
MONTROSS, VIRGINIA

COMPOUND	TEST METHOD	SAMPLE ID			
		Sludge		Wastewater	
		S-1 5/19/00	SS-2 7/19/00	WW-1 5/19/00	WW-2 7/19/00
Select VOCs, Total		ug/kg	ug/kg	ug/l	ug/l
1,1,1-Trichloroethane	8270/8260B	ND	ND	ND	**1.2 J**
1,1,2-Trichloroethane	8270/8260B	ND	ND	ND	ND
1,1-Dichloroethane	8270/8260B	ND	ND	ND	ND
1,1-Dichloroethene	8270/8260B	ND	**27.3**	**3.5**	**2.8**
1,2-Dichloroethane	8270/8260B	ND	ND	ND	ND
1,2-Dichloroethene (trans)	8270/8260B	ND	ND	ND	ND
1,2-Dichloroethene (cis)	8270/8260B	ND	ND	ND	ND
2-Butanone	8270/8260B	ND	ND	ND	ND
4-Methyl-2-pentanone	8270/8260B	ND	ND	**3.0 J**	ND
Acetone	8270/8260B	ND	**7.5**	**82.8**	ND
Benzene	8270/8260B	ND	ND	ND	ND
Carbon Disulfide	8270/8260B	**6.6 J**	ND	ND	ND
Chloroethane	8270/8260B	ND	ND	ND	ND
Chloroform	8270/8260B	ND	ND	ND	ND
Ethylbenzene	8270/8260B	ND	ND	ND	ND
Methylene Chloride	8270/8260B	ND	ND	ND	ND
Tetrachloroethene	8270/8260B	**66.6**	**84.3**	**11.5**	**8.7**
Toluene	8270/8260B	ND	ND	ND	ND
Trichloroethene	8270/8260B	**7.7 J**	**121**	**11.4**	**14.7**
Vinyl Chloride	8270/8260B	ND	ND	ND	ND
Xylenes (total)	8270/8260B	ND	ND	ND	ND

TABLE B-7

INVESTIGATION DERIVED WASTE CHARACTERIZATION LABORATORY DATA
ARROWHEAD PLATING FACILITY
MONTROSS, VIRGINIA

COMPOUND	TEST METHOD	SAMPLE ID			
		Sludge		Wastewater	
		S-1 5/19/00	SS-2 7/19/00	WW-1 5/19/00	WW-2 7/19/00
Select VOCs, TCLP Leachate					
1,1,1-Trichloroethane	1311/8270/8260B	NT	ND	NA	NA
1,1,2-Trichloroethane	1311/8270/8260B	NT	ND	NA	NA
1,1-Dichloroethane	1311/8270/8260B	NT	ND	NA	NA
1,1-Dichloroethene	1311/8270/8260B	NT	ND	NA	NA
1,2-Dichloroethane	1311/8270/8260B	NT	ND	NA	NA
1,2-Dichloroethene (trans)	1311/8270/8260B	NT	ND	NA	NA
1,2-Dichloroethene (cis)	1311/8270/8260B	NT	ND	NA	NA
2-Butanone	1311/8270/8260B	NT	ND	NA	NA
4-Methyl-2-pentanone	1311/8270/8260B	NT	ND	NA	NA
Acetone	1311/8270/8260B	NT	ND	NA	NA
Benzene	1311/8270/8260B	NT	ND	NA	NA
Carbon Disulfide	1311/8270/8260B	NT	ND	NA	NA
Chloroethane	1311/8270/8260B	NT	ND	NA	NA
Chloroform	1311/8270/8260B	NT	ND	NA	NA
Ethylbenzene	1311/8270/8260B	NT	ND	NA	NA
Methylene Chloride	1311/8270/8260B	NT	ND	NA	NA
Tetrachloroethene	1311/8270/8260B	NT	ND	NA	NA
Toluene	1311/8270/8260B	NT	ND	NA	NA
Trichloroethene	1311/8270/8260B	NT	ND	NA	NA
Vinyl Chloride	1311/8270/8260B	NT	ND	NA	NA
Xylenes (total)	1311/8270/8260B	NT	ND	NA	NA

TABLE B-7

INVESTIGATION DERIVED WASTE CHARACTERIZATION LABORATORY DATA
ARROWHEAD PLATING FACILITY
MONTROSS, VIRGINIA

COMPOUND	TEST METHOD	SAMPLE ID			
		Sludge		Wastewater	
		S-1 5/19/00	SS-2 7/19/00	WW-1 5/19/00	WW-2 7/19/00
Select Metals, Total		mg/kg	mg/kg	ug/l	ug/l
Arsenic	6000/7000/6010B	**5.2**	**5.6**	**137**	**166**
Barium	6000/7000/6010B	**27.2**	< 26	**1080**	**563**
Cadmium	6000/7000/6010B	< 0.41	< 0.66	< 8.0	**6.0**
Calcium	6000/7000/6010B	**9630**	< 660	**771000**	**33500**
Chromium	6000/7000/6010B	**11.8**	**12.4**	**331**	**510**
Copper	6000/7000/6010B	**4.8**	< 3.3	**182**	**171**
Iron	6000/7000/6010B	**16500**	**18400**	**410000**	**514000**
Lead	6000/7000/6010B	< 8.1	< 13	**168**	**208**
Magnesium	6000/7000/6010B	**1660**	**860**	**62100**	**36400**
Manganese	6000/7000/6010B	**191**	**65.3**	**6440**	**1850**
Mercury	7471	< 0.071	< 0.039	**0.84**	PENDING
Nickel	6000/7000/6010B	**7.1**	< 5.3	**242**	**86.6**
Potassium	6000/7000/6010B	**1580**	**1880**	**58000**	**65200**
Selenium	6000/7000/6010B	< 8.1	< 13	< 10	**14.1**
Silver	6000/7000/6010B	< 0.81	< 1.3	< 20	< 10
Sodium	6000/7000/6010B	< 410	< 660	**125000**	**84800**
Zinc	6000/7000/6010B	**25.7**	**10.1**	**819**	**809**

TABLE B-7

INVESTIGATION DERIVED WASTE CHARACTERIZATION LABORATORY DATA
ARROWHEAD PLATING FACILITY
MONTROSS, VIRGINIA

COMPOUND	TEST METHOD	SAMPLE ID			
		Sludge		Wastewater	
		S-1 5/19/00	SS-2 7/19/00	WW-1 5/19/00	WW-2 7/19/00
Select Metals, TCLP Leachate		mg/l	mg/l		
Arsenic	1311/6000/7000/6010B	< 0.50	< 0.50	NA	NA
Barium	1311/6000/7000/6010B	< 1.0	< 1.0	NA	NA
Cadmium	1311/6000/7000/6010B	< 0.0050	< 0.0050	NA	NA
Calcium	1311/6000/7000/6010B	**93.5**	< 0.50	NA	NA
Chromium	1311/6000/7000/6010B	< 0.010	< 0.025	NA	NA
Copper	1311/6000/7000/6010B	< 0.025	< 0.025	NA	NA
Iron	1311/6000/7000/6010B	**2.1**	< 0.10	NA	NA
Lead	1311/6000/7000/6010B	< 0.50	< 0.50	NA	NA
Magnesium	1311/6000/7000/6010B	< 5.0	< 5.0	NA	NA
Manganese	1311/6000/7000/6010B	**0.46**	**0.75**	NA	NA
Mercury	1311/7471	< 0.00020	< 0.00020	NA	NA
Nickel	1311/6000/7000/6010B	< 0.040	< 0.040	NA	NA
Potassium	1311/6000/7000/6010B	< 5.0	< 5.0	NA	NA
Selenium	1311/6000/7000/6010B	< 0.50	< 0.50	NA	NA
Silver	1311/6000/7000/6010B	< 0.010	< 0.010	NA	NA
Sodium	1311/6000/7000/6010B	NA	NA	NA	NA
Zinc	1311/6000/7000/6010B	**0.035**	**0.048**	NA	NA

NOTES:
J = Indicates an estimated value
NA = Not applicable
ND = Not detected
NT = Not tested
PENDING = Results will be submitted with the Pre-Final (90%) Design Report

APPENDIX C

Groundwater VOC Degradation in Iron Reactivity Test

FIGURE C-1
TCE CONCENTRATION PROFILE VS. RESIDENCE TIME AT 40PV
Arrowhead Plating Facility, Montross, Virginia

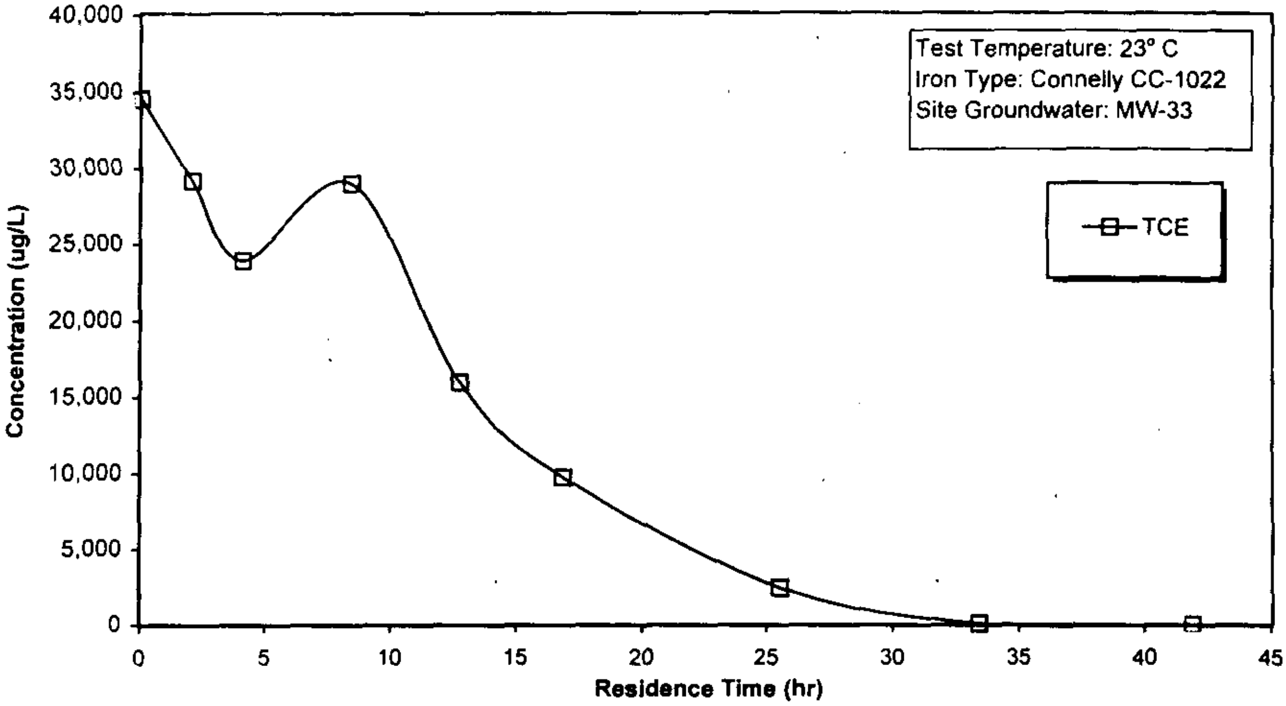


FIGURE C-2
PCE AND 11DCE CONCENTRATION PROFILES VS. RESIDENCE TIME AT 40PV
Arrowhead Plating Favility, Montross, Virginia

