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REMEDIAL ACTION PLAN SITE 1159 BRONSON FIELD WITH TRANSMITTAL LETTER NAS PENSACOLA FL

9/6/2002

TETRA TECH

REMEDIAL ACTION PLAN
for
SITE 1159

OUTLYING LANDING FIELD BRONSON
Pensacola, Florida

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order 0112

September 2002

TETRA TECH NUS, INC.
800 Oak Ridge Turnpike, A-600 ▪ Oak Ridge, Tennessee 37830
(865) 483-9900 ▪ FAX: (865) 483-2014 ▪ www.tetratech.com

0902-153

September 6, 2002

Project Number N0401

Ms. Tracie Vaught
Remedial Project Manager
Technical Review/Federal Facilities
Florida Department of Environmental Protection
2600 Blair Stone Road
Mail Station 4535
Tallahassee, Florida 32399-2400

Reference: CLEAN Contract Number N62467-94-D-0888
Contract Task Order (CTO) Number 0112

Subject: Remedial Action Plan
Site 1159
Outlying Landing Field Bronson
Pensacola, Florida

Dear Ms. Vaught:

Tetra Tech NUS Inc. (TtNUS) is pleased to submit two copies the final Remedial Action Plan for Site 1159 at Outlying Landing Field, Bronson Pensacola, Florida, for your review. This report has been prepared for the U.S. Navy Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) under CTO 0112, for the Comprehensive Long-term Environmental Action Navy (CLEAN) Contract Number N62467-94-D-0888.

If you have any questions regarding the enclosed material, or if I can be of assistance in any way, please contact me at (850) 385-9899, or e-mail at walkerg@ttnus.com.

Sincerely,

Gerald Walker, P.G.
Project Manager

Enclosures

GW:cf

c: Mr. B. Glover, SOUTHNAVEFACENGCOM
Mr. G. Campbell, NAS Pensacola NPWC
Ms. D. Wroblewski, TtNUS (cover letter only)
Mr. M. Perry, TtNUS (unbound copy)
Mr. Mike Albert, TtNUS (cover letter only)
Tallahassee Project File
Project Office File N0401.0000.FL0160215

PROFESSIONAL ENGINEER CERTIFICATION

I hereby certify that this document, *Remedial Action Plan for Site 1159*, Outlying Landing Field Bronson, Pensacola, Florida, was prepared under my direct supervision. The work and professional opinions rendered in this report were conducted or developed in accordance with commonly accepted procedures consistent with applicable standards of practice.

Tetra Tech NUS, Inc.
800 Oak Ridge Turnpike, Suite A-600
Oak Ridge, Tennessee 37830
Certificate of Authorization No. 7988

Michael F. Albert
Professional Engineer
State of Florida License No. 55239

Michael F. Albert
9/6/2

Rev. 2
09/06/02

REMEDIAL ACTION PLAN
FOR
SITE 1159

OUTLYING LANDING FIELD BRONSON
PENSACOLA, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:
Tetra Tech NUS, Inc.
661 Andersen Drive
Foster Plaza 7
Pittsburgh, Pennsylvania 15220

CONTRACT NO. N62467-94-D-0888
CONTRACT TASK ORDER 0112

SEPTEMBER 2002

PREPARED UNDER THE SUPERVISION OF:

Michael F. Albert FOR

GERALD WALKER, P.G.
TASK ORDER MANAGER
TETRA TECH NUS, INC.
TALLAHASSEE, FLORIDA

APPROVED FOR SUBMITTAL BY:

Debbie Wroblewski

DEBBIE WROBLEWSKI
PROGRAM MANAGER
TETRA TECH NUS, INC.
PITTSBURGH, PENNSYLVANIA

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ACRONYMS

AFCEE	Air Force Center for Environmental Excellence
AFVR	Aggressive Fluid Vapor Recovery
ASTM	American Society for Testing and Materials
AVGAS	Aviation gasoline
bls	below land surface
BTEX	Benzene, toluene, ethylbenzene, and xylene
CAR	Contamination Assessment Report
CARA	CAR Addendum
CLEAN	Comprehensive Long-term Environmental Action Navy
COC	Chemical of Concern
CTO	Contract Task Order
DO	Dissolved oxygen
DPT	Direct Push Technology
EDB	Ethylene dibromide
F	Fahrenheit
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FID	flame ionization detector
ft	feet
ft^2	square feet
ft^3	cubic feet
GAC	granular-activated carbon
GCTLs	Groundwater Cleanup Target Levels
gpm	gallons per minute
lbs	pounds
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
MW	Monitoring Well
MWR	Morale, Welfare, and Recreation
MPE	Multi-Phase Extraction
MPES	Multi-Phase Extraction System
MTBE	Methyl Tertiary Butyl Ether
NADCs	Natural Attenuation Default Concentrations
NAS	Naval Air Station
Navy	United States Navy

NPWC	Navy Public Works Center
O&M	Operations and Maintenance
OLF	Outlying Landing Field
ORP	Oxygen reduction potential
OSHA	Occupational Safety and Health Administration
OVA	Organic Vapor Analyzer
PAHs	polynuclear aromatic hydrocarbons
POTW	Publicly Owned Treatment Works
ppb	parts per billion
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
TCL	Target Compound List
TRPHs	Total recoverable petroleum hydrocarbons
TtNUS	Tetra Tech NUS, Inc.
USEPA	U.S. Environmental Protection Agency
UST	Underground storage tank
VE/GE	Vapor Extraction/Groundwater Extraction
VOAs	volatile organic aromatics
VOCs	volatile organic compounds

EXECUTIVE SUMMARY

Tetra Tech NUS, Inc., (TtNUS) has completed a Remedial Action Plan (RAP) for Site 1159 at the Outlying Landing Field Bronson, Pensacola, Florida, in accordance with the requirements of Chapter 62-770, Florida Administrative Code. This plan is being submitted to the Florida Department of Environmental Protection for approval.

The following tasks were performed during the RAP:

- Reviewed the Contamination Assessment Report and Contamination Assessment Report Addendum (NPWC, 1997; TtNUS, 2001)
- Evaluated remedial alternatives to address groundwater and free-product contamination
- Prepared a RAP to remove free product, remediate contaminated groundwater, and provide remedial equipment specifications
- Specified a sampling plan to track the remediation status of the site.

The remedial action goals of this RAP are to (1) identify a method to perform free-product recovery and (2) select a remedial alternative to reduce hydrocarbon and lead constituents within the groundwater matrix. This RAP identifies bioslurping, a variation of Multi-Phase Extraction, for free-product recovery and groundwater pump and treat for groundwater remediation, with discharge to the local publicly owned treatment works as the selected alternative for remediation at Site 1159. This remedial alternative was selected because it was determined to be the most effective method for removal of free product and remediation of groundwater impacted by aviation gasoline. If implemented, approximately 12 to 18 months will be required for system design and construction. Active remediation will occur for approximately five years for free-product recovery and five additional years for groundwater pump and treat. Post-active remediation and/or natural attenuation monitoring will take place for approximately a further five years.

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

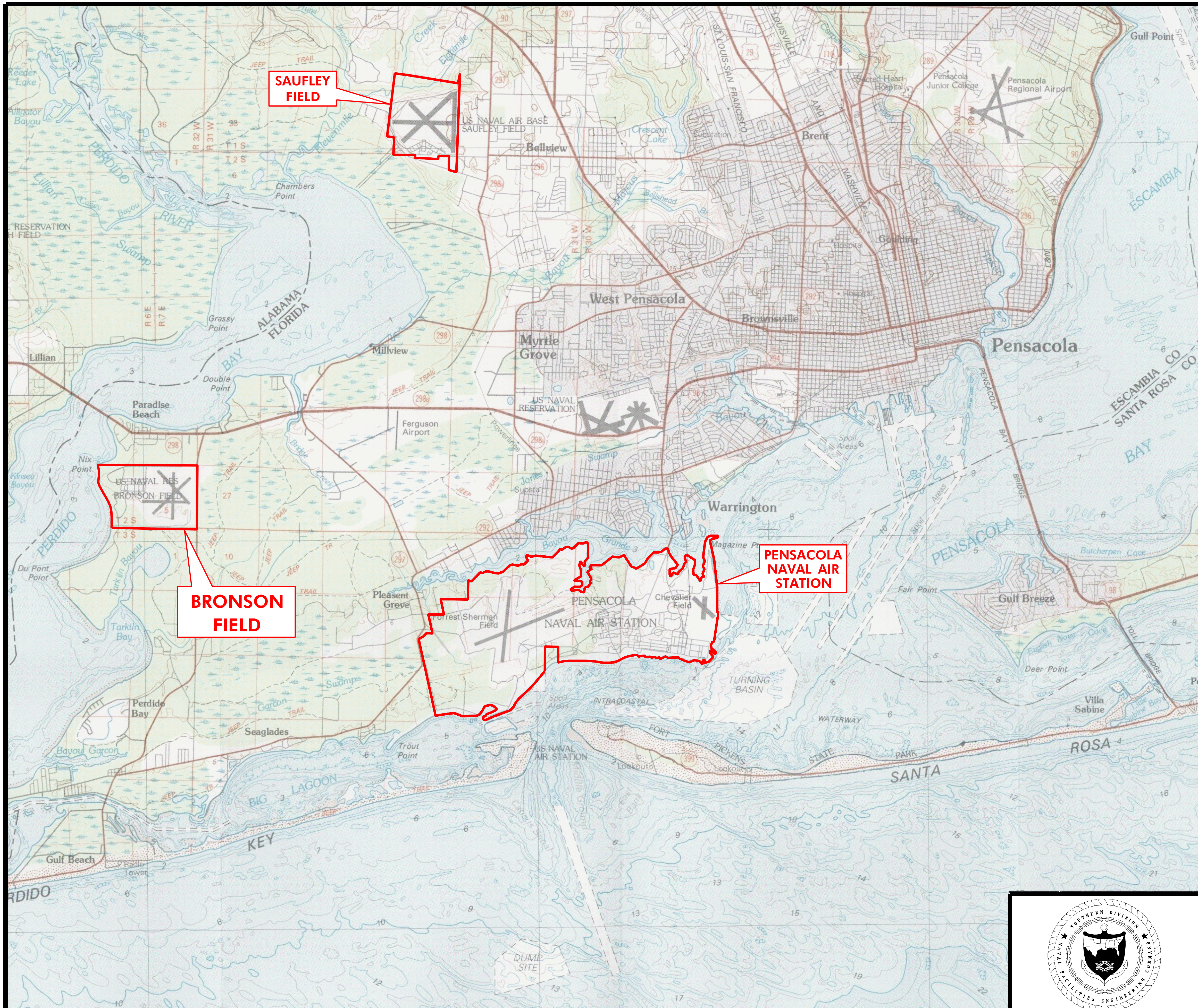
This Remedial Action Plan (RAP) was prepared by Tetra Tech NUS, Inc., (TtNUS) for the United States Navy (Navy) Southern Division, Naval Facilities Engineering Command under Contract Task Order (CTO) 0112, for the Comprehensive Long-term Environmental Action Navy (CLEAN), Contract Number N62467-94-D-0888. The RAP was prepared to recommend treatment options for the contaminated groundwater and free-phase hydrocarbons (free product) present at Outlying Landing Field (OLF) Bronson, Site 1159, Pensacola, Florida, as a result of a release of aviation gasoline (AVGAS) fuel at the site (NWPC, 1997).

In June 1997, a Contamination Assessment Report (CAR) for OLF Bronson, Site 1159, was submitted by Naval Air Station (NAS) Pensacola, Navy Public Works Center (NPWC) to Florida Department of Environmental Protection (FDEP) for review. A Contamination Assessment Report Addendum (CARA) was completed for the site and submitted to FDEP on May 22, 2001 (TtNUS, 2001). Following submission of the CARA, the FDEP requested preparation and submittal of a RAP to address the AVGAS fuel released at Site 1159.

The purpose of this RAP is to determine a remedial alternative to address impacted groundwater and free product in accordance with the requirements of Chapter 62-770 F.A.C. This RAP will evaluate applicable alternatives that protect human health and the environment, reduce hydrocarbon constituent concentrations within impacted groundwater, and retard further migration of hydrocarbon constituents to downgradient areas. The RAP will also provide a conceptual design for the selected remedial alternative.

1.2 SITE DESCRIPTION

Site 1159 is within the confines of OLF Bronson. OLF Bronson is located in northwest Florida on the east side of Perdido Bay, approximately five miles west of Pensacola, Florida, and approximately one mile from the Alabama state line. Located on OLF Bronson are four abandoned airstrips and the remains of old airfield support buildings. OLF Bronson is now known as the Blue Angel Recreation Park and is used for recreation purposes (NPWC, 1997). Figures 1-1 and 1-2 illustrate the site location and site vicinity, respectively. OLF Bronson consists of approximately 950 acres of mostly grass and forest. The surrounding area is sparsely populated. Two small communities, Paradise Beach and Perdido Heights, are approximately one mile north of the old airfield. A few houses are located around the perimeter of the old airfield, but most of the surrounding area is wetland, forest, or the waters of Perdido Bay. Scattered residential structures, mobile homes, farm buildings, stores, and churches are north,



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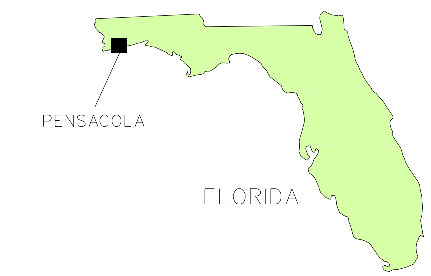

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SCALE IN FEET

FIGURE 1-1

SITE LOCATION MAP
UST SITE NO. 1159
REMEDIAL ACTION PLAN

OUTLYING FIELD BRONSON
PENSACOLA, FLORIDA

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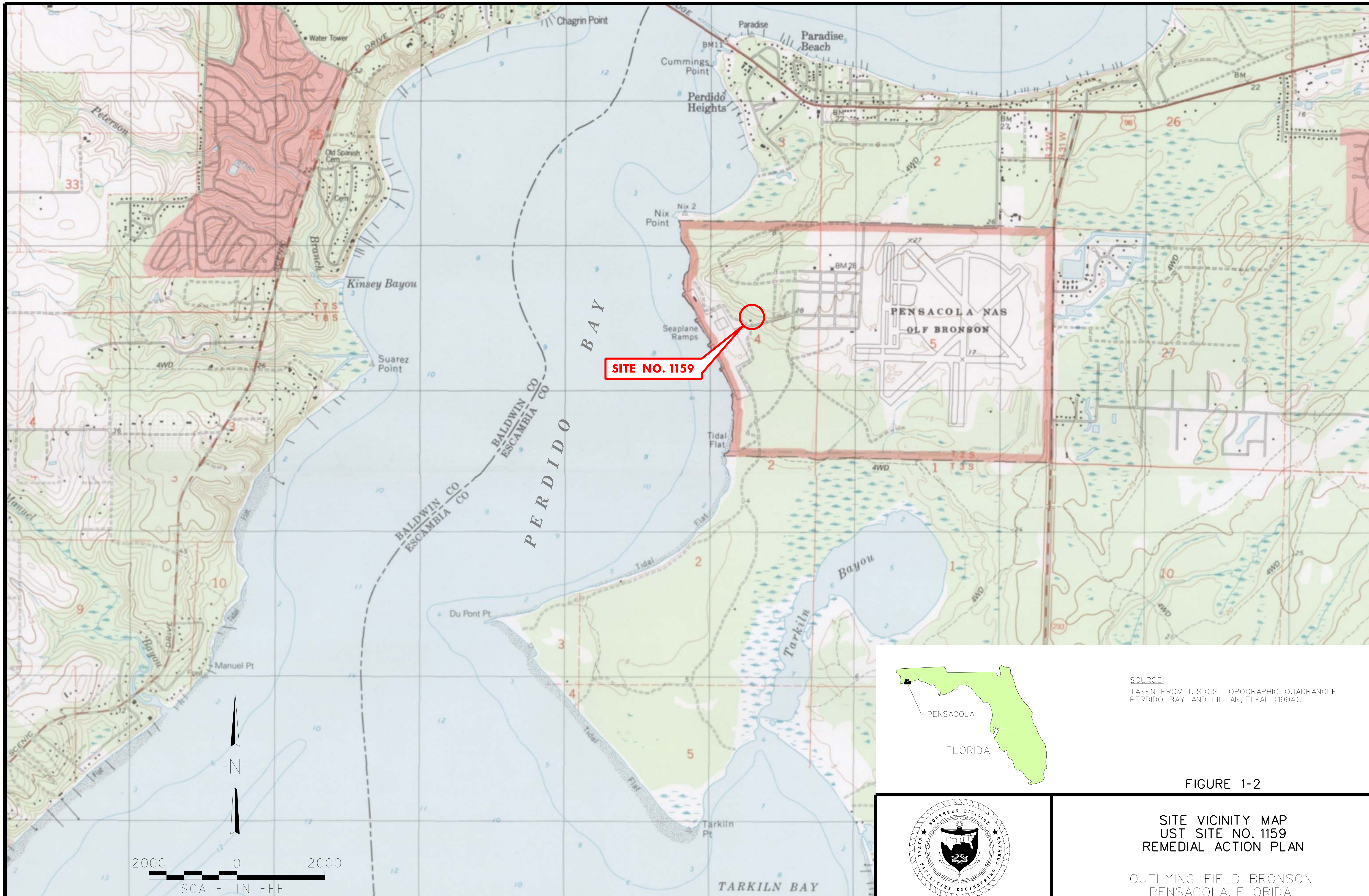

SOURCE:
TAKEN FROM U.S.G.S. TOPOGRAPHIC QUADRANGLE PERDIDO BAY AND LILLIAN, FL-AL (1994).

FIGURE 1-2

SITE VICINITY MAP
UST SITE NO. 1159
REMEDIAL ACTION PLAN

OUTLYING FIELD BRONSON
PENSACOLA, FLORIDA

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south, and east of OLF Bronson. Site 1159 is located at latitude 30° 23' 16" N, longitude 87° 25' 09" W. A fuel oil underground storage tank (UST) on the east side of Building 1159 was removed from the site. In addition, six AVGAS USTs northeast of Site 1159 were apparently removed. North of the site are dense woods, to the south is a main dirt road running east to west, to the east are woods (tent camping area) and a road, and to the west is a concrete parking area for campers. Figure 1-3 presents the site plan.

1.3 SITE HISTORY

OLF Bronson was used as an Outlying Landing Field for NAS Pensacola from 1942-1950. When first opened in 1942, the 950-acre airfield was originally called Tarkiln Field but, in 1944, the name was changed to OLF Bronson. During that time, the Base used large amounts of AVGAS, oil products, and solvents. OLF Bronson was closed as an active airfield in late 1950. Helicopters from Combat Support Squadron 16 used the area for occasional training until the squadron was dismantled in 1995. Presently, all the runways are inactive. All buildings at OLF Bronson have been dismantled and parts of the Base have been sold to private parties. Maps of OLF Bronson show that Building 1159 was designated as a Boiler House. The only current employees at Bronson are Morale, Recreation, and Welfare (MWR) personnel. Duties of MWR personnel at OLF Bronson include operating the campground, minor maintenance of the facility, and teaching sailing and windsurfing.

According to the CAR, six 25,000-gallon gasoline tanks and piping were apparently removed in the 1980s. The tanks were used to store AVGAS for refueling. No further information is currently available.

NPWC personnel removed a 500-gallon UST adjacent to Building 1159 on August 15, 1994. The tank, approximately 50 years old, had been used to store diesel for an emergency generator. The closure assessment performed during the tank removal revealed petroleum contamination of the groundwater at levels greater than the allowable FDEP target levels.

1.4 REPORT ORGANIZATION

This report is organized into seven sections. The following is a list of the sections and a brief description of their purposes:

Section 1: Introduction. Supplies the report's purpose, scope, site information, and report organization

Section 2: Contamination Assessment Reports Findings and Conclusions. Reviews the approved CARA and summarizes the CAR and CARA findings and conclusions

Figure 1-3 Site Plan (11X 17)

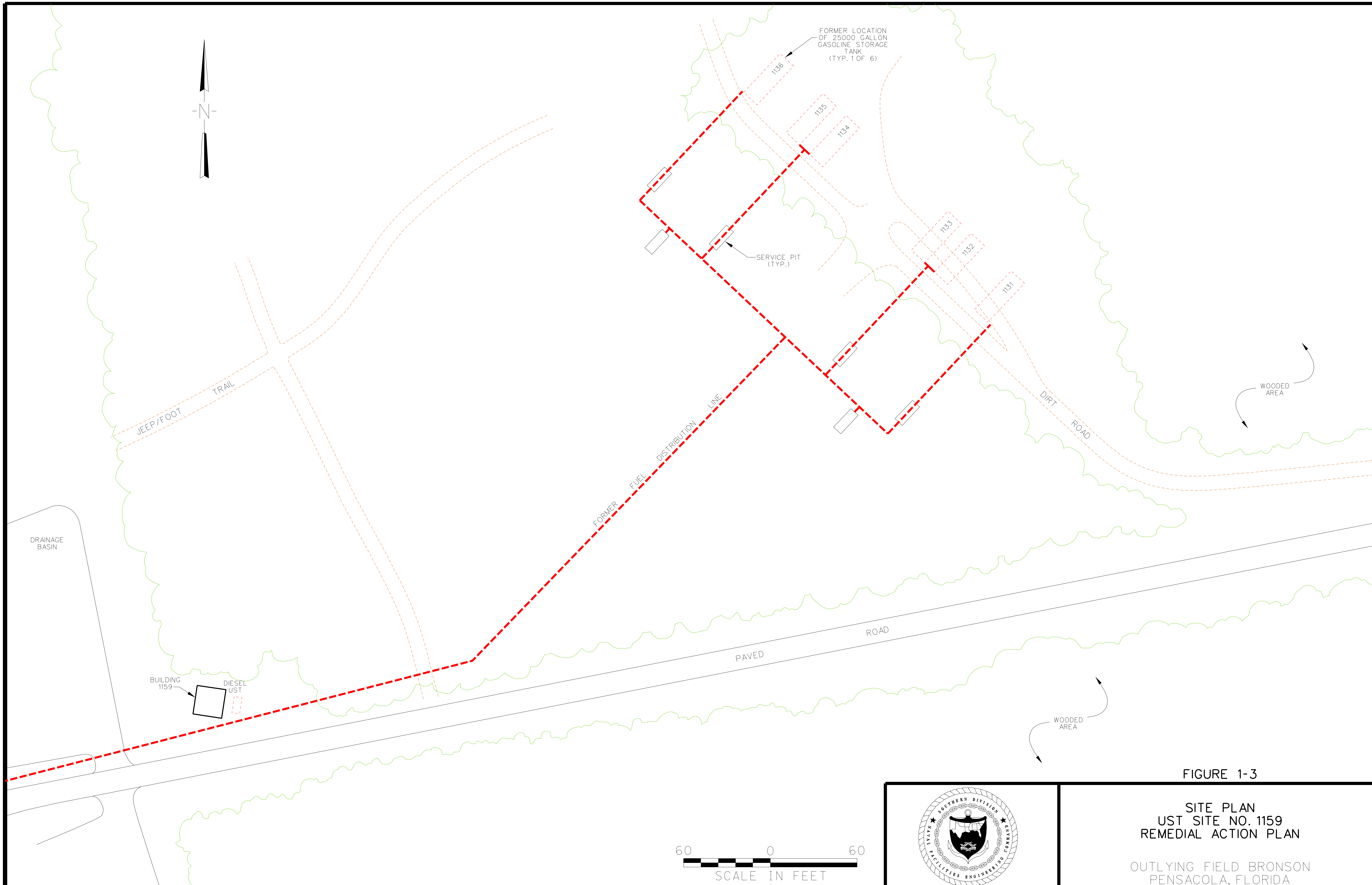

FIGURE 1-3

SITE PLAN
UST SITE NO. 1159
REMEDIAL ACTION PLAN

OUTLYING FIELD BRONSON
PENSACOLA, FLORIDA

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Section 3: Remedial Action Plan Goals. Sets the groundwater and free-product treatment objectives for the remedial system/plan

Section 4: Contaminant Distribution. Estimates the mass of free product in the subsurface and contaminants in the groundwater

Section 5: Remedial Technology Screening. Presents the alternatives for remediation, determines their suitability for the site, and develops budgetary costs for each

Section 6: Remedial System Design. Presents all assumptions made and provides the conceptual design of the preferred remedial alternative

Section 7: Remedial Action Monitoring. Establishes start-up and operations and maintenance (O&M) procedures and provides a monitoring plan for the remediation system and sampling frequencies to evaluate the system's effectiveness.

References: Lists all references used.

