0305-12/12/97-00757

DRAFT
CORRECTIVE MEASURES STUDY WORK PLAN
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS

CONTRACT TASK ORDER 0277

DECEMBER 12, 1997

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

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TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS iv

1.0 INTRODUCTION **1-1**
- 1.1 Basis for the Work Plan 1-1
- 1.2 Site Status Summary 1-1
- 1.3 Organization of the CMS Work Plan 1-2

2.0 CMS OBJECTIVES AND GOALS **2-1**
- 2.1 Objectives and Goals 2-1
- 2.2 Corrective Measures Standards 2-1

3.0 ADDITIONAL INVESTIGATIONS **3-1**
- 3.1 Introduction 3-1
- 3.2 Soil Investigation 3-1
- 3.3 Soil Gas Investigation 3-2
- 3.4 Vertical Permeability Testing 3-2
- 3.5 Groundwater Investigation 3-3
- 3.6 In-Situ Hydraulic Conductivity Tests 3-3
- 3.7 Groundwater Elevations 3-3
- 3.8 Baildown Tests 3-4
- 3.9 Underground Utility Location 3-4
- 3.10 Miscellaneous Investigation Considerations 3-4
  - 3.10.1 Surveying 3-5
  - 3.10.2 Laboratory Analysis 3-5
  - 3.10.3 Data Validation 3-5
  - 3.10.4 Investigation Derived Waste (IDW) 3-5
  - 3.10.5 Standard Operating Procedures (SOPs) 3-6
- 3.11 Data Evaluation 3-6

4.0 ELECTROCHEMICAL GEO-OXIDATION DEMONSTRATION **4-1**
- 4.1 Introduction 4-1
  - 4.1.1 Overview of the Demonstration 4-1
  - 4.1.2 Site Background 4-2
  - 4.1.3 Technical Approach - Upper TWFF Soils 4-3
  - 4.1.4 Technical Approach - Lower TWFF Free Product/Soils 4-4
- 4.2 Scope of Work 4-5
  - 4.2.1 Project Management 4-6
  - 4.2.2 Work Plan 4-6
  - 4.2.3 Initial Characterization 4-7
  - 4.2.4 Remedial Progress Sampling - Events 1, 2, and 3 4-8
  - 4.2.5 Final Sampling 4-8
  - 4.2.6 Design of the ECGO Demonstration System 4-9
  - 4.2.7 Installation of the ECGO Demonstration System 4-10
  - 4.2.8 Operation of the ECGO Demonstration System 4-10
  - 4.2.9 Technical Report 4-10

5.0 POTENTIAL CORRECTIVE MEASURES 5-1
5.1 Task I - Identification and Development of the Corrective Measure Alternative or Alternatives 5-1
5.1.1 Description of the Current Situation 5-1
5.1.2 Establishment of Corrective Action Objectives 5-1
5.1.3 Screening of Corrective Measure Technologies 5-1
5.1.4 Identification of the Corrective Measure Alternative or Alternatives 5-2
5.2 Task II - Evaluation of the Corrective Measure Alternative or Alternatives ... 5-2
5.2.1 Technical/Environmental/Human Health/Institutional 5-2
5.2.2 Cost Estimate 5-3
5.3 Task III - Justification and Recommendation of the Corrective Measure or Measures 5-3
5.3.1 Technical 5-4
5.3.2 Human Health 5-4
5.3.3 Environmental 5-5
5.4 Task IV - Reports 5-5
5.4.1 Progress 5-5
5.4.2 Corrective Measure Study (CMS) Final Report 5-5

6.0 SCHEDULE 6-1

7.0 REFERENCES 7-1

LIST OF FIGURES

2-1 Site Plan

3-1 Subsurface Soil, Soil Gas, and Vertical Permeability Testing Sampling Locations
3-2 Groundwater Sampling Locations
3-3 Typical Baildown Test Record Sheet

5-1 Project Schedule

APPENDICES

A ManTech Case Studies

LIST OF ACRONYMS AND ABBREVIATIONS

BTEX	benzene, toluene, ethylbenzene, and xylene
CAP	Corrective Action Plan
CFR	Code of Federal Regulations
CMS	Corrective Measure Study
ICM	Interim Corrective Measure
IDW	Investigation Derived Waste
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
MCLs	maximum contaminant levels
NSRR	Naval Station Roosevelt Roads
PREQB	Puerto Rico Environmental Quality Board
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SOPs	Standard Operating Procedures
SWMU	Solid Waste Management Unit
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSCA	Toxic Substance Control Act
TWFF	Tow Way Fuel Farm
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank

1.0 INTRODUCTION

This work plan presents the technical approach for conducting a Corrective Measures Study (CMS) at the Tow Way Fuel Farm (TWFF) located at Naval Station Roosevelt Roads (NSRR), located in Ceiba, Puerto Rico. This CMS has been prepared under contract to the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), Contract Number N62470-89-4814.

1.1 Basis for the Work Plan

The TWFF has been the subject of intense scrutiny for a number of years. Repeated spills and other releases at the site have resulted in the presence of free product in the subsurface, elevated total petroleum hydrocarbon (TPH) levels in soil, and relatively low levels of benzene, toluene, ethylbenzene, and xylene (BTEX) in the groundwater. Based on these conditions, a CMS for the site is warranted. When completed, the appropriate corrective measure will have been selected and design of the remedial alternative can be started.

1.2 Site Status Summary

The TWFF was originally addressed under the Puerto Rico Environmental Quality Board's (PREQB) Underground Storage Tank (UST) regulations. During this time, the site was subjected to a number of investigations which eventually led to the submittal of a Corrective Action Plan (CAP). Implementation of the CAP recommendations was planned; however, at this point the regulatory status of the site changed and it became subject to the requirements of the Resource Conservation and Recovery Act (RCRA) and was classed under this program as a Solid Waste Management Unit (SWMU).

The RCRA corrective action portion of the facility's permit contained specific requirements for investigation and, potentially, eventual remediation at the site. To accomplish the goals of the permit, a RCRA Facility Investigation (RFI) work plan was submitted and approved by the United States Environmental Protection Agency (USEPA) Region II. This work plan provided the framework for site characterization activities.

The Navy recognized the need for early action at the site to halt the movement of the free product plume. An "emergency response" type program was implemented which immediately started to recover free

product and limit the potential for the product plume to be a source of continuing release. Coincident with this "emergency response", the Navy started the design of an Interim Corrective Measure (ICM) which would address the free product in the subsurface much more aggressively. The ICM was commissioned in April 1997 and is still operational. Quarterly progress reports of the ICM's effectiveness are submitted which include any recommendations for system upgrades. As a result of these most recent recommendations, six new wells were recently installed at the site to enhance the free product recovery system by providing additional potential pumping wells and additional monitoring points outside the plume.

The RFI has been completed at the site. The results of the investigations are provided in a report entitled "Revised Draft, RCRA Facility Investigation Report, Operable Unit 2 (SWMU 7/8), Naval Station Roosevelt Roads, Ceiba, Puerto Rico" (Baker, June 1997a). The report received contingent approval in a September 9, 1997 letter from the USEPA. Its approval was contingent on addressing certain USEPA comments in the CMS which was recommended by the Navy in the report. The approval also was given that certain additional site characterization activities would be conducted prior to the start of the formal CMS process since the information was needed to adequately screen technologies that may be applicable as remedial alternatives for site clean-up. A work plan for these investigations is provided in a Section 3.0 of this overall CMS work plan.

1.3 Organization of the CMS Work Plan

This CMS Work Plan is organized into five sections. The first section, the Introduction, is designed to introduce the reader to the basis for the work plan and a summary of the site status. Section 2.0 provides the objectives, goals, and the corrective measure standards being utilized for this project. The additional investigations to be performed are discussed in Section 3.0. The work associated with the ElectroChemical GeoOxidation Demonstration is detailed in Section 4.0. The tasks to be accomplished as part of the Corrective Measure Study are described in Section 5.0. The project schedule is provided in Section 6.0. Section 7.0 provides the references cited in this report.

2.0 CMS OBJECTIVES AND GOALS

2.1 Objectives and Goals

The objective of this CMS Work Plan is to identify those tasks required to obtain additional data to assist in screening applicable remedial technologies for the Tow Way Fuel Farm at Naval Station Roosevelt Roads. Figure 2-1 shows the area to be investigated under this Work Plan. This Work Plan also documents the scope and objectives of the full CMS, and the activities required to implement the program. The Work Plan serves as a tool for assigning responsibilities and establishing the project schedule and costs.

There are three goals established for this CMS. The first goal is to remove the free product from beneath the Tow Way Fuel Farm. The other two goals are to remediate contaminated soils and groundwater at the site so that they are protective of human health and the environment.

2.2 Corrective Measures Standards

Corrective measure standards which may be applicable to the Tow Way Fuel Farm will be developed following this field effort as part of the CMS "Task I" reporting effort. Once the possible corrective measures are selected for applicability to this site the appropriate standards will be developed.

The corrective measure standards will include the applicable Federal maximum contaminant levels (MCLs) established under the Safe Drinking Water Act and Toxic Substance Control Act (TSCA) regulations and the PREQB standards. The Code of Federal Regulations (40 CFR 264.100) will also be reviewed for applicability to the site.

3.0 ADDITIONAL INVESTIGATIONS

3.1 Introduction

Previous work at the site, both investigatory and free product recovery, has indicated the apparent applicability of a number of remedial technologies. While this is the case, newer technologies have come to light, potential synergies exist between various technologies and the age of the soil TPH and groundwater BTEX information all indicate the need for additional characterization of the site. The requirements for additional work have been carefully selected so as to provide sufficient information for a thorough formal screening of remedial alternatives and the eventual selection of one or more to be implemented.

This section (Section 3.0) provides details of the proposed additional investigations for the TWFF. Included in the discussion are details of the proposed investigatory scope, a detailed rationale which explains each element of the scope and a description of the intended data use.

In addition, a number of general considerations related to the overall investigation are discussed in this section.

3.2 Soil Investigation

Subsurface soil sampling will be conducted at the TWFF to provide updated information regarding the extent and concentration of TPH in the subsurface soils and obtain additional data to assist in the screening of possible corrective measure alternatives for the TWFF. A total of 32 direct push soil borings are proposed. The locations are shown on Figure 4-1.

All subsurface soils will be collected utilizing direct push technology. Subsurface soil samples will be collected on five foot centers until groundwater is encountered or tool refusal. The soil samples will be analyzed for TPH diesel and gasoline range organics using SW-846 modified Method 8015, BTEX, particle size, total organic carbon (TOC) and moisture content. Ten TOC samples will be collected from borings estimated to be outside of the contaminant zone. Only one TOC sample will be collected from each boring just above the soil groundwater interface. In addition, some of the samples will be combined to provide a sufficient sample volume for the performance of bulk density testing.

The soil sample locations and analytical parameters have been carefully selected to address specific needs. TPH values are needed because the existing data is quite old and mat not reflect present site conditions. In addition, knowing TPH levels will assist in delineating areas requiring remediation. BTEX concentrations are needed to assess certain remedial alternatives (e.g. air sparging) that may applicable to site use. The present BTEX data is also old and new data will more nearly approximate present site conditions. TOC is required to assess natural attenuation as an alternative. The TOC levels are used to assess contaminant flow rates. The geotechnical parameters of grain size, moisture content, and bulk density will be used to estimate site permeability and to assess possible removal actions.

3.3 Soil Gas Investigation

Soil gas sampling will be conducted at the TWFF to provide additional data necessary for the screening of possible corrective measures to be evaluated for the TWFF (i.e., in-situ biotreatment, bioventing, bioslurping, etc.). A total of 10 soil gas sampling locations are proposed. The locations are presented on Figure 4-1.

All soil gas samples will be collected from the vadose zone utilizing direct push technology. Soil gas samples will be collected and analyzed for percent oxygen, percent carbon dioxide, and TPH.

3.4 Vertical Permeability Testing

Vertical Permeability testing will be conducted to measure the infiltration rate of water through in-place soils at the TWFF. This data is necessary to evaluate the soil washing/flushing technology including potential reinfiltration of recovered groundwater. A total of three vertical permeability testing locations are proposed as shown on Figure 4-1.

A cylinder open at both ends will be placed into a trench approximately six inches deep and grouted into place with a powdered bentonite grout. After the grout has set, a known volume of water will be poured inside the cylinder. A Hermit® pressure transducer will be used to monitor the infiltration of the water into the soil. The top of the cylinder will be covered to prevent rain infiltration into the cylinder and/or evaporation. The tests will be performed for a minimum of 24 hours and a maximum of 36 hours. Additional water of a known volume will be added to the system as required by the site conditions.

The data will be plotted as volume over time. This will provide an approximation of the vertical permeability of surficial soils at each location.

3.5 Groundwater Investigation

Groundwater sampling will be conducted to provide updated information regarding the extent and concentration of BTEX constituents in the groundwater at the TWFF. Additional analyses will be performed on the groundwater to assist in the screening of possible corrective measure alternatives for the TWFF. This will be accomplished by collecting groundwater samples from 36 monitoring wells throughout the TWFF as shown on Figure 3-2. All of the groundwater samples will be submitted for laboratory analysis of BTEX using the SW-846 Method 8240 including the trimethylbenzene isomers, TPH diesel and gasoline range organics using the SW-846 modified Method 8015, iron II, methane, nitrate, sulfate, alkalinity, and chloride. Temperature, pH, specific conductance, oxidation/reduction (redox) potential, and dissolved oxygen will be measured in the field during sampling.