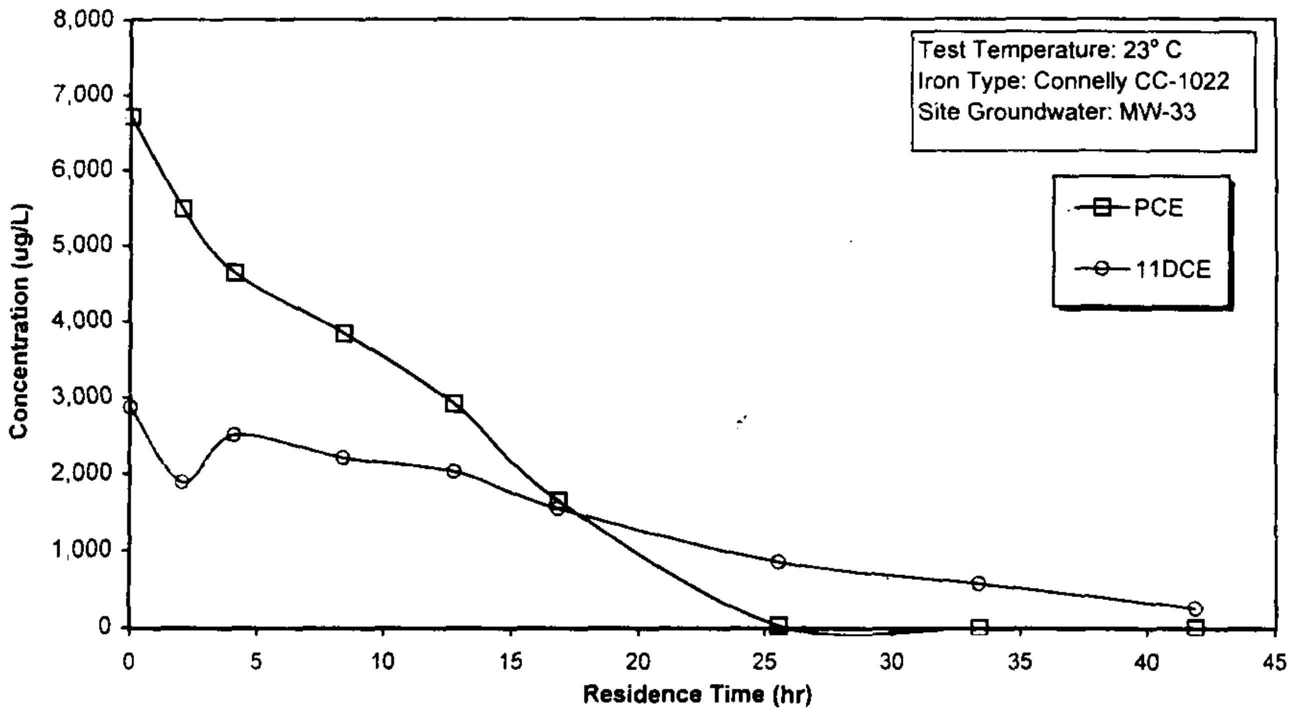


FIGURE C-3
111TCA, cDCE AND 11DCA CONCENTRATION PROFILES VS. RESIDENCE TIME AT 40PV
Arrowhead Plating Facility, Montross, Virginia

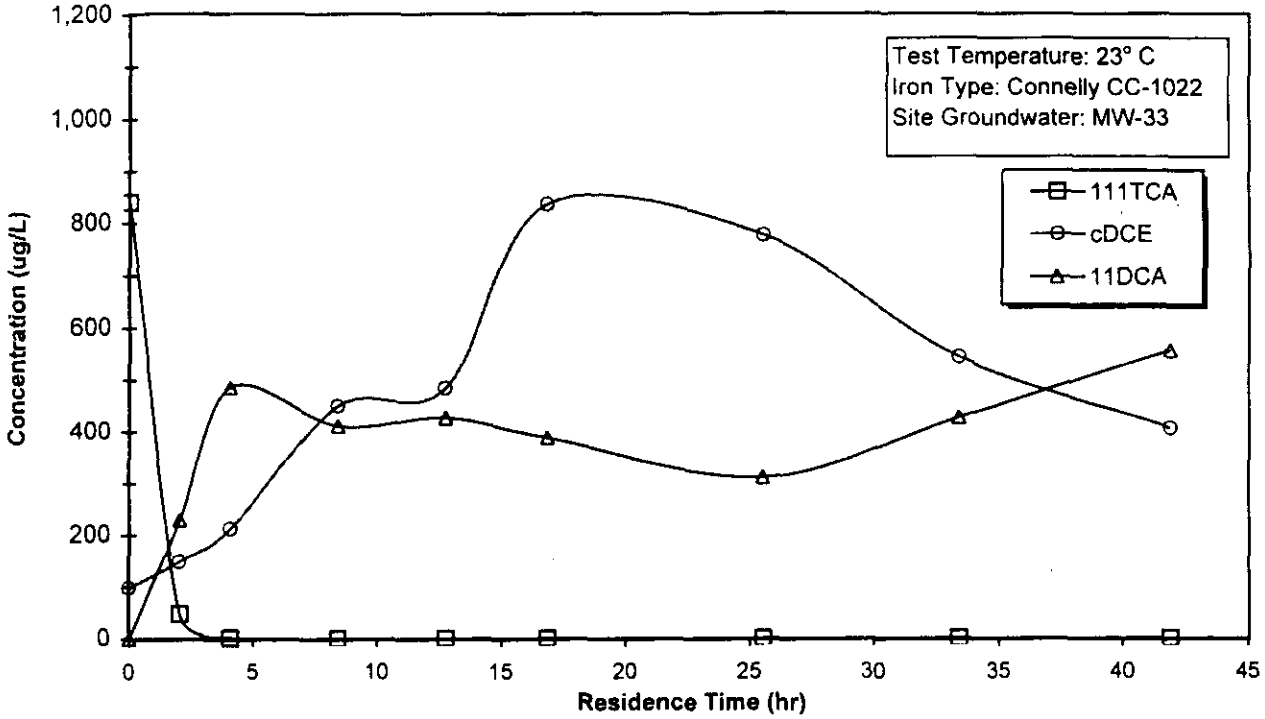


FIGURE C-4
112TCA, tDCE, 12DCA AND VC CONCENTRATION PROFILES VS. RESIDENCE TIME AT 40PV
Arrowhead Plating Favility, Montross, Virginia

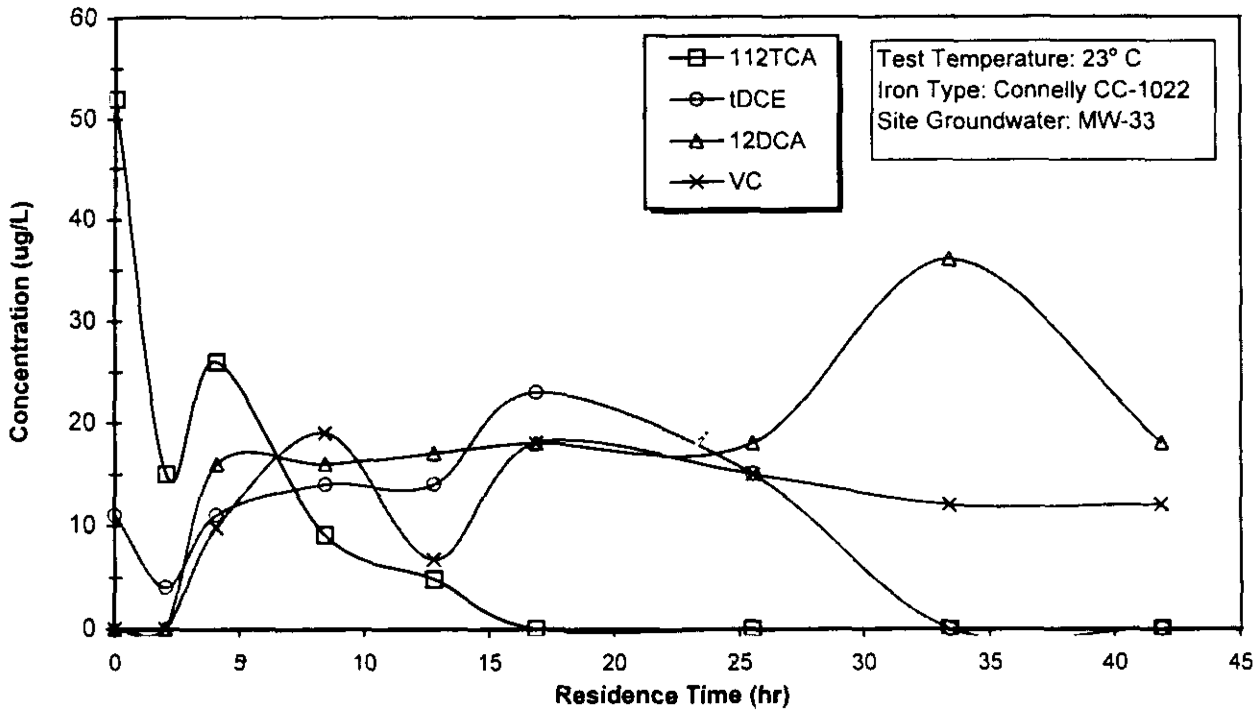
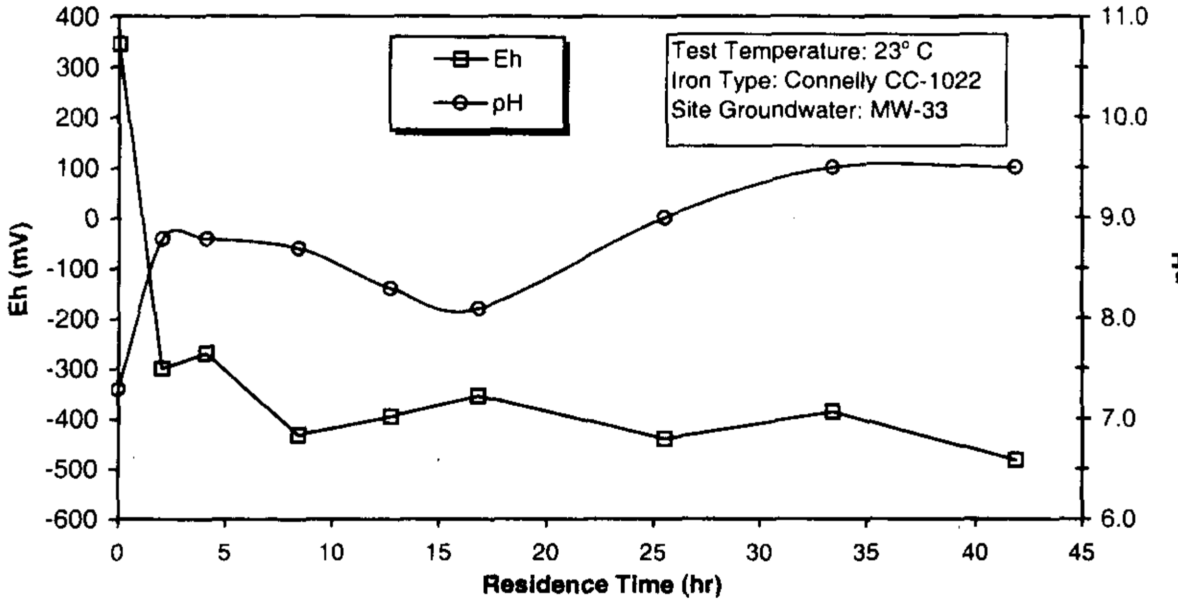


FIGURE C-5
Eh AND pH PROFILES VS. RESIDENCE TIME AT 37PV
Arrowhead Plating Facility, Montross, Virginia



Note: PV refers to number of pore volume flushes of the iron column by Site groundwater.