2.0 CONTAMINATION ASSESSMENT REPORTS FINDINGS AND CONCLUSIONS

In November 1997, a CAR for OLF Bronson, Site 1159, was submitted by NAS Pensacola NPWC to the FDEP for review. A CARA was completed for the site on May 22, 2001, and submitted to FDEP. The CAR and CARA were conducted to determine the extent of soil and groundwater contamination at the site. The following is a summary of the findings of the CAR and CARA for Site 1159.

2.1 LITHOLOGIC FINDINGS

The area adjacent to Building 1159 is underlain by red/brown silty, fine sand grading to a fine to medium tan to white sand to a depth of 40 feet (ft) at Monitoring Well (MW) 61. At MW-60, 220 ft northeast of Building 1159, beneath the free-product plume is a dark brown medium sand grading to a medium to coarse beige to white sand to a depth of 29.5 ft. MW-61 extends to 40 ft below land surface (bls), which is approximately five ft below sea level and is the maximum depth drilled during the contamination assessment investigation. Site survey data is based on an assumed elevation of 30 ft above sea level at MW-1. Boring logs are located in the CAR and CARA for Site 1159.

2.2 GROUNDWATER AND AQUIFER CHARACTERISTICS

Groundwater elevations were measured and aquifer testing performed in July 2000. The groundwater table at the site occurs between 10 and 20 ft bls and is relatively flat, with variances corresponding to decreases in elevation from east to west. The horizontal hydraulic gradient calculations, which estimate the gradient to be 0.00096 ft/ft, support the observation that there is a negligible horizontal gradient at this site. Using this hydraulic gradient, an average hydraulic conductivity of 3.86×10^{-4} ft/second, and an effective porosity for sand of 0.30, the estimated groundwater seepage velocity is 22 ft/year (TtNUS, 2001). Figures 2-1 and 2-2 present the July 2000 groundwater potentiometric surface map and geologic cross-section, respectively.

The following aquifer parameters were estimated in the CARA (TtNUS, 2001).

Hydraulic conductivity	K	=	33.46 ft per day
Flow velocity	V	=	0.06 ft/day or 22 ft/year
Effective porosity	n_e	=	0.30 (unitless)

2.3 TANK REMOVAL AND INITIAL REMEDIAL ACTION

A closure assessment was performed during removal of the 500-gallon fuel oil UST that consisted of collecting soil and groundwater samples. Soil samples were collected on August 15, 1994 from the center, sides, and bottom of the excavation and analyzed for Priority Pollutants volatiles by EPA Method

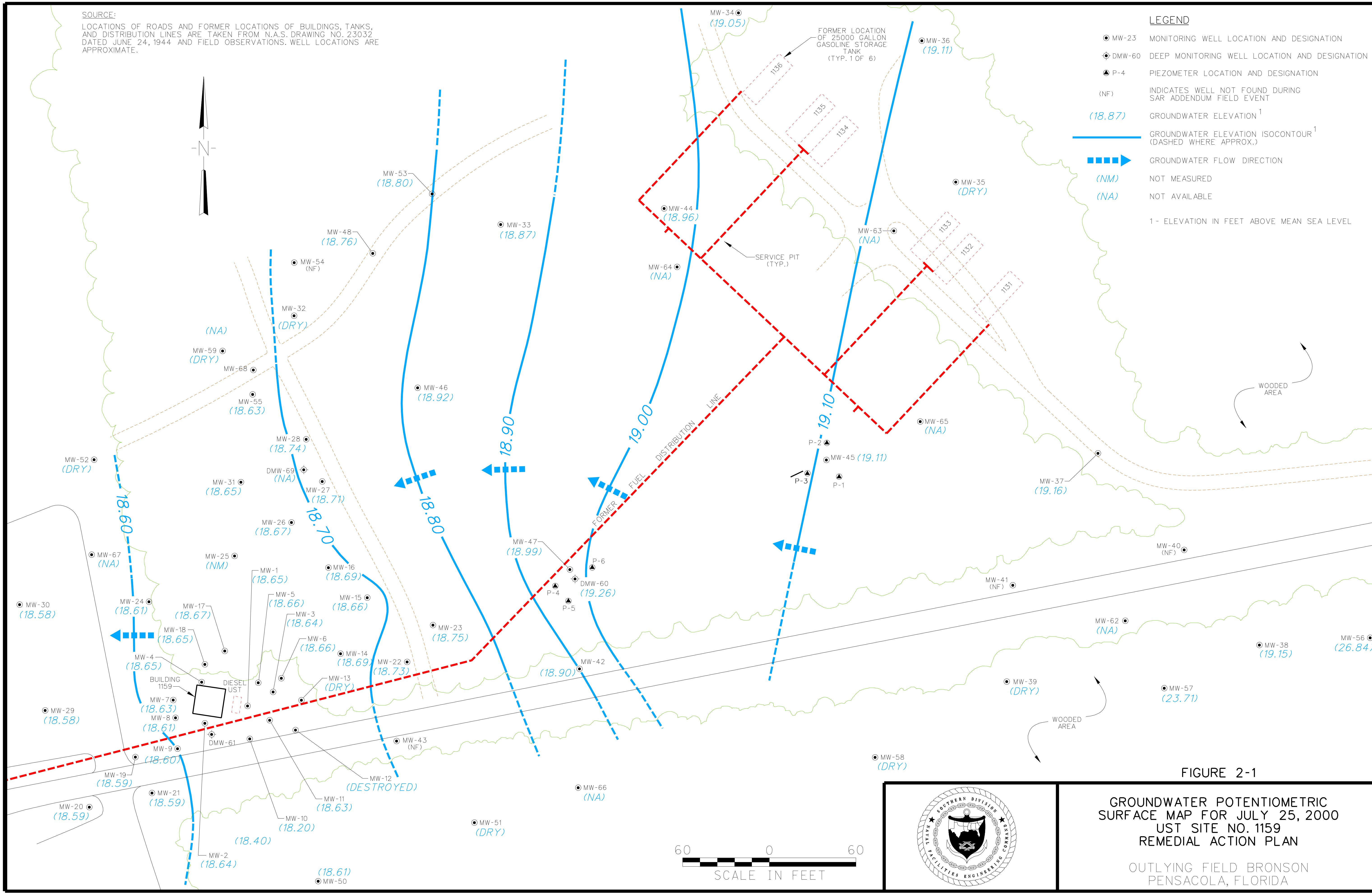
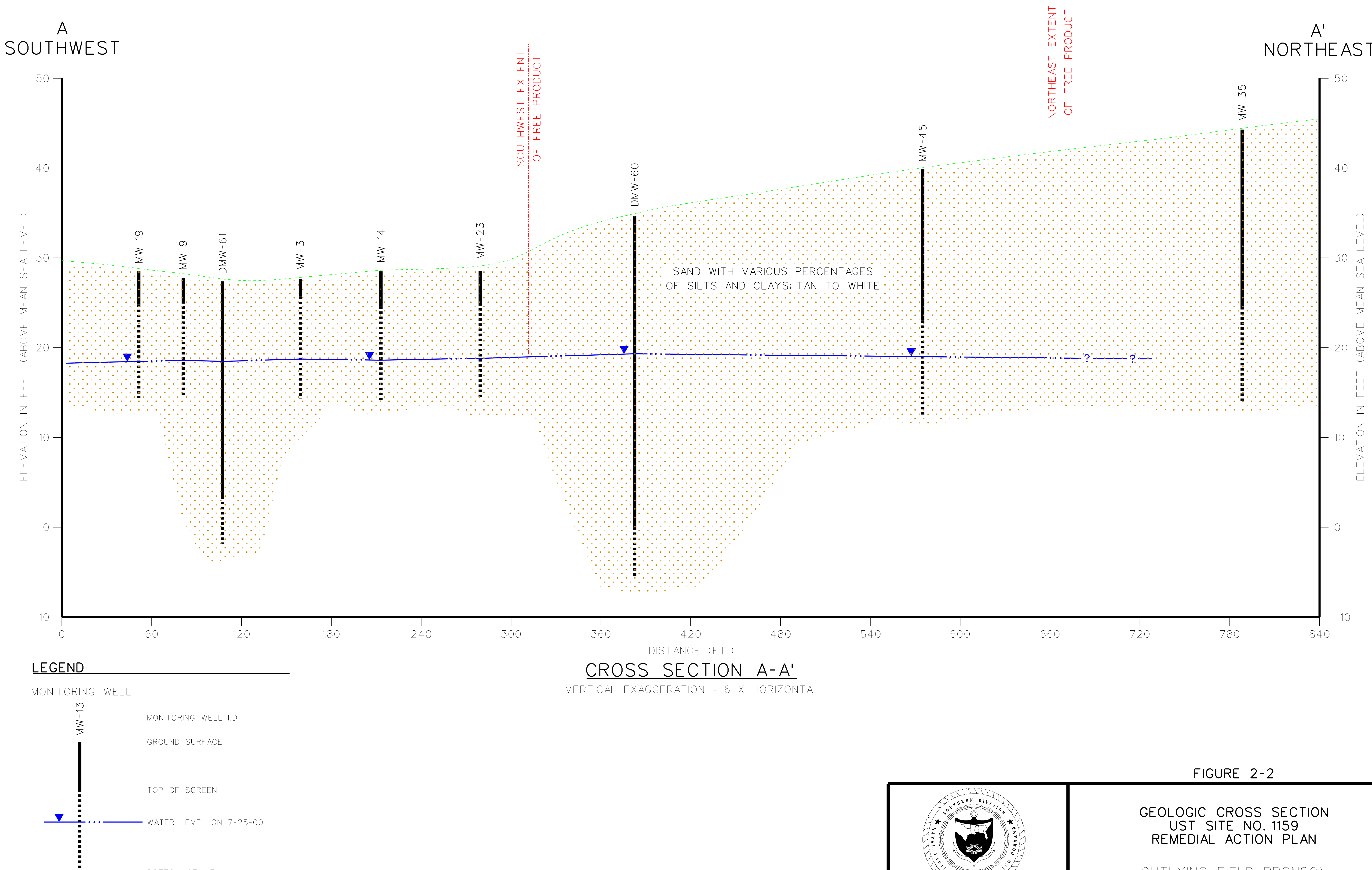


FIGURE 2-1

GROUNDWATER POTENTIOMETRIC SURFACE MAP FOR JULY 25, 2000
UST SITE NO. 1159
REMEDIAL ACTION PLAN

OUTLYING FIELD BRONSON
PENSACOLA, FLORIDA



CROSS SECTION A-A'

VERTICAL EXAGGERATION = 6 X HORIZONTAL

FIGURE 2-2

GEOLOGIC CROSS SECTION
UST SITE NO. 1159
REMEDIAL ACTION PLAN

OUTLYING FIELD BRONSON
PENSACOLA, FLORIDA

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8260. Laboratory analyses of soil samples indicated that contaminants were below detection limits. A shallow groundwater monitoring well (MW-17) was installed at Site 1159 on May 25, 1996 (see Figure 2-3 for well location). A groundwater sample was collected from MW-17 on May 30, 1995, and analyzed for volatile organic aromatics (VOAs) and polynuclear aromatic hydrocarbons (PAHs). The total VOAs and benzene, toluene, ethylbenzene, and xylene (BTEX) detected by EPA Method 8260 in the groundwater were above the FDEP allowable levels. Free product was not observed in the excavation. Information about the removal of the six 25,000-gallon AVGAS USTs is discussed in Section 1.3 - Site History.

2.4 SOIL CONTAMINATION ASSESSMENT

The site soil was assessed from data collected during the field investigations described in the CAR and CARA for Site 1159 (NPWC, 1997; TtNUS, 2001). In 1996, soil samples were collected for the CAR from 57 borings at 3-foot intervals, beginning at 1 ft bls and ending at 1 ft above the groundwater table. Organic vapor analyzer (OVA) readings indicated diesel contamination directly above the water table in the capillary fringe. On June 1, 2000, two soil borings (SB-1 and SB-2) were completed to depths of 24 and 12 ft bls, respectively, at Site 1159 using Direct Push Technology (DPT). OVA readings again indicated diesel contamination directly above the water table in the capillary fringe. Two soil samples were collected from each of the two soil borings and analyzed for compounds specified in the Gasoline and Kerosene Analytical Groups. Contaminants were not detected at concentrations exceeding direct exposure or leachability limits from Chapter 62-777, F.A.C. Therefore, soil was not assessed further.

2.5 FREE-PRODUCT CONTAMINATION ASSESSMENT

- The vertical and horizontal extent of the free-product plume was assessed from data collected during the field investigations described in the CAR and CARA for Site 1159 (NPWC, 1997; TtNUS, 2001). The assessments included plume delineation from plume thickness measurements in vertical monitoring wells during two field efforts. The first assessment performed for the CAR consisted of the installation and sampling of 60 groundwater monitoring wells. Free product existed in MW-45 and MW-47 at a thickness of 0.04 ft and 0.52 ft, respectively. The second assessment performed for the CARA consisted of the installation of six piezometers and eight monitoring wells for free-product plume delineation and for measurement of free-product thickness. Free-product thickness was measured in six monitoring wells (MW-45, MW-46, MW-47, MW-62, MW-64, and MW-65) on July 25, 2000, and in two monitoring wells (MW-45 and MW-47) and five piezometers (P-1, P-3, P-4, P-5, and P-6) on February 15, 2001. See Tables 2-1 and 2-2 for free-product measurement data and Figure 2-3 for the estimated extent of free product present at the site, as indicated in the CARA (TtNUS, 2001).

TABLE 2-1
GROUNDWATER ELEVATION AND FREE-PRODUCT THICKNESS FOR JULY 25, 2000-SITE 1159
OUTLYING FIELD BRONSON, PENSACOLA, FLORIDA
PAGE 1 OF 2

Well Number	Top of Casing Elevation (1) (ft)	Depth to Product BTOC (ft)	Depth to Water BTOC (ft)	Product Thickness (ft)	Groundwater Elevation (2) (ft)
MW-1	30.00	NA	11.35	NA	18.65
MW-2	27.36	NA	8.72	NA	18.64
MW-3	27.66	NA	9.02	NA	18.64
MW-4	26.97	NA	8.32	NA	18.65
MW-5	27.57	NA	8.91	NA	18.66
MW-6	27.68	NA	9.02	NA	18.66
MW-7	27.13	NA	8.50	NA	18.63
MW-8	27.54	NA	8.93	NA	18.61
MW-9	27.89	NA	9.29	NA	18.60
MW-10	27.99	NA	9.79	NA	18.20
MW-11	28.19	NA	9.56	NA	18.63
MW-12	28.24	NA	Destroyed	NA	NA
MW-13	28.39	NA	Dry	NA	NA
MW-14	28.47	NA	9.78	NA	18.69
MW-15	28.18	NA	9.52	NA	18.66
MW-16	27.75	NA	9.06	NA	18.69
MW-17	27.47	NA	8.80	NA	18.67
MW-18	27.70	NA	9.05	NA	18.65
MW-19	28.60	NA	10.01	NA	18.59
MW-20	28.56	NA	9.97	NA	18.59
MW-21	28.27	NA	9.68	NA	18.59
MW-22	28.86	NA	10.13	NA	18.73
MW-23	28.72	NA	9.97	NA	18.75
MW-24	26.73	NA	8.12	NA	18.61
MW-25	27.70	NA	NM	NA	NM
MW-26	28.30	NA	9.63	NA	18.67
MW-27	29.06	NA	10.35	NA	18.71
MW-28	29.21	NA	10.47	NA	18.74
MW-29	25.49	NA	6.91	NA	18.58
MW-30	25.14	NA	6.56	NA	18.58
MW-31	27.20	NA	8.55	NA	18.65
MW-32	32.98	NA	Dry	NA	NA
MW-33	41.49	NA	22.62	NA	18.87
MW-34	44.93	NA	25.88	NA	19.05
MW-35	44.31	NA	Dry	NA	NA
MW-36	44.83	NA	25.72	NA	19.11
MW-37	44.32	NA	25.16	NA	19.16
MW-38	39.63	NA	20.48	NA	19.15
MW-39	32.86	NA	Dry	NA	NA
MW-40	35.61	NA	NF	NA	NA
MW-41	33.36	NA	NF	NA	NA
MW-42	30.88	NA	11.98	NA	18.90
MW-43	28.88	NA	NF	NA	NA
MW-44	42.70	NA	23.74	NA	18.96

TABLE 2-1 (Continued)
GROUNDWATER ELEVATION AND FREE-PRODUCT THICKNESS FOR JULY 25, 2000-SITE 1159
OUTLYING FIELD BRONSON, PENSACOLA, FLORIDA
PAGE 2 OF 2

Well Number	Top of Casing Elevation [(1)] (ft)	Depth to Product BTOC (ft)	Depth to Water BTOC (ft)	Product Thickness (ft)	Groundwater Elevation [(2)] (ft)
MW-45	39.97	20.35	22.88	2.53	18.80
MW-46	34.41	14.97	17.59	2.62	18.59
MW-47	34.74	15.20	17.94	2.74	18.65
MW-48	37.05	NA	18.29	NA	18.76
MW-49	37.99	NA	NF	NA	NA
MW-50	27.10	NA	8.49	NA	18.61
MW-51	27.67	NA	Dry	NA	NA
MW-52	26.91	NA	Dry	NA	NA
MW-53	41.00	NA	22.20	NA	18.80
MW-54	35.76	NA	NF	NA	NA
MW-55	29.94	NA	11.31	NA	18.63
MW-56	43.24	NA	16.40	NA	26.84
MW-57	39.90	NA	16.19	NA	23.71
MW-58	29.10	NA	Dry	NA	NA
MW-59	30.64	NA	Dry	NA	NA
DMW-60	34.78	NA	15.52	NA	19.26
DMW-61	27.39	NA	8.99	NA	18.40
MW-62	NS	18.46	20.39	1.93	NC
MW-63	NS	NA	24.27	NA	NC
MW-64	NS	21.97	23.36	1.39	NC
MW-65	NS	22.04	NA	1.32 (min.)[(3)]	NC
MW-66	NS	NA	9.23	NA	NC
MW-67	NS	NA	9.12	NA	NC
MW-68	NS	NA	13.68	NA	NC
DMW-69	NS	NA	11.20	NA	NC

Notes:

BTOC - Below Top of Casing

NA - Not Applicable.

NF - Not Found.

NS - Not Surveyed.

NC - Not Calculatable without top of casing elevations.

[1] Elevations based upon arbitrary elevation of 30 ft. above mean sea level assigned to the top-of-casing of MW-1

[2] A specific gravity of 0.675 (for gasoline) used in water-level calculations to correct for free product : (depth to water) - (free-product thickness*0.675) = corrected depth to water.

[3] Only free product was detected in this well. No water was observed.

TABLE 2-2
FREE-PRODUCT THICKNESS FOR FEBRUARY 15, 2001-SITE 1159
OUTLYING FIELD BRONSON, PENSACOLA, FLORIDA

Well Number	Depth to Product BTOC (ft)	Depth to Water BTOC (ft)	Product Thickness (ft)
MW-45	19.95	21.44	1.49
P-1	21.04	22.05	1.01
P-2	NL	NL	NL
P-3	18.90	20.60	1.7
MW-47	14.90	16.64	1.74
P-4	15.54	16.49	0.95
P-5	15.91	17.69	1.78
P-6	16.98	48.64	1.66

Notes:

BTOC - Below Top of Casing

NL - Not located.

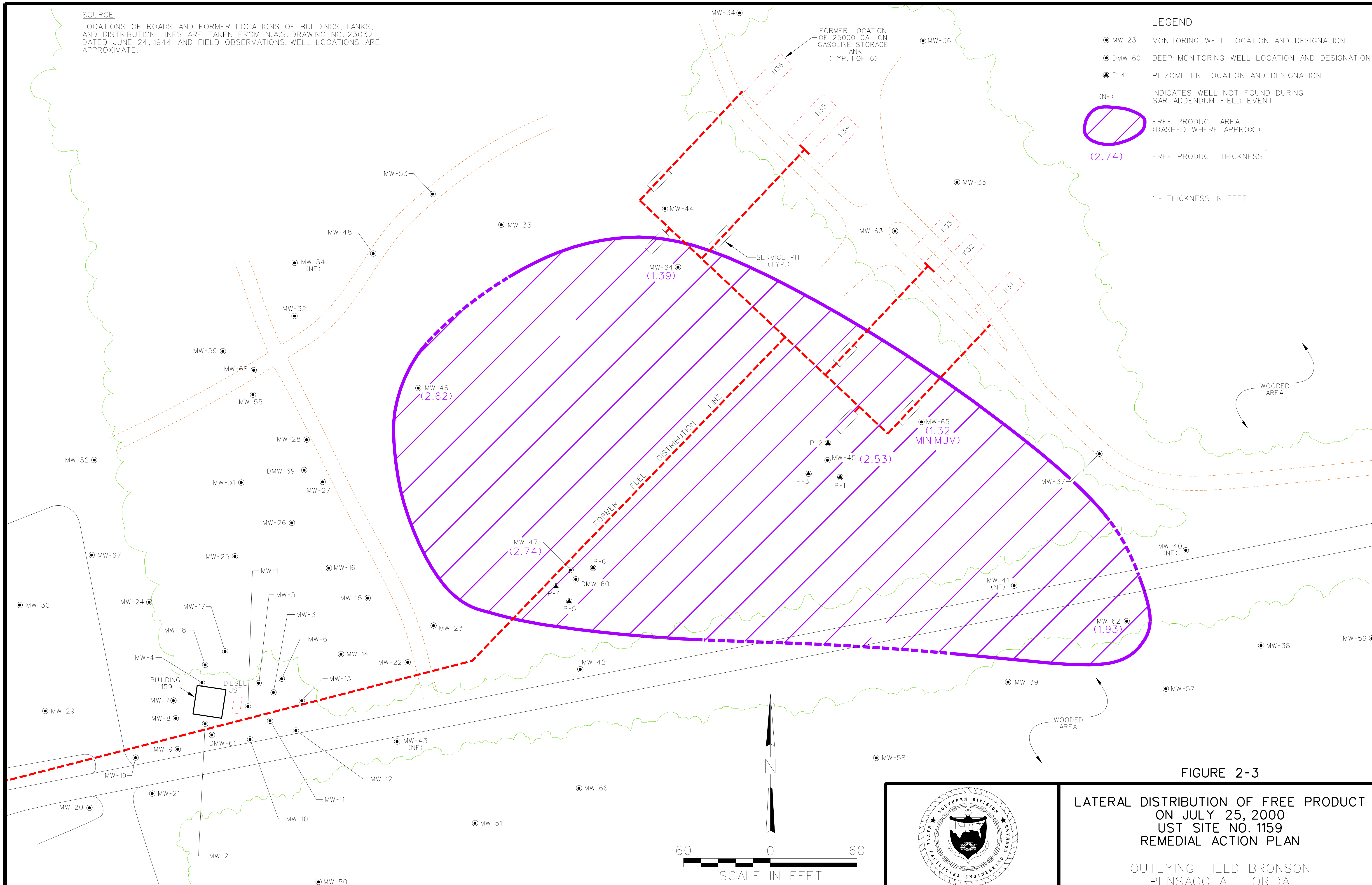

FIGURE 2-3

LATERAL DISTRIBUTION OF FREE PRODUCT ON JULY 25, 2000 UST SITE NO. 1159 REMEDIAL ACTION PLAN

OUTLYING FIELD BRONSON PENSACOLA, FLORIDA

n11x17b.dgn

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The free product measured was low viscosity liquid, similar to AVGAS, and was up to 2.74 ft thick. No laboratory analysis of the free product has been conducted.

2.6 GROUNDWATER CONTAMINATION ASSESSMENT

Sixty-one groundwater monitoring wells (59 shallow and 2 deep) were installed during the CAR investigation (NWPC, 1997) and groundwater samples were collected from the monitoring wells in 1996 and 1997. These groundwater samples were analyzed for VOA, PAHs, Total Recoverable Petroleum Hydrocarbons (TRPHs), ethylene dibromide (EDB), and total lead, using USEPA methods 8260, 8270A, FLPRO, 504, and 7421, respectively. Due to the age of the CAR sampling, these results are not considered in this groundwater quality assessment, but are used to help establish the contaminated groundwater plume limits.

During the performance of the CARA, eight monitoring wells were installed at locations as requested by the FDEP. From July 9 through 11, 2000, groundwater samples were collected from 23 monitoring wells and 6 of the 8 newly installed monitoring wells at Site 1159. Newly installed monitoring wells MW-62 and MW-65 were not sampled, due to the presence of free product. The monitoring well locations are shown on Figure 2-3.