3.6 In-Situ Hydraulic Conductivity Tests

In-situ hydraulic conductivity tests will be conducted to provide additional information to assist in the screening of possible corrective measures. This will be accomplished by performing slug tests on six monitoring wells (UGW-24, 7MW04, 7MW03, 7MW02, 7MW01A, and UGW-11) throughout the TWFF as shown on Figure 3-2.

3.7 Groundwater Elevations

A single set of groundwater elevations will be obtained from the 36 wells which were sampled for groundwater at the TWFF utilizing an oil/water interface probe. This will provide a time equivalent picture of groundwater occurrence in the subsurface which will be utilized to help understand groundwater flow direction and rate. In addition, free product measurements will be obtained if free product is detected in the monitoring wells.

3.8 Baildown Tests

Two baildown tests will be performed on two monitoring wells containing free product at the TWFF to determine the rate of free product recovery. This data will assist in the screening of possible corrective measure alternatives for the TWFF. After the groundwater elevation task is completed two monitoring wells containing free product will be selected for this test. The monitoring wells selected will be representative of the free product plume and the TWFF site.

A clean, bottom filling, bailer will be lowered into each well to collect any floating free product. The free product will be removed from the well and poured into a calibrated cylinder to determine its volume. Efforts will be made to minimize the volume of water removed from the well, and bailing will cease when the measurable thickness in the well cannot be further significantly reduced (confirmed with the oil/water interface probe).

Baildown tests will be monitored periodically using the oil/water interface probe to determine the rate of free product recovery. Measurements will be taken every hour for two hours, then every two to four hours for a maximum of 24 hours. The time between measurements can be more frequent if free product recovery is rapid or less frequent if recovery is very slow. Data will be recorded on a baildown test record sheet as shown on Figure 3-3.

3.9 Underground Utility Location

A file search will be performed at LANTDIV and NSRR offices to obtain as-built drawings of all underground utilities associated with the TWFF. These as built drawings will be utilized to verify underground utilities at the TWFF site. Where possible, the drawings will be field checked by "ground truthing" the locations using electromagnetic utility tracers.

3.10 Miscellaneous Investigation Considerations

This section contains some miscellaneous investigations and related work that are required for the work proposed in the previous sections.

3.10.1 Surveying

All sampling locations will be flagged in the field and will be surveyed using established control. This surveying will be performed by the firm which did the previous work to ensure that the same level of survey quality and detail is attained.

3.10.2 Laboratory Analysis

All laboratory analyses will be performed in accordance with the methodologies contained in the approved Final RCRA Facility Investigation, Naval Station Roosevelt Roads, Puerto Rico (Baker, September, 1995) Work Plans.

3.10.3 Data Validation

All laboratory data generated by these investigations will be subjected to independent, third party, validation. The EPA Region II Data Validation SOPs approved in the Final RFI Workplans will be followed. The same firm which has performed data validation for the previous RFI steps will continue. This will ensure that the same techniques are followed and that an equivalent review of the data is performed.

3.10.4 Investigation Derived Waste (IDW)

The IDW generated during the investigation will be handled in accordance with the SOPs. Waste generated by direct push work produces little cuttings. Any cuttings which remain after this work will be mixed with powdered bentonite and returned to the hole from which they came. As much as possible, soils last out of the hole will be placed first thereby approximating original stratigraphy.

Development/sampling derived waters will be transferred to the ICM storage tank since the source of the water will be the same as that in the tank. It will be disposed along with the material collected from the free product recovery system.

3.10.5 Standard Operating Procedures (SOPs)

All the SOPs required to complete the investigations described herein are provided in the Final RFI Work Plans (Baker, September, 1995) and Addendum 2 to the Final RFI Work Plans (Baker, June, 1997b). The only exceptions to this are the vertical permeability testing and baildown tests which are described in detail in the text of this CMS work plan.

3.11 Data Evaluation

The data obtained from this investigation will be managed in the same manner as it was for the RFI report. Results will be provided as a stand alone report of investigation findings and will be produced during the conduct of the CMS. This information is necessary to adequately contemplate the various remedial possibilities.

4.0 ELECTROCHEMICAL GEO-OXIDATION DEMONSTRATION

4.1 Introduction

Two demonstration projects are planned utilizing ElectroChemical GeoOxidation (ECGO) at two separate locations within the TWFF. The first area will be in the upper TWFF which will treat contaminated subsurface soils and the second will be in the lower TWFF which will treat contaminated subsurface soil, free product, and groundwater. ManTech Environmental Corporation (ManTech) will conduct all the work associated with these demonstrations as a subcontractor to Baker.

ECGO is proposed for remediation of subsurface soil contaminated with semi-volatile organics and total petroleum hydrocarbons (TPH) in the upper TWFF. ECGO is also proposed to address free product and contaminated soil in a demonstration treatment area within the lower TWFF north of Forestal Drive.

ManTech is licensed to implement the ECGO remediation technology at U.S. commercial, industrial, and governmental sites. ECGO is an in situ process that applies electrical current to electrodes driven into the ground to rapidly address a wide range of both organic and inorganic compounds, including free product, detected in soil and groundwater. Case studies of this technology are provided in Appendix A.

4.1.1 Overview of the Demonstration

This project is designed to demonstrate the effectiveness of the ECGO technology in reducing contaminant levels in site soil to meet cleanup goals and to demonstrate the effectiveness of the ECGO technology in reducing free product levels. The demonstration study duration has been estimated at 180 days; a longer treatment time may be required once cleanup goals have been identified.

An ECGO demonstration system will be installed and operated in the Upper Tank Farm Area, near Tank 83, to demonstrate that concentrations of semivolatile organic contaminants can be effectively reduced. A second ECGO system will be installed and operated in the vicinity of RW-2 to demonstrate its effectiveness in reducing free product levels. Results from operation of these technology demonstrations will be used to estimate the full-scale remediation costs to address impacted soils and groundwater at the Tow Way Fuel Farm.

4.1.2 Site Background

Petroleum products such as jet fuel and diesel fuels were released at the site over a period of 30 years from piping and tank leaks, overfills, and past disposal practices. Previous site investigations indicate that several petroleum product constituent compounds have been detected in soil and groundwater. Free product has also been identified at the site and a product recovery system has been operated since 1994, recovering approximately 5% of the estimated 240,000 gallons of free product that have been released. Previous studies have been conducted to define the extent of groundwater and soil contamination, to locate sludge burial pits, to characterize the site lithology and the underlying aquifer, and to identify risk-based contaminant concentrations for chemicals of concern. Although chemicals of concern and their respective risk based cleanup goals have been proposed in the RFI, the final list of chemicals and cleanup goals has not been finalized.

Surface and subsurface soil in and around tanks 83, 84, and 1080 have been impacted by semi-volatile organic compounds and a limited number of inorganics. While there are other areas of the site where impacted soil has been identified, it was reported that this area may serve as a source area for continuing impacts to groundwater. Chemicals of concern detected in surface soils include benzo[a]anthracene, benzo[b]fluoranthene, benzo[a]pyrene, arsenic, berylium, chromium, and vanadium. In addition to high TPH concentrations, chemicals of concern identified in subsurface soils include 2-methyl naphthalene, phenanthrene, benzo[a]anthracene, benzo[b]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, arsenic, and chromium. Soil sample data are generally limited to a depth of 25 feet bgs, with most of the samples having been collected from less than 16 feet bgs.

Lithology in this area of the site contains a five to eight feet thick surface layer of topsoil consisting of medium sand with some silt. Beneath this layer, an approximately 55 feet thick layer of fine to medium sand and silt extends to the groundwater table. This layer contains increasing amounts of fine to coarse sand with depth as weathered rock is approached.

High TPH and semi-volatile organics concentrations have been detected in groundwater in the Upper Tank Farm Area to the Lower Tank Farm Area. High BTEX concentrations have also been detected in the groundwater around Forestal Drive. Several feet of free product have been identified around the sloped area between the upper and lower tank farms and on the north side of Forestal Drive. Prior efforts to recover free product have not been as successful as desired, based on measurements of the free product

plume size and the amount of product recovered over the past three years. This is due in part to the low permeability soils underlying the site and the difficulty in accessing the product plume (i.e., building and other obstructions).

4.1.3 Technical Approach - Upper TWFF Soils

A pilot demonstration using the ECGO technology will be conducted to determine its effectiveness to remediate subsurface soils in the area between Tanks 83, 84, and 1080 (see Figure 2-1). The technical approach consists of applying ECGO within a defined study area for a treatment period of 180 days to address the organic contaminants (semi-volatile organics and TPHs). The success of the demonstration study will be determined by sampling and analysis of soil from designated soil boring locations within the treatment area.

Based on the soil sampling data presented in the RFI, soil contaminated with TPH and semivolatile compounds is present in the proposed demonstration area to a depth of 16 to 25 feet bgs; however, little information is available that fully defines the vertical extent of contamination in soils to the groundwater table at a depth of approximately 60 feet bgs. Based on a review of the soil boring logs and input from potential sheet pile subcontractors, the subsurface soils are very dense and would prohibit use of standard sheet pile beyond 30 feet bgs. As a result, installing ECGO electrodes deeper than 30 feet bgs would require use of "H piles" and a heavier impact hammer, both of which are more costly. One soil boring will be installed within the proposed test area to approximately 60 feet below grade and four soil borings to approximately 30 feet below grade to verify the vertical extent of organic contamination. Soil samples will be collected continuously from each boring to provide a clear delineation of TPH contamination with depth in the demonstration area. This baseline of data will also serve as a basis of comparison in evaluating the efficency of the ECGO technology. If it is determined based on the results of this additional characterization that significant contamination is not present beyond 30 feet bgs, a standard piling application will be designed and installed.

A Work Plan based on a detailed review of the existing site characterization data and baseline data that will be collected at five locations within the treatment area will be developed. All existing information, such as the ground penetrating radar study, will be utilized to assist in developing the Work Plan. While the Work Plan and system design must be completed to specify the exact number and depth of electrodes, the following assumptions regarding the voltage and current requirements, and the number of power

plants needed have been made:

- The soil remediation ECGO demonstration study for treatment of semi-volatiles and TPHs will consist of approximately 16 electrodes (standard sheet piles) extending to approximately 30 feet bgs connected to one aboveground ECGO power plant that will be operated for a period of 180 days;

- Prior to design and installation of the ECGO system, a Work Plan will be submitted for review and approval by LANTDIV, EPA Region II, and PREQB;

- Five soil sampling/monitoring locations within the treatment area will be identified to collect soil samples within the treatment area prior to Work Plan development. These sampling locations will be sampled initially for baseline data and to finalize the ECGO system design. These same locations will be sampled periodically throughout the demonstration project to track remediation progress.

The detailed engineering design and construction of the ECGO system will be completed by ManTech with assistance from P+P Geotechnologies, a subcontractor to ManTech. Monitoring and operation of the ECGO system will be conducted by a electrical subcontractor retained by ManTech. The engineering design prepared by ManTech and P+P will specify the operation parameters and system layout.

4.1.4 Technical Approach - Lower TWFF Free Product/Soils

The second demonstration area will be in the vicinity of recovery well RW-2, north of Forestall Road, to address free product and contaminated soils (see Figure 2-1). As the electrodes (sheet piles) will extend some distance into the groundwater, any dissolved phase constituents will also be locally removed. The RW-2 location was selected since it is on the up gradient side of the inferred free product plume and the area is generally accessible. The actual location of the test area will be selected based on results of the initial soil borings and piezometer free product level measurements. As in the upper TWFF, an initial set of data will be collected, a work plan with an ECGO system design will be prepared and submitted for review, and the system will be installed and operated while collecting data periodically to monitor it's progress.

Initial data will include soil borings with split spoon sampling to the water table and installing five piezometers to monitor free product levels. The split spoon sampling results will be used as a baseline for comparison and the same general locations will be sampled repeatedly during the project to track TPH concentrations. The piezometers will be ideally positioned to obtain a very low or non-detectable free product thickness in an up gradient position; two lateral and one central piezometer to measure product thickness within the test area; and one piezometer located down gradient to track product level trends on the plume side of the treatment area. Frequent groundwater and free product measurements will be needed to support the assumption that free product will not recharge significantly against the southerly groundwater gradient into the treatment area. Recharge of free product would mask successful free product degradation by the ECGO system and is a significant consideration since the testing is being conducted without hydraulic containment of the free product test area. While this is the case, even with recharge of product (if found to be present) the up and downgradient piezometers should indicate treatment success. Another option may be to analyze samples of product up and downgradient to asceertain the extent to which the product is being degraded by the treatment technologies. Since free product may preferentially accumulate in the more permeable piezometers, free product will be bailed from the piezometers and allowed to recharge prior to measuring free product levels. The demonstration study relies on there being no up gradient source of free product and depends on the natural aquifer gradient to be steep enough to prevent down gradient free product from recharging back into the treatment area.

The field demonstration will be conducted in accordance with the Work Plan which will describe the ECGO installation and the monitoring data requirements. Data to be recorded includes: free product levels in the test area and nearby wells before, during, and after the testing; carbon dioxide levels in the piezometer air spaces; and, soil boring sample TPH analysis data. Data collected from the field demonstration will be used to prepare a conceptual full-scale design and engineering estimate for free product remediation at the Tow Way Fuel Farm.