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Column and Iron Properties

Iron:

Source	Connelly-GPM., Chicago, IL
Grain Size	1.4 to 0.20 mm (-14 to +84 mesh)
Surface Area	
Hydraulic Conductivity	

Column:

Flow Velocity	29 cm/day (0.94 ft/day)
Residence Time	42 hr
Pore Volume	316 mL
Porosity	0.56
Bulk Density	2.65 g/cm^3 (165 lb/ft^3)
Iron to Volume of Solution Ratio	4.8 g : 1 mL
Surface Area to Volume of Solution Ratio	

Method Detection Limits (MDL) and Detection Limits (DL)

Organic Compounds:	**MDL (µg/L)**
Tetrachloroethene	0.8
Trichloroethene	0.9
Trichloromethane	1.1
1,1,2-Trichloroethane	0.5
cis 1,2-Dichloroethene	2.5
trans 1,2-Dichloroethene	3.3
1,1-Dichloroethene	4.0
Vinyl Chloride	2.0
Inorganic Compounds	**DL (mg/L)**
Calcium	0.05
Iron, Total	0.01
Magnesium	0.05
Manganese	0.005
Potassium	1.0
Silica, Reactive	0.05
Sodium	1.0
Ammonia	0.03
Nitrate	0.2
Chloride	50
Sulphate	5.0
Alkalinity (as $CaCO_3$)	1.0
Total Dissolved Solids (Calculated)	-
Dissolved Organic Carbon (DOC)	0.2

Column Influent and Effluent Inorganic Concentrations at Steady State, Arrowhead Plating Site, Montross, Virginia

	Concentration (mg/L)	
	Influent	**Effluent**
Cations:		
Calcium	6.4 6.3	11 10
Iron, Total	0.02 0.01	0.01 <0.01
Magnesium	2.7 2.8	2.2 2.3
Manganese	0.68 0.69	0.02 0.02
Potassium	2 1	2 2
Silica, Reactive	4.4 4.5	0.17 0.26
Sodium	168 175	176 175
Sulfur	103 105	95 94
Ammonia	<0.03 <0.03	1.1 1.7
Anions:		
Chloride	36 36	77 74
Sulphate	294 296	264 266
Alkalinity (as mg $CaCO_3$/L)	10 11	21 26
Nitrate	2.9 2.9	<0.2 0.6
Dissolved Organic Carbon	46 45	7.8 26
Total Dissolved Solids	612 625	656 657

Laboratory Organic Analyses for Bench-Scale Testing Involving the EnviroMetal Process

Treatability Test	Column Identification:	363
Arrowhead	Column Composition:	100 % Connelly Golders-Sierra cc-1022 Iron (UW#20
	Pore Volume	316 mL
	Porosity:	0.56
	Column Length:	1.6 ft (50 cm)
	Column Diameter:	1.5 in (3.8 cm)
	Flow Velocity:	0.94 ft/day (28.6 cm/day)

Column Distance (ft)		0.0	0.08	0.16	0.33	0.50	0.66	1.0	1.3	1.6
Residence Time (hr)		0.0	2.0	4.1	8.4	12.8	16.9	25.5	33.4	41.9
PV	*RN*	*Influent*			*Organic Concentration (μg/L)*					*Effluent*
PCE										
3.5	a	7655	2485	nd	nd	nd	nd	nd	nd	nd
7.7	a	6235	3636	1849	6.1	nd	nd	nd	nd	nd
10.0	a	5788	3422	2616	103	nd	nd	nd	nd	nd
13.2	a	5436	3362	3326	642	nd	nd	nd	nd	nd
19.3	a	6945	6298	4809	2653	793	18	nd	nd	nd
23.8	a	6710	5714	5352	3451	1615	172	nd	nd	nd
27.7	a	4379	3634	3357	2556	1415	334	nd	nd	nd
32.3	a	7712	5129	4568	.3312	2439	1021	nd	nd	nd
35.2	a	6610	4664	4653	3768	2576	1315	nd	nd	nd
39.5	a	6718	5493	4642	3842	2917	1648	29	nd	nd
TCE										
3.5	a	45664	23473	19000	8974	909	3.3	nd	nd	nd
7.7	a	40074	25822	15152	8012	3356	229	2.5	nd	nd
10.0	a	38548	23182	20038	11588	5204	508	nd	nd	nd
13.2	a	34049	22860	23210	8401	4944	703	nd	nd	nd
19.3	a	43997	43193	34276	27856	19180	9372	1936	22	2.3
23.8	a	43758	38523	36518	26873	21484	13120	2000	32	7.2
27.7	a	41268	20409	26923	19025	12875	8671	1145	22	3.5
32.3	a	39109	29106	22127	20507	14213	8120	1901	37	nd
35.2	a	33419	26069	26374	22790	17113	10803	2058	28	3.1
39.5	a	34519	29124	23886	28935	15934	9702	2452	55	nd
111TCA										
3.5	a	1029	nd	nd	nd	nd	nd	nd	nd	nd
7.7	a	903	nd	nd	nd	nd	nd	nd	nd	nd
10.0	a	895	1.2	nd	nd	nd	nd	nd	nd	nd
13.2	a	1001	5.2	nd	nd	nd	nd	nd	nd	nd
19 3	a	875	25	1.0	nd	nd	nd	nd	nd	nd
23.8	a	900	46	nd	nd	nd	nd	nd	nd	nd
27.7	a	987	23	nd	nd	nd	nd	nd	nd	nd
32.3	a	860	42	nd	nd	nd	nd	nd	nd	nd
35.2	a	853	29	nd	nd	nd	nd	nd	nd	nd
39.5	a	841	48	2	nd	nd	nd	nd	nd	nd

nd = not detected
RN = reservoir number

BOLD = *peak concentration*

Treatability Test	Column Identification:	363
Arrowhead	Column Composition:	100 % Connelly Golders-Sierra cc-1022 Iron (UW#20
	Pore Volume	316 mL
	Porosity:	0.56
	Column Length:	1.6 ft (50 cm)
	Column Diameter:	1.5 in (3.8 cm)
	Flow Velocity:	0.94 ft/day (28.6 cm/day)

Column Distance (ft)		0.0	0.08	0.16	0.33	0.50	0.66	1.0	1.3	1.6
Residence Time (hr)		0.0	2.0	4.1	8.4	12.8	16.9	25.5	33.4	41.9
PV	RN	Influent			Organic Concentration (µg/L)					Effluent
112TCA										
3.5	a	40	5.1	nd	nd	nd	nd	nd	nd	nd
7.7	a	34	3.7	nd	nd	nd	nd	nd	nd	nd
10.0	a	37	7.1	2.0	nd	nd	nd	nd	nd	nd
13.2	a	39	9.7	nd	nd	nd	nd	nd	nd	nd
19.3	a	49	25	16	5.5	nd	nd	nd	nd	nd
23.8	a	50	29	17	6.5	nd	nd	nd	nd	nd
27.7	a	63	38	27	16	nd	nd	nd	nd	nd
32.3	a	38	20	17	6.2	2.5	nd	nd	nd	nd
35.2	a	48	30	21	7.9	2.6	nd	nd	nd	nd
39.5	a	52	15	26	9.1	4.8	nd	nd	nd	nd
11DCA										
3.5	a	nd	185	137	115	97	89	76	nd	nd
7.7	a	nd	395	387	322	301	259	238	53	nd
10.0	a	nd	373	351	271	183	223	313	114	nd
13.2	a	nd	487	421	375	299	280	473	228	79
19.3	a	nd	417	523	403	328	285	282	322	351
23.8	a	nd	188	580	401	269	272	211	395	482
27.7	a	nd	580	562	509	333	299	356	434	578
32.3	a	nd	228	**388**	351	312	260	233	156	160
35.2	a	nd	236	481	347	415	363	332	**455**	322
39.5	a	nd	229	486	411	426	387	310	425	553
12 DCA										
3.5	a	na	18	10	10	10	155	95	72	nd
7.7	a	na	16	17	14	16	20	137	76	13
10.0	a•	na	14	16	15	11	18	17	19	19
13.2	a	na	16	15	16	16	18	16	16	16
19.8	a	na	na	16	15	16	10	20	18	18
23.8	a	na	na	17	15	11	11	11	12	11
27.7	a	na	20	14	14	11	10	18	44	101
32.3	a	na	na	12	13	13	14	16	11	13
35.2	a	na	na	14	9.7	15	15	19	61	15
39.5	a	na	na	16	16	17	18	18	36	18

nd = not detected
na = not applicable
RN = reservoir number

BOLD = peak concentration

Treatability Test	Column Identification:	363
Arrowhead	Column Composition:	100 % Connelly Golders-Sierra cc-1022 Iron (UW#20
	Pore Volume	316 mL
	Porosity:	0.56
	Column Length:	1.6 ft (50 cm)
	Column Diameter:	1.5 in (3.8 cm)
	Flow Velocity:	0.94 ft/day (28.6 cm/day)

Column Distance (ft)			*0.0*	*0.08*	*0.16*	*0.33*	*0.50*	*0.66*	*1.0*	*1.3*	*1.6*
Residence Time (hr)			0.0	2.0	4.1	8.4	12.8	16.9	25.5	33.4	41.9
	PV	RN	Influent	Organic Concentration (µg/L)							Effluent
cDCE											
	4.0	a	147	738	887	1328	1466	862	50	nd	nd
	6.6	a	137	576	720	932	1036	716	223	9.0	nd
	10.5	a	111	336	539	689	547	114	385	9.8	nd
	14.0	a	149	320	491	714	597	512	120	10	nd
	20.6	a	121	257	425	712	817	1088	861	386	200
	24.3	a	104	227	276	665	808	825	739	303	210
	28.8	a	143	239	357	798	737	817	656	310	225
	32.8	a	140	239	342	569	602	700	**848**	215	164
	36.4	a	103	126	268	480	535	545	**575**	350	321
	40.1	a	98	149	212	449	483	**835**	774	541	404
tDCE											
	4.0	a	4.9	14	12	12	6.7	nd	nd	nd	nd
	6.6	a	5	10	13	14	11	1.9	nd	nd	nd
	10.5	a	3.1	6.5	8.6	10	5.4	nd	nd	nd	nd
	14.0	a	3.9	6.1	8.7	12	5.8	nd	nd	nd	nd
	20.6	a	2.3	5.7	8.6	12	15	26	30	15	7
	24.3	a	2.7	4.3	4.5	12	15	18	27	20	nd
	28.8	a	4.7	6.2	9.9	13	1.5	16	13	nd	nd
	32.8	a	3.4	8.6	10	14	17	15	nd	nd	nd
	36.4	a	12	nd	14	10	13	16	10	nd	nd
	40.1	a	11	4	11	14	14	23	15	nd	nd
11DCE											
	4.0	a	4032	1984	2067	1768	1417	847	30	nd	nd
	6.6	a	3541	2357	1918	1640	1130	476	104	nd	nd
	10.5	a	3779	2496	2208	1200	507	410	288	nd	nd
	14.0	a	2482	2864	2476	1468	594	415	41	nd	nd
	20.6	a	5829	4576	6456	5020	2724	2772	1389	394	206
	24.3	a	3232	5140	4928	3461	3340	2278	1048	372	192
	28.8	a	5710	5143	4099	3189	2659	2012	808	201	101
	32.8	a	4496	3663	2684	2929	1872	1414	914	91	52
	36.4	a	3296	2948	2415	2416	2422	1588	755	308	172
	40.1	a	2866	1886	2503	2209	2028	1548	856	571	248

nd = not detected

RN = *reservoir number*

BOLD = peak concentration

Treatability Test		Column Identification:	363
Arrowhead		Column Composition:	100 % Connelly Golders-Sierra cc-1022 Iron (UW#20
		Pore Volume	316 mL
		Porosity:	0.56
		Column Length:	1.6 ft (50 cm)
		Column Diameter:	1.5 in (3.8 cm)
		Flow Velocity:	0.94 ft/day (28.6 cm/day)