The samples were analyzed for VOAs, TRPHs, and total lead, using USEPA methods 8260B, FLPRO, and 6010B, respectively. In addition, samples from monitoring wells MW-23 and MW-38 were analyzed for EDB, using USEPA method 504. A summary of analytes detected in groundwater is presented in Table 2-3 and exceedances are indicated on Figure 2-4. Seventeen monitoring wells contained analytes at concentrations exceeding FDEP Groundwater Cleanup Target Levels (GCTLs). BTEX was detected at concentrations exceeding the FDEP GCTLs from Chapter 62-777, F.A.C. in 17 groundwater samples. Methy tertiary butyl ether (MTBE) was detected in 12 samples, with concentrations exceeding GCTLs in 2 samples. TRPH was detected in samples from 14 monitoring wells. Detected concentrations of TRPH exceeded the GCTL of 5,000 micrograms per liter (µg/L) in samples from monitoring wells MW-27 (7,070 µg/L) and MW-28 (5,430 µg/L). Lead was detected in 12 groundwater samples, with concentrations in 11 samples exceeding the FDEP GCTL (15 µg/L). EDB was not detected in any groundwater samples.

2.7 CONTAMINATION ASSESSMENT REPORT CONCLUSIONS

The most recent investigative data for the site from the CARA (TtNUS, 2001) concluded the following:

An AVGAS-type free-product plume is present at the site over an approximately 107,000-square foot (ft^2) area, with a measured thickness up to 2.74 ft.

TABLE 2-3
SUMMARY OF ANALYTES DETECTED IN THE GROUNDWATER
UST Site 1159, OLF Bronson, Pensacola, Florida

Parameter	Benzene[2]	Toluene[2]	Ethelbenzene[2]	Total Xylenes[2]	Ethylene dibromide[2]	Methyl tertiary butyl ether[2]	TRPH[3]	Lead[4]
FDEP GCTL[1]	1	40	30	20	0.02	50	5000	15
Sample Location								
MW-1	**547**	**1580[J]**	**195**	**909**	NA	12.2	1750	**99.1**
MW-2	--	--	**44.8**	**83**	NA	--	1210	**97.8**
MW-4	**54.8**	**296**	**52.9**	**262**	NA	24.1	3210	**136**
MW-18	**748**	**5820**	**516**	**3200**	NA	30.2	3720	**62.9**
MW-19	--	--	--	--	NA	--	--	--
MW-20	0.61[J]	4.6	1.2	**21.8**	NA	--	204[J]	--
MW-21	--	0.94[J]	1	**40.3**	NA	--	--	--
MW-22	--	5.3	**162**	**512**	NA	38.6	1180	**31.6**
MW-23	**225**	**1750**	**173**	**1040**	--	--	4240	**189**
MW-23D	**214**	**1590**	**177**	**1030**	NA	9.2[J]	3340	**177**
MW-27	**483**	**2000[J]**	**223**	**1680**	NA	--	**7070**	**809**
MW-28	--	**815**	**238**	**1550**	NA	17.5	**5430**	**566**
MW-30	**1.2**	--	1.9	4.8	NA	--	--	--
MW-33	--	--	--	--	NA	--	--	--
MW-34	--	--	--	--	NA	--	--	--
MW-38	NA	NA	NA	NA	--	NA	NA	NA
MW-44	--	--	0.77[J]	--	NA	5.4	--	--
MW-47	**301**	**5870**	**574**	**3620**	NA	**109**	1670	**46.8**
MW-51	--	--	--	--	NA	--	--	--
MW-52	--	--	--	--	NA	--	--	--
MW-53	--	--	--	--	NA	--	--	--
MW-55	--	**403**	**344**	**1300**	NA	**63**	1540	**70.1**
DMW-60	--	--	--	--	NA	--	--	--
DMW-60 (Duplicate)	--	--	--	--	NA	--	--	--
DMW-61	--	--	--	--	NA	--	--	--
DMW-61 (Duplicate)	--	--	--	--	NA	--	--	--
MW-63	--	--	--	--	NA	--	--	--
MW-64	--	--	14.1	**32.4**	NA	31.1	--	--
MW-66	--	--	--	--	NA	--	--	--
MW-67	**3.1**	4.8	**42.6**	**140**	NA	7.7	945	9.6
MW-68	--	--	**43.2**	**116**	NA	20.6	361	--
DMW-69	--	--	--	--	NA	--	--	--

NOTES:

All units are µg/L

[1] GCTLs in µg/L as provided in Chapter 62-777, F.A.C.

[2] SW-846 8260B, [3] FDEP FLPRO, [4] SW-846 6010B

[J] indicates the presence of a chemical at an estimated concentration.

Bold indicates an exceedance of limits.

-- = not detected

NA = not applicable

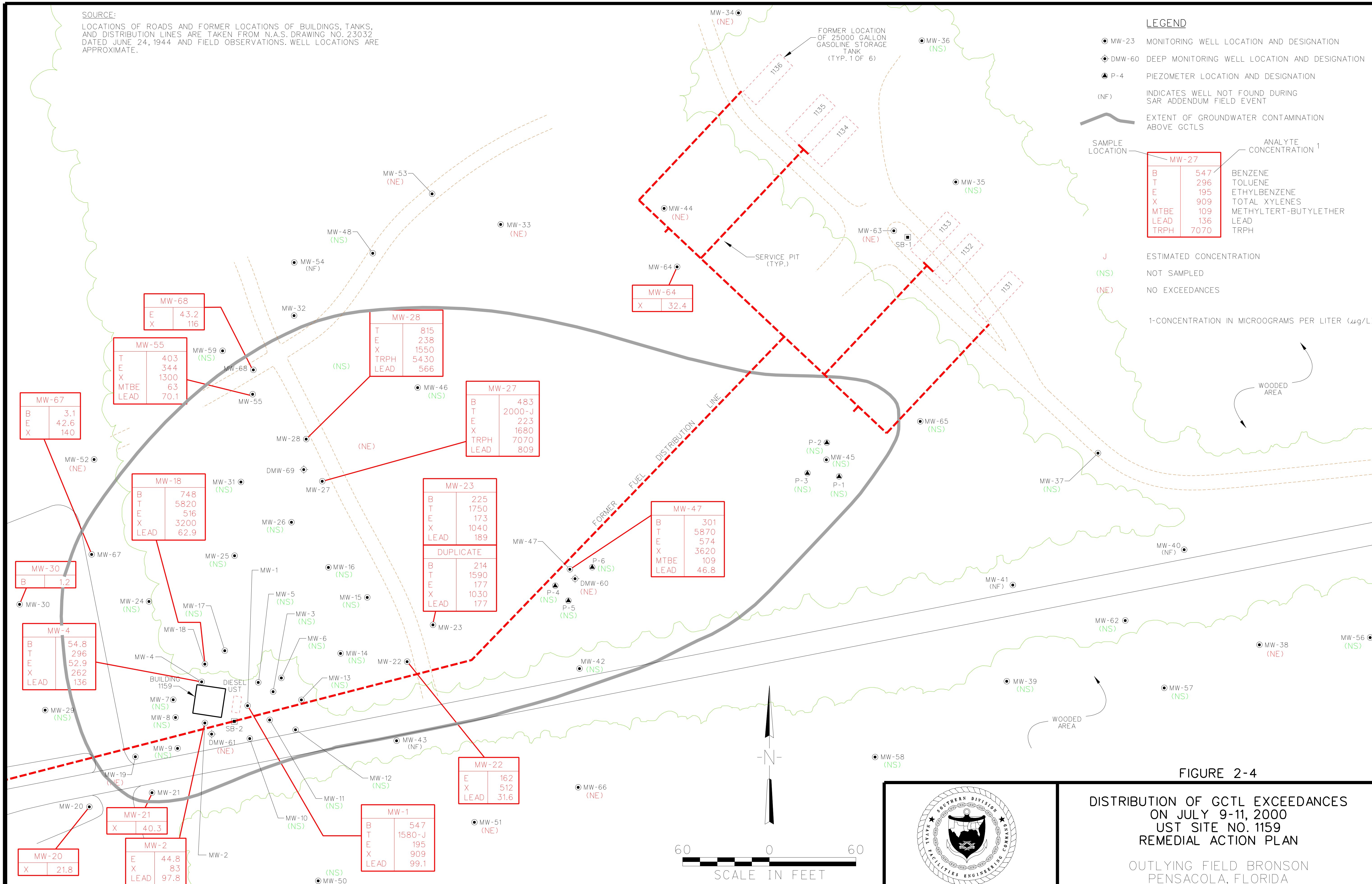

FIGURE 2-4

DISTRIBUTION OF GCTL EXCEEDANCES ON JULY 9-11, 2000
UST SITE NO. 1159
REMEDIAL ACTION PLAN

OUTLYING FIELD BRONSON
PENSACOLA, FLORIDA

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- Soil samples collected from Site 1159 did not contain any analytes at concentrations exceeding FDEP's direct exposure or leachability limits.

- Seventeen monitoring well groundwater samples contained volatile organic compounds (VOC) analytes at concentrations exceeding FDEP GCTLs. The concentration of TRPH exceeded the GCTL (5,000 parts per billion [ppb]) in the groundwater samples from monitoring wells MW-27 (7,070 ppb) and MW-28 (5,430 ppb). Lead was detected in 11 monitoring well groundwater samples at concentrations exceeding the FDEP GCTL (15 ppb).

- Both nested well pairs indicated a vertical gradient of 0.015 ft/ft. However, the vertical gradient for monitoring well pair MW-2/DMW-61 is downwards, while the vertical gradient for monitoring well pair MW-47/DMW-60 is upwards. Therefore, the current vertical gradient investigation is inconclusive.

- The groundwater flows west toward Perdido Bay.

- The horizontal hydraulic gradient calculations, which estimate the gradient to be 0.00096 ft/ft, support the observation that there is a negligible horizontal gradient at this site. Using this hydraulic gradient, a hydraulic conductivity of 3.86×10^{-4} ft/second and an effective porosity of 0.30, the estimated groundwater seepage velocity is 39 ft/year. When retardation is taken into account, the estimated groundwater seepage velocity decreases to 22 ft/year.

2.8 CAR & CARA FINDINGS FOR REMEDIAL ACTION CONSIDERATION

- The site appears to have had two different releases from two different sources. The first source appears to be leaks or spills associated with the removed diesel (fuel oil) UST at Building 1159. The second source appears to be leakage and/or spills around the six AVGAS USTs to the northeast and an associated distribution line. The majority of contamination appears to have been released from the six AVGAS USTs.

- The free-product plume is extensive in area and thickness. The presence of free product may restrict the options available for groundwater remediation. Therefore, a two-phase remedial approach is required. The first phase will consist of aggressive free-product recovery. The second phase will address remaining groundwater contamination, as appropriate.

- The areal extent of impacted groundwater is extensive. Low groundwater gradient and aquifer permeability creates a slow-migrating groundwater plume. The six AVGAS USTs were removed over 20 years ago, but the free-product plume does not appear to have migrated significantly. In addition, the impacted groundwater plume associated with Building 1159 remains centralized around the site, appearing to spread radially as opposed to migrating in any given direction.

- Soil above the groundwater in the area of free product is a fine to medium silty sand with moderate to high permeability. Based on a blow count evaluation of SB-1 data, the sandy soils increase in the relative compactness from medium to moderately dense and relative consistency from stiff to very stiff with depth.

- MTBE occurs in only two wells, one associated with the Building 1159 UST and the other beneath the free-product plume. In either case, groundwater remediation options for BTEX, TRPH, and lead are expected to address MTBE as well.

3.0 REMEDIAL ACTION PLAN GOALS

The objective of this RAP is to present proven, reliable, and cost-effective methods to remediate petroleum-impacted groundwater, remove free product, and protect human health and the environment by reducing the concentrations of hydrocarbons detected at the site to target cleanup levels.

The goals and expected accomplishments of the RAP include the following:

- Identify a method to perform free-product recovery in the source area, to the extent practicable, in accordance with Chapter 62-770.300 F.A.C.

- Select a remedial alternative for BTEX, TRPH, MTBE, and lead contamination in the groundwater.

The GCTLs of Chapter 62-777 F.A.C. apply to the site. In addition, the Natural Attenuation Default Concentrations (NADCs) of Chapter 62-777 F.A.C. also apply for natural attenuation, if applicable, based on monitored site conditions. Table 3-1 presents natural attenuation default concentrations and target levels for the site-specific chemicals of concern.

TABLE 3-1

CHEMICALS OF CONCERN AND ASSOCIATED SELECTED GROUNDWATER CLEANUP TARGET LEVELS

Site-Specific Chemical of Concern	Groundwater Natural Attenuation Default Concentrations	Groundwater Cleanup Target Levels
Benzene	100 μg/L	1 μg/L
Toluene	400 μg/L	40 μg/L
Ethelbenzene	300 μg/L	30 μg/L
Total Xylenes	200 μg/L	20 μg/L
Methyl Tert-Butyl Ether	500 μg/L	50 μg/L
Total Recoverable Petroleum Hydrocarbons	50,000 μg/L	5,000 μg/L
Lead	150 μg/L	15 μg/L

GCTLs and NADCs from Chapter 62-777, F.A.C. (effective August 5, 1999)
μg/L = micrograms per liter

4.0 CONTAMINANT DISTRIBUTION

The contaminant distribution estimate is based on data obtained during the CAR (NWPC, 1997) and CARA (TtNUS, 2001) and assumes no unidentified sources. Calculation methods published by the U.S. Environmental Protection Agency (USEPA) (USEPA, 1996) are used. Calculations of impacted groundwater and free-product limits and mass are an estimate and actual product volumes can vary significantly.

4.1 ESTIMATED MASS OF FREE PRODUCT

Based on the assumed lateral limits of the free-product plume and specific-site characteristics, the total volume of free product was estimated. Data acquired during the contamination assessments determined the presence of free product within the “smear zone” from 10 to 24 ft bls. The lateral limit of the free-product plume, as depicted in Figure 2-3, is estimated to be 107,158 ft^2. The average actual thickness of the free-product layer is estimated to be 1.01 ft, using the De Pastrovich equation (USEPA, 1996). Due to the sandy nature of the subsurface soil and the relatively thick free-product layer, the estimated volume of free product may be slightly exaggerated. Based on February 15, 2000, data, approximately 242,000 gallons (1,363,000 pounds [lbs]) of free product are estimated to be present at Site 1159. See Appendix A for thickness and mass calculations.

4.2 ESTIMATED MASS OF GROUNDWATER AND CONTAMINANTS

The vertical and horizontal extents of contaminated groundwater are estimated from monitoring well measurements and analytical results from the CAR and CARA. The estimated lateral extent of 160,000 ft^2 is depicted in Figure 2-4. The vertical extent or thickness of contaminated groundwater was assumed to be 9.5 ft, based on the absence of contaminants in the deep monitoring wells DMW-60, DWM-61, and DWM-69. The estimated volume of contaminated groundwater is 3,411,000 gallons. The estimated dissolved mass of BTEX, MTBE, TRPH, and total lead in the groundwater plume, as defined by the estimated vertical and horizontal extents, are 67.7 lbs, 0.63 lbs, 57.88 lbs, and 3.77 lbs, respectively. Calculations are presented in Appendix B.

5.0 REMEDIAL TECHNOLOGY SCREENING

A screening of remedial technologies was conducted in order to determine the best remedial alternative for UST Site 1159. Potential remedial technologies and process options for free-product removal and groundwater remediation have been identified and screened, based on effectiveness, implementability, and cost. A significant number of UST sites have been remediated during the past 10 years. This considerable experience with remedial technologies has been used to limit this screening process to commonly used technologies with proven results.

The significant volume of free product and groundwater contamination at the site dictates the need for a two-phase remedial approach. The first phase will consist of implementing an aggressive free-product recovery action. The second phase will follow free-product recovery and consist of groundwater remediation. A significant portion of the plume exists outside the free-product layer, allowing for partial groundwater remediation in conjunction with free-product recovery activities.

The presence of free product and groundwater contaminated with lead limits the applicable options for groundwater remediation, based on a preliminary technology screening (EPA CLU-IN). Options eliminated in this RAP because of current conditions may prove more effective following free-product removal and re-assessment based on actual site conditions at that time. This screening process assumes that all contaminant sources have been identified and that recovered free product will not be a hazardous waste.

5.1 SCREENING OF FREE-PRODUCT REMOVAL TECHNOLOGIES

Based on the CAR and CARA data, an estimated volume of 242,000 gallons of free product is located in the subsurface at Site 1159 (see Appendix A). The plume is spread over a 107,000-ft^2 area. The following methods for removal of free product were screened.

- Subsurface collection trench
- Skimming
- Vapor Extraction/Groundwater Extraction (VE/GE)
- Multi-phase extraction (MPE)
- Water-table depression

The following technologies were eliminated because of effectiveness concerns:

- Subsurface collection trenches were eliminated from this screening because of the site's low horizontal hydraulic gradient and the conflicting results from vertical gradient tests. These hydraulic conditions will slow gravity flow of the free product significantly (increasing cleanup time) and could cause bypass of the system.

- Skimming is also eliminated as a stand-alone remedial technology because of the extent and thickness of the free-product plume. Skimming may be incorporated into a future remedy for the site as a method to recover residual free product, following termination of active recovery. In addition, skimming and/or bailing could be initiated for immediate recovery and evaluation of the freeproduct's chemical and physical properties, which could affect recovery rates and treatment requirements. This engineering data would be the basis for the pilot test and final remedial designs.

- VE/GE technology was eliminated from this screening because of the extensive free product present. VE/GE is only recommended for use after significant free-product removal has taken place (USEPA, 1996).

5.1.1 Multi-Phase Extraction

The approach of MPE is to extract free product and vapor by vacuum-enhanced pumping techniques. The vacuum facilitates freeproduct movement to the extraction point and increases the rate and completeness of recovery. MPE systems (MPES) recover free product and facilitate vapor-based unsaturated zone cleanup through each well point (USEPA, 1996). This approach has several other benefits, compared to other free-product recovery methods. A cone of depression is not formed at the air/oil interface or the air/water interface; therefore, smearing of the free-product zone is minimized. Vapor-phase hydrocarbons in the capillary fringe and mobile free product in the groundwater are collected simultaneously.

MPES are most applicable in medium-to low-permeability media or thin (less than 0.5 ft) saturated thicknesses, with water-table depths of 5 to 20 ft and settings in which conventional pumping approaches or trenches are inappropriate or ineffective. (USEPA, 1996). A lack of accepted design methods for free-product recovery requires the performance of a pilot test to gather site-specific data.

There are two main conceptual approaches to MPE that differ only in the vertical positioning of the pump intake. The first approach consists of recovery of free product and water by a single vacuum/liquids pump placed within the well. The pump intake is positioned below the anticipated groundwater elevation.

The second approach consists of extraction of free product, air, and water with a single vacuum pump placed aboveground, with the extraction point set at the air/product interface. The second technology is commonly referred to as bioslurping.

Bioslurping systems are designed and operated to significantly increase the rate of free-product recovery while minimizing co-extracted groundwater, relative to other MPE methods. Bioslurping also minimizes the free-product smear zone and provides for some removal of residual volatiles in the smear zone by vapor extraction and enhanced biodegradation.

MPE can also be applied by using either an in situ system or via specialized mobile vacuum trucks. The use of mobile vacuum trucks is a variation of MPE known as aggressive fluid vapor recovery (AFVR). AFVR allows sites with small amounts of free product to be remediated via MPE with low capital cost. AFVR is eliminated as an option due to the extensive free product present at this site.

Bioslurping is retained as the MPE option for free product removal because it is a proven technology that can effectively recover the free product at the site. Bioslurping is implemented with conventional equipment that is reliable and durable. In addition, the site is flat and contains no significant structures. Bioslurping capital and O&M costs are relatively high.

5.1.2 Water Table Depression

This method of recovery creates a depression in the water table so that any free product is directed by gravity toward the pumping wells within the plume area. Both free product and groundwater are collected during recovery operations. The design of these systems is constrained by the need to minimize drawdown of the water table to reduce the volume of co-produced water, as well as the smearing of free product along the drawdown surface.

Product recovery systems utilizing water table depression are most applicable when hydraulic control of the hydrocarbon plume is necessary. These systems can operate in a wide range of permeability values and geologic media. However, because of the costs associated with the separation and treatment of dissolved hydrocarbons, these systems are better suited for formations of moderate to low permeability (greater than 10^{-4} centimeters per second).

Water table depression is not the preferred option for free-product recovery at the site, due to effectiveness concerns. The site's low hydraulic gradient would significantly increase recovery time. In addition, water table depression removes less total free product at lower rates and more groundwater during operation, which would greatly increase the overall cost of remediation.

5.1.3 Extracted Liquid Treatment and Final Disposition

Regardless of the extraction option, the extracted liquid will require phase separation, groundwater treatment and discharge, and free product disposal or recycling. The anticipated rate of extraction will be low, at approximately 10 gallons per minute (gpm) for groundwater and 0.07 gpm for free product. The technologies screened are commonly used and are effective and implementable at the site.

5.1.3.1 Phase Separation

The most common technology for phase separation consists of a filter tank followed by an oil/water separator. Turbulence generated by extraction mixes light non-aquious petroleum liquid and water. In some cases, an emulsion of light non-aquious petroleum liquid can form that is stable enough to prevent successful separation in an oil/water separator. Field experience has shown that significant emulsion control can be accomplished by allowing the mixture increased residence time in a filter tank prior to entering the oil/water separator (AFCEE, 1997). Once separated, free product would be collected in a storage tank for removal and recycling. The remaining liquid could require additional treatment prior to discharge. Other options for phase separation, such as dissolved air flotation, are considerably higher in capital and O&M costs and normally are only used under special conditions.

5.1.3.2 Hydrocarbon Treatment

Typically BTEX, MTBE, and TRPH are removed from groundwater through air stripping. Air stripping units are typically capable of a 99-percent removal rate of aromatic petroleum hydrocarbons with moderate O&M. Treatment would be performed using a low-profile air stripper. The most common style is the tray-type unit, in which a shallow layer of water is allowed to flow along one or more trays. Air is blown through hundreds of holes in the bottom of the tray(s) to generate a foam of bubbles. As a result, the surface area of the impacted water is maximized and hydrocarbon constituents at the air-water interface are volatilized and discharged to the off-gas treatment system, which is comprised of a vapor phase granular activated carbon (GAC) unit. Liquid-phase GAC adsorption could be used following air stripping to enhance removal efficiency and to reduce treatment costs for lead.

5.1.3.3 Lead Treatment

Ex situ groundwater treatment for lead can be accomplished by ion exchange, chemical precipitation, or specialized media adsorption/absorption. Vender discussions eliminated other specialized media as cost-effective technologies. Specialized media are typically required for lead concentrations significantly higher than those present at UST Site 1159. Ion exchange and chemical precipitation are discussed below.

5.1.3.3.1 Ion Exchange

Ion exchange is a process in which ions held by electrostatic forces on the surface of a porous solid are exchanged for ions similar in charge in a solution in which the porous solid is immersed. By this means specific constituents can be removed from a solution that contains multiple constituents. Exchange is accomplished by passing the solution through porous solid materials, usually minerals of the zeolite group or specially prepared synthetic resins (plastics) containing large complex molecules. Certain ions in the solution replace ions or groups of ions in the resin or zeolite, from which they can then be washed out. By controlling the acidity, strength, and composition of the solution and the nature of the resin, ions in solution are more or less selectively exchanged for the exchangeable ions that are in the resin. Ion exchange media must be periodically regenerated. Regeneration requires a backwash subsystem and creates a sludge that requires handling and disposal.

Ion exchange units can be designed to remove 99 percent of selected ionic contaminants. Due to the low extraction rate and the relatively low contaminant concentrations expected, the cost for ion exchange is considered moderately high, but significantly lower than chemical precipitation.

5.1.3.3.2 Chemical Precipitation

Groundwater treatment with chemical precipitation involves the addition of chemicals to alter the physical state of dissolved and suspended solids and facilitate their removal. Sedimentation and filtration are then used to remove precipitated particles. Chemical precipitation requires the addition of a coagulating agent and creates significant sludge that requires additional handling and disposal. Chemical precipitation capital and O&M costs are high. Therefore, chemical precipitation is eliminated from further consideration, based on its high relative cost.

5.1.3.4 Treated Groundwater Discharge

The discharge options screened below are effective for discharge of treated groundwater. In addition, the site is flat and contains no significant structures that could interfere with implementation.

5.1.3.4.1 Re-injection with an Infiltration Gallery

An infiltration gallery consists of a shallow trench filled with course aggregate. Treated groundwater would be discharged to the trench and allowed to seep into the ground. An infiltration gallery requires a moderately high capital investment, but will function without O&M costs. A permit is required for re-injection with an infiltration gallery.

5.1.3.4.2 Discharge to Publicly Owned Treatment Works

Discharge to an existing sewer system (Publicly Owned Treatment Works [POTW]) consists of pretreatment and transference to an existing sewer system. The Escambia County Utilities Authority now accepts wastewater from OLF Bronson. A discussion with the Authority's Coordinator of Pretreatment indicated that extracted groundwater with free product removed would be acceptable without further pretreatment. In addition, permitting issues should be minor. The cost of connecting to the existing sewer system would require a capital investment for a dedicated force main from the site to an existing force main at OLF Bronson's north boundary. Costs from discharge fees would be a regular expense, based on flow rate, and are considered moderate.