4.2 Scope of Work

This section provides the scope of work necessary to implement the ECGO technology demonstration at the Tow Way Fuel Farm Site in accordance with LANTDIV requirements. Each technical element within the scope of work is discussed below.

4.2.1 Project Management

ManTech will provide all project management functions necessary to manage, coordinate, and direct the technical aspects of the scope of work. Mr. Ronald Adams, P.E. will serve as the Program Manager for implementation of the demonstration study at the TWFF. In this role, Mr. Adams will direct staff and provide budget and schedule information as necessary and prepare periodic status reports to Baker. Mr. Robert Briggs, P.E., will serve as Technical Manager for ManTech responsible for directing, coordinating, and managing all technical elements of the scope of work. Three site visits have been scheduled for Mr. Adams and Mr. Briggs, one for initial project startup and two for site progress evaluations and meetings as necessary.

4.2.2 Work Plan

A draft and final Work Plan will be prepared detailing specific elements of the planning, site investigation, design, installation, operation, and sampling and analyses associated with the demonstration project. The Work Plan will be based on the initial characterization results and will include specific soil boring locations, sampling depths, and analytical methods to be used to monitor remedial progress at both treatment areas. The Work Plan will also specify monitoring wells where free product may be measured, and will detail the methods used to collect data during demonstration.

4.2.2.1 Sampling and Analysis Plan

The RFI Project Plans will be utilized were appropriate. Any sampling or analysis procedures not discussed in the RFI Project Plans will be included in the Work Plan.

4.2.2.2 Site Health and Safety Plan

The Site Health and Safety Plan used for the RFI work will be utilized except for modifications regarding the hazards involved in installation and operation of the demonstration systems and power plants, and for field activities including electrode installation and ECGO system operation. These modifications will be included in the Work Plan.

4.2.2.3 Waste Management Plan

The Site Waste Management Plan from the RFI Project Plans will be adhered to where appropriate to containerize and label any residual wastes generated during site characterization and technology demonstration activities. All generated waste will be containerized and labeled at the point of generation and relocated as necessary for storage prior to characterization and disposal.

4.2.3 Initial Characterization

An initial site visit will be conducted to evaluate the proposed study areas, to determine locations of existing utilities, to install soil borings within the ECGO treatment area, and to collect free product levels and gauge free product and water levels in the lower TWFF study area. Soil borings will be advanced in five designated areas within the two treatment areas to collect baseline soil data for system design. The soil borings will be generally located in the four quadrants of the test areas with one boring in the middle of each area. Final locations will be selected in the field based on previous study boring locations and existing utilities.

In the upper TWFF, the center position soil boring will be installed to approximately 60 feet below grade with continuous split spoon sampling for a total of 30 soil samples. The remaining four soil borings will be installed to approximately 30 feet below grade with continuous split spoon sampling for a total of 15 soil samples per boring. All five borings will yield 90 soil samples. Assuming 10% QA samples required, a total of 99 soil samples will be analyzed for TPH-diesel by USEPA Method 8015M.

Seven day laboratory turn-around has been included in this task since results of these samples will be used to determine the optimum electrode placement and depth within the treatment area. These data will be required quickly in order to rapidly prepare a work plan that will meet the schedule. No data validation will be performed and the data with any qualifiers will be tabulated for submittal with the Work Plan.

Assuming 10% QA samples required, a total of 55 soil samples will be analyzed for TPH-diesel by USEPA Method 8015M. These borings will be continued to a total depth of approximately 30 feet below grade and piezometers will be installed. Piezometers will be screened to intercept the free product and groundwater table. ManTech will bail free product from the piezometers and allow product to

recharge prior to measuring free product levels. Collected free product will be transferred to the ICM free product recovery system. No data validation will be performed and the data with any qualifiers will be tabulated for submittal with the Work Plan. Results of these samples and piezometer free product levels will be used to determine the optimum electrode placement and depth within the treatment area.

4.2.4 Remedial Progress Sampling - Events 1, 2, and 3

The progress of the demonstration project will be tracked by collecting soil samples from the five designated boring locations within each demonstration area. The progress sampling will be executed three times over the course of the demonstration. The scope of work description that follows will apply to each of the three sampling events. No data validation will be performed and the data with any qualifiers will be tabulated for submittal.

In the upper TWFF, the five soil borings will be advanced to approximately 30 feet bgs with samples collected at three intervals (to be specified in the work plan) for a total of 15 soil samples. Including two QA samples, the total of 17 soil samples will be analyzed for the presence of TPH diesel by USEPA Method 8015M.

In the lower TWFF demonstration area, the five soil borings will be advanced to approximately 20 feet bgs with samples collected at three intervals (to be specified in the work plan) for a total of 15 soil samples. Including two QA samples, the total of 17 soil samples will be analyzed for the presence of TPH diesel by USEPA Method 8015M. After bailing free product and allowing for recharge, the free product levels and depth to groundwater levels will be gauged in the test area piezometers to track free product reduction. The five piezometers will be gauged when conducting routine monitoring measurements at the site. Carbon dioxide concentrations will also be measured in the five piezometers to confirm oxidation of free product.

4.2.5 Final Sampling

At the conclusion of the demonstration test, a final round of soil samples will be collected from the five designated locations within each demonstration area. At the upper TWFF, all five borings will be advanced to approximately 30 feet below grade with continuous split spoon sampling. The 83 soil samples (75 field samples and 8 QA samples) will be analyzed by USEPA Method 8015M for TPH diesel.

At the lower TWFF location, free product will be bailed and allowed to recharge prior to measuring free product levels. Carbon dioxide levels will also be measured and soil samples collected. The five soil borings will be advanced to approximately 20 feet below grade with continuous split spoon sampling for a total of 50 soil samples. Assuming 10% QA samples, the 55 soil samples will be analyzed for TPH diesel by USEPA Method 8015M. No data validation will be performed on the final sampling data and the data with any qualifiers will be tabulated.

4.2.6 Design of the ECGO Demonstration System

ManTech and its subcontractor, P+P Geotechnologies, will prepare the detailed design of the ECGO Demonstration System for the Tow Way Fuel Farm site. The design documentation that will be provided includes:

- A scaled map identifying the locations of the electrodes to be installed;
- A map showing the diagram for the electrical leads between the electrodes and the power plants;
- A specification for completion of trenching, conductor installation, trench backfill, and surface repair; and
- A specification for procurement of electrodes and installation of electrodes.
    - It is anticipated that the upper tank farm area treatment system will include 16 electrodes (standard piles) installed to a maximum depth of 30 feet below grade. It is anticipated that one power plant will be used for this area.
    - It is anticipated that the lower TWFF will utilize 12 electrodes and one power plant. Electrodes will be standard piles driven to approximately 30 feet below grade.

4.2.7 Installation of the ECGO Demonstration System

A total of 16 electrodes will be installed in the upper TWFF and 12 electrodes will be installed in the lower TWFF (using standard sheet piles) to a maximum depth of 30 feet below grade. Conductors will be installed above and below grade and will be connected to the electrodes and the power plant. Two mobile ECGO power plants will be utilized for the operational period of 180 days for the ECGO demonstration. The power supply and drops consisting of a 100 amp, 480 Volt, 3-phase supplies will be provided by Naval Station Roosevelt Roads. A potable water source will also be made available near the treatment areas by the Navy for site hydration, as required.

4.2.8 Operation of the ECGO Demonstration System

Daily (weekdays) site visits will be conducted at the TWFF for the first thirty days of operation followed by three times per week for the remaining 180 days of operation. The site visits will include recording of voltage and current readings from each channel within each power plant and making adjustments as necessary. In addition, all exposed components of the ECGO system will be inspected and an observation of any changes to the treatment area or electrical equipment will be made. Two troubleshooting O&M visits over the course of 180 day treatment period are provided for in the schedule if required.

Upon completion of the 180-days of operation of the first phase of treatment, the conductors will be disconnected from the power plants and electrodes and the power plants will be demobilized from Naval Station Roosevelt Roads. All conductor material that was placed below grade will remain in place while conductors that are above ground will be removed.

4.2.9 Technical Report

A draft and final technical report will be prepared and submitted to LANTDIV. The report will document all field work that was performed during the demonstration project including field equipment specifications and operating information for equipment used at the site. Analytical results from the field sampling program will be presented along with conclusions concerning the effectiveness of the ECGO technology in reducing soil contaminant concentrations and free product levels. Recommendations with conceptual designs and engineering estimates for the full-scale implementation of ECGO for remediation over other areas of the Tow Way Fuel Farm will also be provided in the report.

5.0 POTENTIAL CORRECTIVE MEASURES

Following completion of the additional investigations, work will be started on the formal CMS. This section of the CMS work plan describes the stepwise approach to be taken in performing the CMS. The CMS consists of four tasks which are described in the following sections.

5.1 Task I - Identification and Development of the Corrective Measure Alternative or Alternatives

This task will identify, screen, and develop the alternative or alternatives for removal, containment, treatment and/or other remediation of the contamination based on the objectives established for the corrective action. This will be based on the results of the previous investigations at the TWFF along with the additional investigations described within this document.

5.1.1 Description of the Current Situation

The current situation and the known nature and extent of contamination of the TWFF will be described in this section along with an update of the interim corrective measures already in place at the TWFF. A statement of the purpose for the response, based on the results of the previous investigations will be provided as will the actual or potential exposure pathways that will be addressed by the corrective measures.

5.1.2 Establishment of Corrective Action Objectives

Site specific objectives for the corrective action will be established in conjunction with the EPA. These objectives will be based be based on public health and environmental criteria, information obtained from previous investigations, EPA guidance, and any applicable federal or Commonwealth of Puerto Rico statutes. The corrective actions will be consistent with 40 CFR §264.100 as applicable.

5.1.3 Screening of Corrective Measure Technologies

The preliminary corrective measure technologies screened in the Pre-Investigative Measures Screening Report (Baker, 1994), and any additional technologies which are applicable at the facility, will be

reviewed based on all the available data and information of the TWFF. This screening process focuses on eliminating those technologies which have severe limitations for a given set of waste and site-specific conditions or due to inherent technology limitations. The screening of the technologies will look in detail at the site and waste characteristics as well as the technology limitations.

5.1.4 Identification of the Corrective Measure Alternative or Alternatives

The corrective measure alternative or alternatives will be developed based on the corrective action objectives and analysis of the corrective measure technologies. Those alternative which appear most suitable for the site based on sound engineering shall be retained. Technologies can be combined to form the overall corrective action alternative or alternatives. The reasons for excluding any technology shall be documented.

5.2 Task II - Evaluation of the Corrective Measure Alternative or Alternatives

Each corrective measure technology and its components which passed through the initial screening in Task I shall be described and evaluated. This evaluation shall be based on technical, environmental, human health, and institutional concerns. Cost estimates for each corrective measure will also be developed.

5.2.1 Technical/Environmental/Human Health/Institutional

A description of each corrective measure alternative which includes but is not limited to preliminary process flow sheets, preliminary sizing and type of construction for buildings and structures, and rough quantities of utilities required will be provided. Each alternative will be evaluated in the following four areas:

5.2.1.1 Technical

Each corrective measure alternative will be evaluated based on performance, reliability, implementability, and safety.

5.2.1.2 Environmental

An environmental assessment will be performed for each alternative which will focus on the facility conditions and pathways of contamination actually addressed by each alternative. The environmental assessment for each alternative will include, at a minimum, an evaluation of: the short and long term beneficial and adverse effects of the response alternative; any adverse effects on environmentally sensitive areas; and an analysis of measures to mitigate adverse effects.

5.2.1.3 Human Health

Each alternative will be assessed in terms of the extent to which it mitigates short and long term potential exposure to any residual contamination and protects human health both during and after implementation of the corrective measure. The assessment will describe the levels and characterizations of contaminants on-site, potential exposure routes, and potentially affected populations. Each alternative will be evaluated to determine the level of exposure to contaminants and the reduction over time. For management of mitigation measures, the relative reduction of impact will be determined by comparing residual levels of each alternative with existing criteria, standards, or guidelines acceptable to the EPA.

5.2.1.4 Institutional

The relevant institutional needs for each alternative will be assessed. Specifically the effects of Federal, State, and local environmental and public health standards, regulations, guidance, advisories, ordinances, or community relations on the design, operation, and timing of each alternative.

5.2.2 Cost Estimate

A cost estimate of each corrective measure alternative will be developed. The cost estimate will include both capital and operation and maintenance costs.

5.3 Task III - Justification and Recommendation of the Corrective Measure or Measures

The corrective measure alternative will be recommended and justified using technical, human health, and environmental criteria. Tradeoffs among health risks, environmental effects, and other pertinent factors

will be highlighted. The EPA will select the corrective measure alternative or alternatives to be implemented based on the results of Task II and III. At a minimum the criteria in the following sections will be used to justify the final corrective measure or measures.

5.3.1 Technical

5.3.1.1 Performance

Corrective measure or measures which are most effective at performing their intended functions and maintaining the performance over extended periods of time will be given preference.

5.3.1.2 Reliability

Corrective measure or measures which do not require frequent or complex operation and maintenance activities and that have proven effective under waste and facility conditions similar to those anticipated will be given preference.

5.3.1.3 Implementability

Corrective measure or measures which can be constructed and operated to reduce levels of contamination to attain or exceed applicable standards in the shortest period of time will be preferred.