Column Distance (ft)			0.0	0.08	0.16	0.33	0.50	0.66	1.0	1.3	1.6
Residence Time (hr)			0.0	2.0	4.1	8.4	12.8	16.9	25.5	33.4	41.9
	PV	RN	Influent	Organic Concentration (µg/L)							Effluent
VC											
	4.0	a	nd	35	36	36	42	44	15	nd	nd
	6.6	a	nd	32	34	32	34	28	27	nd	nd
	10.5	a	nd	22	29	29	17	10	17	nd	nd
	14.0	a	nd	25	28	35	16	26	9.2	nd	nd
	20.6	a	nd	26	34	41	37	42	38	29	24
	24.3	a	nd	23	26	40	37	31	35	25	21
	28.8	a	nd	12	15	22	nd	23	18	10	8.9
	32.8	a	nd	8.1	15	23	23	**24**	15	nd	nd
	36.4	a	nd	nd	12	16	**21**	17	8.7	10	11
	40.1	a	nd	nd	9.8	19	6.7	18	15	12	12
			pH Along Column								
pH											
	3.1	a	6.2	7.8	9.4	9.5	9.3	9.4	9.2	9.2	8.8
	8.0	a	6.6	8.1	8.4	9.3	9.4	9.5	9.5	9.4	9.0
	10.9	a	6.8	7.3	8.1	8.8	9.2	9.5	9.5	9.4	9.4
	15.1	a	7.1	8.4	8.8	8.7	9.0	9.3	9.3	9.4	9.5
	21.2	a	7.3	8.8	8.8	8.5	8.3	8.8	9.3	9.4	9.6
	25.4	a	7.3	8.6	8.8	8.6	8.3	8.3	9.3	9.2	9.3
	27.1	a	6.9	8.8	8.8	8.5	8.2	8.0	9.2	9.1	9.3
	33.3	a	7.2	7.6	8.6	8.5	8.0	7.9	9.0	9.5	9.5
	36.9	a	7.3	8.8	8.8	8.7	8.3	8.1	9.0	9.5	9.5
			Redox Potential Along Column (mV)								
Eh											
	3.1	a	324	-330	-408	-191	-451	-461	-484	-492	-365
	8.0	a	374	-210	-305	-225	-309	-378	-260	-376	-142
	10.9	a	294	-126	-71	-119	-195	-190	-243	-267	-113
	15.1	a	357	-44	-124	-196	-175	-210	-180	-201	-166
	21.2	a	373	-55	-101	-106	-123	-167	-227	-226	-118
	25.4	a	402	-101	-136	-144	-174	-270	-317	-238	-198
	27.1	a	384	-56	-86	-121	-137	-165	-179	-190	-2
	33.3	a	390	-36	-347	-430	-356	-331	-487	-546	-128
	36.9	a	345	-299	-269	-432	-395	-355	-440	-387	-483

nd = not detected
RN = reservoir number

BOLD = peak concentration

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Laboratory Inorganic Analyses for Bench-Scale Testing Involving the EnviroMetal Process

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Water Samples

Arrowhead samples

Sample Id	Ag ICAP mg/L	Al ICAP mg/L	As ICAP mg/L	B ICAP mg/L	Ba ICAP mg/L	Be ICAP mg/L	Bi ICAP mg/L	Ca ICAP mg/L
UW-363 influent, col 363, 38.1 pv	<0.003	<0.03	<0.1	0.56	0.013	<0.0005	<0.1	6.43
UW-364 effluent	<0.003	<0.03	<0.1	0.69	0.045	<0.0005	<0.1	10.6
UW-365 influent, col 363, 40.1 pv.	<0.003	<0.03	<0.1	0.62	0.013	<0.0005	<0.1	6.33
UW-366 effluent	<0.003	<0.03	<0.1	0.70	0.043	<0.0005	<0.1	10.2
UW-367 other project	<0.003	<0.03	<0.1	0.15	0.012	<0.0005	<0.1	178.
Sample+Spike (found)	---	---	1.1	---	1.06	1.11	---	7.39
Sample+Spike (expected)	---	---	1.0	---	1.01	1.00	---	7.43
Blank	<0.003	<0.03	<0.1	<0.01	<0.005	<0.0005	<0.1	<0.05
QC Standard (found)	0.027	9.80	1.0	0.19	0.957	0.998	1.0	50.0
QC Standard (expected)	0.030	10.0	1.0	0.20	1.00	1.00	1.0	51.0
Repeat UW-363	<0.003	<0.03	<0.1	0.60	0.013	<0.0005	<0.1	6.41

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Water Samples

Arrowhead

Sample Id	Cd ICAP mg/L	Co ICAP mg/L	Cr ICAP mg/L	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L
UW-363 influent, col 363, 38.1 pv.	<0.005	0.017	<0.005	<0.003	0.02	2	2.71	0.682
UW-364 effluent	<0.005	<0.005	<0.005	<0.003	0.01	2	2.22	0.016
UW-365 influent, col 363, 40.1 pv.	<0.005	0.018	<0.005	<0.003	0.01	1	2.79	0.693
UW-366 eff	<0.005	<0.005	<0.005	<0.003	<0.01	2	2.31	0.021
UW-367 other project	0.006	<0.005	<0.005	<0.003	0.01	1	64.5	<0.005
Sample+Spike (found)	1.00	1.03	1.00	1.05	1.02	---	---	1.70
Sample+Spike (expected)	1.00	1.01	1.00	1.00	1.02	---	---	1.68
Blank	<0.005	<0.005	<0.005	<0.003	<0.01	<1	<0.05	<0.005
QC Standard (found)	0.928	0.923	0.916	0.927	0.91	10	10.6	0.925
QC Standard (expected)	1.00	1.00	1.00	1.00	1.00	10	11.0	1.00
Repeat UW-363	<0.005	0.015	<0.005	<0.003	0.02	1	2.83	0.695

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Arrowhead

Water Samples

Sample Id	Mo ICAP mg/L	Na ICAP mg/L	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	S ICAP mg/L	Sb ICAP mg/L	Se ICAP mg/L
UW-363 influent, col 363, 38.1 pV.	<0.02	168.	<0.02	<0.1	<0.05	103.	<0.1	<0.1
UW-364 effluent	<0.02	176.	<0.02	<0.1	<0.05	95.3	<0.1	<0.1
UW-365 influent, col 363, 40.1 pV	<0.02	275.	<0.02	<0.1	<0.05	105.	<0.1	<0.1
UW-366 effluent	<0.02	175.	<0.02	<0.1	<0.05	94.1	<0.1	<0.1
UW-367 other project	<0.02	142.	<0.02	<0.1	<0.05	168.	<0.1	<0.1
Sample+Spike (found)	0.98	---	1.04	---	0.99	---	1.0	1.0
Sample+Spike (expected)	1.00	---	1.00	---	1.00	---	1.0	1.0
Blank	<0.02	<0.1	<0.02	<0.1	<0.05	<0.1	<0.1	<0.1
QC Standard (found)	1.02	48.1	0.92	2.0	0.93	9.6	0.9	0.9
QC Standard (expected)	1.10	50.0	1.00	2.0	1.00	10.0	1.0	1.0
Repeat UW-363	<0.02	179.	<0.02	<0.1	<0.05	107.	<0.1	<0.1

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Water Samples

Arrowhead

Sample Id	Si ICAP mg/L	Sn ICAP mg/L	Sr ICAP mg/L	Ti ICAP mg/L	V ICAP mg/L	Zn ICAP mg/L	F- SM 4500F mg/L	Cl- SM 4110B mg/L
UW-363 influent, vol 363, 38.1 pv.	4.40	<0.05	0.037	<0.005	<0.005	0.013	<0.1	36.0
UW-364 effluent	0.17	<0.05	0.050	<0.005	<0.005	0.009	<0.1	77.0
UW-365 influent, vol 363, 40.1 pv.	4.46	<0.05	0.039	<0.005	<0.005	0.011	<0.1	35.9
UW-366 effluent	0.26	<0.05	0.049	<0.005	<0.005	<0.005	<0.1	71.9
UW-367 other project	6.28	<0.05	0.914	<0.005	<0.005	<0.005	<0.1	70.4
Sample+Spike (found)	---	---	---	1.01	1.01	1.02	---	---
Sample+Spike (expected)	---	---	---	1.00	1.00	1.01	---	---
Blank	<0.05	<0.05	<0.001	<0.005	<0.005	<0.005	<0.1	<0.5
QC Standard (found)	1.94	0.98	0.903	0.912	0.922	0.918	5.1	64.8
QC Standard (expected)	2.00	1.00	1.00	1.00	1.00	1.00	4.5	60.0
Repeat UW-363	4.51	<0.05	0.039	<0.005	<0.005	0.013	<0.1	36.7

AR301461

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PO #:
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Job: 2056175

Status: Final

Arrow head

Water Samples

Sample Id	NO2-N SM 4110B mg/L	PO4-3 SM 4110B mg/L	Br- SM 4110B mg/L	NO3-N SM 4110B mg/L	SO4= SM 4110B mg/L	pH SM 4500B pH Units	Alk 8.3 SM 2320B mg CaCO3/L
UW-363 influent, col 363, 38.1 pv.	<0.2	<1	<0.5	2.9	294.	6.62	<1
UW-364 effluent	<0.2	<1	<0.5	<0.2	264.	6.48	<1
UW-365 influent, col 363, 40.1 pv.	<0.2	<1	<0.5	2.9	296.	6.52	<1
UW-366 effluent	<0.2	<1	<0.5	0.6	266.	6.93	<1
UW-367 other proj	<0.2	<1	<0.5	<0.2	482.	7.83	<1
Sample+Spike (found)	---	---	---	---	---	---	---
Sample+Spike (expected)	---	---	---	---	---	---	---
Blank	<0.2	<1	<0.5	<0.2	<0.5	---	---
QC Standard (found)	9.6	6	10.0	30.0	62.8	7.03	<1
QC Standard (expected)	10.0	6	10.0	30.0	60.0	7.00	<1
Repeat UW-363	<0.2	<1	<0.5	2.9	298.	---	<1