5.1.3.4.3 Discharged to the Surface

Treated water could be discharged to a drainage basin adjacent to the site to the southwest. Surface discharge would require a gravity pipeline and an National Pollutant Discharge Elimination System permit. Surface discharge normally involves a low capital investment and negligible O&M costs. The cost of permitting must also be considered.

5.2 SCREENING OF GROUNDWATER TREATMENT ALTERNATIVES

Based on the CARA data, a total volume of approximately 3,450,880 gallons of groundwater exhibits hydrocarbon and lead concentrations in excess of FDEP GCTLs. The following alternatives have been identified for remediation of groundwater and will be evaluated in this RAP:

- Natural attenuation
- In situ bioremediation
- Pump and treat
- Passive/reactive funnel and gate.

The following technologies were eliminated, based on effectiveness concerns:

- In situ bioremediation was eliminated from further screening because lead is not readily biodegradable.

- Passive/reactive funnel and gate technology was eliminated from further screening. This technology has been applied to lead treatment of groundwater on a very limited basis. In addition, site hydraulic dynamics are not conducive to a timely remedial duration without significant hydraulic gradient control.

5.2.1 Natural Attenuation

Natural attenuation (also known as passive bioremediation, intrinsic bioremediation, or intrinsic remediation) is a passive remedial approach that depends upon natural processes to reduce the potential impact of petroleum hydrocarbon releases by either preventing constituents being transported to sensitive receptors or by reducing constituent concentrations to less harmful levels. The processes involved in natural attenuation include aerobic and anaerobic biodegradation, dispersion, volatilization, and adsorption.

Petroleum hydrocarbon constituents are generally biodegradable, regardless of their molecular weight, as long as indigenous micro-organisms have an adequate supply of nutrients and toxic substances do not inhibit biological activity. For heavier petroleum hydrocarbons, which are less volatile and less soluble than many lighter components, biodegradation will exceed volatilization as the primary removal mechanism, even though degradation is generally slower for heavier molecular weight constituents than for lighter ones. The essential nutrients required for biodegradation are usually naturally present in the subsurface. Aerobic biodegradation consumes oxygen that, if not replenished, can limit the effectiveness of the biodegradation processes. When the geologic materials at a site are relatively porous and permeable, oxygen is naturally replenished through the soil and groundwater.

Natural attenuation and in situ biodegradation would not be effective as stand-alone options because lead does not biodegrade nor readily naturally attenuate. Results from the BIOSCREEN™ model indicate that, after a 50-year attenuation period, lead levels would still exceed the GCTL near the source area. See Appendix D for modeling results and detailed explanations.

Approximately seven pore volumes of contaminated groundwater at the site will be extracted during free-product recovery. Lead levels could be reduced considerably during free-product recovery. The removal of this volume of groundwater could significantly alter the site's hydrologic dynamics, making natural attenuation a viable option for groundwater remediation.

5.2.2 Groundwater Pump and Treat

Contaminated groundwater can be recovered by using conventional pump and treat techniques from one or more vertical wells, horizontal wells, or trenches. Free-product removal is required prior to groundwater pump and treat. Recovered groundwater would be treated by using an aeration treatment system to strip and remove hydrocarbon constituents and ion exchange to remove lead (see Section 5.1.3).

Experience with the pump and treat technology at sites with similar lithology in Florida indicates that adsorbed petroleum hydrocarbons within saturated zone soil continually leach into the groundwater, and can prolong remedial time periods. Preliminary calculations indicate remediation of the groundwater in 10 years (see Appendix B), if free product were not present.

The bioslurping system could be easily modified to a groundwater pump and treat system by lowering select bioslurping dip tubes into the groundwater or replacing tubes with submersible pumps. Therefore, costs for groundwater treatment are considered moderate. Because a low capital expense would be required for system modification, start-up and testing, and discharge permitting, pump and treat is the selected option for groundwater remediation at this time.

Active groundwater pump and treat remediation will occur in conjunction with free-product recovery. In addition, select wells outside the horizontal extent of the free-product layer could be used to extract groundwater for treatment from areas of high lead concentrations. This mixing would be expected to have little effect on the operation and cost of the MPES. As discussed previously, a re-assessment of site conditions following free-product recovery could allow remediation by natural attenuation and/or in situ bioremediation.

5.3 ALTERNATIVES FROM TECHNOLOGY SCREENING

The remedial technology options for free-product removal and groundwater remediation have been identified and screened according to effectiveness, implementability, and cost. A summary of reasons for retention or elimination of technology options is presented in Table 5-1. Based on the screening results, two alternatives exist.

5.3.1 Alternative One

Alternative One consists of free-product recovery with bioslurping and groundwater remediation by pump and treat, with pretreatment and discharge to a POTW. The pretreatment would include phase separation in an oil/water separator and extracted vapor treatment with GAC. Separated free product would be collected and taken offsite for disposal or recycling.

TABLE 5-1

SUMMARY OF TECHNOLOGY SCREENING

UST SITE 1159

Remedial Goal	Technology Option	Reasons for Selection or Elimination	Comments
Free Product Recovery	Skimming	1. Free-product layer is too extensive. 2. Would greatly extend recovery time.	Eliminated as a stand-alone option, but could be used for recovery of free product residual following termination of bioslurping.
	Vapor Extraction/Groundwater Extraction	1. Only used after extensive free product removal. 2. Bioslurping system would require major modifications.	Eliminated from further consideration.
	Subsurface Trench	1. Low horizontal hydraulic gradient will slow gravity flow of the free product, significantly increasing cleanup time. 2. Low horizontal hydraulic gradient and vertical gradient unknowns could cause by-pass of the system.	Eliminated from further consideration.
	Multi-Phase Extraction (Bioslurping)	1. The free-product plume is extensive in area and thickness. 2. Can significantly increase the rate and quantity of free-product recovery relative to water table depression. 3. Minimizes the free-product smear zone. 4. Minimizes the volume of co-extracted groundwater. 5. Provides a secondary treatment of residual free product in the smear zone by vapor extraction and enhancement of biodegradation.	Selected for free product recovery.
	Water Table Depression	1. A lower production of free product relative to groundwater production, compared to bioslurping. 2. Slower extraction of free product compared to bioslurping. 3. Time required for recovery relatively longer than bioslurping.	Eliminated from further consideration.
Groundwater Remediation	Natural Attenuation	Present data indicates remediation time period too long.	Eliminated as a stand-alone option, but could become viable following free-product recovery.
	In Situ Bioremediation	Lead is not biodegradable.	Eliminated from further consideration.
	Pump and Treat	1. Can be performed with only slight modifications to the bioslurping system required for free-product recovery. 2. System operators will have considerable experience gained during free-product recovery.	Selected for groundwater remediation.
	Passive/Reactive Funnel and Gate	1. Limited application to lead treatment of groundwater. 2. Site hydraulic dynamics are not conducive to a timely remedial duration without significant hydraulic gradient control.	Eliminated from further consideration.

5.3.2 Alternative Two

Alternative Two consists of free-product recovery with bioslurping and groundwater remediation by pump and treat, with onsite treatment and surface discharge. Treatment would include phase separation in an oil/water separator, BTEX removal with an air stripper, extracted and stripped vapor treatment with GAC, and lead removal with ion exchange. Separated free product would be collected and taken offsite for disposal or recycling.

5.4 ALTERNATIVE COMPARISON AND RATIONALE FOR SELECTION

The selection of a preferred remedial alternatives for free-product removal and groundwater remediation is based on long- and short-term human health and environmental impacts, implementability, O&M requirements, reliability, feasibility, anticipated duration, and cost.

5.4.1 Long- and Short-term Human Health and Environmental Impacts

Both alternatives would reduce long-term human health and environmental impacts by the removal and disposal or recycling of free product and treatment of contaminated groundwater from the subsurface at UST Site 1159. Short-term impacts could be minimized by eliminating contact with contaminates through engineering controls and proper handling and disposal of residuals produced during construction and O&M.

5.4.2 Implementability

Both alternatives are implementable, due to the site's flat terrain and the absence of significant structures. In addition, utilities are available in reasonable proximity to the site, including potable water, electricity, communications, and sewer.

5.4.3 O&M Requirements

O&M requirements for the extraction, collection, phase separation, monitoring, and reporting are similar for both alternatives. Since complete groundwater treatment will be required, Alternative Two would have substantially higher O&M requirements for air stripping and ion exchange. Alternative Two's increased complexity would increase downtime for routine O&M, optimization, and non-preventable malfunction. Ion exchange media regeneration and sludge handling constitute the majority of this increased effort.

While the systems for vapor treatment would be similar, Alternative Two would also include influent from the air stripper, requiring a larger system and more frequent GAC change-out.

5.4.4 Reliability

Both systems consist of conventional components with proven reliability if they are operated and maintained properly. Alternative Two is the more complex system, therefore, it would be less reliable than Alternative One, due to increased downtime for routine maintenance and non-preventable malfunction.

5.4.5 Feasibility

Both alternatives are technically feasible. The expertise for design, construction, and operation are regionally (if not locally) available. All components are conventional "off-the-shelf" equipment, readily available from multiple vendors.

5.4.6 Anticipated Duration of Remediation

Both alternatives would have the same duration of operation because the basic remedial process and goals are the same. The alternatives only differ in the level of treatment and the discharge option.

5.4.7 Cost

Detailed cost estimates for both alternatives are presented in Appendix C. The estimated present worth costs for Alternatives One and Two are $1,780,000 and $2,090,000, respectively. The differential in cost consists of Alternative Two's higher capital and O&M costs.

5.5 ALTERNATIVE SELECTION

Alternative One, free-product recovery with bioslurping, groundwater remediation by pump and treat, and discharge to the POTW is selected for site remediation, based on cost. A conceptual design for Alternative One is presented in Section 6.0.

6.0 REMEDIAL SYSTEM DESIGN

Potential remedial technologies and process options for UST Site 1159 were identified and screened. The results are presented in Section 5.0. The selected alternative is free-product recovery with bioslurping, groundwater remediation by pump and treat, and discharge to the POTW.

A phased approach will be used for site remediation. The first phase will consist of free-product recovery. Because groundwater will be co-extracted as a by-product during free-product recovery, some groundwater remediation will be accomplished in the first phase. In the second phase, following the termination of free-product recovery, natural attenuation as a groundwater remediation option will be re-assessed according to data collected during and following free-product recovery. If natural attenuation is still not a viable option, the free-product recovery system will be converted a groundwater pump and treat system. The pump and treat system will be operated until the site data demonstrates that natural attenuation is a viable remedial option.

In an effort to decrease active remediation time, select wells outside the horizontal extent of the free-product layer will be included to extract groundwater from areas of high lead concentrations for treatment during the first phase of site remediation. Submersible pumps will be used to extract groundwater from these wells. Extraction rates from these wells will be low to prevent their influence on the adjacent free-product layer.

6.1 BASIS OF DESIGN

The following design is based on the findings of the preceding sections and assumptions made from literature and engineering judgment. A summary of design criteria follows.

6.1.1 Findings from Preceding Sections

- The selected technologies for free-product recovery and groundwater remediation are multi-phase extraction by bioslurping and groundwater pump and treat.
- Groundwater remediation is required for BTEX, MTBE, TRPH, and total lead.
- The free-product volume is estimated to be 242,000 gallons.
- Contaminated groundwater volume is estimated to be 3,411,000 gallons.

- A reduction of groundwater concentrations for the chemicals of concern below GCTLs or NADCs is required.

- Liquids extracted during bioslurping and pump and treat operations will be pretreated with phase separation and discharged to the POTW. An NPDES permit will be required for discharge.

6.1.2 Assumptions

- A reasonable and technically feasible goal for free-product recovery is five years.

- A maximum of 70 percent of the free product is recoverable.

- Extracted vapor will require treatment.

6.1.3 Design Limitations

At this time, there are few standard design methods for bioslurping systems. A literature review yielded no predictive models or suggested rules-of-thumb for system sizing or remediation period predictions (USEPA, 1994; USEPA, 1996; USEPA CLU-IN; AFCEE, 1997). The standard design for bioslurping is dependent on site-specific pilot testing. The conceptual design presented in this RAP is based on average recovery rates from two field tests performed at Tyndall Air Force Base, Florida, in similar aquifer lithology (AFCEE, 1997) and engineering judgement gained from the design, construction, and operation of MPESs.

6.2 TECHNOLOGY DESCRIPTION AND SYSTEM DESIGN

Major components of the selected remedial alternative will include the following:

- Pre-design engineering data
- Free-product recovery
- Groundwater remediation
- Remedial system operation and maintenance
- Remedial system termination criteria, and
- Site restoration.

See Figure 6-1 for the remedial system layout and Figure 6-2 for the treatment system process flow diagram.

6.2.1 Collection of Engineering Design Data

Sampling and analysis of the free product will be required to evaluate the freeproduct's chemical and physical properties. Properties that will affect recovery rates and pretreatment requirements include, but are not limited to, density, viscosity, molecular weight, total lead, MTBE, and BTEX. This engineering data will be used in planning for a pilot test. The final bioslurping design will be based on pilot test results. Recovered free product will be contained in a plastic tank and disposed or recycled.

An additional round of groundwater sampling and analysis will be performed in accordance with Chapter 62-770.700(3)(c) F.A.C., because the analyses in the CARA are more than 270 days old, the monitoring wells sampled and analyses performed in the CARA will basically be repeated; thus, 30 monitoring wells will be sampled. These groundwater samples will be analyzed for BTEX, MTBE, TRPH, and total lead by the same analytical methods as the CARA (see Section 2.6 for details).

6.2.2 Free-product Recovery

6.2.2.1 General Requirements Prior to the Beginning of Construction Activities

- A utility clearance will be required.
- All operators must be certified to be in compliance with 29 Code of Federal Regulations 1910.120 health and safety requirements.
- The locations of the bioslurping wells, the routes of the collection piping, and the limits of the pretreatment plant and related areas will be surveyed and staked in the field.
- The contractor will prepare all required planning documents, such as an Erosion and Sediment Control Plan, Health and Safety Plan, Removal Action Plan, and Waste Management Plan and also obtain all necessary permits.
- Erosion and sediment controls will be implemented prior to and during site activities.

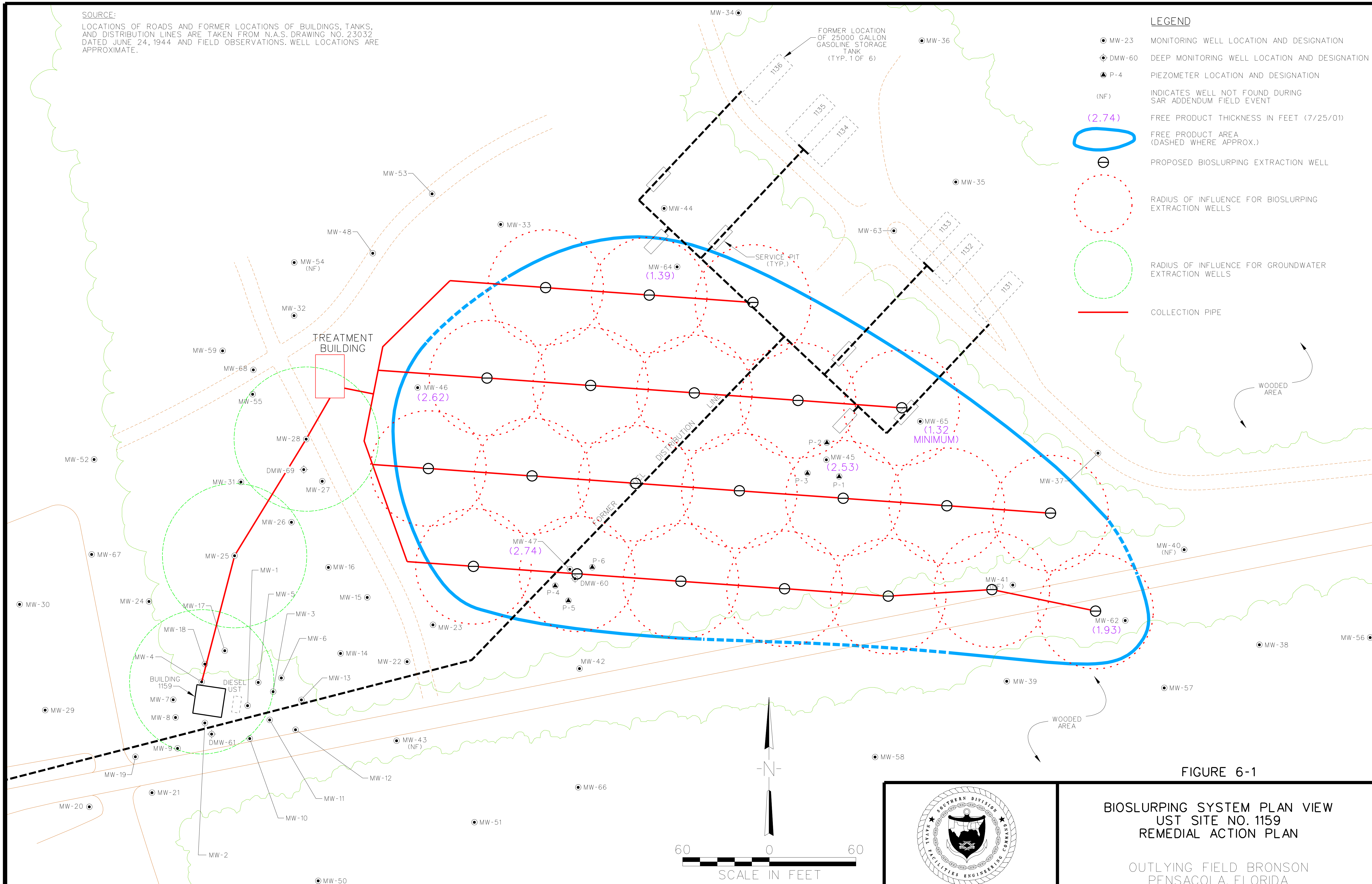


FIGURE 6-1

BIOSLURPING SYSTEM PLAN VIEW
UST SITE NO. 1159
REMEDIAL ACTION PLAN

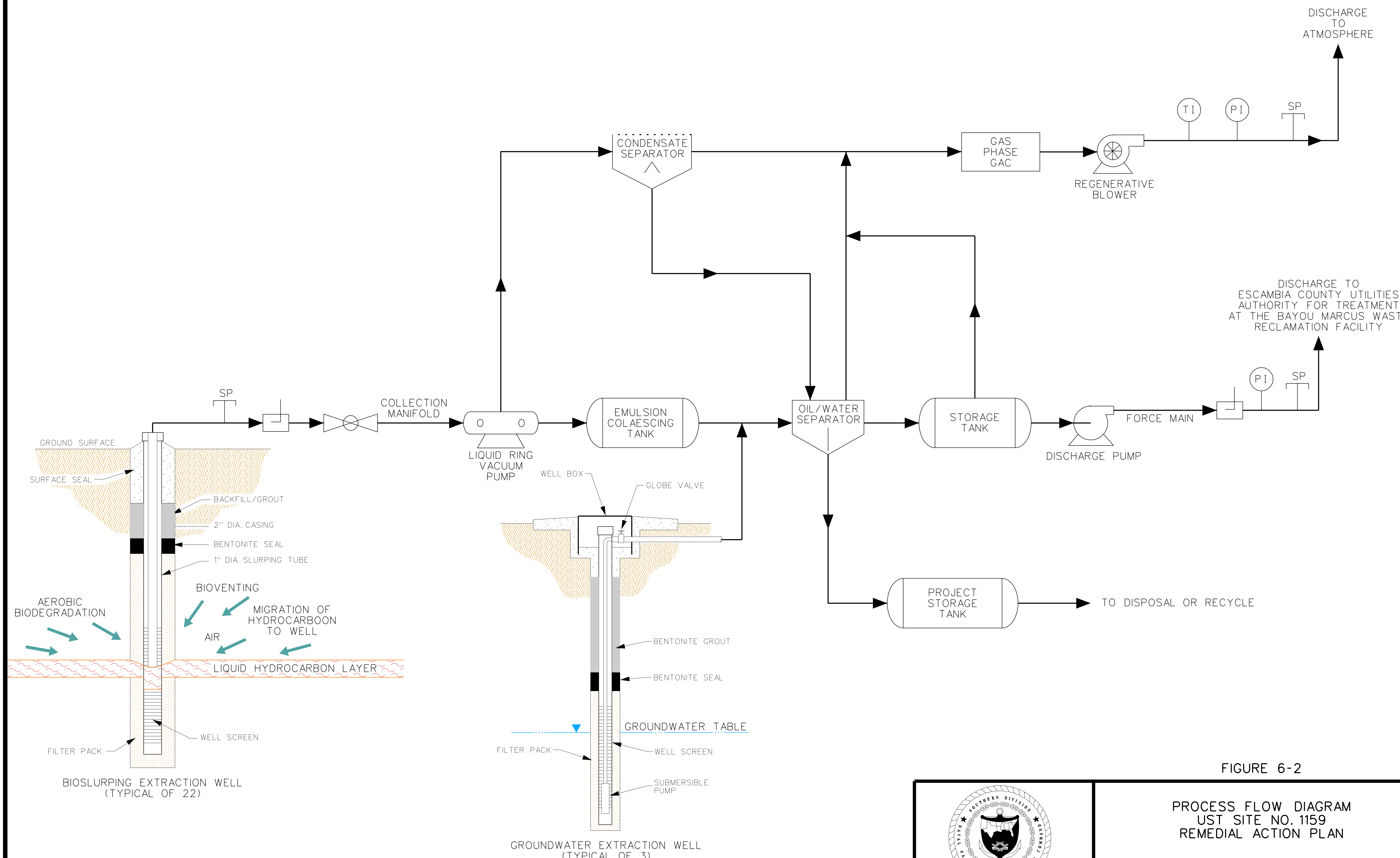


FIGURE 6-2

PROCESS FLOW DIAGRAM
UST SITE NO. 1159
REMEDIAL ACTION PLAN

OUTLYING FIELD BRONSON
PENSACOLA, FLORIDA

n11x17b.dgn

CAD FILE NO./DATE: k:\dgn\navy\pensacol\bronson\ 0401c\ 0401c009.dgn/11-5-01

6.2.2.2 Recovery System Description

The conceptual bioslurping system will consist of 22 4-inch-diameter polyvinyl chloride extraction wells placed on 80-ft centers and ranging in depth from 15 to 27 ft. The wells will be screened from two ft above the groundwater table to three ft below. The wells will be fitted with two-inch-diameter dip or vacuum tubes placed with the intake near the free-product layer. The wells will be constructed to efficiently maintain the operational vacuum. A 20-horsepower liquid ring vacuum pump located at the treatment plant will supply the vacuum. A 100-gallon tank will be located immediately upstream of the vacuum pump to protect against slug surges.

The extracted vapor and fluid will be collected by a system of underground pipelines and transferred to a pretreatment plant. All collection and manifold piping will be two-inch- or four-inch-diameter polyvinyl chloride Schedule 40 pipe. The collection piping trench backfill will be placed in 12-inch lifts and compacted to 90 percent Modified Proctor Density.

The treatment plant will be located west of the well field for isolation purposes. The plant will consist of a metal building on a concrete slab, designed for leakage and spill containment. The plant will have gravel parking and access areas and a chainlink security fence. Electric power, telephone service, and potable water will also be required. The treatment system will consist of separate liquid and vapor trains. See the Process Flow Diagram (Figure 6-2) and the detailed cost estimate (Appendix C) for additional details.

The liquid train will receive fluid from the vacuum pump and include the following components:

- 20-HP liquid ring vacuum pump
- A 1,000-gallon fiberglass filter tank for emulsion control
- A 1,000-gallon fiberglass gravity oil/water separator
- A 1,000-gallon fiberglass product storage tank
- Associated transfer pumps, piping, and instrumentation.

A 50 to 150-cubic feet per minute GAC vapor phase treatment system will receive extracted air from the vacuum pump and off-gas vented from the product storage tank and include associated transfer pumps, piping and instrumentation.

6.2.3 Groundwater Pump and Treat

Free-product rates are expected to gradually decrease in the first phase. When appropriate, based on free-product levels, the system will be modified into a groundwater pump and treat system. Modifications will include extending dip tubes into the saturated zone, replacing select dip tubes with submersible pumps, and installing minor collection piping. The treatment plant will require only minor operational modifications.

6.2.4 Routine Remedial System Operation and Maintenance

The proposed remedial system is designed to operate continually and automatically with minimal maintenance. Site visits for system inspection and maintenance will be performed by a trained and qualified technician in conjunction with regularly scheduled sampling events. The following inspection and maintenance items are scheduled to be performed daily for the first week and biweekly thereafter.