5.3.1.4 Safety

Corrective measure or measures which pose the least threat to the safety of nearby residents and environments as well as workers during implementation will be preferred.

5.3.2 Human Health

The corrective measure or measures will comply with existing EPA criteria, standards, or guidelines for the protection of human health. Corrective measures which provide the minimum level of exposure to contaminants and the maximum reduction in exposure with time are preferred.

5.3.3 Environmental

The corrective measure or measures posing the least adverse impact (or greatest improvement) over the shortest period of time on the environment will be favored.

5.4 Task IV - Reports

5.4.1 Progress

The EPA will be provided with signed progress reports as required by Condition B.8.(a) of Module III of the Permit.

5.4.2 Corrective Measure Study (CMS) Final Report

A CMS Final Report will be developed which includes all the information gathered under the approved CMS Work Plan. At a minimum the report will include a description of the facility, a summary of the corrective measure or measures, a summary of the previous investigations impact on the selected corrective measure or measures, design and implementation precautions, and cost estimates and schedules.

6.0 SCHEDULE

The project schedule is presented in Figure 6-1.

7.0 REFERENCES

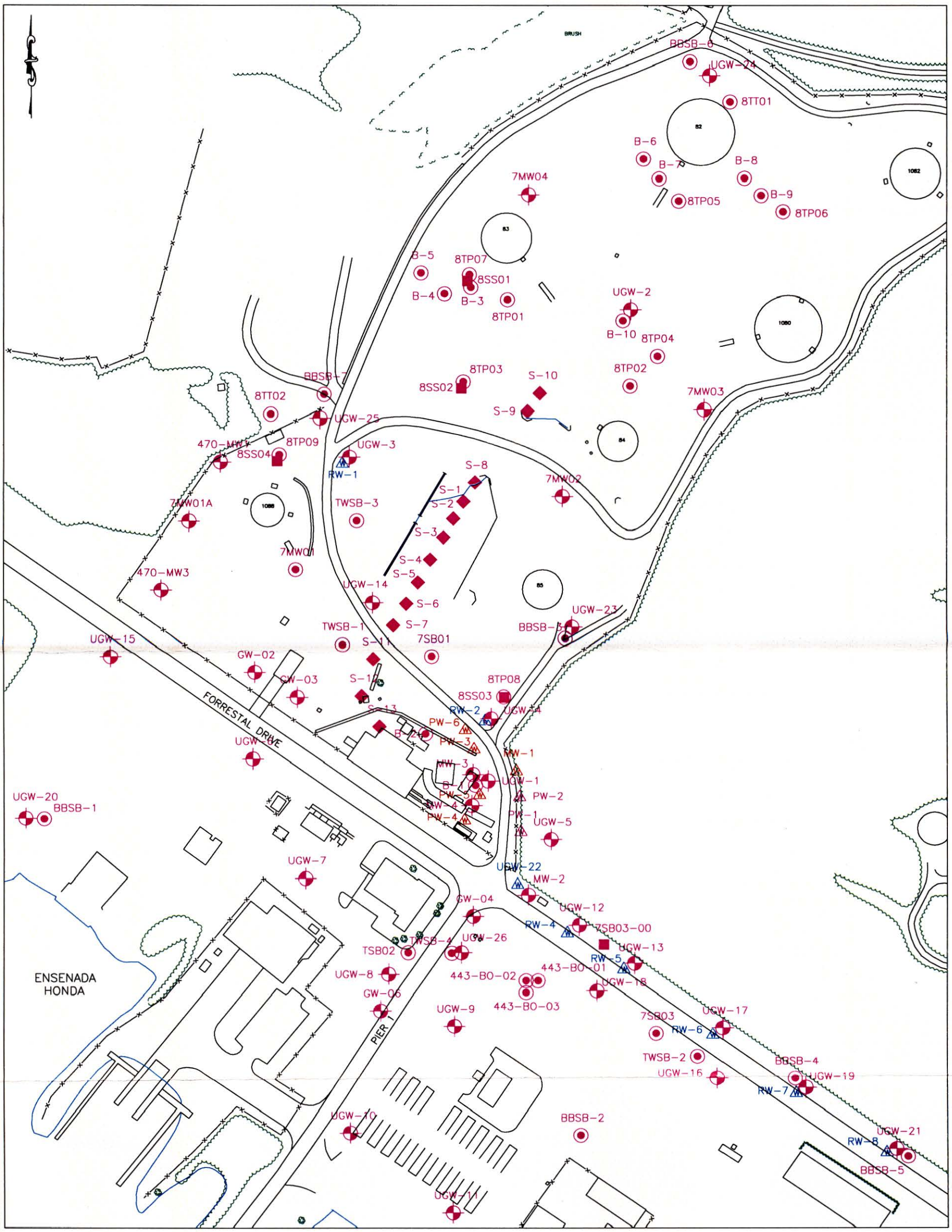
Baker Environmental, Inc. (Baker). 1997a. Revised Draft, RCRA Facility Investigation Report, Operable Unit 2 (SWMU 7/8), Naval Station Roosevelt Roads, Ceiba, Puerto Rico. June 16, 1997. Coraopolis, Pennsylvania.

Baker. 1997b. Final, RCRA Facility Investigation Work Plans, Addendum 2 (Revised), Naval Station Roosevelt Roads, Puerto Rico. June 13, 1997. Coraopolis, Pennsylvania.

Baker. 1995. Final, RCRA Facility Investigation, Naval Station Roosevelt Roads, Puerto Rico. September 14, 1995. Coraopolis, Pennsylvania.

Baker. 1994. Draft Final, Pre-Investigation Corrective Measures Screening Report, Naval Station Roosevelt Roads, Puerto Rico. April 29, 1994. Coraopolis, Pennsylvania.

FIGURES



LEGEND

- UGW-9 – MONITORING WELL LOCATION
- S-4 OR 7SB03 OR 8SS02 – SOIL BORING LOCATION
- PW-1 – TERRAVAC PRODUCT RECOVERY WELLS
- RW-1 – ICHOR PRODUCT RECOVERY WELLS
- BUILDING
- WALL

FIGURE 2-1
SITE PLAN
TOW WAY FUEL FARM
CTO – 0277

NAVAL STATION ROOSEVELT ROADS
CEIBA, PUERTO RICO

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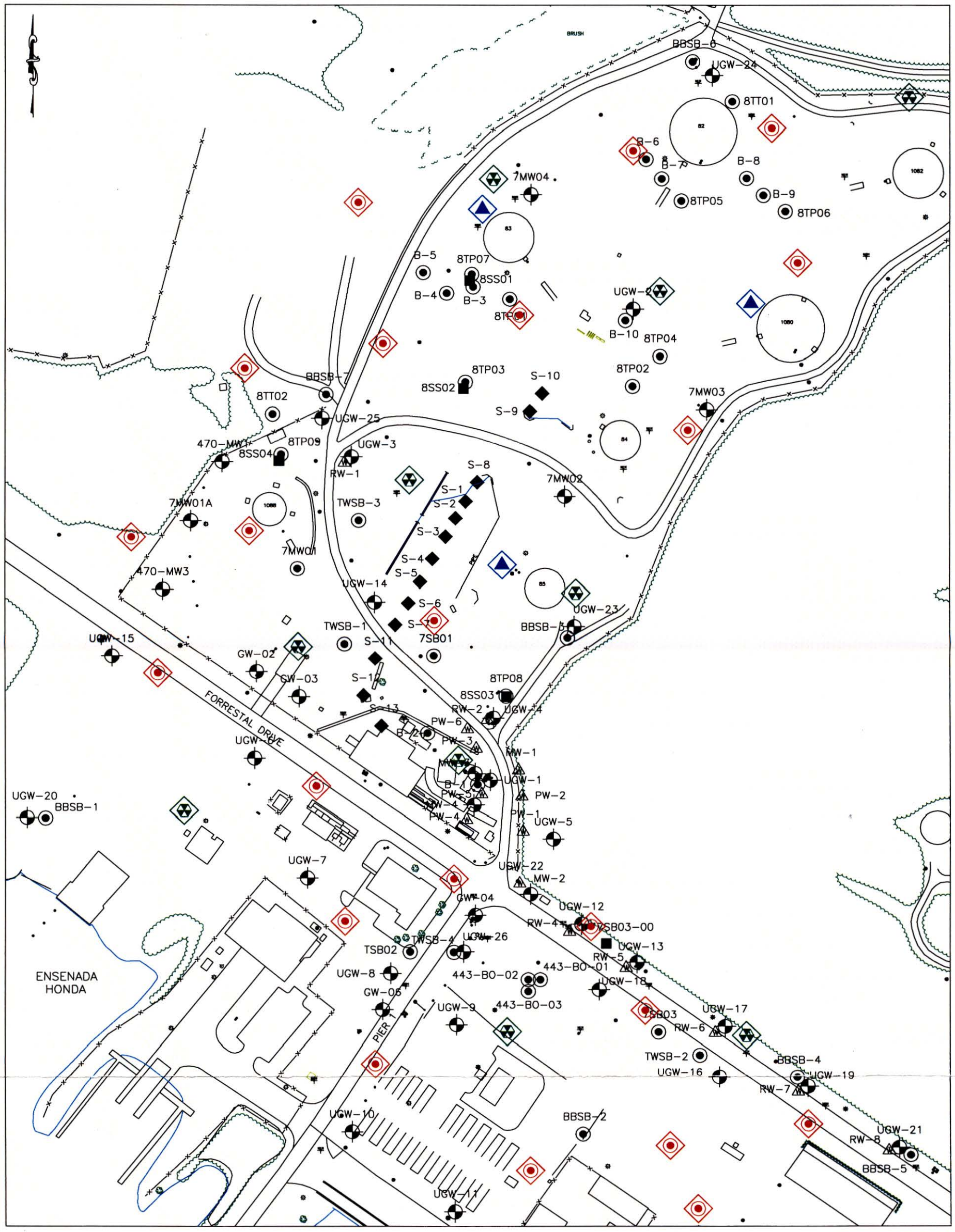


120 0 60 120

1 inch = 120 ft.

Baker

Baker Environmental, Inc.

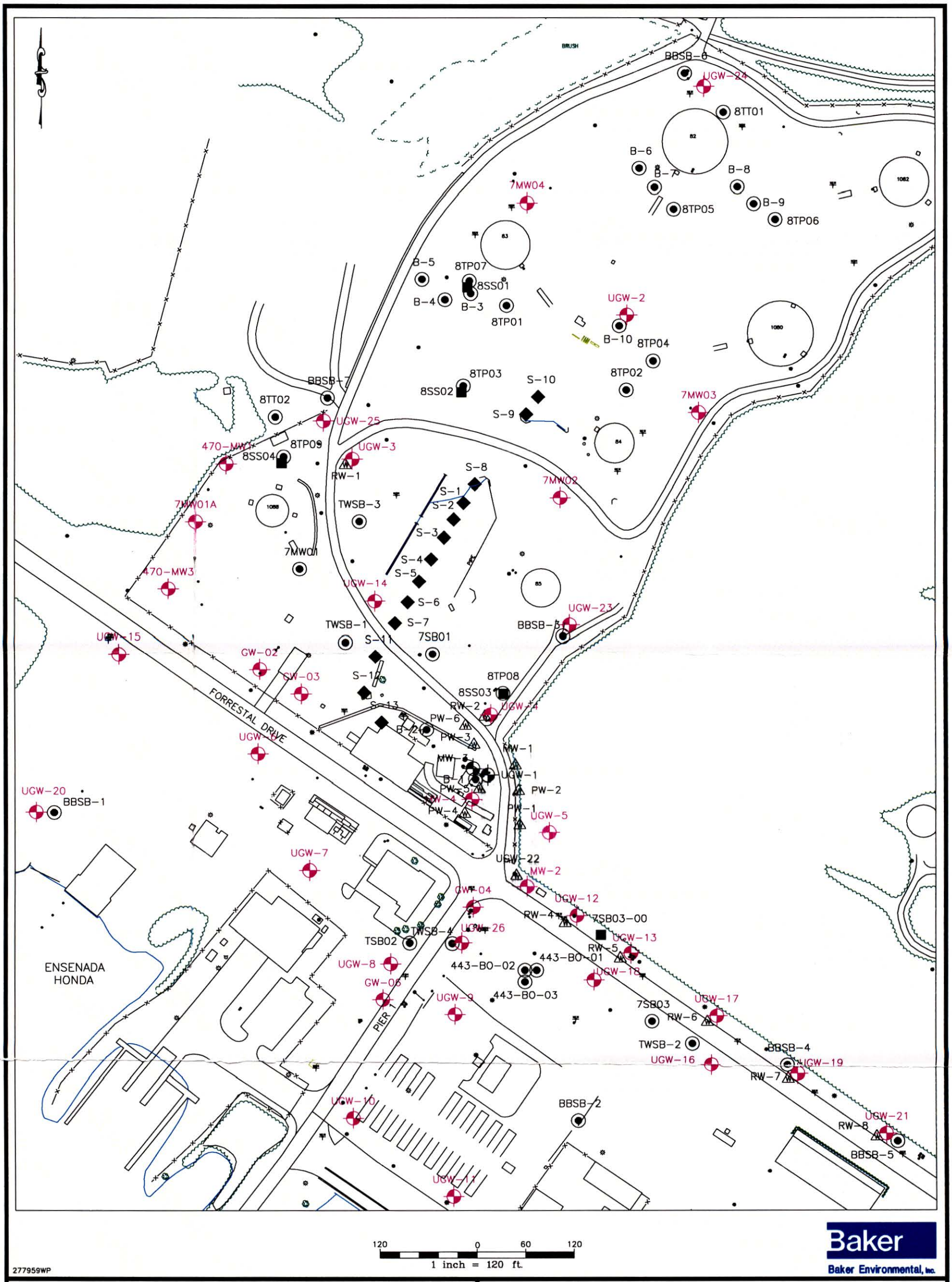
277960WP

LEGEND

- UGW-9 – MONITORING WELL LOCATION
- S-4 OR 7SB03 OR 8SS02 – SOIL BORING LOCATION
- PW-1 – TERRAVAC PRODUCT RECOVERY WELLS
- RW-1 – ICHOR PRODUCT RECOVERY WELLS
- BUILDING
- WALL
- PROPOSED SUBSURFACE SOIL SAMPLING LOCATION
- PROPOSED SUBSURFACE SOIL AND SOIL GAS SAMPLING LOCATION
- PROPOSED VERTICAL PERMEABILITY TESTING LOCATION