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Water Samples

Sample Id	Alk 4.2 SM 2320B mg CaCO3/L	NH3-N SM 4500B mg/L	DOC SM 5310C mg/L	Th. Cond. Calc. umhos/cm	Th. TDS Calc. mg/L	pHs Calc. pH Units	CAB Calc. %
UW-363 influent, col 363, 38.1 pv.	10	<0.03	46.4	940.9	612	9.68	-2.34
UW-364 effluent	21	1.10	7.8	1008.	656	9.14	-2.29
UW-365 influent, col 363, 40.1 pv.	11	<0.03	45.0	962.0	625	9.64	-3.88
UW-366 effluent	26	1.73	26.2	1010.	657	9.06	-1.89
UW-367 other project	383	0.03	2.5	2244.	1459	6.71	-1.91
Sample+Spike (found)	---	---	---	nan	nan	nan	nan
Sample+Spike (expected)	---	---	---	nan	nan	nan	nan
Blank	<1	<0.03	<0.2	nan	nan	nan	20.6
QC Standard (found)	248	1.51	10.0	893.9	581	7.39	27.5
QC Standard (expected)	250	1.50	10.0	889.6	578	7.38	25.4
Repeat UW-363	10	<0.03	46.5	nan	nan	nan	-4.57

AR301463

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Job: 2056175

Status: Final

Water Samples

Arrowhead

Sample Id	Hard(Calc) SM 2340B mg CaCO3/L	CO3= Calc. mg/L	HCO3- Calc. mg/L	L.I. Calc. None	A.I. Calc. None	R.S.I. Calc. None	Colour SM 2120B TCU	Turb. SM 2130B NTU
UW-363 influent, id 363, 38.1 pv.	27.2	1	10	-3.1	9.06	12.7	<1	0.7
UW-364 effluent	35.6	1	23	-2.7	9.35	11.8	16	4.3
UW-365 influent, id 363, 40.1 pv.	27.3	1	11	-3.1	9.00	12.8	<1	0.7
UW-366 effluent	35.2	1	29	-2.1	9.89	11.2	14	2.4
UW-367 other project	711.8	1	465	1.1	13.27	5.6	10	0.4
Sample+Spike (found)	nan	nan	nan	nan	nan	nan	---	---
Sample+Spike (expected)	nan	nan	nan	nan	nan	nan	---	---
Blank	0.3	nan	nan	nan	nan	nan	<1	0.1
QC Standard (found)	168.8	1	300	-0.4	11.65	7.7	50	1.8
QC Standard (expected)	172.6	1	302	-0.4	11.64	7.8	50	1.8
Repeat UW-363	27.7	nan	nan	nan	nan	nan	<1	0.7

AR301464

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Received: 19-Jul-2000 12:19

Job: 2056175

Status: Final

Water Samples

Arrowhead

Sample Id	Sp. Cond. SM 2510B umhos/cm
UW-363 influent, col 363, 38.1 pv.	817
UW-364 effluent	843
UW-365 influent, col 363, 40.1 pv.	821
UW-366 effluent	846
UW-367 other project	1461
Sample+Spike (found)	---
Sample+Spike (expected)	---
Blank	3
QC Standard (found)	700
QC Standard (expected)	718
Repeat UW-363	818

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Job: 2056175
Status: Final

All work recorded herein has been done in accordance with normal professional standards using accepted testing methodologies and QA/QC procedures. Philip Analytical is limited in liability to the actual cost of the pertinent analyses done unless otherwise agreed upon by contractual arrangement. Your samples will be retained by PASC for a period of 30 days following reporting or as per specific contractual arrangements.

Job approved by:

Signed: ....
Ralph Siebert, B.Sc.
Project Manager

APPENDIX D

Infiltration Analysis HELP Modeling Simulations

APPENDIX D-1 Existing Conditions

APPENDIX D-2 Cap System Alternatives A, B, C & D

APPENDIX D-1

Existing Conditions

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******************************************************************************
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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
**                                                                          **
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******************************************************************************
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```
PRECIPITATION DATA FILE:      C:\HELP3\montross.D4
TEMPERATURE DATA FILE:        C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\20MON05.D10
OUTPUT DATA FILE:             C:\HELP3\20mon05.OUT
```

TIME: 10: 4   DATE: 1/19/2001

```
******************************************************************************