- Inspect system area for signs of trespassing/tampering, weather damage, deterioration, unusual noises, temperature, fire extinguisher charge, and general cleanliness.
- Inspect all signs and markings for condition and legibility.
- Inspect extraction wells and measure flow.
- Inspect and replace any gauge, valve, or sensor found to be leaking or inoperable.
- Inspect free-product holding tank and remove and dispose of accumulated free product. Record volume of free product recovered.
- Inspect air/water separator and filters; remove and dispose of filters, as required.
- Record vapor extraction flow rates and adjust according to requirements.
- Replace GAC vapor treatment canisters, as required.
- Record run time meter readings, groundwater discharge flow rate, and total gallons of water discharged.
- Log all inspection activities and repairs performed.

6.2.5 Remedial System Termination Criteria

The free-product recovery operation will terminate when the follow conditions are met.

- Free-product recovery will be terminated when production rates fall below 0.1 percent of co-extracted groundwater or when thickness in individual wells falls below 0.01 ft.
- Treatment for vapor will terminated when consecutive analyses demonstrate that discharge rates are below 13.7 lbs per day, in accordance with Rule 62-770.700(5)(e) F.A.C.
- Groundwater pump and treat will terminate when site contaminant concentrations meet the natural attenuation criteria in Rule 62-770.690 F.A.C. Natural attenuation monitoring will then be performed according to Rule 62-770-690(7) F.A.C.

Individual free-product recovery wells will be taken off-line as thickness conditions are achieved. These wells will then be modified into groundwater extraction or monitoring wells, or used in passive skimming with adsorbent socks to remove free-product residuals.

6.2.6 Site Restoration

Following completion of remediation, the extraction wells will be abandoned, the collection piping removed, the treatment system dismantled and salvaged, the treatment building and foundation demolished and recycled, and site utilities capped or removed. Erosion and sediment controls will be installed to protect all disturbed areas prior to establishment of permanent vegetation.

7.0 REMEDIAL ACTION MONITORING

The following section outlines the remedial action monitoring required by Chapter 62-770 F.A.C.

7.1 MONITORING PLAN

A system- and site-monitoring program will be initiated upon approval of this RAP and subsequent to the completion of remedial activities. The monitoring plan has the following three main objectives:

- Monitor the overall effectiveness of remedial activities in reducing free-product volume and groundwater contaminant concentrations.
- Verify that the contaminant plumes have not migrated beyond current boundaries.
- Comply with Chapter 62-770 F.A.C.

7.2 SYSTEM AND SITE MONITORING

The proposed monitoring plan includes the following requirements and is summarized in Table 7-1. The final selection of monitoring wells will be based on pre-design and construction data. Initial system start-up and testing will incorporate the requirements below, but will be performed daily for the first three days with a 24-hour analysis turnaround, then monthly for two months, quarterly for the first year, and semi-annually thereafter.

- The remedial system's 22 extraction wells will be monitored on a quarterly basis for free-product thickness, groundwater elevation, individual well pressures, and extraction rates.

- Measurements of groundwater levels in the three groundwater extraction wells and four selected monitoring wells will determine groundwater flow on a quarterly basis.

- Sampling and laboratory testing of groundwater from three groundwater extraction wells and four selected monitoring wells (to document remediation progress) will be performed quarterly for the first two years and semi-annually, thereafter. Groundwater samples will be analyzed for BTEX, TRPH, MTBE, and total lead. Dissolved oxygen (DO), oxygen reduction potential (ORP), pH, temperature, conductivity, and turbidity will also be measured. Preliminary analyses will include total suspended solids, total dissolved solids, iron, and hardness.

TABLE 7-1

REMEDIAL ACTION MONITORING SUMMARY

Monitoring/Sample Location	Parameters	Frequency/Reporting
Monitoring wells (active remediation field measurements)	Water levels, pH, conductivity, turbidity, DO, ORP, and temperature	Quarterly
Monitoring wells and groundwater extraction wells	BTEX, MTBE, TRPH, and total lead	Quarterly
Treatment system influent and effluent	pH, TSS, TDS, Iron, BTEX, MTBE, TRPH, and total lead (or as required by POTW permit for discharge)	Monthly[1,2]
Bioslurping system wells	Free-product thickness and level, flow rate, and vacuum	Quarterly[3]
Groundwater extraction wells	Water levels and flow rate	Monthly
Treatment system	Vacuums, pressures, flows, and phase production quantities	Monthly
Air discharge (treated vapor effluent)	Volatile organic aromatic hydrocarbons	Quarterly[1]
Groundwater monitoring for natural attenuation	NO_3, SO_4, CH_4, and Fe^{2+}	Pre-design and following active remediation
Direct push saturated soil testing	D, K_{OC}, and foc	Pre-design
Monitoring wells (post-active remediation)	BTEX, MTBE, TRPH, and total Lead	Quarterly for one year, then semi-annually

TSS - Total suspended solids
TDS - Total dissolved solids
NO_3 - Nitrate
SO_4 - Sulfate
CH_4 - Methane
Fe^{2+} - Ferrous iron
D - Density
K_{OC} - Partition coefficient
foc - Fraction organic compound

Notes:
1 - Once weekly for first month, monthly for two months, and then quarterly
2 - Preliminary analyses will include TSS, TDS, iron, and hardness or as required for system operation
3 - Once daily for the first three days, once monthly for two months, and then quarterly

- Samples will be collected from four selected groundwater monitoring wells for natural attenuation parameters. These samples will be analyzed for DO, ORP, nitrate, sulfate, methane, and ferrous iron, and any other constituents required for the natural attenuation evaluation.

- Saturated soil samples will be collected by direct push and tested for density, partition coefficient, and fraction organic carbon.

- Free product, groundwater influent and effluent,and extracted vapor will be monitored quarterly at the treatment system for quality and flow rates.

- The gas phase GAC monitoring will be performed as required to predict breakthrough and change-out requirements. The vapor samples will be analyzed for VOA hydrocarbons according to 40 CFR Part 60, Appendix A, Method 18, Section 7. The daily discharge mass will be estimated for comparison to the 13.7 lbs/day limit. If the daily mass estimated from two consecutive sampling events is below 13.7 lbs, vapor treatment will be discontinued.

- Internal treatment systems flows, quality, and pressures will be measured on a monthly basis.

- Additional monitoring and analyses will be performed as needed for system optimization.

If chemicals of concern do not exceed the background concentrations or the applicable GCTLs in samples from the groundwater extraction wells or monitoring wells for three consecutive quarters, these wells may be excluded from subsequent monitoring events, per Rule 62-770.700(3)4(h) F.A.C.

7.3 REMEDIAL ACTION REPORTS

7.3.1 Status/Monitoring Reports

A summary of remedial activities and groundwater monitoring activities will be submitted quarterly, as is required in Rule 62-770.700 (12) F.A.C. The first status report will also include bioslurping system "As Built" drawings and start-up and testing results. Status reports will also include requests and/or documentation for revisions to the remedial goals, system modifications, operation variances, or problems encountered with implemented solutions, per Rule 62-770.700 (13), (14), and (15) F.A.C. As discussed previously, as the system transitions from bioslurping to natural attenuation, the status/monitoring reports will be revised accordingly. Status/monitoring reports will summarize all remedial and monitoring activities and contain at least the following information:

- Startup date
- Total volume of free product recovered and recycled/disposed
- Total volume of groundwater extracted and disposed
- Discharge and disposal analytical results
- Copies of all waste manifests
- System downtimes percentage and evaluation of efficiency for all operating components
- All other sampling, testing, and analytical results
- A figure showing the bioslurping system layout
- A figure showing free product extent
- A figure indicating the locations of all existing monitoring wells
- A figure showing groundwater contour and contaminant maps, and
- Conclusions as to the effectiveness of the remedial activities, prediction of time required for complete remediation, and recommendations on future monitoring and operations of the system.

7.3.2 Request to Discontinue Active Remediation

A request to discontinue active remediation will be prepared and submitted once site conditions warrant at any time during the remedial activities at UST Site 1159. Submittals will be made for termination of free-product recovery, groundwater pump and treat, and natural attenuation monitoring, according to Section 6.2.5 of this RAP and Rule 62-770.700(15) and (16) F.A.C.

7.3.3 Post-Remedial Action Monitoring Plan

Following approval for discontinuation of active remediation, a Post-Remedial Action Monitoring Plan will be prepared and submitted. Groundwater monitoring will continue on a quarterly basis until chemicals of concern fall to predicted natural attenuation concentrations. Monitoring for natural attenuation will then proceed in four wells on an annual basis. Analyses will include BTEX, TRPH, MTBE, and total lead. Status reports will be submitted, as applicable.

REFERENCES

AFCEE (Air Force Center of Environmental Excellence), 1997. Engineering Evaluation and Cost Analysis for Bioslurper Initiative (AOO5), Prepared for the Air Force Center of Environmental Excellence. March 1997.

F.A.C. (Florida Administrative Code), 1999. Petroleum Contamination Site Cleanup Site Criteria, Chapter 62-770. August 1999

NPWC (Navy Public Works Center), 1997. *Contamination Assessment Report (CAR) – Site 1107, U.S. Navy Outlying Landing Field (OLF) Bronson, Pensacola, Florida*. Prepared for Southern Division, Naval Facilities Engineering Command, North Charleston, South Carolina. June 1997.

TtNUS (Tetra Tech NUS, Inc.), 2001. *Contamination Assessment Report Addendum, For Site 1107, Outlying Landing Field (OLF) Bronson, Pensacola, Florida*. Prepared for Southern Division, Naval Facilities Engineering Command, North Charleston, South Carolina. January 2001.

USEPA (U.S. Environmental Protection Agency), 1994. *How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank sites, A Guide for Corrective Action Plan Reviewers*. USEPA 510-B-95-007. October 1995.

USEPA, 1996. *How To Effectively Recovery Free Product at Leaking Underground Storage Tank Sites, A Guide For State Regulators*, USEPA 510-R-96-001. September 1996.

USEPA, CLU-IN. USEPA Clean-up Information Web Page (http;//www.frtr.gov/matrix2/section3/matrix.htm).

APPENDIX A

FREE-PRODUCT VOLUME ESTIMATION

APPENDIX A.1
Estimating Thickness and Volume of Free Product

Remedial Action Plan
Site 1159, Outlying Landing Field Bronson
Pensacola, Florida

Method of de Pastrovich (1979)

$$H_f = \frac{H_o\,(\rho_w - \rho_o)}{\rho_o}$$

Where: H_f = thickness of mobile hydrocarbon in the adjacent formation
H_o = hydrocarbon thickness measured in well
ρ_ω = the density of water
ρ_o = the density of the liquid hydrocarbon

H_o =	63.70	cm	(2.09) ft	(TtNUS 2001)
ρ_ω =	1	gm/cm^3		
ρ_o =	0.675	gm/cm^3		
H_f =	30.67	cm	(1.01) ft	

Assumptions:
1. Density of AVGAS = 0.675 gm/cm^3 (TtNUS, 2001)
2. Product measured = average of 7 wells (TtNUS, 2001)

This method depends only upon the density of the liquid hydrocarbon relative to the density of water. For a hydrocarbon liquid with a density of 0.8, and assuming that the density of water is equal to 1, the hydrocarbon thickness in the formation (the actual thickness) is only one-fourth the thickness measured in the well (the apparent thickness). The principal weakness of this method is that it does not account for the effects of different soil types. In general, the ratio of apparent to true free product thickness increases as soil grain size decreases Thus, this method may be more accurate in finer grained soil (e.g., silt, clay) than coarser-grained soil (e.g., sand, loam).

Estimated Volume of Total Free Product in Subsurface

Assumptions:

Estimated area of free product	=	107,000	ft^2	(TtNUS 2001)
Actual thickness of product	=	1.01	ft	
Effective porosity	=	0.3		(NPWC 1997)

Volume of product area = area x thickness
107,000 ft^2 x 1.01 ft = 107,674 ft^3

Free product volume = volume of product area x effective porosity
107,674 ft^3 x 0.30 = 32,302 ft^3

Gallons of free product = free product volume x 7.4794 gallons/ft^3
32,302 ft^3 x 7.48 gallons/ft^3 = 241,620 gallons

Total volume of free-product in subsurface = 242,000 gallons
1,363,000 lbs

Prepared By: Clifton Blanchard 11/07/01 (Date)

Checked By: PKT 11/09/01 (Date)

Approved By: MFA 11/9/01 (Date)

APPENDIX A.2.

Tetra Tech Nus, Inc. **CALCULATION WORKSHEET**

CLIENT NAVY SOUTH DIV / UST SITE 1159		JOB NUMBER N0401.0000.FL0160205	
SUBJECT ESTIMATE FREE PRODUCT AND GW EXTRACTION RATES			
BASED ON		DRAWING NUMBER	
BY CFB	CHECKED BY PKJ	APPROVED BY 11/09/01 MFA	DATE 10/19/01

PROBLEM: FREE PRODUCT (FP) AND GROUNDWATER (GW) EXTRACTION RATES FOR BIOSLURPING ARE REQUIRED FOR CONCEPTUAL SYSTEM DESIGN. FOR UST SITE 1159.

REFERENCES:

- AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE. "ENGINEERING EVALUATION AND COST ESTIMATE FOR BIOSLURPER INITIATIVE (A005). MARCH 1997. PGS 50-51.
- APPENDIX A.1

APPROACH: EXTRATION RATES ARE ESTIMATED FROM AVERAGES FOR 2 TESTS PERFORMED AT TYNDALL AFB, FL IN SIMILAR AQUIFER MEDIA (SANDY SOILS).

PROCEDURE:

FROM TYNDALL AFB BIOSLURPING TESTS

SUSTAINED FP RECOVERY RATE = 9 GPD/WELL

SUSTAINED GW RECOVERY RATE = 1100 GPD/WELL

AVE. RADIUS OF INFLUENCE = 45 FT
(14 TESTS - AFCEE 1997)

OFFGAS RATE = 6 scfm

APPENDIX 4.2

Tetra Tech Nus, Inc. **CALCULATION WORKSHEET**

CLIENT NAVY / UST SITE 1159		JOB NUMBER 11201	
SUBJECT ESTIMATE BIOSLURPING RATES			
BASED ON		DRAWING NUMBER	
BY CFB	CHECKED BY PKJ 11/09/01	APPROVED BY MAA	DATE 10/20/01

ASSUMING AN AVERAGE RATE FOR DESIGN, RECOVERY TIME BECOMES APPROX. 5 YRS WHERE

FP VOLUME = 242,000 GALS

70% RECOVERABLE = (242,000 GAL)(0.7) = 169,400 GAL

5 YR DAILY RATE = $\frac{169,400 \text{ GAL}}{5 \text{ YR} \cdot 365 \frac{\text{DAY}}{\text{YR}}}$ = 93 GPD (0.065 GPM)

ASSUMING A 40 FT ROI & 22 wells (RAP FIG. 6-1)

FP RECOVERY RATE = 4.23 GPD / WELL

GW EXTRACTION RATE (PROPORTIONAL) = 517 GPD / WELL

FOR THE SYSTEM

GW RATE = $517 \frac{\text{GPD}}{\text{WELL}} \cdot 22$ WELLS = 11,375 GPD

= 7.9 GPM

TOTAL FLUID RATE (BIOSLURPING) = 7.9 + 0.065

= 8 GPM

WITH 3 GROUNDWATER EX. WELLS (0.5 GPM/WELL)

TOTAL FLUID RATE = 1.5 GPM + 8 GPM

= 9.5 GAL/MIN

Use 10 gpm

APPENDIX B

GROUNDWATER CALCULATIONS

APPENDIX B.1.1

Estimated Mass of Dissolved and Adsorbed Contaminants in Saturated Zone

Remedial Action Plan

Naval Air Station Pensacola
Pensacola, Florida

Mass of Soluble Contaminants

Well Number	Benzene (µg/L)	Ethylbenzene (µg/L)	Toluene (µg/L)	Xylene (µg/L)	MTBE (µg/L)	Lead (µg/L)	TRPH (µg/L)	Impacted Thickness (feet)
MW-1	547	195	1580	909	12.2	99.1	1750	9 5
MW-2	--	44.8	--	83	--	97.8	1210	9 5
MW-4	54.8	52.9	296	282	24 1	136	3210	9 5
MW-18	748	516	5820	3200	30 2	82.9	3720	9 5
MW-20	0 61	1.2	4 6	21.8	--	--	204	9 5
MW-21	--	1	0.94	40.3	--	--	--	9 5
MW-22	--	162	5 3	512	38.6	31.6	1180	9 5
MW-23	225	173	1750	1040	--	189	4240	9 5
MW-27	483	223	2000	1680	--	809	7070	9 5
MW-28	--	238	815	1550	17.5	586	5430	9 5
MW-30	1.2	1.9	--	4 8	--	--	--	9 5
MW-47	301	574	5870	3620	109	46.8	1670	9 5
MW-55	--	344	403	1300	63	70.1	1540	9 5
MW-64	--	14 1	--	32.4	31 1	--	--	9 5
MW-67	3.1	42.6	4 8	140	7 7	9 6	945	9 5
MW-68	--	43.2	--	116	20 6	--	361	9 5
Average Dissolved Contaminant Concentration (µg/L)	147 7	164 2	1159 4	907 0	22.1	132 4	2033 1	
Estimated Mass of Dissolved Contaminants (lbs)	4.21	4.67	33.00	25.82	0.63	3.77	57 88	
Estimated Mass of Dissolved Contaminants (kg)	**1.91**	**2.12**	**15.00**	**11.74**	**0.29**	**1.71**	**26.31**	
Maximum Dissolved Contaminant Concentration (µg/L)	748 0	574.0	5870.0	3620 0	22.8	809 0	5430 0	

Estimated GW Volume:

Impacted Area x Thickness x Porosity (n) = $(160{,}000\ ft^2)*(9.5\ ft)*(0.30)*(7.48\ gal/ft^3)$ = 3,410,880 gallons

Estimated Mass of Soluble Contaminants:

$M_{dissolved}$ (lbs) = $C_{dissolved}$ (µg/L) * V_{gw} (gal) * 3.7854 (L/gal) * 2.205E-9 (lb/µg)

where $M_{dissolved}$ = mass of dissolved contaminants (lbs)

$C_{dissolved}$ = average dissolved contaminant concentration (µg/L)

V_{gw} = volume of impacted groundwater (gal)

Prepared By: Clifton Blanchard Date: 11/7/2002

Checked By: KT 11/09/01 Date:

Approved By: MFA Date: 11/9/01

APPENDIX B.1.2
Estimated Mass of Dissolved and Adsorbed Contaminants in Saturated Zone

Remedial Action Plan
Site 1159
Naval Air Station Pensacola
Pensacola, Florida

Mass of Adsorbed Contaminants Calculations

Concentration of Contaminants Adsorbed to Soil: C(soil) = C(dissolved) x Kd

where: C(soil) = contaminant concentration in soil (mg/kg)
C(dissolved) = average dissolved contaminant concentration (mg/L)
Kd = solid/liquid distribution coefficient (l/kg)

For organics: Kd = Koc x Foc

where: Koc = organic carbon/water partition coefficient (l/kg) (from Mullens & Rogers, AICE 1993) (note Koc for Naphthalene used as constant for 1&2 methylnapthalene.
Foc = fractional organic carbon content (0.5 % by weight for typical sand) (from EPA 440/5-89-002)

	Benzene	Ethylbenzene	Toluene	Xylene	MTBE	Lead	TPH
Koc (l/kg)	59	363	188	153	11.2	4.5	1580
Foc (kg/kg)	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Kd (l/kg) =	**0.30**	**1.82**	**0.94**	**0.77**	**0.06**	**0.02**	**7.90**

C(dissolved) (mg/L)	0.148	0.164	1.159	0.907	0.02	0.13	2.03
Kd (l/kg)	0.30	1.82	0.94	0.77	0.06	0.02	7.90
C(adsorbed) (mg/kg) =	**0.0436**	**0.2980**	**1.090**	**0.694**	**0.0012**	**0.003**	**16.06**

Estimated Impacted Soil Mass: 'M(soil) = Impacted Area x Impacted Thickness x (1-n) = (160,000 ft^2)(9.5ft)(1-0.3)(1.0 yd^3/27 ft^3)(1.28 tons/yd^3)(907.2 kg/ton) = **4.58E+07 kg**

Estimated Mass of Contaminants Adsorbed to Soil: M(adsorbed)(lbs) = C(soil)(mg/kg) x M(soil)(kg) x 2.205E-6 (lb/mg)

C(soil) (mg/kg)	0.04358	0.297966	1.090	0.694	0.001	0.003	16.062
M(soil)	4.58E+07	4.58E+07	4.58E+07	4.58E+07	4.58E+07	4.58E+07	4.58E+07
M(adsorbed) (lbs) =	**4.40**	**30.07**	**109.96**	**70.01**	**0.13**	**0.30**	**1621**
M(adsorbed) (kg) =	**2.00**	**13.67**	**49.98**	**31.82**	**0.06**	**0.14**	**736.86**

Estimated Total Mass of Adsorbed Contaminants Based on TRPH Concentration = 1621 lbs

TOTAL ESTIMATED MASS OF HYDROCARBONS IN SATURATED ZONE (LBS) = ADSORBED MASS + DISSOLVED MASS = 1679 lbs

Prepared By: Clifton Blanchard — Date: 11/7/01

Checked By: PKJ — Date: 11/09/01

Approved By: ____________ — Date: ____________

Tetra Tech Nus, Inc. **CALCULATION WORKSHEET**

CLIENT NAVY SOUTHDIV	JOB NUMBER N0401.0000.FL0160205
SUBJECT PUMP & TREAT DRAWDOWN EVALUATION	
BASED ON	DRAWING NUMBER
BY CFB / CHECKED BY PKS 11/09/01	APPROVED BY MFA / DATE 10/19/01

PROBLEM: ESTIMATION OF A REASONABLE DRAWDOWN & FLOW RATE FOR GROUNDWATER PUMP AND TREAT FOR UST SITE 1159

REFERENCE:

DRISCOLL, F.G. GROUNDWATER AND WELLS. JOHNSON DIVISION, 2ND EDITION, PG. 1021.

APPROACH: DRAWDOWNS ARE ESTIMATE FROM SITE MEASURED HYDRAULIC CONDUCTIVITY

PROCEDURE:

$$\frac{Q \text{ GPM}}{S \text{ ft.}} = \frac{T \text{ GPD/FT}}{2000} \quad \text{(EQ. 2)}$$

Q - FLOW (GPM)

S - DRAWDOWN (FT)

T - TRANSMISSIVITY (GPD/FT)

HYDRAULIC CONDUCTIVITY $= 3.86 \times 10^{-4}$ FT/SEC (CARA 2001)

$$HC = 3.86 \times 10^{-4} \frac{FT^3/sec}{FT^2} \cdot \frac{7.48 \text{ GAL}}{1 \text{ FT}^3} \cdot \frac{86{,}400}{1} \frac{sec}{day}$$

APPENDIX B.2

Tetra Tech Nus, Inc.

CALCULATION WORKSHEET

CLIENT NAVY	JOB NUMBER N0401		
SUBJECT DRAWDOWN EVAL.			
BASED ON	DRAWING NUMBER		
BY CFB	CHECKED BY PKJ 11/09/01	APPROVED BY MFA	DATE 10/19/01

$HC = 250 \text{ GPD/FT}^2$

$T = HC \cdot$ CONTRIBUTING AQUIFER THICKNESS

$T = (250 \text{ GPD/FT}^2)(9.5 \text{ FT})$

$T = 2,377 \text{ GPD/FT}$

CALCULATE DRAWDOWN FOR A RANGE OF FLOWS

$Q = 1 \text{ GPM}$

$$\frac{Q_{GPM}}{S_{FT}} = \frac{2377 \text{ GPD/FT}}{2000}$$

$S = 0.84\,Q$

$S = 0.84$

FOR Q, GPM	S, FT
0.5	0.42
1.0	0.84
1.5	1.26
2.0	1.68

APPENDIX B 3

CAPTURE ZONE CALCULATIONS

To completely contain the plume of gasoline hydrocarbons at this site, the capture zone produced by the pumping well should encompass the entire hydrocarbon plume. The limits of the capture zone can be calculated using the equations presented by Todd (1980) and refined by Javandel and Tsang (1986). Under steady-state conditions, the shape of the capture zone for one recovery well is defined by the following equations:

$$A = \frac{Q}{2\pi Ti}$$

$$B = \frac{Q}{4Ti}$$

$$C = \frac{Q}{2Ti}$$

where:

- A = the distance from the pumping well to the dividing streamline downgradient, ft
- B = the distance from the pumping well to the dividing streamline perpendicular to the regional groundwater flow, ft
- C = the distance from the capture zone axis to the dividing streamline far upgradient, ft
- Q = pumping rate, gpd
- T = aquifer transmissivity, gpd/ft
- i = regional hydraulic gradient, ft/ft

Substituting the values of T and i into the above equations for pumping one well at selected flowrates, the capture zone dimensions can be estimated. The capture zone dimensions are calculated on the attached spreadsheet.