FIGURE 3-1
SUBSURFACE SOIL, SOIL GAS, AND VERTICAL PERMEABILITY SAMPLING LOCATIONS
TOW WAY FUEL FARM
CTO - 0277

NAVAL STATION ROOSEVELT ROADS
CEIBA, PUERTO RICO



LEGEND

- UGW-9 – MONITORING WELL LOCATION
- S-4 OR 7SB03 OR 8SS02 – SOIL BORING LOCATION
- PW-1 – TERRAVAC PRODUCT RECOVERY WELLS
- RW-1 – ICHOR PRODUCT RECOVERY WELLS
- BUILDING
- WALL
- UGW-9 – PROPOSED GROUNDWATER SAMPLING LOCATION

FIGURE 3-2
GROUNDWATER SAMPLING LOCATIONS
TOW WAY FUEL FARM
CTO - 0277

NAVAL STATION ROOSEVELT ROADS
CEIBA, PUERTO RICO

Baildown Test Record Sheet

Site: _____

Well Identification: _____

Well Diameter (OD/ID): _____

Date at Start of Test: _____ Sampler's Initials: _____

Time at Start of Test: _____

Initial Readings

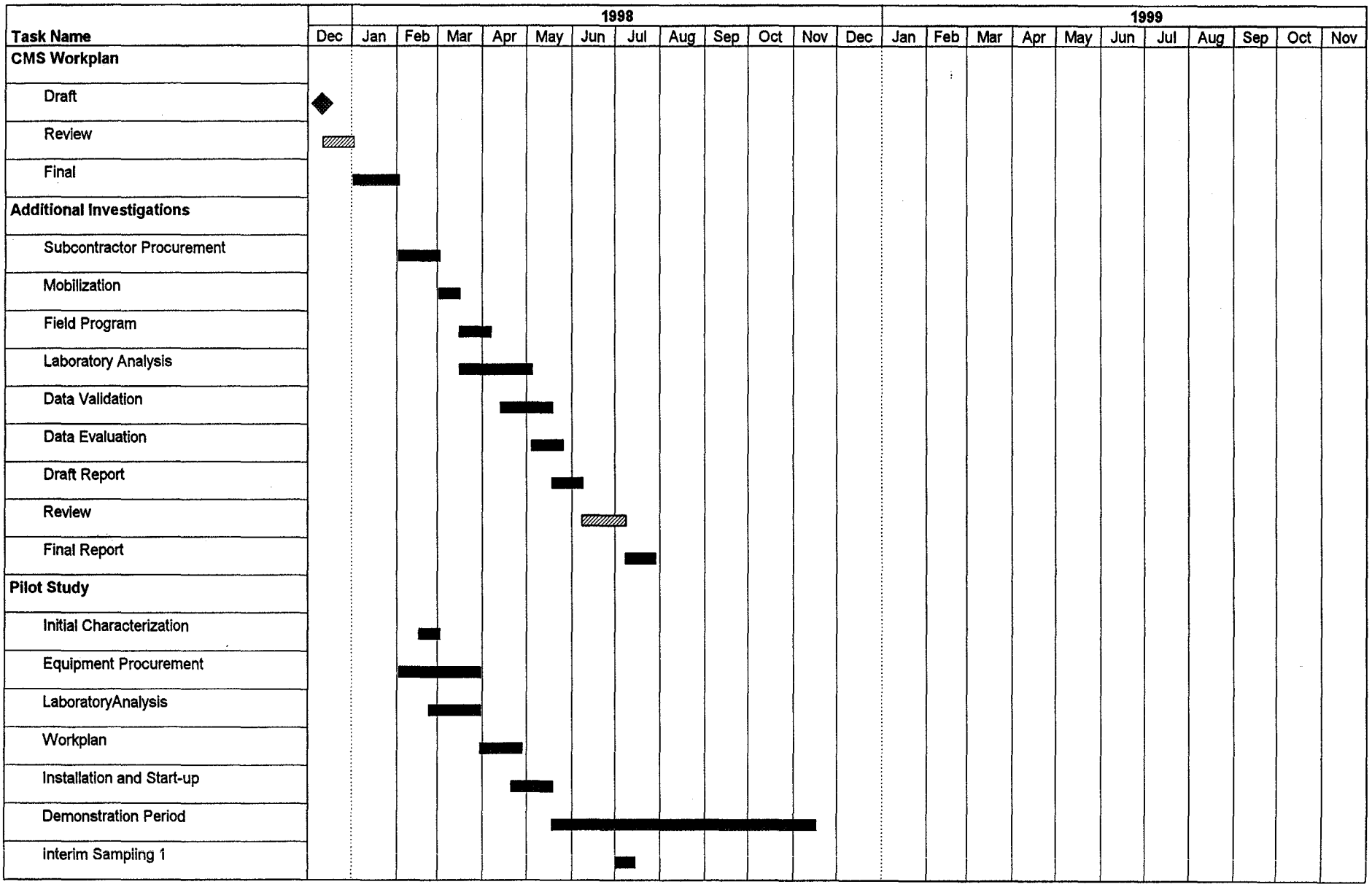
Depth to Groundwater (ft)	Depth to Free Product (ft)	Free Product Thickness (ft)	Total Volume Bailed (L)

Test Data

Sample Collection Time	Depth to Groundwater (ft)	Depth to Free Product (ft)	Free Product Thickness (ft)

FIGURE 3-3. TYPICAL BAILDOWN TEST RECORD SHEET

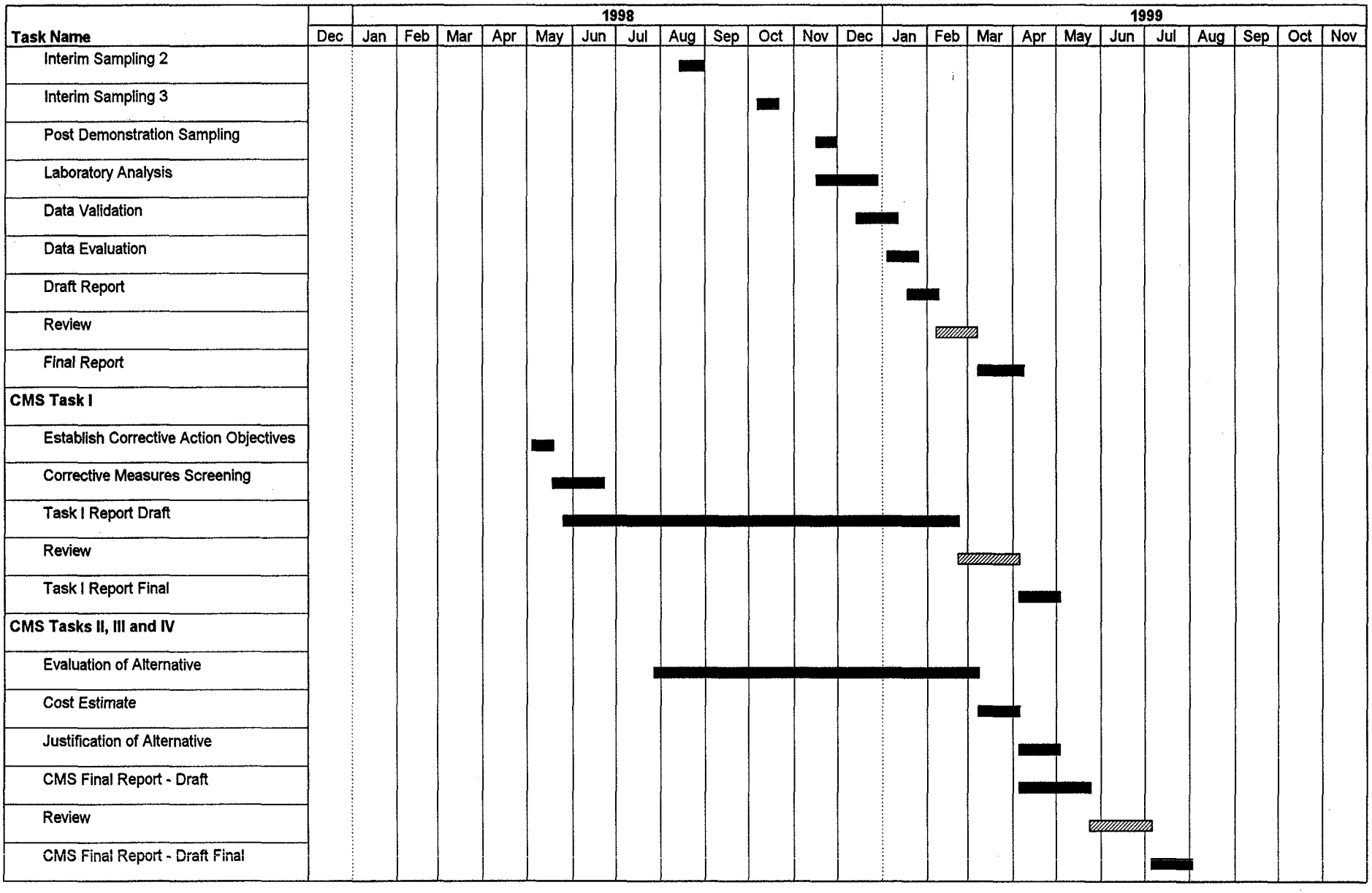
Figure
Corrective Measure Study Schedule
Project Manager: Thomas Fuller



Project: CTO-0277
Date: 12/12/97

Task Review Milestone

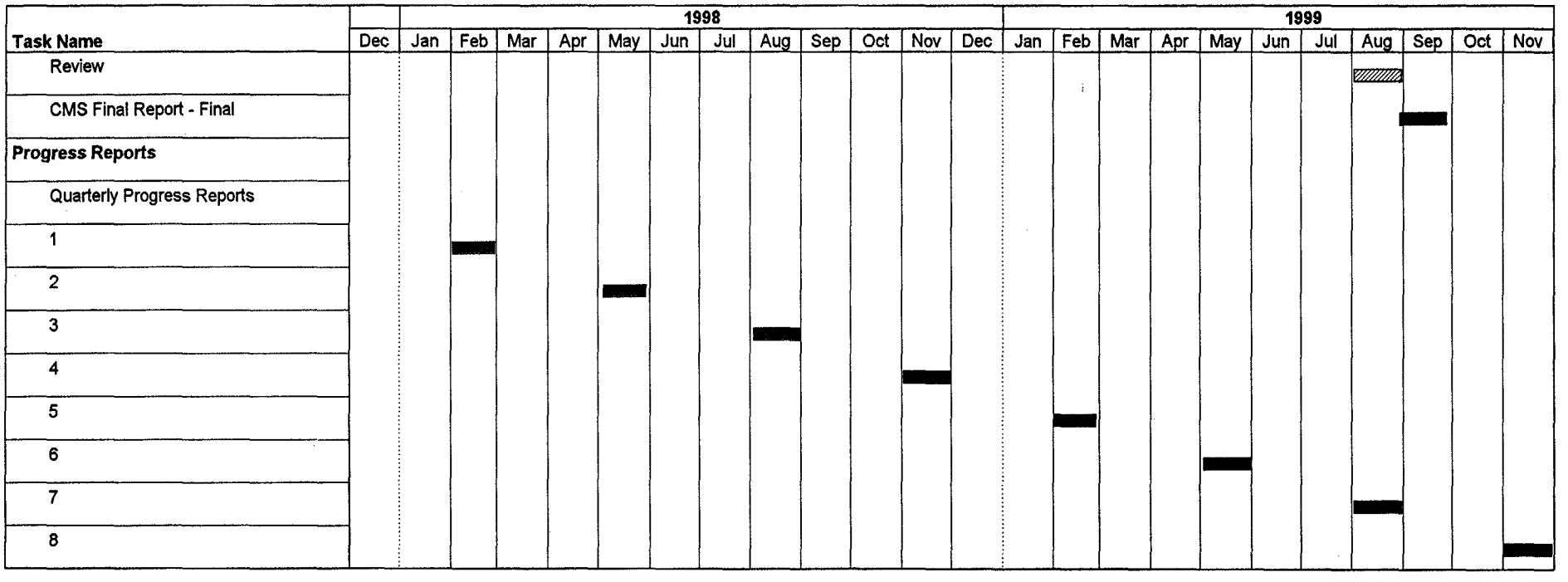
Figure
Corrective Measure Study Schedule
Project Manager: Thomas Fuller



Project: CTO-0277
Date: 12/12/97

Task Review Milestone

Figure
Corrective Measure Study Schedule
Project Manager: Thomas Fuller



Project: CTO-0277
Date: 12/12/97

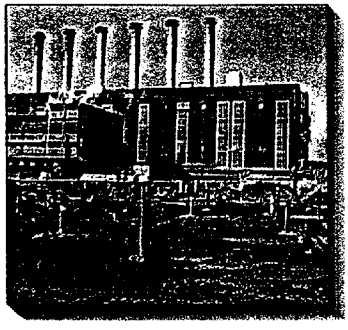
Task Review Milestone

APPENDIX A

MANTECH CASE STUDIES

ElectroChemical GeoOxidation

Fast, Effective, Safe Solution to your Soil and Water Contamination Problems



ElectroChemical GeoOxidation, ECGO, is a patented technology that remediates soil and water contaminated with organic and inorganic compounds.