     TITLE:  Existing Conditions - 20 feet @ 0.5% Surface Slope

******************************************************************************
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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

```
                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER 10
     THICKNESS                   =     240.00   INCHES
     POROSITY                    =       0.3980 VOL/VOL
     FIELD CAPACITY              =       0.2440 VOL/VOL
     WILTING POINT               =       0.1360 VOL/VOL
     INITIAL SOIL WATER CONTENT  =       0.2637 VOL/VOL
     EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
   NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
          FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

AR301469

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 0.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	89.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.293	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	63.280	INCHES
TOTAL INITIAL WATER	=	63.280	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA AND STATION LATITUDE = 38.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.139	0.116	0.372	0.103	0.268	0.201
	0.472	0.388	0.529	0.179	0.199	0.321
STD. DEVIATIONS	0.233	0.211	0.605	0.190	0.365	0.243
	0.651	0.382	0.561	0.233	0.309	0.319
EVAPOTRANSPIRATION						
TOTALS	1.235	1.582	3.047	3.171	3.883	3.568
	3.829	3.806	2.695	1.483	1.249	1.017
STD. DEVIATIONS	0.209	0.293	0.263	0.880	0.889	1.750
	1.339	1.213	1.040	0.463	0.294	0.200
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.2871	0.4809	0.7178	0.8410	1.0453	0.8560

	0.7403	0.5949	0.4970	0.4122	0.3795	0.3085
STD. DEVIATIONS	0.4460	0.4625	0.5869	0.6612	0.4796	0.3663
	0.2085	0.1941	0.1454	0.1318	0.1684	0.1705

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.12	(5.848)	149272.9	100.00
RUNOFF	3.285	(1.3854)	11926.34	7.990
EVAPOTRANSPIRATION	30.565	(3.4052)	110952.00	74.328
PERCOLATION/LEAKAGE THROUGH LAYER 1	7.16045	(2.98112)	25992.437	17.41270
CHANGE IN WATER STORAGE	0.111	(3.2516)	402.09	0.269

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.124	7710.7397
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.134781	489.25519
SNOW WATER	3.00	10891.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3049	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

****

****

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	66.6032	0.2775
SNOW WATER	0.000	

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**            FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                          **
**                                                                          **
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******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3\montross.D4
TEMPERATURE DATA FILE:        C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\20MON02.D10
OUTPUT DATA FILE:             C:\HELP3\20mon02.OUT


TIME:  10: 5      DATE:   1/19/2001


******************************************************************************

     TITLE:  Existing Conditions - 20 feet @ 2.5% Surface Slope

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  10
           THICKNESS                   =    240.00   INCHES
           POROSITY                    =      0.3980 VOL/VOL
           FIELD CAPACITY              =      0.2440 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2630 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

AR301474

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	89.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.293	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	63.128	INCHES
TOTAL INITIAL WATER	=	63.128	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.153	0.126	0.397	0.113	0.288	0.220
	0.505	0.417	0.560	0.194	0.215	0.345
STD. DEVIATIONS	0.251	0.216	0.616	0.202	0.384	0.257
	0.678	0.399	0.584	0.246	0.327	0.336
EVAPOTRANSPIRATION						
TOTALS	1.234	1.582	3.043	3.169	3.892	3.551
	3.808	3.791	2.680	1.481	1.246	1.013
STD. DEVIATIONS	0.210	0.294	0.261	0.879	0.888	1.737
	1.331	1.208	1.037	0.463	0.293	0.200
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.2712	0.4518	0.6999	0.8060	1.0227	0.8475

	0.7242	0.5892	0.4925	0.4134	0.3704	0.3004
STD. DEVIATIONS	0.4016	0.4448	0.5777	0.6504	0.4785	0.3647
	0.1995	0.1864	0.1429	0.1265	0.1549	0.1662

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.12 (5.848)	149272.9	100.00
RUNOFF	3.532 (1.4433)	12820.05	8.588
EVAPOTRANSPIRATION	30.488 (3.3762)	110672.23	74.141
PERCOLATION/LEAKAGE THROUGH LAYER 1	6.98911 (2.91216)	25370.467	16.99603
CHANGE IN WATER STORAGE	0.113 (3.1888)	410.13	0.275

****

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.176	7899.0508
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.136666	496.09586
SNOW WATER	3.00	10891.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3049	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	66.5179	0.2772
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3\montross.D4
TEMPERATURE DATA FILE:        C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\20MON10.D10
OUTPUT DATA FILE:             C:\HELP3\20mon10.OUT


TIME:  10: 7      DATE:   1/19/2001


******************************************************************************

     TITLE:  Existing Conditions - 20 feet @ 10 % Surface Slope

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  10
          THICKNESS                  =    240.00   INCHES
          POROSITY                   =      0.3980 VOL/VOL
          FIELD CAPACITY             =      0.2440 VOL/VOL
          WILTING POINT              =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2626 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 10.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	90.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.294	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	63.023	INCHES
TOTAL INITIAL WATER	=	63.023	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.163	0.133	0.418	0.121	0.303	0.235
	0.533	0.439	0.584	0.207	0.227	0.364
STD. DEVIATIONS	0.264	0.219	0.624	0.212	0.396	0.268
	0.699	0.414	0.600	0.256	0.339	0.351
EVAPOTRANSPIRATION						
TOTALS	1.234	1.582	3.041	3.160	3.894	3.530
	3.800	3.775	2.672	1.480	1.244	1.012
STD. DEVIATIONS	0.210	0.294	0.261	0.877	0.877	1.717
	1.328	1.201	1.036	0.464	0.292	0.198
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.2548	0.4335	0.6852	0.7768	1.0052	0.8375

	0.7187	0.5875	0.4860	0.4114	0.3637	0.2974
STD. DEVIATIONS	0.3667	0.4318	0.5902	0.6257	0.4730	0.3631
	0.2034	0.1874	0.1357	0.1214	0.1477	0.1661

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.12 (5.848)	149272.9	100.00
RUNOFF	3.726 (1.4802)	13525.49	9.061
EVAPOTRANSPIRATION	30.424 (3.3795)	110438.61	73.984
PERCOLATION/LEAKAGE THROUGH LAYER 1	6.85785 (2.85528)	24893.984	16.67683
CHANGE IN WATER STORAGE	0.114 (3.1501)	414.78	0.278

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.214	8036.1309
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.135781	492.88455
SNOW WATER	3.00	10891.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3057	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	66.4511	0.2769
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**               DEVELOPED BY ENVIRONMENTAL LABORATORY                      **
**                 USAE WATERWAYS EXPERIMENT STATION                        **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP3\montross.D4
TEMPERATURE DATA FILE:       C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\20MON25.D10
OUTPUT DATA FILE:            C:\HELP3\20mon25.OUT


TIME:  10: 8     DATE:   1/19/2001


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     TITLE:  Existing Conditions - 20 feet @ 25 % Surface Slope

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =     240.00   INCHES
          POROSITY                     =       0.3980 VOL/VOL
          FIELD CAPACITY               =       0.2440 VOL/VOL
          WILTING POINT                =       0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.2620 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	90.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.294	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	62.880	INCHES
TOTAL INITIAL WATER	=	62.880	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.173	0.142	0.441	0.130	0.320	0.251
	0.559	0.465	0.610	0.220	0.240	0.385
STD. DEVIATIONS	0.275	0.223	0.634	0.224	0.411	0.281
	0.719	0.429	0.619	0.266	0.352	0.368
EVAPOTRANSPIRATION						
TOTALS	1.233	1.582	3.042	3.159	3.891	3.505
	3.784	3.758	2.661	1.481	1.242	1.011
STD. DEVIATIONS	0.209	0.294	0.261	0.878	0.875	1.708
	1.323	1.194	1.035	0.465	0.292	0.197
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.2473	0.4062	0.6558	0.7493	0.9902	0.8300

	0.7103	0.5809	0.4828	0.4089	0.3621	0.2975
STD. DEVIATIONS	0.3351	0.4066	0.5599	0.6229	0.4681	0.3635
	0.2002	0.1849	0.1310	0.1207	0.1454	0.1633

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.12	(5.848)	149272.9	100.00
RUNOFF	3.938	(1.5243)	14294.89	9.576
EVAPOTRANSPIRATION	30.348	(3.3742)	110164.27	73.801
PERCOLATION/LEAKAGE THROUGH LAYER 1	6.72135	(2.77678)	24398.504	16.34490
CHANGE IN WATER STORAGE	0.114	(3.0992)	415.19	0.278

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.245	8148.4463
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.136198	494.40042
SNOW WATER	3.00	10891.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3070

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1360

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	66.3117	0.2763
SNOW WATER	0.000	

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AR301488

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\HELP3\montross.D4
TEMPERATURE DATA FILE:      C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\15mon05.D10
OUTPUT DATA FILE:           C:\HELP3\15mon05.OUT


TIME:  10:10     DATE:   1/19/2001


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     TITLE:  Existing Conditions - 15 feet @ 0.5% Surface Slope

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  10
          THICKNESS                  =     180.00   INCHES
          POROSITY                   =       0.3980 VOL/VOL
          FIELD CAPACITY             =       0.2440 VOL/VOL
          WILTING POINT              =       0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =       0.2689 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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AR301489

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 0.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	89.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.293	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	48.410	INCHES
TOTAL INITIAL WATER	=	48.410	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.139	0.116	0.372	0.103	0.268	0.201
	0.472	0.388	0.529	0.179	0.199	0.321
STD. DEVIATIONS	0.233	0.211	0.605	0.190	0.365	0.243
	0.651	0.382	0.561	0.233	0.309	0.319
EVAPOTRANSPIRATION						
TOTALS	1.235	1.582	3.047	3.171	3.883	3.568
	3.829	3.806	2.695	1.483	1.249	1.017
STD. DEVIATIONS	0.209	0.293	0.263	0.880	0.889	1.750
	1.339	1.213	1.040	0.463	0.294	0.200
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.3751	0.7212	0.8321	0.9804	1.0322	0.7735

	0.6396	0.4930	0.4097	0.3297	0.3161	0.3019
STD. DEVIATIONS	0.6032	0.7130	0.6480	0.6814	0.4283	0.3190
	0.1612	0.1571	0.1082	0.1090	0.1406	0.2484

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.12	(5.848)	149272.9	100.00
RUNOFF	3.285	(1.3854)	11926.34	7.990
EVAPOTRANSPIRATION	30.565	(3.4052)	110952.00	74.328
PERCOLATION/LEAKAGE THROUGH LAYER 1	7.20458	(2.99345)	26152.607	17.52000
CHANGE IN WATER STORAGE	0.067	(3.1882)	241.92	0.162

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.124	7710.7397
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.181104	657.40918
SNOW WATER	3.00	10891.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3049

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1360

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	50.4096	0.2801

SNOW WATER 0.000

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\HELP3\montross.D4
TEMPERATURE DATA FILE:      C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\15mon02.D10
OUTPUT DATA FILE:           C:\HELP3\15mon02.OUT


TIME:  10:11     DATE:   1/19/2001


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     TITLE:  Existing Conditions - 15 feet @ 2.5% Surface Slope

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                             MATERIAL TEXTURE NUMBER  10
          THICKNESS                  =     180.00   INCHES
          POROSITY                   =       0.3980 VOL/VOL
          FIELD CAPACITY             =       0.2440 VOL/VOL
          WILTING POINT              =       0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =       0.2682 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =   0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	89.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.293	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	48.269	INCHES
TOTAL INITIAL WATER	=	48.269	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.153	0.126	0.397	0.113	0.288	0.220
	0.505	0.417	0.560	0.194	0.215	0.345
STD. DEVIATIONS	0.251	0.216	0.616	0.202	0.384	0.257
	0.678	0.399	0.584	0.246	0.327	0.336
EVAPOTRANSPIRATION						
TOTALS	1.234	1.582	3.043	3.169	3.892	3.551
	3.808	3.791	2.680	1.481	1.246	1.013
STD. DEVIATIONS	0.210	0.294	0.261	0.879	0.888	1.737
	1.331	1.208	1.037	0.463	0.293	0.200
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.3586	0.6885	0.8136	0.9465	1.0136	0.7688

	0.6264	0.4896	0.4058	0.3319	0.3063	0.2836
STD. DEVIATIONS	0.6005	0.6889	0.6439	0.6692	0.4320	0.3202
	0.1488	0.1498	0.1058	0.1027	0.1257	0.1799

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.12	(5.848)	149272.9	100.00
RUNOFF	3.532	(1.4433)	12820.05	8.588
EVAPOTRANSPIRATION	30.488	(3.3762)	110672.23	74.141
PERCOLATION/LEAKAGE THROUGH LAYER 1	7.03329	(2.97074)	25530.857	17.10348
CHANGE IN WATER STORAGE	0.069	(3.1672)	249.74	0.167

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.176	7899.0508
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.149334	542.08405
SNOW WATER	3.00	10891.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3049	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	50.3331	0.2796
SNOW WATER	0.000	

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AR301498

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**            FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP3\montross.D4
TEMPERATURE DATA FILE:       C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\15mon10.D10
OUTPUT DATA FILE:            C:\HELP3\15mon10.OUT


TIME:  10:13     DATE:   1/19/2001


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     TITLE:  Existing Conditions - 15 feet @ 10 % Surface Slope

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    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  10
          THICKNESS                  =    180.00   INCHES
          POROSITY                   =      0.3980 VOL/VOL
          FIELD CAPACITY             =      0.2440 VOL/VOL
          WILTING POINT              =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2676 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 10.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	90.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.294	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	48.169	INCHES
TOTAL INITIAL WATER	=	48.169	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.163	0.133	0.418	0.121	0.303	0.235
	0.533	0.439	0.584	0.207	0.227	0.364
STD. DEVIATIONS	0.264	0.219	0.624	0.212	0.396	0.268
	0.699	0.414	0.600	0.256	0.339	0.351
EVAPOTRANSPIRATION						
TOTALS	1.234	1.582	3.041	3.160	3.894	3.530
	3.800	3.775	2.672	1.480	1.244	1.012
STD. DEVIATIONS	0.210	0.294	0.261	0.877	0.877	1.717
	1.328	1.201	1.036	0.464	0.292	0.198
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.3383	0.6696	0.7993	0.9146	1.0008	0.7617

	0.6232	0.4892	0.4005	0.3307	0.2999	0.2745
STD. DEVIATIONS	0.5784	0.6776	0.6540	0.6481	0.4293	0.3197
	0.1527	0.1480	0.0997	0.0979	0.1179	0.1624

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.12	(5.848)	149272.9	100.00
RUNOFF	3.726	(1.4802)	13525.49	9.061
EVAPOTRANSPIRATION	30.424	(3.3795)	110438.61	73.984
PERCOLATION/LEAKAGE THROUGH LAYER 1	6.90214	(2.93984)	25054.785	16.78455
CHANGE IN WATER STORAGE	0.070	(3.1532)	253.98	0.170

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.214	8036.1309
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.148590	539.38184
SNOW WATER	3.00	10891.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3057
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	50.2684	0.2793
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP3\montross.D4
TEMPERATURE DATA FILE:       C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\15mon25.D10
OUTPUT DATA FILE:            C:\HELP3\15mon25.OUT


TIME:  10:14     DATE:   1/19/2001


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     TITLE:  Existing Conditions - 15 feet @ 25 % Surface Slope

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
          THICKNESS                   =    180.00    INCHES
          POROSITY                    =      0.3980 VOL/VOL
          FIELD CAPACITY              =      0.2440 VOL/VOL
          WILTING POINT               =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.2668 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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AR301504

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	90.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.294	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	48.030	INCHES
TOTAL INITIAL WATER	=	48.030	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.173	0.142	0.441	0.130	0.320	0.251
	0.559	0.465	0.610	0.220	0.240	0.385
STD. DEVIATIONS	0.275	0.223	0.634	0.224	0.411	0.281
	0.719	0.429	0.619	0.266	0.352	0.368
EVAPOTRANSPIRATION						
TOTALS	1.233	1.582	3.042	3.159	3.891	3.505
	3.784	3.758	2.661	1.481	1.242	1.011
STD. DEVIATIONS	0.209	0.294	0.261	0.878	0.875	1.708
	1.323	1.194	1.035	0.465	0.292	0.197
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.3267	0.6381	0.7659	0.8912	0.9931	0.7573

	0.6169	0.4844	0.3979	0.3284	0.2975	0.2677
STD. DEVIATIONS	0.5620	0.6545	0.6248	0.6527	0.4284	0.3215
	0.1500	0.1462	0.0959	0.0971	0.1142	0.1410

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.12	(5.848)	149272.9	100.00
RUNOFF	3.938	(1.5243)	14294.89	9.576
EVAPOTRANSPIRATION	30.348	(3.3742)	110164.27	73.801
PERCOLATION/LEAKAGE THROUGH LAYER 1	6.76501	(2.89261)	24556.977	16.45107
CHANGE IN WATER STORAGE	0.071	(3.1280)	256.72	0.172

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.245	8148.4463
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.135905	493.33417
SNOW WATER	3.00	10891.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3070	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

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AR301507

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	50.1519	0.2786

SNOW WATER 0.000

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP3\montross.D4
TEMPERATURE DATA FILE:       C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\10MON05.D10
OUTPUT DATA FILE:            C:\HELP3\10MON05.OUT


TIME: 11:33     DATE:  1/19/2001


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     TITLE:  Existing Conditions - 10 feet @ 0.5% Surface Slope

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =    120.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2781 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
     NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
              FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 0.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	89.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.293	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	33.373	INCHES
TOTAL INITIAL WATER	=	33.373	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.139	0.116	0.372	0.103	0.268	0.201
	0.472	0.388	0.529	0.179	0.199	0.321
STD. DEVIATIONS	0.233	0.211	0.605	0.190	0.365	0.243
	0.651	0.382	0.561	0.233	0.309	0.319
EVAPOTRANSPIRATION						
TOTALS	1.235	1.582	3.047	3.171	3.883	3.568
	3.829	3.806	2.695	1.483	1.249	1.017
STD. DEVIATIONS	0.209	0.293	0.263	0.880	0.889	1.750
	1.339	1.213	1.040	0.463	0.294	0.200
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.7912	0.9785	1.0121	1.0669	0.9061	0.6012

	0.4695	0.3441	0.2833	0.2308	0.2236	0.3268
STD. DEVIATIONS	0.8898	0.8922	0.6239	0.6562	0.3232	0.2462
	0.1192	0.1172	0.0779	0.0845	0.1523	0.7143

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.12	(5.848)	149272.9	100.00
RUNOFF	3.285	(1.3854)	11926.34	7.990
EVAPOTRANSPIRATION	30.565	(3.4052)	110952.00	74.328
PERCOLATION/LEAKAGE THROUGH LAYER 1	7.23411	(2.77400)	26259.832	17.59183
CHANGE IN WATER STORAGE	0.037	(2.8452)	134.68	0.090

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.124	7710.7397
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.385996	1401.16675
SNOW WATER	3.00	10891.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3049	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	34.4861	0.2874
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HELP3\montross.D4
TEMPERATURE DATA FILE:        C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\10mon02.D10
OUTPUT DATA FILE:             C:\HELP3\10mon02.OUT


TIME:  10:28      DATE:   1/19/2001


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     TITLE:  Existing Conditions - 10 feet @ 2.5% Surface Slope

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  10
          THICKNESS                  =    120.00   INCHES
          POROSITY                   =      0.3980 VOL/VOL
          FIELD CAPACITY             =      0.2440 VOL/VOL
          WILTING POINT              =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2772 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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AR301514

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	89.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.293	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	33.261	INCHES
TOTAL INITIAL WATER	=	33.261	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.153	0.126	0.397	0.113	0.288	0.220
	0.505	0.417	0.560	0.194	0.215	0.345
STD. DEVIATIONS	0.251	0.216	0.616	0.202	0.384	0.257
	0.678	0.399	0.584	0.246	0.327	0.336
EVAPOTRANSPIRATION						
TOTALS	1.234	1.582	3.043	3.169	3.892	3.551
	3.808	3.791	2.680	1.481	1.246	1.013
STD. DEVIATIONS	0.210	0.294	0.261	0.879	0.888	1.737
	1.331	1.208	1.037	0.463	0.293	0.200
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.7486	0.9646	0.9968	1.0430	0.8924	0.5998

	0.4589	0.3423	0.2811	0.2286	0.2059	0.3016
STD. DEVIATIONS	0.8850	0.9032	0.6205	0.6337	0.3187	0.2520
	0.0980	0.1117	0.0753	0.0796	0.1412	0.6401

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.12 (5.848)	149272.9	100.00
RUNOFF	3.532 (1.4433)	12820.05	8.588
EVAPOTRANSPIRATION	30.488 (3.3762)	110672.23	74.141
PERCOLATION/LEAKAGE THROUGH LAYER 1	7.06350 (2.75174)	25640.490	17.17693
CHANGE IN WATER STORAGE	0.039 (2.8451)	140.11	0.094

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.176	7899.0508
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.277167	1006.11572
SNOW WATER	3.00	10891.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3049	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	34.4185	0.2868

SNOW WATER 0.000

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
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PRECIPITATION DATA FILE:     C:\HELP3\montross.D4
TEMPERATURE DATA FILE:       C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\10mon10.D10
OUTPUT DATA FILE:            C:\HELP3\10mon10.OUT
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TIME: 10:30   DATE: 1/19/2001

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     TITLE:  Existing Conditions - 10 feet @ 10.0% Surface Slope

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