Appendix B.3.1

GROUNDWATER PUMP AND TREAT CAPTURE ZONE

Site Information

Site:	**UST Site 1159**
Location:	**Pensacola, Flordia**
Client:	**NAVY**
Project #	**N0401.0000.FL0160205**

Well Information	**Units**	**Value**
Extraction Well Numbers		**EW-1, 2, 3, 4, &5**
Static Water Level Depth	ft	10
Top of Filter Screen Depth	ft	5
Bottom of Filter Screen Depth	ft	16
Outside Diameter of Well	in	4
Open Area of Screen	in2/ft	3.89
Modeling Data		
Pumping Rate	gpm	1
Drawdown in Well	ft	0.84
Additional Depth of Influence	ft	3.5
Hydraulic Conductivity (K)	cm/sec	1.18E-02
Regional Hydraulic Gradient (i)	ft/ft	9.60E-04
Aquifer Transmissivity		
Screen Depth below Water Table	ft	6
Total Aquifer Thickness Contributing to	ft	9.5
Well Flow (b)	m	2.9
Hydraulic Conductivity (K)	gpd/ft2	250
Aquifer Transmissivity (T = Kb)	m2/sec	3.40E-04
	gpd/ft	2,377
Flow Velocity		
Submerged Screen Length while Pumping	ft	5.16
Flow Velocity through Screen (must be < 0.1 ft/second)	ft/sec	0.016
Capture Zone		
Distance from Well to Dividing Streamline Downgradient (A = Q/(2*3.141*T*i))	ft	100
Distance from Well to Dividing Streamline Perpendicular to Regional Groundwater Flow (B = Q/(4*T*i))	ft	158
Distance from Capture Zone Axis to Dividing Streamline Far Upgradient (C = Q/(2*T*i))	ft	316

Prepared By: Clifton Blanchard 11/7/2001
Date

Checked By: [signature] 11/09/01
Date

Approved By: MCA / 11/9/01
Date

Appendix B.3.2

Bioslurping System Groundwater Extraction Well Capture Zone

Site Information

Site:	**UST Site 1159**
Location:	**Pensacola, Flordia**
Client:	**NAVY**
Project #	**N0401.0000.FL0160205**

Well Information	**Units**	**Value**
Extraction Well Numbers		**MW-4, 25, & 28**
Static Water Level Depth	ft	10
Top of Filter Screen Depth	ft	5
Bottom of Filter Screen Depth	ft	16
Outside Diameter of Well	in	4
Open Area of Screen	in2/ft	3.89
Modeling Data		
Pumping Rate	gpm	0.5
Drawdown in Well	ft	0.42
Additional Depth of Influence	ft	3.5
Hydraulic Conductivity (K)	cm/sec	1.18E-02
Regional Hydraulic Gradient (i)	ft/ft	9.60E-04
Aquifer Transmissivity		
Screen Depth below Water Table	ft	6
Total Aquifer Thickness Contributing to	ft	9.5
Well Flow (b)	m	2.9
Hydraulic Conductivity (K)	gpd/ft2	250
Aquifer Transmissivity (T = Kb)	m2/sec	3.40E-04
	gpd/ft	2,377
Flow Velocity		
Submerged Screen Length while Pumping	ft	5.58
Flow Velocity through Screen (must be < 0.1 ft/second)	ft/sec	0.007
Capture Zone		
Distance from Well to Dividing Streamline Downgradient (A = Q/(2*3.141*T*i))	ft	50
Distance from Well to Dividing Streamline Perpendicular to Regional Groundwater Flow (B = Q/(4*T*i))	ft	79
Distance from Capture Zone Axis to Dividing Streamline Far Upgradient (C = Q/(2*T*i))	ft	158

Prepared By: Clifton Blanchard 11/7/2001
Date

Checked By: [signature] 11/08/01
Date

Approved By: MFA 11/9/01
Date

APPENDIX B.4
Estimated Remedial Time
Groundwater Pump and Treat

Remedial Action Plan
UST Site 1159
Naval Air Station Pensacola
Pensacola, Florida

Plume Description

Plume Location	Shallow
Surface Area of Plume (sq ft)	160,000
Average Plume Thickness (ft)	9.5
Estimated Porosity	0.30
Plume Volume (gal. of water)	3,410,880

Groundwater Effective Flow Rates

Compound	Pumping Rate (Q)	Retardation Coefficient	Initial Ave. Concentration (C_o)	Effective Flow Rate (Q_e)	Residence Time (T_r)
	gpm		ppb	gpd	day
Benzene	5	1.3	148	5560	613
Ethelbenzene	5	2.8	164	2558	1334
Toluene	5	1.9	1159	3711	919
Xylene	5	1.8	907	4079	836
MTBE	5	5.5	22	1309	2606
Lead	5	1.1	132	6818	500
TRPH	5	8.9	2033	809	4216

Notes:
TtNUS calculated the retardation factor using the concentration distributions calculated on Table C2 to determine the retardation factor.
The retardation factor is determined by the following equation: R = 1 + adsorbed concentration / dissolved concentration (Remediation Engineering, Suthersan, 1997)
The concentrations shown below are based on the continuous Flow Mixed Tank Equation [C=Co*e^(-t/Tr)]. Concentrations shown below are mg/L.
$Q_e = Q/r$
T_r = Plume Volume/Qe
gpm = gallons per minute
gpd = gallons per day
ppb = parts per billion

Contaminant Concentration Decline During Remediation

Time After Start of Remediation	Contaminant Concentration at End of Period							Total Extracted Volume	Treatment Completed
t (months)	Benzene	Toluene	Ethylbenzene	Xylene	Lead	MTBE	TRPH	MG[1]	
0	148	1159	164	907	132	22	2033	0.22	MTBE & TRPH
1	141	1122	160	875	125	22	2019	0.44	
2	134	1085	157	843	117	22	2004	0.66	
3	127	1050	153	813	110	21	1990	0.88	
4	121	1016	150	784	104	21	1975	1.10	
5	115	983	146	756	98	21	1961	1.31	
6	110	951	143	729	92	21	1947	1.53	
7	104	920	140	703	86	20	1933	1.75	
8	99	890	137	678	81	20	1919	1.97	
9	95	861	134	654	77	20	1905	2.19	
10	90	833	131	630	72	20	1892	2.41	
11	86	806	128	608	68	19	1878	2.63	
12	81	779	125	586	64	19	1865	2.85	
13	78	754	122	565	60	19	1851	3.07	
14	74	729	119	545	57	19	1838	3.29	
15	70	706	117	526	53	19	1825	3.50	
16	67	683	114	507	50	18	1811	3.72	
17	64	660	111	489	47	18	1798	3.94	
18	61	639	109	471	44	18	1786	4.16	
19	58	618	106	454	42	18	1773	4.38	
20	55	598	104	438	39	18	1760	4.60	
21	52	579	102	422	37	17	1747	4.82	
22	50	560	99	407	35	17	1735	5.04	
23	47	542	97	393	33	17	1722	5.26	
24	45	524	95	379	31	17	1710	5.48	
25	43	507	93	365	29	17	1698	5.69	
26	41	490	91	352	27	16	1685	5.91	
27	39	474	89	340	26	16	1673	6.13	
28	37	459	87	328	24	16	1661	6.35	
29	35	444	85	316	23	16	1649	6.57	
30	33	430	83	305	21	16	1637	6.79	
31	32	416	81	294	20	15	1626	7.01	
32	30	402	79	283	19	15	1614	7.23	
33	29	389	77	273	18	15	1602	7.45	
34	27	376	76	263	17	15	1591	7.67	
35	26	364	74	254	16	15	1579	7.88	
36	25	352	72	245	15	15	1568	8.10	
37	24	341	71	236	14	14	1557	8.32	
38	22	330	69	228	13	14	1546	8.54	
39	21	319	67	220	12	14	1535	8.76	
40	20	309	66	212	12	14	1523	8.98	
41	19	298	64	204	11	14	1513	9.20	
42	18	289	63	197	10	14	1502	9.42	
43	18	279	62	190	10	13	1491	9.64	
44	17	270	60	183	9	13	1480	9.86	
45	16	261	59	176	9	13	1470	10.07	

1 - Million gallons (MG)

Table B.4 (Continued)
Estimated Remedial Time
Pump and Treat

Remedial Action Plan
UST Site 1159
Naval Air Station Pensacola
Pensacola, Florida

Time After Start of Remediation	Contaminant Concentration at End of Period							Total Extracted Volume	Treatment Completed
t (months)	Benzene	Toluene	Ethelbenzene	Xylene	Lead	MTBE	TRPH	MG[1]	
46	15	253	57	170	8	13	1459	10.29	
47	14	245	56	164	8	13	1448	10.51	
48	14	237	55	158	7	13	1438	10.73	
49	13	229	54	153	7	12	1428	10.95	
50	12	222	52	147	6	12	1417	11.17	
51	12	214	51	142	6	12	1407	11.39	
52	11	207	50	137	6	12	1397	11.61	
53	11	201	49	132	5	12	1387	11.83	
54	10	194	48	127	5	12	1377	12.05	
55	10	188	47	123	5	12	1367	12.26	
56	9	182	46	118	4	12	1357	12.48	
57	9	176	45	114	4	11	1348	12.70	
58	8	170	44	110	4	11	1338	12.92	
59	8	165	43	106	4	11	1328	13.14	
60	8	159	42	102	3	11	1319	13.36	
61	7	154	41	99	3	11	1309	13.58	
62	7	149	40	95	3	11	1300	13.80	
63	7	144	39	92	3	11	1291	14.02	
64	6	139	38	88	3	10	1281	14.24	
65	6	135	37	85	3	10	1272	14.45	
66	6	130	36	82	2	10	1263	14.67	
67	5	126	36	79	2	10	1254	14.89	
68	5	122	35	76	2	10	1245	15.11	
69	5	118	34	74	2	10	1236	15.33	
70	5	114	33	71	2	10	1227	15.55	
71	4	111	33	69	2	10	1218	15.77	
72	4	107	32	66	2	10	1209	15.99	
73	4	104	31	64	2	9	1201	16.21	
74	4	100	30	61	1	9	1192	16.43	**E. Benzene**
75	4	97	30	59	1	9	1184	16.64	
76	3	94	29	57	1	9	1175	16.86	
77	3	91	28	55	1	9	1167	17.08	
78	3	88	28	53	1	9	1158	17.30	
79	3	85	27	51	1	9	1150	17.52	
80	3	82	26	49	1	9	1142	17.74	
81	3	79	26	48	1	9	1133	17.96	
82	3	77	25	46	1	8	1125	18.18	
83	2	74	25	44	1	8	1117	18.40	
84	2	72	24	43	1	8	1109	18.62	
85	2	70	24	41	1	8	1101	18.83	
86	2	67	23	40	1	8	1093	19.05	
87	2	65	23	38	1	8	1085	19.27	
88	2	63	22	37	1	8	1078	19.49	
89	2	61	22	36	1	8	1070	19.71	
90	2	59	21	34	1	8	1062	19.93	
91	2	57	21	33	1	8	1055	20.15	
92	2	55	20	32	0	8	1047	20.37	
93	1	53	20	31	0	7	1039	20.59	**Benzene**
94	1	52	19	30	0	7	1032	20.81	
95	1	50	19	29	0	7	1025	21.02	
96	1	48	18	28	0	7	1017	21.24	
97	1	47	18	27	0	7	1010	21.46	
98	1	45	18	26	0	7	1003	21.68	
99	1	44	17	25	0	7	995	21.90	
100	1	42	17	24	0	7	988	22.12	
101	1	41	16	23	0	7	981	22.34	
102	1	40	16	22	0	7	974	22.56	
103	1	38	16	21	0	7	967	22.78	**Toluene**
104	1	37	15	21	0	7	960	23.00	
105	1	36	15	20	0	6	953	23.21	**Xylene**

Prepared By Clifton Blanchard 11/7/2001
Date

Checked By PKJ 11/09/01
Date

Approved By MFA 11/9/01
Date

APPENDIX C

ALTERNATIVE COST ESTIMATES

Appendix C
Table C.1
Alternative One
PRESENT WORTH ANALYSIS

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Yearly Cost	Present-Worth Factor (i = 7%)	Present Worth
0	$514,809			$514,809	1.000	$514,809
1		$116,426	$87,220	$203,646	0.935	$190,409
2		$116,426	$81,760	$198,186	0.873	$173,016
3		$116,426	$65,760	$182,186	0.816	$148,664
4		$116,426	$65,760	$182,186	0.763	$139,008
5		$116,426	$69,600	$186,026	0.713	$132,637
6	$17,100	$77,842	$65,760	$143,602	0.666	$95,639
7		$77,842	$65,760	$143,602	0.623	$89,464
8		$77,842	$65,760	$143,602	0.582	$83,576
9		$77,842	$65,760	$143,602	0.544	$78,119
10		$77,842	$69,600	$147,442	0.508	$74,901
11			$33,100	$33,100	0.475	$15,723
12			$14,790	$14,790	0.444	$6,567
13			$14,790	$14,790	0.415	$6,138
14			$14,790	$14,790	0.388	$5,739
15			$14,790	$14,790	0.362	$5,354
16			$14,790	$14,790	0.339	$5,014
17			$14,790	$14,790	0.317	$4,688
18			$14,790	$14,790	0.296	$4,378
19			$14,790	$14,790	0.277	$4,097
20			$14,790	$14,790	0.258	$3,816

TOTAL PRESENT WORTH $1,781,754

Appendix C
Table C.2
Alternative One
Bioslurping/Groundwater Pump and Treat/Discharge to POTW Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
A. PRE-DESIGN DATA				
(1) Groundwater and product sampling and analysis				
(a) Groundwater and Product Sampling and Analysis Work Plan				
1 Jr. Level Engineer	40	hrs	$45	$1,800
1 Senior Engineer	8	hrs	$90	$720
Word processing	4	hrs	$35	$140
Technical Expert	6	hrs	$75	$450
Editor	2	hrs	$60	$120
CADD operator, 2 dwgs per report @ 8 hours per dwg	16	hrs	$60	$960
Reproduction & Shipping/binding: 20 reports, 60 pgs @ 20 copies	1	ls	$400	$400
(b) Groundwater Analysis for Contaminant Monitoring (assume 30 wells, 3 QC)				
Volatile Organics, SW-846 Method 8260,	36	ea	$65	$2,340
Total Lead, SW-846 Method 7421	33	ea	$15	$495
TRPH (FLPRO)	33	ea	$80	$2,640
(c) Groundwater Analysis for System Operation Parameters (assume 2 wells - no QA)				
Total Suspended Solids	2	ea	$15	$30
Total Dissolved Solids	2	ea	$15	$30
Total Iron	2	ea	$15	$30
Hardness	2	ea	$45	$90
Free Product Analysis	2	ea	$1,200	$2,400
(d) Groundwater Analysis for Natural Attenuation Parameters (assume 2 wells - no QA)				
Methane	2	ea	$85	$170
Ferrous Iron (Fe^{2+})	2	ea	$15	$30
Sulfate (SO_4)	2	ea	$15	$30
Nitrate (NO_3)	2	ea	$15	$30
(e) Expendables and Equipment Rental				
Gloves (2 boxes per event)	4	box	$10	$40
Teflon tubing (600 feet per event)	600	ft	$2.00	$1,200
Silicon tubing (200 feet per event)	200	ft	$2.00	$400
Shipping and supplies (tape, bubble wrap, ice)	1	ls	$400	$400
Rental of Horiba U-22 meter for conductivity, Oxidation-Reduction Potential, pH, dissolved oxygen, turbidity, and temperature.	10	days	$60	$600
PumPumps for purging wells (assume 2 for 10 days)	20	days	$35	$700
First Aid kit	1	ls	$50	$50
Water level indicator	10	days	$25	$250
Free Porduct Probe	10	days	$25	$250
Disposal of purge water, assume nonhaz., drums	8	ls	$150	$1,200
Car Renta w/fuel	10	ls	$65	$650
(f) Labor				
1 Technician, 10 days per sampling event @10 hour days	100	hrs	$30	$3,000
1 Geologist, 10 days per sampling event @10 hour days	100	hrs	$45	$4,500
(2) Pilot Test				
(a) Pilot Test Work Plan				
1 Jr. Level Engineer	80	hrs	$45	$3,600
1 Senior Engineer	32	hrs	$90	$2,880
Word processing	6	hrs	$35	$210
Technical Expert	32	hrs	$75	$2,400
Editor	6	hrs	$60	$360

Appendix C
Table C.2
Alternative One
Bioslurping/Groundwater Pump and Treat/Discharge to POTW Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
CADD operator, 4 dwgs per report @ 8 hours per dwg	32	hrs	$60	$1,920
Reproduction & Shipping/binding: 20 reports, 100 pgs @ 20 copies	1	ls	$600	$600
(b) Pilot Test (Subcontract includes test and evaluation report)	1	ls	$15,000	$15,000
(c) Oversight Labor				
1 Jr. Level Engineer (4, 10 hr days)	40	hrs	$45	$1,800
1 Senior Engineer	8	hrs	$90	$720
Subtotal Pre-Design Data Collection Cost:				**$51,045**
B. BIOSLURPING SYSTEM ENGINEERING DESIGN				
Engineering includes preparation of all submittals, such as HASP, Erosion and Sediment Control Plan, Waste Management Plan, Construction Documentation Report, System Operations Manual, "As Builts" and Start and Testing Report (20% of construction cost)	1	ls	$86,000	$86,000
Subtotal Bioslurping System Engineering Design Cost:				**$86,000**
C. SITE PREPARATION				
(1) Mobilization	1	ls	$5,000	$5,000
(2) Construction office trailer	3	mo	$600	$1,800
(3) Trailer delivery, setup, removal	2	ea	$1,000	$2,000
(4) Storage bin	3	mo	$120	$360
(5) Construction office and storage area fencing, 40'x80'	240	ft	$18	$4,320
(6) Signs, temp fencing, barricades to seclude construction area	1	ls	$1,500	$1,500
(7) Pressure washer and water tank	1	mo	$504	$504
(8) Plastic sheeting, drums, pumps, hoses, supplies	1	ls	$2,000	$2,000
(9) Oversight Labor				
1 Jr. Level Engineer, 6 days @ 8 hrs/gay	48	hrs	$45	$2,160
1 Sr. Engineer, 16 hours	8	hrs	$90	$720
Subtotal Site Preparation				**$20,364**
D. BIOSLURPING SYSTEM CONSTRUCTION				
(1) Well Installation				
(a) Bioslurping wells, 22 wells @ 4'ID, PVC, 22' aveage bgs, includes disposal of cuttings, vacuum tight well heads, downhole dip tube, sampling port, pitot tube, and ball valve	484	ft	$100	$48,400
(b) Groundwater extraction wells, 3 @ 4" ID, 20' bgs, includes disposal of drill cuttings, well head, downhole piping, sampling port, pitot tube, ball valve, and electrical wiring	60	ft	$100	$6,000
(c) Electrical to pumps	1	ls	$3,000	$3,000
(d) Groundwater extraction pump, 2" submersible pump, 0.25-3 GPM, installed	3	ls	$1,200	$3,600
(e) Well head Access Road (2000' graveled)	2000	ft	$5	$10,000
(f) Testing for Lead K_d (K_{oc} & foc)	1	ls	$3,500	$3,500
(g) Oversight and Sampling Labor				
1 Jr. Level Engineer, 4 weeks @ 40 hrs/wk	160	hrs	$45	$7,200
1 Sr. Engineer	32	hrs	$90	$2,880
Subtotal Well Installation Cost				**$84,580**

Appendix C
Table C.2
Alternative One
Bioslurping/Groundwater Pump and Treat/Discharge to POTW Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
(2) Collection System				
(a) Liquid Ring Vacuum Pump (20-HP)	1	ls	$16,000	$16,000
(b) Bioslurping wells to treatment sytem, 4" ID PVC (double walled), w/handholes, includes excavation and backfilling	1800	ft	$18	$32,400
(c) Groundwater extraction wells to treatment sytem, 2" ID PVC (double walled), includes excavation and backfilling	220	ft	$15	$3,300
(d) Electrician w/helper, 1 week @ 50 hrs/wk	200	hrs	$90	$18,000
(e) Oversight Labor				
1 Jr. Level Engineer, 3 weeks @ 50 hrs/wk	120	hrs	$45	$5,400
1 Sr. Engineer, 24 hours	24	hrs	$90	$2,160
Subtotal Piping and Equipment				$77,260

(3) Treatment System	Quantity	Unit	Unit Cost	Total Cost
(a) Electrical connection for treatment system (including electric poles, cable, transformer, phone line for telemetry)	1	ls	$15,000	$15,000
(b) Waterline Connection for Treatment System (includes underground piping and appurtenences)	1	ls	$5,000	$5,000
(c) Treatment system building w/concrete slab 18'x24'	432	SF	$100	$43,200
(d) Fencing, 45'x30', with manway and 14' gate	150	ft	$18	$2,700
(e) Filter tank for emulsion control, 1000-gallon fiberglass	1	ls	$3,000	$3,000
(f) Gravity oil/water separator, 1000-gallon fiberglass	1	ls	$3,800	$3,800
(g) Product storage tank, 1000-gallon fiberglass	1	ls	$2,500	$2,500
(h) Vapor Phase GAC, 150 SCFM capactity (Rental Unit)	1	ls	$1,200	$1,200
(i) Liquid phase storage tank 200-gallon fiberglass	1	ls	$400	$400
(j) Discharge pump (Duplex system)	1	ls	$2,000	$2,000
(k) Force main to POTW collection pipeline	4000	ft	$10	$40,000
(l) Associated piping and valves @ 12% total treatment system cost	1	ls	$24,000	$24,000
(m) Flow meters	4	ls	$300	$1,200
(n) Flow indicators	4	ls	$150	$600
(o) Pressure gauges	4	ls	$200	$800
(p) Instrument panel, controls	1	ls	$10,000	$10,000
(q) Transfer pump	1	ls	$1,000	$1,000
(r) Telemetry	1	ls	$10,000	$10,000
(S) Oversite Labor				
1 Jr. Engineer (8 weeks @ 50 hrs/week)	400	hrs	$45	$18,000
1 Sr. Engineer (8 weeks @ 16 hrs/week)	124	hrs	$90	$11,160
Subtotal Treatment System Cost				$195,560
Subtotal Capital Cost				$514,809

E. BIOSLURPING SYSTEM O&M (annual)

(1) Labor				
(a) Jr. Engineer, 12 hrs per month, system operating data, control	144	hr	$45	$6,480
(b) Sr. Engineer, 4 hours per month	48	hr	$90	$4,320
(c) Technician, 20 hrs per month	240	hr	$30	$7,200

Appendix C
Table C.2
Alternative One
Bioslurping/Groundwater Pump and Treat/Discharge to POTW Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
(d) Project Mgr, 2 hrs per month	12	hr	$100	$1,200
(e) Electrician, 4 hours per year	4	hr	$75	$300
(2) Vapor Phase GAC (assume 2 change outs w/disposal per year)	2	ls	$815	$1,630
(3) POTW discharge fee	5,256	Kgal	$5	$26,280
(5) Misc. equip/supplies	12	mo	$800	$9,600
(6) Electricity (70 kW*24 hr/day*365 day/yr = 613,200 kWh/yr)	613,200	kWh	$0.08	$49,056
(7) Water (assume $500/year)	1	ls	$500	$500
(8) Free Product Recycling	34,000	gal	$0.29	$9,860
Subtotal Bioslurping System O&M				**$116,426**
F. MODIFICATION TO GROUNDWATER PUMP AND TREAT				
(1) Labor				
(a) 2 Technicians, 10 days @10 hour days	200	hr	$30	$6,000
(b) 1 Jr. Level Engineer, 10 days @ 8 hrs/day	80	hr	$45	$3,600
(c) 1 Sr. Level Engineer	24	hr	$90	$2,160
(2) Misc. equip/supplies	1	ls	$1,500	$1,500
Subtotal Modification to Groundwater Pump and Treat				**$13,260**
G. GROUNDWATER PUMP AND TREAT SYSTEM O&M (annual)				
(1) Labor				
(a) Jr. Engineer, 8 hrs per month, system operating data, control	96	hr	$45	$4,320
(b) Sr. Engineer, 2 hours per month	24	hr	$90	$2,160
(c) Technician, 16 hrs per month	192	hr	$35	$6,720
(d) Project Mgr, 2 hrs per month	24	hr	$100	$2,400
(e) Electrician w/helper (4 hrs/year)	4	hr	$75	$300
(2) Vapor Phase GAC (assume 2 change outs w/disposal per year)	2	ls	$815	$1,630
(3) POTW discharge fee	5,256	Kgal	$5	$26,280
(4) Misc. equip/supplies	12	mo	$500	$6,000
(5) Electricity, Assume 40 kW*24 hr/day*365 day/yr = 350,400 kWh/yr	350,400	kWh	$0.08	$28,032
Subtotal Groundwater Pump and Treat System O&M				**$77,842**
H. REMEDIAL ACTION MONITORING				
(1) Quarterly Groundwater Monitoring (Includes 4 monitoring wells, 3 GW extraction wells, and 1 QA)				
(a) Labor				
1 Technician, 5 days per sampling event @10 hour days	50	hrs	$30	$1,500
1 Geologist, 5 days per sampling event @10 hour days	50	hrs	$45	$2,250
Car Renta w/fuel (5 days per event)	5	ls	$65	$325
(b) Analysis				
Volatile Organics, SW-846 Method 8260	9	ea	$65	$585
Total Lead, SW-846 Method 7421	8	ea	$15	$120
TRPH (FLPRO)	8	ea	$80	$640
(c) Expendables and Equipment Rental				
Gloves (2 boxes per event)	2	box	$10	$20
Teflon tubing (400 feet per event)	400	ft	$2.00	$800