- Requires No Excavation
- Treats Organic and Inorganic Contaminants
- Acts Quickly (120-180 days)
- Suitable for Urban and Developed Areas
- Limited Interference with On-Site Activities
- Treats Soil and Groundwater
- Cost Effective, No Long-Term Operation and Maintenance (O&M) Costs

ManTech Environmental, is the U.S. licensee for implementing the ECGO technology at U.S. commercial, industrial, and governmental environmental sites.

ECGO is an *in-situ* process that applies electrical current to electrodes driven into the ground to rapidly address a wide range of both organic and inorganic compounds. ECGO is installed without excavating the site, disturbing existing structures, and with limited disruption to ongoing activities. Once installed and operating, ECGO is clean, noiseless, and unobtrusive, making ECGO especially suitable for use in urban and other developed areas. The ECGO process produces no waste streams that require permitting, treatment, and discharge.

ManTech Environmental provides a broad spectrum of environmental services to commercial, industrial, and government customers, including program management, site assessment, interaction with regulatory agencies, and remedial services.

MANTECH ENVIRONMENTAL CORPORATION

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

Electrochemical GeoOxidation, ECGO, is a patented *in situ* process that uses induced electric current to create oxidation-reduction (Redox) reactions leading to complete mineralization of organic constituents [or mobilization of inorganic constituents] present in a volume of soil and groundwater between [and laterally extending beyond] the electrode locations. The electrical resistivity, site geology, and hydrogeology of the subsurface determine the voltage and intensity of the induced current to precisely control and maximize contaminant degradation. Rapid and comprehensive degradation of organic contaminants has been demonstrated in soil formations of coarse sands to the most impermeable clays and silts.

When treating organics, ECGO induces the polarization of naturally-occurring iron, magnesium, titanium, and elemental carbon surfaces in soil and rock particles. Naturally-occurring heavy metal impurities act as catalysts for the Redox reactions creating numerous microscopic anodic and cathodic (oxidative and reactive) reaction sites. These reactions occur at the interfaces between liquids (soil moisture and groundwater) and solids (soil particles).

Organic constituents that are amenable to anodic mineralization degrade locally by taking an oxidative route: petroleum hydrocarbons degrade to alcohols, then to aldehydes and oxalic acids, and finally to carbon dioxide and water. Organic constituents that are amenable to cathodic mineralization degrade by taking the reductive route: chlorinated organics are reductively dehalogenated.

ECGO has successfully treated organic contaminants in soil and groundwater, and liquid and sludge waste streams at numerous sites. ECGO is effective against a wide range of organic contaminants including benzene, toluene, ethylbenzene, and xylene (BTEX), chlorinated solvents, pesticides, polychlorinated biphenyls (PCBs), total petroleum hydrocarbons (TPHs), phenols, polyaromatic hydrocarbons (PAHs), and nitro aromatics.

When treating metals, ECGO applies electrokinetic processes. An electrical current of predetermined voltage and intensity is directed to the contaminated soils and groundwater. The process uses electrokinetic phenomena that have been known for over 200 years, including:

Electrolysis - the transport of ions to electrodes through the action of an applied current;

Electrophoresis - a process the governs the mobilization of colloids and complex ions; and

Faraday's Law - precipitation of metals on electrodes.

ECGO SUCCESSES:

- Consistently Achieved Established Cleanup Standards in less than 180 days
- Applied to a Depth of 180 Feet
- Successful Treatment of Approximately 2 Million Metric Tons of Soil

For more information on ECGO, please contact:

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Houston, Texas 77027
(713) 585-7003

ElectroChemical GeoOxidation

Fast, Effective, Safe Solution to your Soil and Water Contamination Problems

ElectroChemical GeoOxidation, ECGO, is a patented technology that remediates soil and water contaminated with organic and inorganic compounds.

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Case Study: Remediation of Chlorinated Solvents

ECGO USED TO SUCCESSFULLY DEGRADE CHLORINATED SOLVENTS

PROBLEM

Clients requested that ECGO be utilized to remediate chlorinated solvent contamination. No *in situ* technology is currently available to effectively degrade chlorinated solvents in a compressed time schedule.

SOLUTION

Completed ECGO laboratory-scale and field-scale pilot studies of ECGO to verify the effectiveness of ECGO in remediating chlorinated solvents. The laboratory study consisted of degrading a mixture of chlorinated solvents by an independent testing laboratory, and the field-scale study consisted of treating approximately 1,600 tons of soil contaminated with chlorinated solvents.

RESULTS

ECGO system operated for 140 days during the laboratory-scale study and 71 days during the field-scale study. The results of the mixed chlorinated solvent feasibility study, demonstrated reduction of tetrachloroethylene (PCE), trichloroethylene (TCE), and dichloroethylene (DCE) to less than 1 ppm after 100 days of treatment. In the case of the field-scale study, chlorinated solvent contamination decreased in concentration by an order-of-magnitude at all sampling locations.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGO USED TO REMEDIATE CHLORINATED SOLVENTS

Laboratory and Field-Scale Treatment of Chlorinated Solvents. Two laboratory-scale and one field-scale project involving treatment of chlorinated solvents by ECGO have been selected and summarized. The laboratory studies involve the treatment of PCE and other chlorinated solvents in water. The field-scale project was focussed on chlorinated solvents in soil.

Laboratory Studies - Two laboratory tests were performed by an outside testing laboratory to determine the effectiveness of ECGO in remediating PCE and a mixture of PCE, TCE, and DCE. In the first study, 40 kg of a loamy soil was doped with PCE. In the second feasibility study, 40 kg of soil was doped with a mixture of PCE, TCE, and DCE. The soil test cells were then saturated with water, allowed to equilibrate, and ECGO electrodes were installed within the treatment cells. A specific electrical voltage was applied to the electrodes within the cells for 150 days in the first study and 100 days in the second study. Water samples were withdrawn every 10 to 20 days to analyze for chlorinated solvent concentrations. The results of each study are discussed below.

In the PCE study, the initial PCE concentrations of about 3 ppm in the water samples decreased to below the analytical method detection limit in about 25 days. However, detectable concentrations of TCE and DCE, breakdown products of PCE, appeared in the water sample collected after the first-ten days of treatment. PCE and TCE were not detected in the water samples collected and analyzed after twenty days of treatment. DCE increased in concentration to about 2 ppm in the water sample collected after twenty days of treatment, although it decreased in concentration after 140 days of treatment to a concentration of 53 ppb.

The results of the mixed chlorinated solvent (PCE, TCE, and DCE) were similar to the first test in that PCE and TCE degraded from 10 ppm to below detection limits in less than 40 days. DCE decreased from an initial concentration of 17.5 ppm to about 7.5 ppm in twenty days, increased to about 12 ppm after 30 days, and began to decrease over subsequent sampling to less than 1 ppm after 100 days of treatment.

Field Test in Dunningen, Germany - An area of about 200 feet by 100 feet was found to be contaminated with chlorinated solvents to a depth of about 12 feet below ground surface. The on-site soil was a loamish clay, considered to be sediments from a small river close to the site. A 65-foot by 30-foot area of the site was selected for a field-scale test of ECGO. ECGO electrodes were installed to a depth of approximately 15 feet below ground surface and the ECGO system was operated for 71 days. A cleanup level of 10 ppm for total chlorinated solvents in soil was required for this site. The following data were collected at three sampling locations taken before ECGO operation and 71 days after ECGO operation.

Field Test Results - Total Cholorinated Solvents

Location	Soil Sampling Interval (feet)	Initial Concentration (mg/kg)	Final Concentration (mg/kg)	Concentration Reduction
1	0-6	5.1	1.0	80%
1	6-12	8.6	0.3	97%
2	0-6	2.5	0.1	96%
2	6-12	5.3	0.6	89%
3	0-6	298	44	85%
3	6-12	514	83	84%

For more information on ECGO, please contact:

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Case Study: Remediation of Pharmaceutical Plant

ECGO USED SUCCESSFULLY TO REMEDIATE PHARMACEUTICAL PLANT

PROBLEM

Phenol contamination with potential to adversely effect concrete foundations. Facility severely damaged during WW II bombing; unexploded ordnance present. Tight time constraints to complete the remediation project.

SOLUTION

ECGO was selected because of its rapid remediation capability and response time, minimum site disruption, and proven performance record.

RESULTS

Phenol concentrations reduced by 99.96% at two treatment areas totaling one-tenth acre in only 33 days. Approximately 10,000 metric tons of soil were treated to a depth of 100 feet.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGO USED SUCCESSFULLY TO REMEDIATE PHARMACEUTICAL PLANT

A Dutch-German company established a pharmaceuticals manufacturing facility in the greater Berlin area in 1900. The facility operated continuously until 1945, when it was severly damaged near the end of World War II. After the war, operations resumed and pharmaceuticals, mainly painkillers, were again manufactured. Following the reunification of Germany, the facility was returned to the Dutch-German company in 1992. The plant was demolished to allow for construction of a new manufacturing facility. Unexploded, live ordnance was still present in the area.

The site is characterized as quaternary sands and gravels to a depth of approximately 200 feet. Site investigations indicated that phenol concentrations, although lower than German standards for industrial sites, would be potentially harmful to the concrete foundations of the planned new facilities. The requirement to remediate the site quickly and the danger posed by buried unexploded ordinance prompted the selection of ECGO to remediate the site.

RESULTS

Phenol concentrations were reduced from 12 mg/Kg to the target level of less than 0.5 mg/Kg (99.96 % reduction). BTEX concentrations were reduced approximately one order of magnitude, and significant reductions were made in PAH, TOX, and TPH concentrations.

ECGO was employed *in situ* for a period of 33 days at two different areas. Four electrodes were employed: one (steel tube) electrode pair installed to a depth of approximately 100 feet, and one (steel tube) electrode pair installed to a depth of 20 feet. Maximum treatment depth was 100 feet and 10,000 metric tons of soil were treated. Special precautions were taken to avoid setting off any unexploded ordnance.

Numerous soil samples were taken within the treatment area at three locations and at different depths during the 33 days of operation. The results, averaged for three sampling locations, are presented below:

Pharmaceutical Plant, Berlin - Average Concentration (mg/Kg)

Chemical	Depth (m)	Initial Conc.	Final Conc.	% Reduction
Phenol Index	0 to 1	0.09	0.09	0
	1 to 2	0.40	0.12	69
	2 to 3	2.08	0.10	95
	3 to 4	6.05	0.45	93
BTEX	0 to 1	6.63	0.69	90
	1 to 2	34.11	2.66	92
	2 to 3	388.17	26.96	93
	3 to 4	610.67	122.00	80
PAH	0 to 1	24.77	10.97	56
	1 to 2	8.88	4.13	54
	2 to 3	5.53	2.09	62
	3 to 4	1.60	1.60	0
TPH	0 to 1	120	43	64
	1 to 2	68	58	15
	2 to 3	252	62	75
	3 to 4	457	120	74

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Case Study: Remediation of Nitro Aromatics

ECGO USED SUCCESSFULLY TO REMEDIATE NITRO AROMATICS IN SOIL

PROBLEM

Soil contaminated with nitro-aromatic (explosive) constituents.

SOLUTION

Conducted a laboratory pilot test to determine effectiveness of the ECGO technology in degrading explosives in soil. A 44 pound composite soil sample was drawn from the contaminated area. The soil was homogenized, placed in a vessel, water added to saturation, and the ECGO technology applied.

RESULTS

Nitro aromatic concentrations reduced by 98%.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGO USED SUCCESSFULLY TO REMEDIATE NITRO AROMATICS IN SOIL

A laboratory pilot test was conducted to assess the feasibility of using the ECGO process to remediate soils impacted with nitro aromatic constituents. The soils, obtained from a storage area located inside an ammunition factory, consisted of sandy silts containing construction debris and explosives particles.

A composite sample, consisting of approximately 44 pounds of impacted soils, was collected from the site. The soils were homogenized and placed in a plastic container, then water was added to the container until the soils were saturated up to the soil line. The saturated soils were topped with a thin film of synthetic oil to minimize evaporative losses. Water was added periodically during the test to compensate for water losses due to electrolysis and to maintain a water content of approximately 30% by weight. Electrical current was supplied to two plate-shaped electrodes placed near the long ends of the container. The ECGO process was employed for a period of 248 days.

Five soil samples were obtained from the area between the electrodes. The samples were obtained before the test, and on days 52, 103, 174 and 248 of the test. The samples were analyzed for nitro-aromatic constituents.