```
                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
          THICKNESS                  =    120.00   INCHES
          POROSITY                   =      0.3980 VOL/VOL
          FIELD CAPACITY             =      0.2440 VOL/VOL
          WILTING POINT              =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2765 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  = 0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 10.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	90.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.294	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	33.180	INCHES
TOTAL INITIAL WATER	=	33.180	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.163	0.133	0.418	0.121	0.303	0.235
	0.533	0.439	0.584	0.207	0.227	0.364
STD. DEVIATIONS	0.264	0.219	0.624	0.212	0.396	0.268
	0.699	0.414	0.600	0.256	0.339	0.351
EVAPOTRANSPIRATION						
TOTALS	1.234	1.582	3.041	3.160	3.894	3.530
	3.800	3.775	2.672	1.480	1.244	1.012
STD. DEVIATIONS	0.210	0.294	0.261	0.877	0.877	1.717
	1.328	1.201	1.036	0.464	0.292	0.198
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.7141	0.9444	0.9945	1.0136	0.8869	0.5948

	0.4578	0.3415	0.2786	0.2227	0.2053	0.2785
STD. DEVIATIONS	0.8656	0.9072	0.6346	0.6118	0.3174	0.2506
	0.0983	0.1078	0.0682	0.0788	0.1311	0.6092

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.12	(5.848)	149272.9	100.00
RUNOFF	3.726	(1.4802)	13525.49	9.061
EVAPOTRANSPIRATION	30.424	(3.3795)	110438.61	73.984
PERCOLATION/LEAKAGE THROUGH LAYER 1	6.93273	(2.71508)	25165.824	16.85894
CHANGE IN WATER STORAGE	0.039	(2.8461)	142.94	0.096

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.214	8036.1309
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.271786	986.58392
SNOW WATER	3.00	10891.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3057	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	34.3612	0.2863

SNOW WATER 0.000

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**        FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                   **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP3\montross.D4
TEMPERATURE DATA FILE:       C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\10mon25.D10
OUTPUT DATA FILE:            C:\HELP3\10mon25.OUT


TIME:  10:31      DATE:   1/19/2001


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     TITLE:  Existing Conditions - 10 feet @ 25.0% Surface Slope

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                    LAYER  1
                                    --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER  10
           THICKNESS                    =     120.00    INCHES
           POROSITY                     =       0.3980 VOL/VOL
           FIELD CAPACITY               =       0.2440 VOL/VOL
           WILTING POINT                =       0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT   =       0.2755 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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AR301524

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	90.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.294	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	33.060	INCHES
TOTAL INITIAL WATER	=	33.060	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.173	0.142	0.441	0.130	0.320	0.251
	0.559	0.465	0.610	0.220	0.240	0.385
STD. DEVIATIONS	0.275	0.223	0.634	0.224	0.411	0.281
	0.719	0.429	0.619	0.266	0.352	0.368
EVAPOTRANSPIRATION						
TOTALS	1.233	1.582	3.042	3.159	3.891	3.505
	3.784	3.758	2.661	1.481	1.242	1.011
STD. DEVIATIONS	0.209	0.294	0.261	0.878	0.875	1.708
	1.323	1.194	1.035	0.465	0.292	0.197
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.6897	0.9156	0.9565	1.0042	0.8888	0.5930

	0.4536	0.3381	0.2758	0.2177	0.1948	0.2662
STD. DEVIATIONS	0.8484	0.8882	0.5927	0.6257	0.3245	0.2503
	0.0936	0.1056	0.0647	0.0800	0.1267	0.5817

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.12	(5.848)	149272.9	100.00
RUNOFF	3.938	(1.5243)	14294.89	9.576
EVAPOTRANSPIRATION	30.348	(3.3742)	110164.27	73.801
PERCOLATION/LEAKAGE THROUGH LAYER 1	6.79395	(2.68785)	24662.051	16.52146
CHANGE IN WATER STORAGE	0.042	(2.8465)	151.64	0.102

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.245	8148.4463
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.260716	946.39819
SNOW WATER	3.00	10891.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3070	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360	

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	34.3135	0.2859
SNOW WATER	0.000	

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APPENDIX D-2

Cap System Alternatives A, B, C & D

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**                                                                          **
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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HELP3\montross.D4
TEMPERATURE DATA FILE:        C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\gclnet.D10
OUTPUT DATA FILE:             C:\HELP3\gclnet.OUT


TIME:  10:33     DATE:   1/19/2001


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     TITLE:  Alternative A - GCL/Drainage Net/24 inches of soil

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =      24.00   INCHES
          POROSITY                     =       0.3980 VOL/VOL
          FIELD CAPACITY               =       0.2440 VOL/VOL
          WILTING POINT                =       0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.3549 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.8500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.00000000000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	500.0	FEET

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	204.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2446	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #10 WITH A

FAIR STAND OF GRASS, A SURFACE SLOPE OF 1.%
AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.722	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	58.764	INCHES
TOTAL INITIAL WATER	=	58.764	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50

82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.512	0.188	0.647	0.086	0.173	0.084
	0.230	0.171	0.287	0.073	0.154	0.539
STD. DEVIATIONS	1.004	0.355	1.109	0.219	0.405	0.141
	0.419	0.227	0.377	0.129	0.345	0.961
EVAPOTRANSPIRATION						
TOTALS	1.246	1.591	3.060	3.169	3.995	4.070
	4.048	3.986	2.746	1.476	1.253	1.032
STD. DEVIATIONS	0.200	0.295	0.271	0.869	0.879	1.756
	1.428	1.303	1.034	0.446	0.285	0.192
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.6555	0.6397	0.7040	0.6789	0.6402	0.4243
	0.1224	0.1131	0.1386	0.2863	0.3902	0.5563
STD. DEVIATIONS	0.1923	0.0559	0.0825	0.0328	0.1521	0.2392
	0.1785	0.2086	0.2315	0.2947	0.2851	0.2233
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.1689	0.1526	0.1808	0.1263	0.0711	0.0241
	0.0077	0.0046	0.0152	0.0258	0.0520	0.1039

STD. DEVIATIONS	0.1012	0.0750	0.0735	0.0609	0.0483	0.0352
	0.0155	0.0084	0.0343	0.0399	0.0637	0.0911

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0629	0.0441	0.0488	0.0490	0.0478	0.0507
	0.1039	0.1361	0.1263	0.1045	0.0818	0.0737
STD. DEVIATIONS	0.0571	0.0410	0.0329	0.0280	0.0304	0.0438
	0.0809	0.0941	0.0993	0.0891	0.0755	0.0616

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	13.1057	13.0093	14.0358	10.0669	5.3656	1.7226
	0.4213	0.2631	1.1298	1.8916	4.0613	7.9797
STD. DEVIATIONS	7.9836	6.5388	5.8099	4.9702	3.8164	2.8754
	1.2003	0.6014	2.7517	3.0956	5.1544	7.1879

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.12 (5.848)	149272.9	100.00
RUNOFF	3.144 (2.3198)	11411.60	7.645
EVAPOTRANSPIRATION	31.672 (3.6188)	114969.97	77.020
LATERAL DRAINAGE COLLECTED FROM LAYER 2	5.34939 (0.86343)	19418.281	13.00858
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.93297 (0.32989)	3386.691	2.26879
AVERAGE HEAD ON TOP OF LAYER 3	6.088 (2.222)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.92983 (0.36230)	3375.283	2.26115
CHANGE IN WATER STORAGE	0.027 (2.0813)	97.74	0.065

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.018	7324.7417
DRAINAGE COLLECTED FROM LAYER 2	0.02499	90.70297
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.009980	36.22732
AVERAGE HEAD ON TOP OF LAYER 3	24.200	
MAXIMUM HEAD ON TOP OF LAYER 3	29.439	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	216.4 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.011611	42.14651
SNOW WATER	3.00	10891.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	9.2314	0.3846
2	0.1700	0.8500

3	0.1875	0.7500
4	49.9830	0.2450
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
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PRECIPITATION DATA FILE:     C:\HELP3\montross.D4
TEMPERATURE DATA FILE:       C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\gclsoil.D10
OUTPUT DATA FILE:            C:\HELP3\gclsoil.OUT


TIME:  10:37     DATE:   1/19/2001


******************************************************************************

     TITLE:  Alternative B - GCL/12" sand/24" soil

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
          THICKNESS                     =      24.00   INCHES
          POROSITY                      =       0.3980 VOL/VOL
          FIELD CAPACITY                =       0.2440 VOL/VOL
          WILTING POINT                 =       0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT    =       0.3265 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 4

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.1050	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4370	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.170000002000E-02	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	500.0	FEET

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	204.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2449	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #10 WITH A

FAIR STAND OF GRASS, A SURFACE SLOPE OF 1.%
AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.040	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	63.224	INCHES
TOTAL INITIAL WATER	=	63.224	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50