Appendix C
Table C.2
Alternative One
Bioslurping/Groundwater Pump and Treat/Discharge to POTW Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
Silicon tubing (50 feet per event)	50	ft	$2.00	$100
Shipping and supplies (tape, bubble wrap, ice)	1	ls	$250	$250
Rental of Horiba U-22 meter for conductivity, Oxidation-Reduction Potential, pH, dissolved oxygen, turbidity, and temperature.	5	days	$60	$300
Pumps for purging wells (2 pumps, 3 days rental)	6	days	$35	$210
First Aid kit	1	ls	$50	$50
Water level indicator	5	days	$25	$125
Free Porduct Probe	5	days	$25	$125
Disposal of purge water, assume nonhaz., drums	4	ls	$150	$600
Subtotal Quarterly Groundwater Monitoring Costs				**$8,000**
(2) Treatment System Monitoring (Includes water levels and free product thickness in the bioslurping wells)				
(a) Labor:				
2 Technicians (5 days @10 hour days)	100	hrs	$30	$3,000
Car Rental w/fuel (5 days per event)	5	days	$65	$325
(b) Influent & Effluent Analysis (1 QA)				
Volatile Organics, SW-846 Method 8260	4	ea	$65	$260
Total Lead, SW-846 Method 7421	3	ea	$15	$45
TRPH (FLPRO)	3	ea	$80	$240
Total Suspended Solids	3	ea	$15	$45
Total Dissolved Solids	3	ea	$15	$45
Total Iron	3	ea	$15	$45
(c) Air Diacharge Analysis				
Total Petroleum Hydrocarbons	2	ea	$120	$240
(d) Expendables and Equipment Rental				
Gloves	2	box	$10	$20
Shipping and supplies (tape, bubble wrap, ice)	1	ls	$250	$250
Rental of Horiba U-22 meter for conductivity, Oxidation-Reduction Potential, pH, dissolved oxygen, turbidity, and temperature.	2	days	$60	$120
Pumps for purging wells (2 pumps, 5 days rental)	10	days	$35	$350
First Aid kit	1	ls	$50	$50
Water level indicator	5	days	$25	$125
Disposal of purge water, assume nonhaz., drums	2	ls	$150	$300
Subtotal Quarterly Groundwater Monitoring Costs				**$5,460**
(3) Post-Active Remdial Action Monitoring (4 wells, 1 QA, for Natural Attenuation)				
(a) Labor:				
1 Technician, 3 days per sampling event @10 hour days	30	hrs	$30	$900
1 Geologist, 3 days per sampling event @10 hour days	30	hrs	$45	$1,350
Car Renta w/fuel	3	days	$65	$195
(b) Analysis				
Volatile Organics, SW-846 Method 8260	6	ea	$65	$390
Total Lead, SW-846 Method 7421	5	ea	$15	$75
TRPH (FLPRO)	5	ea	$80	$400
(c) Expendables and Equipment Rental				

Appendix C
Table C.2
Alternative One
Bioslurping/Groundwater Pump and Treat/Discharge to POTW Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
Gloves	2	box	$10	$20
Teflon tubing	200	ft	$2.00	$400
Silicon tubing	50	ft	$2.00	$100
Shipping and supplies (tape, bubble wrap, ice)	1	ls	$250	$250
Rental of Horiba U-22 meter for conductivity, Oxidation-Reduction Potential, pH, dissolved oxygen, turbidity, and temperature.	3	days	$60	$180
Pumps for purging wells (2 pumps, 2 days rental)	4	days	$35	$140
First Aid kit	1	ls	$50	$50
Water level indicator	3	days	$25	$75
Disposal of purge water, assume nonhaz., drums	2	ls	$150	$300
Subtotal Quarterly Groundwater Monitoring Costs				**$4,825**
I. SUBMITTALS				
(1) Status/Monitoring Report				
(a) 1 Jr. Level Engineer	80	hrs	$45	$3,600
(b) 1 Senior Engineer	16	hrs	$90	$1,440
(c) Word processing	6	hrs	$35	$210
(d) Technical Expert	6	hrs	$75	$450
(e) Editor	6	hrs	$60	$360
(f) CADD operator, 4 dwgs per report @ 2 hours per dwg	8	hrs	$40	$320
(g) Reproduction & Shipping/binding: 20 reports, 100 pgs @ 20 copies	1	ls	$600	$600
Subtotal Status/Monitoring Report Cost:				**$6,980**
(2) Request for Discontinuation of Active Remediation				
(a) 1 Jr. Level Engineer	32	hrs	$45	$1,440
(b) 1 Senior Engineer	4	hrs	$90	$360
(c) Word processing	4	hrs	$35	$140
(d) Technical Expert	12	hrs	$75	$900
(e) Editor	4	hrs	$60	$240
(f) CADD operator, 2 dwgs per report @ 2 hours per dwg	4	hrs	$40	$160
(g) Reproduction & Shipping/binding: 20 reports, 100 pgs @ 20 copies	1	ls	$600	$600
Subtotal Request for Discontinuation of Active Remediation Report Cost:				**$3,840**
(3) Post-Remedial Monitoring Plan				
(a) 1 Jr. Level Engineer	40	hrs	$45	$1,800
(b) 1 Senior Engineer	4	hrs	$90	$360
(c) Word processing	4	hrs	$35	$140
(d) Technical Expert	4	hrs	$75	$300
(e) Editor	4	hrs	$60	$240
(f) CADD operator, 2 dwgs per report @ 2 hours per dwg	4	hrs	$40	$160
(g) Reproduction & Shipping/binding: 20 reports, 80 pgs @ 20 copies	1	ls	$520	$520
Subtotal Post-Remedial Monitoring Plan Cost:				**$3,520**

Appendix C
Table C.3
Alternative Two
PRESENT WORTH ANALYSIS

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Yearly Cost	Present-Worth Factor (i = 7%)	Present Worth
0	$658,129			$658,129	1.000	$658,129
1		$135,844	$90,220	$226,064	0.935	$211,370
2		$135,844	$84,160	$220,004	0.873	$192,063
3		$135,844	$68,160	$204,004	0.816	$166,467
4		$135,844	$68,160	$204,004	0.763	$155,655
5		$135,844	$72,000	$207,844	0.713	$148,193
6	$17,100	$99,868	$68,160	$168,028	0.666	$111,907
7		$99,868	$68,160	$168,028	0.623	$104,681
8		$99,868	$68,160	$168,028	0.582	$97,792
9		$99,868	$68,160	$168,028	0.544	$91,407
10		$99,868	$72,000	$171,868	0.508	$87,309
11			$33,100	$33,100	0.475	$15,723
12			$14,790	$14,790	0.444	$6,567
13			$14,790	$14,790	0.415	$6,138
14			$14,790	$14,790	0.388	$5,739
15			$14,790	$14,790	0.362	$5,354
16			$14,790	$14,790	0.339	$5,014
17			$14,790	$14,790	0.317	$4,688
18			$14,790	$14,790	0.296	$4,378
19			$14,790	$14,790	0.277	$4,097
20			$14,790	$14,790	0.258	$3,816

TOTAL PRESENT WORTH $2,086,486

Appendix C
Table C.4
Alternative Two
Bioslurping/Groundwater Pump and Treat Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
A. PRE-DESIGN DATA				
(1) Groundwater and product sampling and analysis				
(a) Groundwater and Product Sampling and Analysis Work Plan				
1 Jr. Level Engineer	40	hrs	$45	$1,800
1 Senior Engineer	8	hrs	$90	$720
Word processing	4	hrs	$35	$140
Technical Expert	6	hrs	$75	$450
Editor	2	hrs	$60	$120
CADD operator, 2 dwgs per report @ 8 hours per dwg	16	hrs	$60	$960
Reproduction & Shipping/binding: 20 reports, 60 pgs @ 20 copies	1	ls	$400	$400
(b) Groundwater Analysis for Contaminant Monitoring (assume 30 wells, 3 QC)				
Volatile Organics, SW-846 Method 8260,	36	ea	$65	$2,340
Total Lead, SW-846 Method 7421	33	ea	$15	$495
TRPH (FLPRO)	33	ea	$80	$2,640
(c) Groundwater Analysis for System Operation Parameters (assume 2 wells - no QA)				
Total Suspended Solids	2	ea	$15	$30
Total Dissolved Solids	2	ea	$15	$30
Total Iron	2	ea	$15	$30
Hardness	2	ea	$45	$90
Free Product Analysis	2	ea	$1,200	$2,400
(d) Groundwater Analysis for Natural Attenuation Parameters (assume 2 wells - no QA)				
Methane	2	ea	$85	$170
Ferrous Iron (Fe^{2+})	2	ea	$15	$30
Sulfate (SO_4)	2	ea	$15	$30
Nitrate (NO_3)	2	ea	$15	$30
(e) Expendables and Equipment Rental				
Gloves (2 boxes per event)	4	box	$10	$40
Teflon tubing (600 feet per event)	600	ft	$2.00	$1,200
Silicon tubing (200 feet per event)	200	ft	$2.00	$400
Shipping and supplies (tape, bubble wrap, ice)	1	ls	$400	$400
Rental of Horiba U-22 meter for conductivity, Oxidation-Reduction Potential, pH, dissolved oxygen, turbidity, and temperature.	10	days	$60	$600
PumPumps for purging wells (assume 2 for 10 days)	20	days	$35	$700
First Aid kit	1	ls	$50	$50
Water level indicator	10	days	$25	$250
Free Porduct Probe	10	days	$25	$250
Disposal of purge water, assume nonhaz., drums	8	ls	$150	$1,200
Car Renta w/fuel	10	ls	$65	$650
(f) Labor				
1 Technician, 10 days per sampling event @10 hour days	100	hrs	$30	$3,000
1 Geologist, 10 days per sampling event @10 hour days	100	hrs	$45	$4,500
(2) Pilot Test				
(a) Pilot Test Work Plan				
1 Jr. Level Engineer	80	hrs	$45	$3,600
1 Senior Engineer	32	hrs	$90	$2,880
Word processing	6	hrs	$35	$210
Technical Expert	32	hrs	$75	$2,400
Editor	6	hrs	$60	$360

Appendix C
Table C.4
Alternative Two
Bioslurping/Groundwater Pump and Treat Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
CADD operator, 4 dwgs per report @ 8 hours per dwg	32	hrs	$60	$1,920
Reproduction & Shipping/binding: 20 reports, 100 pgs @ 20 copies	1	ls	$600	$600
(b) Pilot Test (Subcontract includes test and evaluation report)	1	ls	$15,000	$15,000
(c) Oversight Labor				
1 Jr. Level Engineer (4 days @ 10 hr/day)	40	hrs	$45	$1,800
1 Senior Engineer	8	hrs	$90	$720
Subtotal Pre-Design Data Collection Cost:				**$51,045**
B. BIOSLURPING SYSTEM ENGINEERING DESIGN				
Engineering includes preparation of all submittals, such as HASP, Erosion and Sediment Control Plan, Waste Management Plan, Construction Documentation Report, System Operations Manual, "As Builts" and Start and Testing Report (20% of construction cost)	1	ls	$110,000	$110,000
Subtotal Bioslurping System Engineering Design Cost:				**$110,000**
C. SITE PREPARATION				
(1) Mobilization	1	ls	$5,000	$5,000
(2) Construction office trailer	3	mo	$600	$1,800
(3) Trailer delivery, setup, removal	2	ea	$1,000	$2,000
(4) Storage bin	3	mo	$120	$360
(5) Construction office and storage area fencing, 40'x80'	240	ft	$18	$4,320
(6) Signs, temp fencing, barricades to seclude construction area	1	ls	$1,500	$1,500
(7) Pressure washer and water tank	1	mo	$504	$504
(8) Plastic sheeting, drums, pumps, hoses, supplies	1	ls	$2,000	$2,000
(9) Oversight Labor				
1 Jr. Level Engineer, 6 days @ 8 hrs/gay	48	hrs	$45	$2,160
1 Sr. Engineer, 16 hours	8	hrs	$90	$720
Subtotal Site Preparation				**$20,364**
D. BIOSLURPING SYSTEM CONSTRUCTION				
(1) Well Installation				
(a) Bioslurping wells, 22 wells @ 4'ID, PVC, 22' aveage bgs, includes disposal of cuttings, vacuum tight well heads, downhole dip tube, sampling port, pitot tube, and ball valve	484	ft	$100	$48,400
(b) Groundwater extraction wells, 3 @ 4" ID, 20' bgs, includes disposal of drill cuttings, well head, downhole piping, sampling port, pitot tube, ball valve, and electrical wiring	60	ft	$100	$6,000
(c) Electrical to pumps	1	ls	$3,000	$3,000
(d) Groundwater extraction pump, 2" submersible pump, 0.25-3 GPM, installed	3	ls	$1,200	$3,600
(e) Well head Access Road (2000' graveled)	2000	ft	$5	$10,000
(f) Testing for Lead K_d (K_{oc} & foc)	1	ls	$3,500	$3,500
(g) Oversight and Sampling Labor				
1 Jr. Level Engineer, 4 weeks @ 40 hrs/wk	160	hrs	$45	$7,200
1 Sr. Engineer	32	hrs	$90	$2,880
Subtotal Well Installation Cost				**$84,580**

Appendix C
Table C.4
Alternative Two
Bioslurping/Groundwater Pump and Treat Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
(2) Collection System				
(a) Liquid Ring Vacuum Pump (20-HP)	1	ls	$16,000	$16,000
(b) Bioslurping wells to treatment sytem, 4" ID PVC (double walled), w/handholes, includes excavation and backfilling	1800	ft	$18	$32,400
(c) Groundwater extraction wells to treatment sytem, 2" ID PVC (double walled), includes excavation and backfilling	220	ft	$15	$3,300
(d) Electrician w/helper, 1 week @ 50 hrs/wk	200	hrs	$90	$18,000
(e) Oversight Labor				
1 Jr. Level Engineer, 3 weeks @ 50 hrs/wk	120	hrs	$45	$5,400
1 Sr. Engineer, 24 hours	24	hrs	$90	$2,160
Subtotal Piping and Equipment				**$77,260**

	Quantity	Unit	Unit Cost	Total Cost
(3) Treatment System				
(a) Electrical connection for treatment system (including electric poles, cable, transformer, phone line for telemetry)	1	ls	$15,000	$15,000
(b) Waterline Connection for Treatment System (includes underground piping and appurtenences)	1	ls	$5,000	$5,000
(c) Treatment system building w/concrete slab 20'x30'	600	SF	$100	$60,000
(d) Fencing, 50'x30', with manway and 14' gate	160	ft	$18	$2,880
(e) Filter tank for emulsion control, 1000-gallon fiberglass	1	ls	$3,000	$3,000
(f) Gravity oil/water separator, 1000-gallon fiberglass	1	ls	$3,800	$3,800
(g) Product storage tank, 1000-gallon fiberglass	1	ls	$2,500	$2,500
(h) Low profile air stripper, 5-20 gpm	1	ls	$12,000	$12,000
(i) Liquid phase GAC, 5-20 gpm (Rental Unit)	1	ls	$1,200	$1,200
(j) Ion Exchange w/backwash, 5-20 gpm	1	ls	$110,000	$110,000
(k) Vapor Phase GAC, 150 SCFM capactity (Rental Unit)	1	ls	$1,000	$1,000
(l) Associated piping and valves @ 12% total treatment system cost	1	ls	$35,000	$35,000
(m) Flow meters	4	ls	$300	$1,200
(n) Flow indicators	4	ls	$150	$600
(o) Pressure gauges	4	ls	$200	$800
(p) Instrument panel, controls	1	ls	$10,000	$10,000
(q) Transfer and discharge pumps	4	ls	$1,000	$4,000
(r) Telemetry	1	ls	$10,000	$10,000
(s) Oversite Labor				
1 Jr. Engineer, 10 weeks @ 50 hrs/week	500	hrs	$45	$22,500
1 Sr. Engineer	160	hrs	$90	$14,400
Subtotal Treatment System Cost				**$314,880**
Subtotal Capital Cost				**$658,129**

E. BIOSLURPING SYSTEM O&M (annual)

	Quantity	Unit	Unit Cost	Total Cost
(1) Labor				
(a) Jr. Engineer, 24 hrs per month, system operating data, control	288	hr	$45	$12,960
(b) Sr. Engineer, 8 hours per month	96	hr	$90	$8,640
(c) Technician, 40 hrs per month	480	hr	$30	$14,400

Appendix C
Table C.4
Alternative Two
Bioslurping/Groundwater Pump and Treat Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
(d) Project Mgr, 2 hrs per month	24	hr	$100	$2,400
(e) Electrician, 4 hours per year	4	hr	$75	$300
(2) Liquid Phase GAC (assume 4 change outs w/disposal per year)	4	ls	$865	$3,460
(3) Vapor Phase GAC (assume 4 change outs w/disposal per year)	4	ls	$815	$3,260
(4) Ion Exchange Media Backwash and Sludge Handling	4	ls	$4,000	$16,000
(5) Misc. equip/supplies	12	mo	$500	$6,000
(6) Electricity (80 kW*24 hr/day*365 day/yr = 700,800 kWh/yr)	700,800	kWh	$0.08	$56,064
(7) Water (assume $2,500/year)	1	ls	$2,500	$2,500
(8) Free Product Recycling	34,000	gal	$0.29	$9,860
<u>Subtotal Bioslurping System O&M</u>				**<u>$135,844</u>**
F. MODIFICATION TO GROUNDWATER PUMP AND TREAT				
(1) Labor				
(a) 2 Technicians, 10 days @10 hour days	200	hr	$30	$6,000
(b) 1 Jr. Level Engineer, 10 days @ 8 hrs/day	80	hr	$45	$3,600
(c) 1 Sr. Level Engineer	24	hr	$90	$2,160
(2) Misc. equip/supplies	1	ls	$1,500	$1,500
<u>Subtotal Modification to Groundwater Pump and Treat</u>				**<u>$13,260</u>**
G. GROUNDWATER PUMP AND TREAT SYSTEM O&M (annual)				
(1) Labor				
(a) Jr. Engineer, 16 hrs per month, system operating data, control	192	hr	$45	$8,640
(b) Sr. Engineer, 4 hours per month	48	hr	$90	$4,320
(c) Technician, 32 hrs per month	384	hr	$35	$13,440
(d) Project Mgr, 2 hrs per month	24	hr	$100	$2,400
(e) Electrician w/helper (4 hrs/year)	4	hr	$75	$300
(2) Liquid Phase GAC (assume 4 change outs w/disposal per year)	4	ls	$865	$3,460
(3) Vapor Phase GAC (assume 4 change outs w/disposal per year)	4	ls	$815	$3,260
(4) Ion Exchange (assume 4 change outs w/disposal per year)	4	ls	$4,000	$16,000
(5) Misc. equip/supplies	12	mo	$500	$6,000
(6) Electricity, Assume 60 kW*24 hr/day*365 day/yr = 525,600 kWh/yr	525,600	kWh	$0.08	$42,048
<u>Subtotal Groundwater Pump and Treat System O&M</u>				**<u>$99,868</u>**
H. REMEDIAL ACTION MONITORING				
(1) Quarterly Groundwater Monitoring (Includes 4 monitoring wells, 3 GW exytraction wells, and 1 QA)				
(a) Labor				
1 Technician, 5 days per sampling event @10 hour days	50	hrs	$30	$1,500
1 Geologist, 5 days per sampling event @10 hour days	50	hrs	$45	$2,250
Car Renta w/fuel (5 days per event)	5	ls	$65	$325
(b) Analysis				
Volatile Organics, SW-846 Method 8260	9	ea	$65	$585
Total Lead, SW-846 Method 7421	8	ea	$15	$120
TRPH (FLPRO)	8	ea	$80	$640
(c) Expendables and Equipment Rental				

Appendix C
Table C.4
Alternative Two
Bioslurping/Groundwater Pump and Treat Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
Gloves (2 boxes per event)	2	box	$10	$20
Teflon tubing (400 feet per event)	400	ft	$2.00	$800
Silicon tubing (50 feet per event)	50	ft	$2.00	$100
Shipping and supplies (tape, bubble wrap, ice)	1	ls	$250	$250
Rental of Horiba U-22 meter for conductivity, Oxidation-Reduction Potential, pH, dissolved oxygen, turbidity, and temperature.	5	days	$60	$300
Pumps for purging wells (2 pumps, 3 days rental)	6	days	$35	$210
First Aid kit	1	ls	$50	$50
Water level indicator	5	days	$25	$125
Free Porduct Probe	5	days	$25	$125
Disposal of purge water, assume nonhaz., drums	4	ls	$150	$600
Subtotal Quarterly Groundwater Monitoring Costs				$8,000
(2) Treatment System Monitoring (Includes water levels and free product thickness in the bioslurping wells)				
(a) Labor:				
2 Technicians (6 days @10 hour days)	120	hrs	$30	$3,600
Car Rental w/fuel (5 days per event)	5	days	$65	$325
(b) Influent & Effluent Analysis (1 QA)				
Volatile Organics, SW-846 Method 8260	4	ea	$65	$260
Total Lead, SW-846 Method 7421	3	ea	$15	$45
TRPH (FLPRO)	3	ea	$80	$240
Total Suspended Solids	3	ea	$15	$45
Total Dissolved Solids	3	ea	$15	$45
Total Iron	3	ea	$15	$45
(c) Air Diacharge Analysis				
Total Petroleum Hydrocarbons	2	ea	$120	$240
(d) Expendables and Equipment Rental				
Gloves	2	box	$10	$20
Shipping and supplies (tape, bubble wrap, ice)	1	ls	$250	$250
Rental of Horiba U-22 meter for conductivity, Oxidation-Reduction Potential, pH, dissolved oxygen, turbidity, and temperature.	2	days	$60	$120
Pumps for purging wells (2 pumps, 5 days rental) .	10	days	$35	$350
First Aid kit	1	ls	$50	$50
Water level indicator	5	days	$25	$125
Disposal of purge water, assume nonhaz., drums	2	ls	$150	$300
Subtotal Quarterly Groundwater Monitoring Costs				$6,060
(3) Post-Active Remdial Action Monitoring (4 wells, 1 QA, for Natural Attenuation)				
(a) Labor:				
1 Technician, 3 days per sampling event @10 hour days	30	hrs	$30	$900
1 Geologist, 3 days per sampling event @10 hour days	30	hrs	$45	$1,350
Car Renta w/fuel	3	days	$65	$195
(b) Analysis				
Volatile Organics, SW-846 Method 8260	6	ea	$65	$390
Total Lead, SW-846 Method 7421	5	ea	$15	$75

Appendix C
Table C.4
Alternative Two
Bioslurping/Groundwater Pump and Treat Detailed Cost

	Quantity	Unit	Unit Cost	Total Cost
TRPH (FLPRO)	5	ea	$80	$400
(c) Expendables and Equipment Rental				
Gloves	2	box	$10	$20
Teflon tubing	200	ft	$2.00	$400
Silicon tubing	50	ft	$2.00	$100
Shipping and supplies (tape, bubble wrap, ice)	1	ls	$250	$250
Rental of Horiba U-22 meter for conductivity, Oxidation-Reduction Potential, pH, dissolved oxygen, turbidity, and temperature.	3	days	$60	$180
Pumps for purging wells (2 pumps, 2 days rental)	4	days	$35	$140
First Aid kit	1	ls	$50	$50
Water level indicator	3	days	$25	$75
Disposal of purge water, assume nonhaz., drums	2	ls	$150	$300
Subtotal Quarterly Groundwater Monitoring Costs				**$4,825**
I. SUBMITTALS				
(1) Status/Monitoring Report				
(a) 1 Jr. Level Engineer	80	hrs	$45	$3,600
(b) 1 Senior Engineer	16	hrs	$90	$1,440
(c) Word processing	6	hrs	$35	$210
(d) Technical Expert	6	hrs	$75	$450
(e) Editor	6	hrs	$60	$360
(f) CADD operator, 4 dwgs per report @ 2 hours per dwg	8	hrs	$40	$320
(g) Reproduction & Shipping/binding: 20 reports, 100 pgs @ 20 copies	1	ls	$600	$600
Subtotal Status/Monitoring Report Cost:				**$6,980**
(2) Request for Discontinuation of Active Remediation				
(a) 1 Jr. Level Engineer	32	hrs	$45	$1,440
(b) 1 Senior Engineer	4	hrs	$90	$360
(c) Word processing	4	hrs	$35	$140
(d) Technical Expert	12	hrs	$75	$900
(e) Editor	4	hrs	$60	$240
(f) CADD operator, 2 dwgs per report @ 2 hours per dwg	4	hrs	$40	$160
(g) Reproduction & Shipping/binding: 20 reports, 100 pgs @ 20 copies	1	ls	$600	$600
Subtotal Request for Discontinuation of Active Remediation Report Cost:				**$3,840**
(3) Post-Remedial Monitoring Plan				
(a) 1 Jr. Level Engineer	40	hrs	$45	$1,800
(b) 1 Senior Engineer	4	hrs	$90	$360
(c) Word processing	4	hrs	$35	$140
(d) Technical Expert	4	hrs	$75	$300
(e) Editor	4	hrs	$60	$240
(f) CADD operator, 2 dwgs per report @ 2 hours per dwg	4	hrs	$40	$160
(g) Reproduction & Shipping/binding: 20 reports, 80 pgs @ 20 copies	1	ls	$520	$520

	Quantity	Unit	Unit Cost	Total Cost
Subtotal Post-Remedial Monitoring Plan Cost:				$3,520

APPENDIX D

BIOSCREEN MODELING RESULTS

CLIENT: Navy		JOB NUMBER: N0401	
SUBJECT: Natural Attenuation Using Bioscreen Model			
BASED ON:		DRAWING NO.:	
BY:PKJ	CHECKED BY:CFB CFB 11/9/01	APPROVED BY: MFA	DATE:10/19/01

APPENDIX D NATURAL ATTENUATION USING BIOSCREEN MODEL

Problem

Estimate the time to attain the media cleanup standard and the extent of contamination for lead and benzene in groundwater at site 1159 using BIOSCREEN Natural Attenuation Decision Support System.