RESULTS

ECGO succeeded in reducing nitroaromatic concentrations by one to two orders-of-magnitude. The total nitro aromatics concentrations decreased 98%, from an initial value of 147 mg/Kg to a final value of 3 mg/Kg, on a dry soil basis. The concentrations of compounds with a greater number of nitrogen-bonds generally decreased more rapidly than the concentrations of compounds with fewer nitrogen-bonds (e.g., 2,4,6-TNT was mineralized more quickly than 4-NT). The difference in breakdown rates is due to the creation of intermediate mineralization products such as 2,4-DNT and 4-NT, which are themselves subject to further degradation during the ECGO process. In addition to the reduction in the concentrations of nitro aromatic compounds, total PAH concentrations decreased 56% during the laboratory test.

Ammunition Factory, Hirschhagen-Nitro Aromatic Compounds (mg/Kg)

Constituent	Initial Round	Interm. Round	Interm. Round	Interm. Round	Final Round	Percent Reduction
2-Nitrotoluol	1.9	0.8	0.8	1.4	0.3	84
3-Nitrotoluol	0.3	0.1	0.1	0.2	0.04	87
4-Nitrotoluol	0.9	0.4	0.7	0.7	0.18	80
2,4-Dinitrotoluol	64	22	36	48	1.8	97
2,6-Dinitrotoluol	2	0.4	0.4	0.5	0.05	98
3,4-Dinitrotoluol	0.04	0.01	0.01	0.01	0.01	75
2,4,6-Trinitrotoluol	30	0.5	0.5	0.9	0.02	100
2,4-Dinitro-6-aminotoluol	21	4.2	2.7	3.4	0.2	99
2,6-Dinitro-4-aminotoluol	26	5.4	4.8	6.9	0.35	99
1.3.5-Trinitrobenzol	0.5	0.02	0.04	0.02	0.02	96
Total Nitro-aromatics	147	34	46	62	3	98

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Case Study: Remediation of Organic Pesticides

ECGO TREATABILITY TEST FOR LINDANE NEAR PESTICIDE PLANT

PROBLEM

Lindane contamination had been detected in soils on a privately-owned property near a pesticide plant in Delitzsch, Germany. No *in-situ* remediation technologies were available to effectively remediate Lindane within a compressed time schedule.

SOLUTION

Completed laboratory-scale pilot study of ECGO using a Lindane solution to verify effectiveness of ECGO in remediating the contaminant. Conducted field treatability testing of soils using two ECGO electrodes installed to a depth of fifteen feet to confirm the ability of ECGO to operate under field conditions.

RESULTS

ECGO system operated for ten days and reduced Lindane concentrations from an average of 44 mg/kg to 0.19 mg/kg.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGO TREATABILITY TEST TO ADDRESS LINDANE CONTAMINATION NEAR PESTICIDE PLANT IN DELITZSCH

While in the process of planning ECGO remediation activities at a carbonizing plant in Deuben, a nearby privately-owned property was discovered to contain Lindane contamination in soils up to twelve feet below grade. The area was located in close proximity to a pesticide manufacturing facility. In order to verify the effectiveness of ECGO on Lindane, a polychlorinated heterocyclic pesticide, a laboratory pilot-scale study was first performed followed by the full-scale field test.

To complete the laboratory test, 50 liters of a solution containing 35% Lindane, emulsifiers, and water were treated in a test vessel for 12 days. The glass vessel measured 60 cm x 34 cm x 30 cm. Two carbon steel electrodes with a surface area of 400 cm^2 were installed in the vessel operated with 112 W of electrical power. The electrodes were replaced once during the treatment period due to corrosion. A dark-brown iron oxide sludge was produced and settled to the bottom of the vessel. After twelve days of treatment, samples of the test fluid were sent to an independent laboratory for chemical analysis. No chlorinated organic compounds, including Lindane, could be detected in the samples except for traces of chlorobenzene.

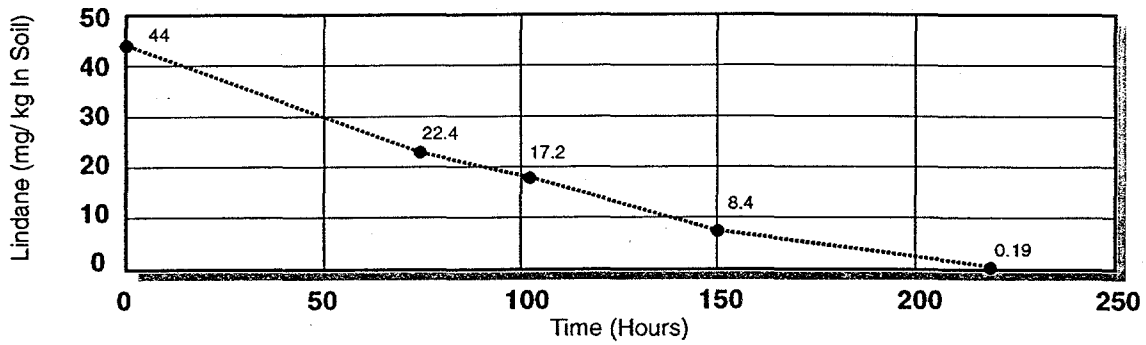
The full-scale treatability program began in August of 1992 as part of a series of treatability studies to evaluate the performance of ECGO to address pesticides and other organic constituents. These studies were performed at several industrial sites near Deuben. The soil at the Delitzsch site, consisting of a weathered gneiss (30% gravel, 50% fine to medium sand, and 20% loam), was contaminated with Lindane to a depth of 12 feet below surface. Two, two-inch diameter, tubular carbon steel electrodes were installed at the site, about 8.2 meters apart. DC current was applied to the electrode pair for ten days. An estimated 360 metric tons of soil were treated.

Soils were sampled at three measuring points in a field about 12 feet by 26 feet in size during treatment and after completion of treatment using ECGO. Core soil samples were collected and analyzed using a gas chromatograph. The average initial concentration in the soil samples collected from the site was 44 mg/kg. A final average concentration of 0.19 mg/kg was achieved after ten days of treatment.

A graph depicting the concentrations of Lindane before, during, and at the end of treatment is shown below. While the treatability study was limited in both the amount of soil treated and period that the ECGO system was operated, these results suggest Lindane and other similar organic pesticide compounds in soil can be reduced using the ECGO process.

Pesticide Contaminated Site, Delitzsch

Average Lindane Concentrations in Soils (mg/kg) vs. Treatment Time (hours)



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Case Study:
Remediation Gas Manufacturing Plant

ECGO USED SUCCESSFULLY TO REMEDIATE GAS MANUFACTURING PLANT

PROBLEM

Site investigations indicated elevated PAH concentrations in the top three feet of a 0.1-acre portion of the site. Prior to reusing the site, the regulatory agencies and responsible parties agreed that a soil and groundwater cleanup program of this surficial zone would be required.

SOLUTION

ECGO was implemented for a period of 82 days. Approximately 800 tons of soil were treated to a maximum depth of about three feet.

RESULTS

ECGO succeeded in reducing total PAH concentrations by approximately 69%. ECGO effected a two order of magnitude decrease in cyanide concentrations from about 40 mg/Kg to about 0.4 mg/Kg.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGO USED SUCCESSFULLY TO REMEDIATE GAS MANUFACTURING PLANT

A manufactured gas plant (MGP) in Sylt, Germany was demolished to allow construction of an industrial area. After demolition, construction debris and miscellaneous waste material in thicknesses of up to six feet covered portions of the site.

Site investigations indicated elevated Polyaromatic Hydrocarbon (PAH) concentrations in the top three feet of a 0.1-acre portion of the site. Prior to reuse, the regulatory agencies and responsible parties agreed on a soil and groundwater cleanup program of this surficial zone using ECGO. ECGO was implemented between August 1994 and February 1995 for a period of 82 days. Approximately 800 tons of soil were treated to a maximum depth of approximately three feet.

Four rounds of soil samples were obtained: one at the beginning of the remediation period, two during the remediation period, and one at the end of treatment. The samples were analyzed for PAHs and BTEX.

RESULTS

ECGO succeeded in reducing total PAH concentrations by approximately 69 percent from a weighted average of 75 mg/Kg to a weighted average of 23 mg/Kg. A decrease in the amount of tar was observed, but tar accumulations in the subsurface were still present at the end of the operating period. The results also appear to indicate that ECGO effected a two order of magnitude decrease in cyanide concentrations from approximately 40 mg/Kg to approximately 0.4 mg/Kg. BTEX concentrations increased from non-detect to maximum 0.23 mg/Kg during the intermediate sampling round, and then decreased to non-detectable levels by the end of the treatment period.

The results led the regulatory agency recommending application of ECGO to the remaining impacted portions of the site which is currently underway.

Manufactured Gas Plant, Sylt - Total PAH Concentrations (mg/Kg)

Location/Sampling Interval	Initial Concentration	Final Concentration
34/ 0 to 0.3m	4.32	23.74
34/ 0.3 to 1m	71.48	7.09
37/ 0 to 0.3m	92.93	111.49
37/ 0.3 to 1m	51.76	19.77
44/ 0 to 0.3m	338.60	29.66
44/ 0.3 to 1m	13.07	2.60
Average	75.39	23.38

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Case Study:
Remediation of Lignite Carbonizing Plant

ECGO USED SUCCESSFULLY TO REMEDIATE LIGNITE CARBONIZING PLANT

PROBLEM

Historical site operations resulted in extensive organic constituent impact beneath the lignite carbonizing complex.

SOLUTION

The regulatory agency directed the client to remediate the site to the top of the lignite seam (i.e., to a depth of approximately 130 feet, and maximum depth of 200 feet). Between January and February, 1992, ECGO was used for a month-long pilot test to verify its performance and obtain design parameters for a full-scale system.

RESULTS

Following the month-long pilot test, ECGO was used successfully in a staged process to remediate an area of approximately 5 acres, located downgradient of the carbonizing plant and coke ovens.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGO USED SUCCESSFULLY TO REMEDIATE LIGNITE CARBONIZING PLANT

Deuben is located in a historical coal mining area, where the mining tradition dates back to the twelfth century. In 1936, a lignite carbonizing complex with a processing capacity of approximately 4.5 million tons of carbon per year was built in Deuben. The complex, which included a carbonizing plant, coke plant, lubricating oil refinery, and by-product (including phenol and tars) processing plants, occupied an area of approximately 50 acres. Pigments, resins and pharmaceuticals were also manufactured at this complex. Operations were halted in August, 1991 following the demolition of the Berlin Wall. As a result of the reunification of Germany and shutdown of the plant, the buildings were razed by the end of 1992.

The subsurface consists of interbedded fine- and coarse-grained deposits, including the lignite unit, which is found at a mean depth of approximately 130 feet below the surface of the ground. A system of tunnels and partially collapsed chambers attributable to the historical room-and-pillar coal mining operations that underlie the site. The water table occurs at a depth of 25 to 40 feet below ground surface.

Site operations resulted in extensive organic constituent contamination beneath the lignite carbonizing complex. The regulatory agency directed the client to remediate the site to the top of the lignite seam to a depth of approximately 130 feet.

ECGO was used in a staged process over about an 80 day period per stage to remediate an area of approximately 5 acres, located downgradient of the carbonizing plant and coke ovens.

RESULTS

Three rounds of soil samples were obtained: one at the beginning of the remediation period, one at the middle, and one at the end. Samples were obtained at one meter (approximately 3.3 feet) intervals down to 4 meters (13 feet), and analyzed for "phenol index", BTEX, PAHs, TPHs and TOX.

ECGO succeeded in reducing phenol, BTEX, PAH, TPH and TOX concentrations by more than two orders of magnitude. Despite the elevated initial constituent concentrations, the final concentrations were generally less than 1 mg/Kg to non-detect, except for TPHs, where the final constituent concentrations were less than 100 mg/Kg. The reduction in constituent concentrations was greater than 99% for the tabulated constituents, and field observations indicate the depletion of NAPLs at all the electrode locations.

Lignite Carbonizing Plant, Deuben-Constituent Concentrations (mg/Kg)

Chemical	Inital Conc.	Interm. Conc.	Final Conc.	% Reduction
Phenol Index	2100.00	600.00	0.44	99.98
BTEX	320.00	0.12	<0.04	99.99
Total PAHs	210.00	39.40	<0.18	99.91
TPH	5300.00	NA	22.80	99.57
TOX	48.00	1.00	<0.10	99.79

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Case Study:
Degrade PCE in Subsurface Soil

ECGO USED TO SUCCESSFULLY DEGRADE CHLORINATED SOLVENTS

PROBLEM

National issuance and land development firm requested that ECGO be utilized to remediate tetrachloroethlene (PCE) in subsurface soil under a former dry cleaning establishment. PCE detected at concentrations exceeding the Texas Natural Resources Conservation Commission (TNRCC) clean up standard of 500 ppb.

SOLUTION

Completed remediation of PCE-contaminated soil underlying a former dry cleaning establishment located in Dallas, Texas. ECGO electrodes installed beneath the concrete building floor and ECGO system operated for approximately five months.