82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.784	0.336	1.029	0.139	0.226	0.100
	0.244	0.173	0.288	0.075	0.196	0.770
STD. DEVIATIONS	1.297	0.427	1.387	0.323	0.535	0.169
	0.480	0.232	0.376	0.131	0.510	1.195
EVAPOTRANSPIRATION						
TOTALS	1.241	1.589	3.052	3.164	4.015	4.977
	4.228	4.027	2.728	1.429	1.237	1.024
STD. DEVIATIONS	0.193	0.295	0.265	0.867	0.850	1.418
	1.476	1.326	1.012	0.414	0.256	0.185
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0917	0.0847	0.0949	0.0843	0.0815	0.0734
	0.0727	0.0705	0.0671	0.0697	0.0715	0.0824
STD. DEVIATIONS	0.0145	0.0097	0.0083	0.0053	0.0032	0.0037
	0.0027	0.0024	0.0048	0.0068	0.0102	0.0135
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.3498	0.3285	0.3800	0.3249	0.2925	0.2147
	0.1740	0.1614	0.1608	0.1784	0.2110	0.2791

STD. DEVIATIONS	0.1038	0.0734	0.0542	0.0381	0.0282	0.0392
	0.0316	0.0252	0.0419	0.0561	0.0793	0.1008

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.2195	0.1365	0.1414	0.1361	0.1955	0.2445
	0.3087	0.3488	0.3356	0.3254	0.2934	0.2669
STD. DEVIATIONS	0.0977	0.0695	0.0657	0.0608	0.0839	0.0913
	0.0934	0.0772	0.0619	0.0551	0.0548	0.0614

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	27.3945	28.2566	29.7841	26.2816	22.8681	17.2842
	13.4982	12.5028	12.8843	13.8472	16.9786	21.8051
STD. DEVIATIONS	8.2012	6.3715	4.2799	3.1108	2.2325	3.2052
	2.4944	1.9917	3.4179	4.4348	6.4766	7.9650

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.12 (5.848)	149272.9	100.00
RUNOFF	4.360 (2.9329)	15828.32	10.604
EVAPOTRANSPIRATION	32.711 (3.5433)	118742.56	79.547
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.94458 (0.04487)	3428.835	2.29703
PERCOLATION/LEAKAGE THROUGH LAYER 3	3.05507 (0.34720)	11089.890	7.42927
AVERAGE HEAD ON TOP OF LAYER 3	20.282 (2.350)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	2.95223 (0.54434)	10716.582	7.17919
CHANGE IN WATER STORAGE	0.153 (2.1563)	556.55	0.373

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.143	7778.7461
DRAINAGE COLLECTED FROM LAYER 2	0.00351	12.74444
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.014797	53.71141
AVERAGE HEAD ON TOP OF LAYER 3	36.000	
MAXIMUM HEAD ON TOP OF LAYER 3	42.553	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	252.7 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.015881	57.64806
SNOW WATER	3.00	10891.1436
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1360

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	9.3505	0.3896
2	5.2440	0.4370

3	0.1875	0.7500
4	53.0419	0.2600
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                 **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\montross.D4
TEMPERATURE DATA FILE:       C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\hdpesoil.D10
OUTPUT DATA FILE:            C:\HELP3\hdpesoil.OUT


TIME:  10:48      DATE:   1/19/2001


******************************************************************************

     TITLE:  Alternative C - HDPE/12"of sand/24" soil

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =      24.00   INCHES
          POROSITY                     =       0.3980 VOL/VOL
          FIELD CAPACITY               =       0.2440 VOL/VOL
          WILTING POINT                =       0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.3505 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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AR301544

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 4

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1050 VOL/VOL
WILTING POINT	=	0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4370 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.170000002000E-02 CM/SEC
SLOPE	=	1.00 PERCENT
DRAINAGE LENGTH	=	500.0 FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	204.00 INCHES
POROSITY	=	0.3980 VOL/VOL
FIELD CAPACITY	=	0.2440 VOL/VOL
WILTING POINT	=	0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.615	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	63.430	INCHES
TOTAL INITIAL WATER	=	63.430	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	1.125	0.607	1.306	0.209	0.304	0.122
	0.272	0.174	0.290	0.086	0.314	1.129
STD. DEVIATIONS	1.458	0.666	1.500	0.440	0.638	0.209
	0.603	0.234	0.375	0.148	0.725	1.432
EVAPOTRANSPIRATION						
TOTALS	1.237	1.586	3.049	3.146	3.989	5.544
	4.434	4.077	2.722	1.407	1.222	1.015
STD. DEVIATIONS	0.193	0.295	0.265	0.848	0.879	1.112
	1.512	1.360	0.990	0.364	0.245	0.186
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0967	0.0888	0.0993	0.0884	0.0860	0.0759
	0.0736	0.0728	0.0712	0.0751	0.0778	0.0886
STD. DEVIATIONS	0.0123	0.0083	0.0052	0.0040	0.0029	0.0041
	0.0032	0.0017	0.0038	0.0060	0.0101	0.0120

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0805	0.0748	0.0851	0.0742	0.0702	0.0530
	0.0420	0.0396	0.0398	0.0457	0.0540	0.0691
STD. DEVIATIONS	0.0171	0.0112	0.0060	0.0046	0.0036	0.0079
	0.0069	0.0050	0.0090	0.0126	0.0175	0.0180

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0793	0.0746	0.0854	0.0754	0.0707	0.0531
	0.0418	0.0398	0.0397	0.0456	0.0542	0.0684
STD. DEVIATIONS	0.0161	0.0111	0.0057	0.0056	0.0040	0.0076
	0.0073	0.0048	0.0090	0.0127	0.0175	0.0171

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	30.0918	30.7753	31.9499	28.6094	26.0316	19.8472
	14.6626	13.7136	14.3361	16.1621	20.2440	25.5537
STD. DEVIATIONS	6.8228	4.8919	2.3923	1.8676	1.4157	3.2857
	2.7950	2.0074	3.7441	5.0836	7.2356	7.1776

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.12 (5.848)	149272.9	100.00
RUNOFF	5.938 (3.1928)	21554.61	14.440
EVAPOTRANSPIRATION	33.428 (3.4874)	121345.21	81.291
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.99430 (0.03593)	3609.306	2.41792
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.72808 (0.05858)	2642.942	1.77054
AVERAGE HEAD ON TOP OF LAYER 3	22.665 (2.008)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.72799 (0.05873)	2642.592	1.77031
CHANGE IN WATER STORAGE	0.033 (1.6455)	121.14	0.081

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.193	7960.6152
DRAINAGE COLLECTED FROM LAYER 2	0.00351	12.74444
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.003078	11.17387
AVERAGE HEAD ON TOP OF LAYER 3	36.000	
MAXIMUM HEAD ON TOP OF LAYER 3	42.553	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	252.7 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.003809	13.82776
SNOW WATER	3.00	10891.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3980

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1360

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)

AR301549

1	9.4093	0.3921
2	5.2440	0.4370
3	0.0000	0.0000
4	49.7776	0.2440
SNOW WATER	0.000	

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**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP3\montross.D4
TEMPERATURE DATA FILE:       C:\HELP3\montross.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\montross.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\montross.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\hdpenet.D10
OUTPUT DATA FILE:            C:\HELP3\hdpenet.OUT


TIME:  10:49     DATE:   1/19/2001


******************************************************************************

     TITLE:  Alternative D - HDPE/Drainage Net/24" soil

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =       24.00    INCHES
          POROSITY                     =        0.3980 VOL/VOL
          FIELD CAPACITY               =        0.2440 VOL/VOL
          WILTING POINT                =        0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =        0.3626 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.8500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.00000000000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	500.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	204.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 1.%
AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.907	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	58.648	INCHES
TOTAL INITIAL WATER	=	58.648	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RICHMOND VIRGINIA

STATION LATITUDE	=	38.08	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	91	
END OF GROWING SEASON (JULIAN DATE)	=	306	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.06	2.74	3.85	3.11	4.07	3.40
4.48	3.50	3.46	3.08	2.89	3.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.30	40.60	50.10	60.80	70.20	78.50
82.00	81.60	72.50	62.30	51.40	41.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR NORFOLK VIRGINIA
AND STATION LATITUDE = 38.08 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.76	2.53	4.29	2.67	3.54	3.50
	4.97	4.38	3.75	2.45	2.72	3.58
STD. DEVIATIONS	1.57	1.06	1.55	1.25	1.55	1.84
	2.21	1.80	2.09	1.34	1.51	1.67
RUNOFF						
TOTALS	0.588	0.217	0.764	0.102	0.187	0.087
	0.231	0.171	0.287	0.074	0.162	0.608
STD. DEVIATIONS	1.093	0.382	1.232	0.249	0.449	0.147
	0.423	0.227	0.377	0.129	0.379	1.046
EVAPOTRANSPIRATION						
TOTALS	1.245	1.590	3.059	3.168	3.982	4.231
	4.084	3.990	2.742	1.465	1.248	1.030
STD. DEVIATIONS	0.198	0.295	0.270	0.868	0.880	1.717
	1.432	1.309	1.034	0.440	0.282	0.191
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.6613	0.6441	0.7112	0.6880	0.6715	0.5048
	0.1592	0.1187	0.1423	0.2900	0.4015	0.5644
STD. DEVIATIONS	0.1921	0.0555	0.0758	0.0170	0.1130	0.2135
	0.1982	0.2142	0.2323	0.2951	0.2838	0.2221
PERCOLATION/LEAKAGE THROUGH LAYER 3						

TOTALS	0.0388	0.0363	0.0434	0.0325	0.0212	0.0081
	0.0018	0.0012	0.0036	0.0067	0.0130	0.0248
STD. DEVIATIONS	0.0214	0.0157	0.0148	0.0122	0.0106	0.0090
	0.0045	0.0026	0.0082	0.0101	0.0148	0.0202

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0386	0.0362	0.0433	0.0325	0.0215	0.0088
	0.0019	0.0013	0.0033	0.0067	0.0130	0.0242
STD. DEVIATIONS	0.0217	0.0159	0.0149	0.0123	0.0102	0.0092
	0.0045	0.0028	0.0074	0.0100	0.0145	0.0205

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	13.7456	14.0333	15.3679	11.4263	6.7040	2.4098
	0.5067	0.2953	1.1660	2.0435	4.3807	8.5166
STD. DEVIATIONS	8.0985	6.6239	5.7312	4.8287	3.8240	3.2009
	1.4269	0.6809	2.8361	3.3178	5.3826	7.4726

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.12	(5.848)	149272.9	100.00
RUNOFF	3.480	(2.5640)	12630.74	8.462
EVAPOTRANSPIRATION	31.834	(3.6415)	115557.98	77.414
LATERAL DRAINAGE COLLECTED FROM LAYER 2	5.55705	(0.84126)	20172.076	13.51356
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.23136	(0.07277)	839.825	0.56261
AVERAGE HEAD ON TOP OF LAYER 3	6.716	(2.296)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.23137	(0.07283)	839.873	0.56264
CHANGE IN WATER STORAGE	0.020	(2.0395)	72.17	0.048

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.08	14810.399
RUNOFF	2.059	7473.3203
DRAINAGE COLLECTED FROM LAYER 2	0.02499	90.70297
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.002116	7.67988
AVERAGE HEAD ON TOP OF LAYER 3	24.200	
MAXIMUM HEAD ON TOP OF LAYER 3	29.439	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	216.4 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.003624	13.15462
SNOW WATER	3.00	10891.1436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)

AR301556

1	9.2996	0.3875
2	0.1700	0.8500
3	0.0000	0.0000
4	49.7745	0.2440
SNOW WATER	0.000	

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