RESULTS

ECGO system reduced PCE concentrations in soils to levels below TNRCC Standard 2 Risk Based Closure Levels. After approximately five months of system operation, PCE concentrations in soil were reduced to less than 500 ppb in all six of the designated soil sampling locations.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGO USED TO REMEDIATE PCE IN SUBSURFACE SOIL

ManTech initially conducted environmental sampling and analysis to characterize and delineate the lateral and vertical extent of chlorinated solvent contamination in soil underlying the dry cleaning establishment. This characterization identified tetrachloroethylene (PCE) at concentrations that exceeded the Texas Natural Resources Conservation Commission (TNRCC) clean up goals of 500 ppb.

Client selected the ECGO remediation technology to remediate the PCE-contaminated soil because the technology could be installed *in situ* with little disruption to adjacent tenants in the strip mall complex. After developing the design parameters using geophysical survey methods, ManTech designed, installed, and operated the ECGO system to reduce levels of PCE concentrations in soils to levels below TNRCC Standard 2 Risk Based Closure Levels. The ECGO system consisted of six electrodes that were installed flush with the ground surface. In conjunction with system operation, which was approximately five months in duration, soil sampling was conducted periodically to assess progress in reducing PCE contamination.

Field Test Results - Perchloroethylene Soil Remediation

Location	Initial Concentration (ug/kg)	Final Concentration (mg/kg)	Concentration Reduction
C-1	2,100	430	80%
C-2	3,000	370	87%
C-3	307	140	54%
C-4	1,300	290	78%
C-5	946	440	53%
C-6	2,410	340	86%

These results indicate that the ECGO process is capable of treating PCE in soils to meet TNRCC cleanup guidelines of 500 ppb.

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Case Study:
Remediation of Polychlorinated Biphenyls

ECGO USED TO SUCCESSFULLY DEGRADE POLYCHLORINATED BIPHENYLS

PROBLEM

Client requested that ECGO be utilized to remediate polychlorinated biphenyl (PCB) contamination in soil. No other *in situ* technology was currently available to effectively degrade PCBs in a compressed time schedule.

SOLUTION

Completed ECGO feasibility study and field-scale pilot studies of ECGO to verify the effectiveness of ECGO in remediating PCBs. The feasibility study consisted of degrading PCB in soil on a laboratory and field scale. The field-scale study consisted of treating approximately 2,400 tons of PCB-contaminated soil.

RESULTS

ECGO system operated for 180 days during the laboratory-scale study and 110 days during the field-scale study. During the laboratory feasibility study, PCB concentrations were reduced from 4,500 ppm to 0.5 ppm, a 99.99 percent reduction. In the case of the field-scale study where ECGO was operated for 110 days, PCB concentrations decreased by an order-of-magnitude at all sampling locations, with an average reduction of approximately 85 percent.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGO USED TO REMEDIATE POLYCHLORINATED BIPHENYLS

The ECGO technology has been applied for the treatment of PCBs in two instances. The first case involved a laboratory-scale project and the second project involved a field-scale *in situ* remediation of soil containing both PCBs and polynuclear aromatic hydrocarbon (PAH) compounds. Each of these studies are briefly described below.

Laboratory-Scale Project. In 1995, a feasibility study was performed to assess the effectiveness of ECGO for treating PCB-contaminated soil at a former waste depository site located in Ibbenbueren, Germany. A limited pilot-scale study was performed to determine the effectiveness of ECGO to degrade PCBs. This study involved treatment of a 40 to 50 kg sample of soil obtained from a contaminated portion of the waste depository site. Analysis of this sample detected an initial PCB concentration of 4,300 mg/kg. The soil was treated using the ECGO process for a period of 180 days. Analysis of the soil following treatment yielded a PCB concentration of 0.5 mg/kg, a 99.99 percent reduction in PCB concentration. Based on these results, a field-scale demonstration project at the waste depository site is presently underway. Consistent with laboratory feasibility testing, ECGO will be operated at the waste depository site for 180 days. Results from this field-scale application are not presently available because the demonstration project has not been completed.

Field-Scale Application. The ECGO technology was applied at a coal mine site in Gladbeck, Germany to remediate PCBs. The primary focus of this remediation project was to address PAH contamination in near surface soils. PAHs, and to a lesser extent PCBs, were detected at a depth of approximately one meter within a treatment area measuring approximately 35 meters by 35 meters. Soil samples were collected and analyzed for PCBs from three locations within the treatment area, including three samples prior to applying the ECGO process and three samples following treatment. The soil samples were collected using a two-inch coring device over a sampling interval of one meter.

The ECGO process, consisting of two-horizonal electrode application, was operated for a period of 110 days. Approximately 2,400 tons of soil were treated during this field-scale demonstration project. The soil clean up target for PCBs, established by the German regulatory authorities, was 100 ug/kg. These results indicate that the ECGO process is capable of treating PCBs in soils to meet USEPA cleanup guidelines of 50 ppm. The following results were obtained.

PCB Remediation Results (ug/kg) - Gladbeck, Germany

Sampling Location	Initial Sampling Event	After 110 days of ECGO Treatment	PCB Concentration Reduction
1	457	57	88%
2	250	49	80%
3	26	3	88%

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Case Study:

Remediation of Mercury Contaminated Soil

ECGO USED SUCCESSFULLY TO REMEDIATE GAS MANUFACTURING PLANT

PROBLEM

Client requested that a single technology be utilized to mobilize and remove mercury contamination in a compressed time schedule.

SOLUTION

Completed a laboratory-scale pilot study using electrokinetic processes to verify the effectiveness of ECGOkinetics in remediating mercury-contaminated soil. The laboratory study consisted of electrophoretic treatment of mercury-contaminated soils obtained from a former mercury recycling facility.

RESULTS

The ECGOkinetics process was successfully demonstrated in that more than 50% of the original estimated mass of mercury in the treatment cell was removed in 12 hours.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGOKINECTIC TREATMENT OF MERCURY CONTAMINATED SOILS

In 1989, a pilot-scale study was performed to evaluate the treatment of soil contaminated with mercury using ECGO. The site was owned by a company that had previously specialized in the removal and recycling of mercury from batteries. The company had been disposing of mercury on the plant site with mercury detected in on-site soils at concentrations as high as 17,000 mg/kg, and at a concentration of 370 mg/kg in soil at a depth of approximately 100 feet below ground surface.

The original proposal from a German engineering firm called for ex-site remediation of the mercury-contaminated site. Their proposed approach consisted of freezing the mercury contaminated soil with liquid nitrogen and then excavating the soil. Because regulatory authorities required that less than 5 mg/m3 mercury emissions into the atmosphere during soil excavating, the engineering firm proposed building an air-tight facility over the excavated portion of the site to contain emissions during removal and treatment.

In response to a request from the company to identify another, more cost-effective, remediation approach, the ECGOkinetic process was proposed to treat the mercury-contaminated soil *in situ*. A pilot study was then successfully performed to demonstrate that the ECGOkinetics process could be used for removal of mercury. Award of a contract for the full-scale remediation of the property is pending.

The pilot study was conducted in a glass container with approximate dimensions of 1.6 feet x 1.0 foot x 1.0 foot (485 mm x 290 mm x 290 mm). Mercury-contaminated soils were placed in this container to a height of approximately 0.6 feet (190 mm). These soils consisted of clayey silts with some fine gravel. Analysis of two soil samples obtained from the treatment cell detected mercury concentrations of 300,000 mg/kg and 320,000 mg/kg, for a total estimated mass of mercury in the container of approximately 5.8 Kg (12.8 lb). The copper cathode, copper anode combination worked best with respect to conducting electricity, and electrode corrosion. The copper-copper combination was subsequently used in a 12-hour test, during which 2.957 Kg (6.5 lb) of mercury were removed. The ECGOkinetic process was successfully demonstrated in that more than 50% of the original estimated mass of mercury in the container was removed in 12 hours.

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ElectroChemical GeoOxidation

Fast, Effective, Safe Solution to your Soil and Water Contamination Problems

ElectroChemical GeoOxidation, ECGO, is a patented technology that remediates soil and water contaminated with organic and inorganic compounds.

- Requires No Excavation
- Treats Organic and Inorganic Contaminants
- Acts Quickly (120-180 days)
- Suitable for Urban and Developed Areas
- Limited Interference with On-Site Activities
- Treats Soil and Groundwater
- Cost Effective, No Long-Term Operation and Maintenance (O&M) Costs

ManTech Environmental, is the U.S. licensee for implementing the ECGO technology at U.S. commercial, industrial, and governmental environmental sites.

Case Study:
Heavy Metal Removal from Harbor Sediments

ECGO USED SUCCESSFULLY TO REMEDIATE GAS MANUFACTURING PLANT

PROBLEM

Client requested that a single technology be utilized to mobilize and remove heavy metal contamination from harbor sediments in a compressed time schedule.

SOLUTION

Completed laboratory-scale study using electrokinetic processes to verify the effectiveness of ECGOkinetics in treating a variety of heavy metals. The laboratory study consisted of mobilizing and removing heavy metals from bottom sediments from the Port of Hamburg.

RESULTS

The ECGOkinetics laboratory-scale study was successful in demonstrating the removal of heavy metals from the harbor sediments. Mobilization and removal of metals, completed during this 14-day study, achieved reductions of metals ranging from 78% to 94%.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGOKINETIC TREATMENT OF BOTTOM SEDIMENTS FROM THE HAMBURG HARBOR

An ECGOkinetic feasibility study was performed of harbor sludges obtained from the Port of Hamburg, Germany. The sludge contained a variety of heavy metals, chlorinated pesticides, and other chlorinated compounds. The study involved the ECGOkinetic treatment of a 150 kg sample of sludge for a period of 14 days.

The dredgings contained cloudy, grey-green water with a light odor of mineral oil. After partial dewatering, the dredgings were placed in a treatment cell with dimensions of 3.3 ft x 1.3 ft x 1.3 ft (100 cm x 40 cm x 40 cm 0.2 yd3). Two plate electrodes were placed in the test cell with a spacing of approximately 1.6 feet (50 cm). Each electrode had a surface area of approximately 62 in2 (400 cm2). Approximately 35 volts and 4.8 amps of electricity was applied to the electrodes. The laboratory test was performed for 14 days. The test results are presented below.

Results from Ecgokinetic Treatment of Bottom Sediments Port of Hamburg Harbor

Parameter	Inital Conc. (mg/kg)	Final Conc. (mg/kg)	% Reduction
Arsenic	13	2.3	82%
Lead	173	38	78%
Cadmium	10	2	80%
Total Chromium	72	16	78%
Copper	143	12	92%
Nickel	56	5	91%
Mercury	0.5	<0.1	—
Zinc	901	54	94%

At the end of treatment, the pore water in the dredgings was clear, colorless, and odorless. The measurement of organic constituent concentrations in the dredgings before and during remediation was not measured because it was beyond the scope of work for this project

The laboratory test demonstrated ECGOkinetics transport of heavy metals to the cathode and their galvanic removal. The laboratory test also demonstrated electrophoretic transport of As, Fe, and Hg ions to the anode and their galvanic removal. The measured removal reinforces earlier observations about the formation of colloids and hydroxi-complexes that are transported anodically.

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Case Study: Metals Treatment of Wastewater Sludge

ECGO USED SUCCESSFULLY TO REMEDIATE GAS MANUFACTURING PLANT

PROBLEM

Client requested that a single technology be utilized to mobilize and remove heavy metal contamination from sludge in a compressed time schedule.

SOLUTION

Completed laboratory-scale pilot study using electrokinetic processes to verify the effectiveness of the ECGOkinetics technology in simultaneously remediating a variety of heavy metals from wastewater treatment sludge.

RESULTS

The ECGOkinetics laboratory-scale study was successful in demonstrating the removal of heavy metals from the wastewater sludge. Mobilization and removal of metals, completed during this 30 day study, achieved percent reductions of metals ranging from 78% to 99%.

ElectroChemical GeoOxidation

MANTECH ENVIRONMENTAL CORPORATION

ECGOKINETICS USED TO SUCCESSFULLY REMOVE HEAVY METALS FROM WASTEWATER TREATMENT PLANT SLUDGE

In 1992, P+P Geotechnologies was retained to implement an ECGOkinetic feasibility study of wastewater sludge from a treatment plant in Brandenburg, Germany. The sludge contained a variety of heavy metal constituents, with the highest concentrations consisting of lead at 2,415 mg/kg, zinc at 2,338 mg/kg, copper at 337 mg/kg, and chlorides at 300 mg/kg.

The feasibility study consisted of treating 3,400 cubic meters of sludge within two, one cubic-yard stainless-steel containers. The ECGOkinetic process was applied using two electrodes placed within the containers and the system was operated on a continuous basis for 30 days. The initial characterization and final verification sampling and analysis results, which were collected and analyzed by an independent analytical laboratory, are summarized below.

Results from Ecgokinetic Treatment of Wastewater Treatment Plant Sludge Brandenburg, Germany

Metal Constituent	Inital Conc. (mg/kg)	Final Conc. (mg/kg)	% Reduction
Lead	2,415	317	87%
Cadmium	335	36	89%
Total Chromium	60	13.2	78%
Mercury	8.7	<0.1	99%
Zinc	2,338	95	96%
Copper	337	20.2	94%
Nickel	60	3	95%
Arsenic	10	<0.1	99%
Cobalt	11.4	1.1	90%
Molybdenum	3.6	<0.1	97%
Vanadium	18.6	1.2	94%
Tin	39	2.7	93%
Chloride	300	10.7	96%

These feasibility study results underscore the effectiveness of the ECGOkinetic process to remove heavy metal constituents.

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