Approach

The time frame to achieve media cleanup standards (MCS) and the extent of contamination was modeled using the BIOSCREEN Natural Attenuation Decision Support System model. BIOSCREEN is a screening model which simulates groundwater remediation through natural attenuation of dissolved hydrocarbons. The model, which is based on the Domenico analytical solute transport model, simulates advection, dispersion, and adsorption, in addition to the aerobic and anaerobic reactions. BIOSCREEN is a very flexible model in that it allows the use of separate decay coefficients for solute (groundwater phase) and the source. It can also estimate dispersion parameters from the plume length. The BIOSCREEN model was developed for the Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division at Brooks Air Force Base by Groundwater Services, Inc., Houston, TX.

The model can be used to predict how far the dissolved contaminant plume will extend if no engineering controls or further source zone reduction measures are implemented. Furthermore, the model can be used to predict the duration the plume would persist until natural attenuation processes would cause it to dissipate (source zone concentration versus time).

BIOSCREEN includes three different model types.

1. Solute transport without decay
2. Solute transport with biodegradation modeled as a first-order decay process.
3. Solute transport with biodegradation modeled as an "instantaneous" biodegradation reaction.

Input parameters

The site-specific data were compiled and used as input to BIOSCREEN. If the site-specific data were not available, the literature values were used in the model. The input parameters along with the source information are presented in the Table 1 below.

Solute half life

The solute half-life of benzene was estimated by calibration by adjusting the solute half-life until the model results matched the field data.

Source thickness in saturated zone

The source thickness in the saturated zone is assumed to be the sum of screen depth of contaminated well (5 ft) and the average of screen depth in the uncontaminated well (11 ft/2 = 5.5 ft).

Estimation of soluble mass

Soluble mass = maximum concentration detected at site x contaminated volume.

The soluble mass of benzene based on the aqueous solubility of organic constituent dissolved from product (Raoult's Law, Attachment 1) was estimated to be 882 Kg (Attachment 2). The soluble mass of Lead based on the average concentration at the site was estimated to be 1.71 kg. The contaminated volume was assumed to be 3,500,000 gallons (one pore volume).

TABLE 1: BIOSCREEN INPUT PARAMETERS

Parameter	Lead	Benzene	Source
Hydraulic Conductivity (K)	1.176E-2 cm/sec	1.176E-2 cm/sec	Site-Specific
Hydraulic gradient (i)	0.00096 ft/ft	0.00096 ft/ft	Site-Specific
Effective Porosity (n)	0.30	0.30	Site-Specific
Seepage velocity (Vs)	Calculated by model	Calculated by model	Calculated by model
Longitudinal Dispersivity (alpha x)	Calculated by model	Calculated by model	Calculated by model
Transverse Dispersivity (alpha y)	Alpha x/3	Alpha x/3	Bioscreen User's Manual
Vertical Dispersivity (alpha z)	Alpha x/20	Alpha x/20	Bioscreen User's Manual
Estimated Plume Length (Lp)	700 ft	700 ft	Estimated plume length
Soil Bulk Density (rho)	1.842 kg/L	1.842 kg/L	Site-Specific
Partition Coefficient (K_{oc})	180000 L/kg	59 L/kg	Lead – RAIS (Kd = 900 cm3/g), BTEX - Florida 62-777, Table 4, Technical Report
Fraction Organic Carbon (f_{oc})	5.0E-3	5.0E-3	Site-Specific
Retardation factor (R)	Calculated by model	Calculated by model	Calculated by model
Solute Half Life (t-half)	0 year	2.95 years	Model calibration based on field data for benzene
1st Order Decay Coefficient	Calculated by model	Calculated by model	Calculated by model
Instantaneous reaction Model			
Delta Oxygen	0	5.8 mg/L	Table 1,EPA/600R-96/087, Median Value
Delta Nitrate	0	6.3 mg/L	Table 1,EPA/600R-96/087, Median Value
Observed Ferrous Iron	0	16.6 mg/L	Table 1,EPA/600R-96/087, Median Value
Delta Sulfate	0	24.6 mg/L	Table 1,EPA/600R-96/087, Median Value
Observed Methane	0	7.2 mg/L	Table 1,EPA/600R-96/087, Median Value
Modeled Area Length	2200 ft	2200 ft	Nearest bay at 1000 ft
Modeled Area Width	350 ft	350 ft	Approximate plume width
Simulation Time	100 Years	15 – 127 Years	Assumed
Source Thickness in Saturated Zone	9.5 ft	9.5 ft	5+(11/2) = 9.5 ft
Soluble Mass	1.71 kg	882 kg	Attachment 2

Output Results

The simulation used the no degradation model for lead and the first order decay model and instantaneous reaction model for benzene. Benzene was the only BTEX component selected for simulation because it has the strictest Risk Based Screening Level (RBSL) and is the most mobile of all the BTEX components. A copy of the BIOSREEN input and output runs are attached.

The modeling results indicate that the contaminants will not reach the Perdido Bay, which is 1000 ft downgradient of the site.

The no degradation model for the lead predicts the presence of lead near the source zone at concentrations above the GCTL (15 ug/L) for a reasonably long time. The first-order decay model for the benzene, predicts that the concentration of benzene near the source zone would be reduced to 1ug/L in approximately 127 years. However, the instantaneous reaction model predicts that the concentration of benzene would be reduced to 1 ug/L in approximately 15 years. The GCTL for benzene in groundwater is 1ug/L.

The first order decay model and instantaneous reaction model for benzene was run using the aqueous solubility of organic constituent dissolved from product given by Raoult's Law. However it is anticipated that after the free product removal, the concentrations of the organic constituents (BTEX) and lead would be considerable lower. Therefore, it is recommended to collect groundwater samples after free product removal and running the simulations for more accurate predictions.

The instantaneous reaction model is based on the median values of DO, NO3, Fe2+, SO4, and CH4 obtained from the BIOSCREEN user manual, since the actual field data was not available. Therefore, it is recommended that site-specific natural attenuation parameters be collected after free product removal and the simulations repeated.

Model Runs

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

Navy, Pensacola, FL	
Site 1159, Benzene	
Run Name	

Data Input Instructions:

115 → 1. Enter value directly....or
↑ or
0.02 → 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.

20 → Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	38.9	(ft/yr)
or		↑ or	
Hydraulic Conductivity	K	1.2E-02	(cm/sec)
Hydraulic Gradient	i	0.00096	(ft/ft)
Porosity	n	0.3	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	21.0	(ft)
Transverse Dispersivity*	alpha y	7.0	(ft)
Vertical Dispersivity*	alpha z	1.0	(ft)
or		↑ or	
Estimated Plume Length	Lp	700	(ft)

3. ADSORPTION

Retardation Factor*	R	2.8	(-)
or		↑ or	
Soil Bulk Density	rho	1.842	(kg/l)
Partition Coefficient	Koc	59	(L/kg)
FractionOrganicCarbon	foc	5.0E-3	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	2.3E-1	(per yr)
or		↑ or	
Solute Half-Life	t-half	2.95	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	5.8	(mg/L)
Delta Nitrate*	NO3	6.3	(mg/L)
Observed Ferrous Iron*	Fe2+	16.6	(mg/L)
Delta Sulfate*	SO4	24.6	(mg/L)
Observed Methane*	CH4	7.2	(mg/L)

5. GENERAL

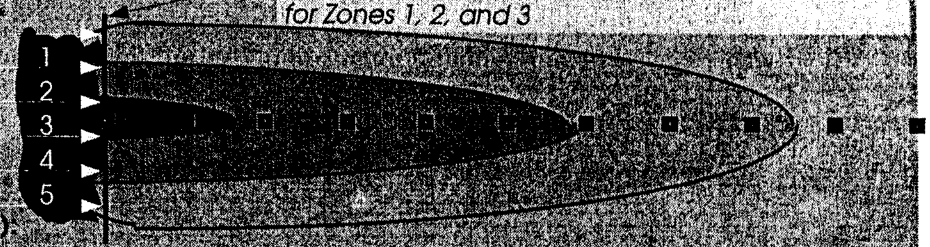
Modeled Area Length*	250	(ft)
Modeled Area Width*	350	(ft)
Simulation Time*	15.00	(yr)

6. SOURCE DATA

Source Thickness in Sat. Zone* 9.5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
30	68.18
130	68.18
30	68.18
130	68.18
30	68.18



Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

Source Halflife (see Help):

Inst. React.	1st Order	
6	8	(yr)

Soluble Mass 882 (Kg)
In Source NAPL, Soil

7. FIELD DATA FOR COMPARISON

7. Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

Concentration (mg/L)	68.18										.748
Dist. from Source (ft)	0	25	50	75	100	125	150	175	200	225	250

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

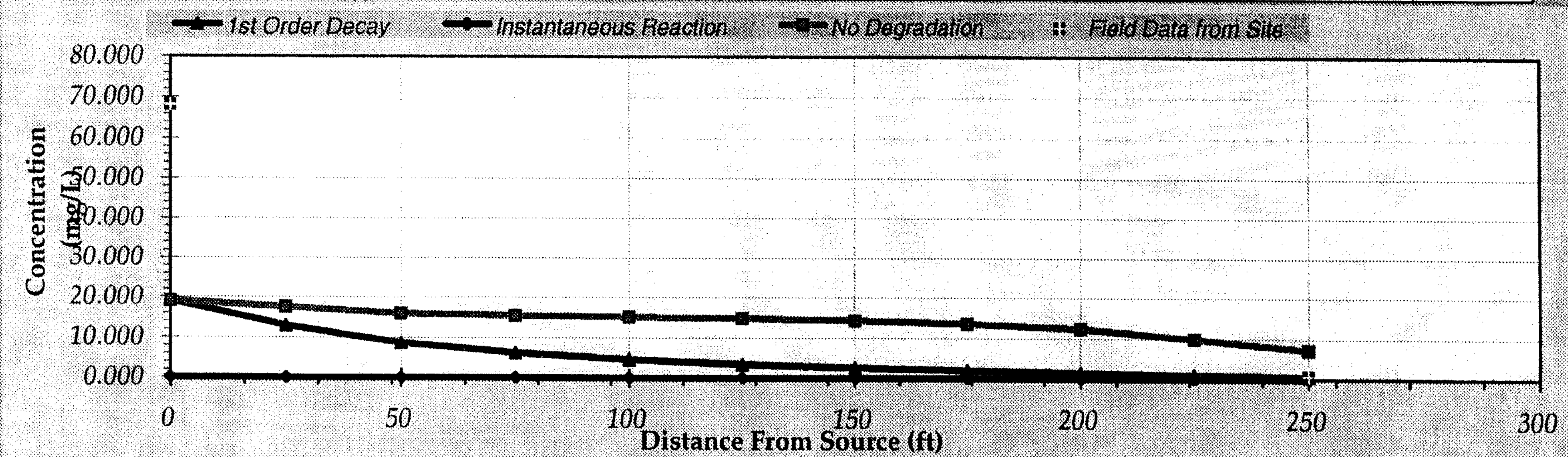
Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	0	25	50	75	100	125	150	175	200	225	250
No Degradation	19.062	17.561	15.988	15.361	15.056	14.760	14.282	13.503	12.373	9.821	7.118
1st Order Decay	19.062	12.918	8.612	6.130	4.522	3.401	2.581	1.961	1.481	0.993	0.622
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	68.180										0.748



Calculate Animation

Time: 15.0 Years

Return to Input

Recalculate This Sheet

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

Navy, Pensacola, FL
Site 1159, Benzene
Run Name

Data Input Instructions:

115	1. Enter value directly... or
↑ or	2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
0.02	
Variable*	→ Data used directly in model.
20	→ Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	*Vs*	38.9	*(ft/yr)*
or		↑ *or*	
Hydraulic Conductivity	*K*	1.2E-02	*(cm/sec)*
Hydraulic Gradient	*i*	0.00096	*(ft/ft)*
Porosity	*n*	0.3	*(-)*

2. DISPERSION

Longitudinal Dispersivity*	*alpha x*	21.0	*(ft)*
Transverse Dispersivity*	*alpha y*	7.0	*(ft)*
Vertical Dispersivity*	*alpha z*	1.0	*(ft)*
or		↑ *or*	
Estimated Plume Length	*Lp*	700	*(ft)*

3. ADSORPTION

Retardation Factor*	*R*	2.8	*(-)*
or		↑ *or*	
Soil Bulk Density	*rho*	1.842	*(kg/l)*
Partition Coefficient	*Koc*	59	*(L/kg)*
FractionOrganicCarbon	*foc*	5.0E-3	*(-)*

4. BIODEGRADATION

1st Order Decay Coeff*	*lambda*	2.3E-1	*(per yr)*
or		↑ *or*	
Solute Half-Life	*t-half*	2.95	*(year)*
or Instantaneous Reaction Model			
Delta Oxygen*	*DO*	5.8	*(mg/L)*
Delta Nitrate*	*NO3*	6.3	*(mg/L)*
Observed Ferrous Iron*	*Fe2+*	16.6	*(mg/L)*
Delta Sulfate*	*SO4*	24.6	*(mg/L)*
Observed Methane*	*CH4*	7.2	*(mg/L)*

5. GENERAL

Modeled Area Length*	2000	*(ft)*
Modeled Area Width*	350	*(ft)*
Simulation Time*	127.00	*(yr)*

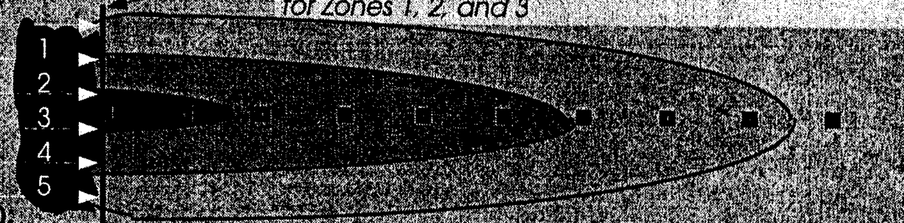
6. SOURCE DATA

Source Thickness in Sat.Zone* 9.5 *(ft)*

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

Source Zones:

Width* (ft)	Conc. (mg/L)*
30	68.18
130	68.18
30	68.18
130	68.18
30	68.18



View of Plume Looking Down

Source Halflife (see Help):

6	8	*(yr)*
Inst. React. ↑	↑ 1st Order	

Soluble Mass 882 *(Kg)*
In Source NAPL, Soil

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	68.18										
Dist. from Source (ft)	*0*	*200*	*400*	*600*	*800*	*1000*	*1200*	*1400*	*1600*	*1800*	*2000*

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

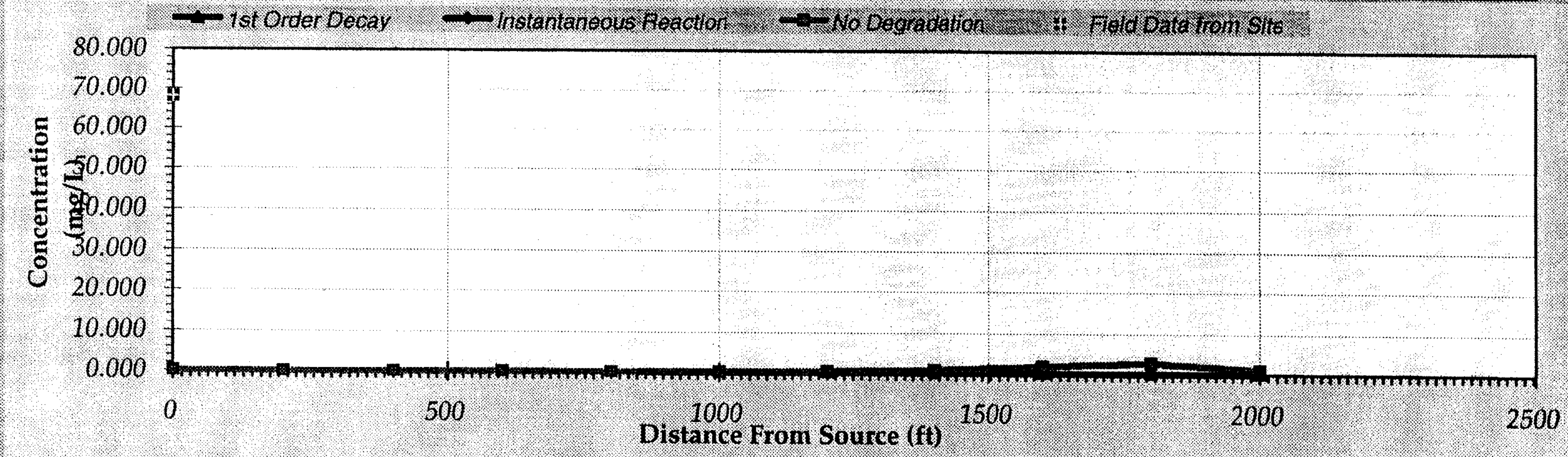
Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.001	0.002	0.004	0.011	0.031	0.092	0.268	0.751	1.831	2.692	1.050
1st Order Decay	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	68.180										



Calculate Animation

Time: 127.0 Years

Return to Input

Recalculate This Sheet

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

Navy, Pensacola, FL	
Site 1159, Lead	
	Run Name

Data Input Instructions:

115	1. Enter value directly....or
↑ or	2. Calculate by filling in grey
0.02	cells below. (To restore formulas, hit button below).
Variable	→ Data used directly in model.
20	→ Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	*Vs*	38.9	*(ft/yr)*
or		↑ *or*	
Hydraulic Conductivity	*K*	1.2E-02	*(cm/sec)*
Hydraulic Gradient	*i*	0.00096	*(ft/ft)*
Porosity	*n*	0.3	*(-)*

2. DISPERSION

Longitudinal Dispersivity*	*alpha x*	21.0	*(ft)*
Transverse Dispersivity*	*alpha y*	7.0	*(ft)*
Vertical Dispersivity*	*alpha z*	1.0	*(ft)*
or		↑ *or*	
Estimated Plume Length	*Lp*	700	*(ft)*

3. ADSORPTION

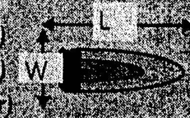
Retardation Factor*	*R*	5527.0	*(-)*
or		↑ *or*	
Soil Bulk Density	*rho*	1.842	*(kg/l)*
Partition Coefficient	*Koc*	180000	*(L/kg)*
FractionOrganicCarbon	*foc*	5.0E-3	*(-)*

4. BIODEGRADATION

1st Order Decay Coeff*	*lambda*	0.0E+0	*(per yr)*
or		↑ *or*	
Solute Half-Life	*t-half*		*(year)*
or Instantaneous Reaction Model			
Delta Oxygen*	*DO*	0	*(mg/L)*
Delta Nitrate*	*NO3*	0	*(mg/L)*
Observed Ferrous Iron*	*Fe2+*	0	*(mg/L)*
Delta Sulfate*	*SO4*	0	*(mg/L)*
Observed Methane*	*CH4*	0	*(mg/L)*

5. GENERAL

Modeled Area Length*	40	*(ft)*
Modeled Area Width*	350	*(ft)*
Simulation Time*	50	*(yr)*



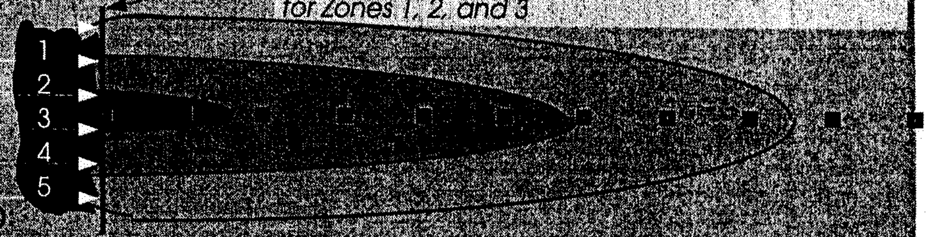
6. SOURCE DATA

Source Thickness in Sat.Zone* 9.5 *(ft)*

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

Source Zones:

Width* (ft)	Conc. (mg/L)*
30	0.015
130	0.1324
30	0.1324
130	0.1324
30	0.015



View of Plume Looking Down

Source Halflife (see Help):

10	10	*(yr)*
Inst. React. ↑	↑ 1st Order	
Soluble Mass	2	*(Kg)*
In Source NAPL, Soil		

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)											
Dist. from Source (ft)	0	4	8	12	16	20	24	28	32	36	40

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

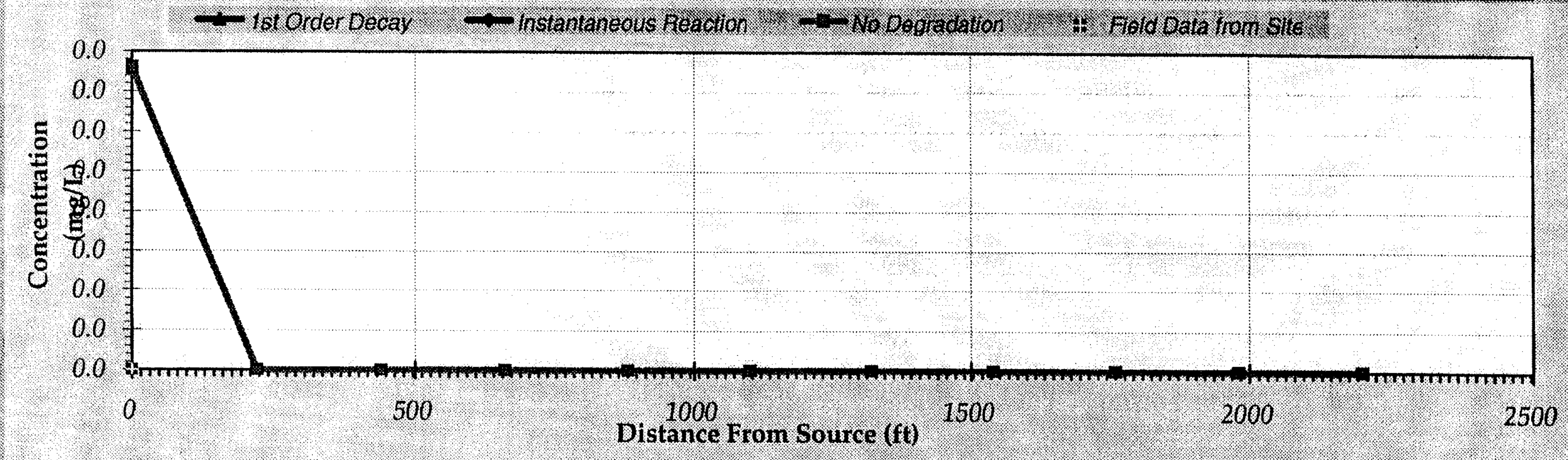
Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	220	440	660	880	1100	1320	1540	1760	1980	2200
No Degradation	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1st Order Decay	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Replay Animation

Next Timestep

Prev Timestep

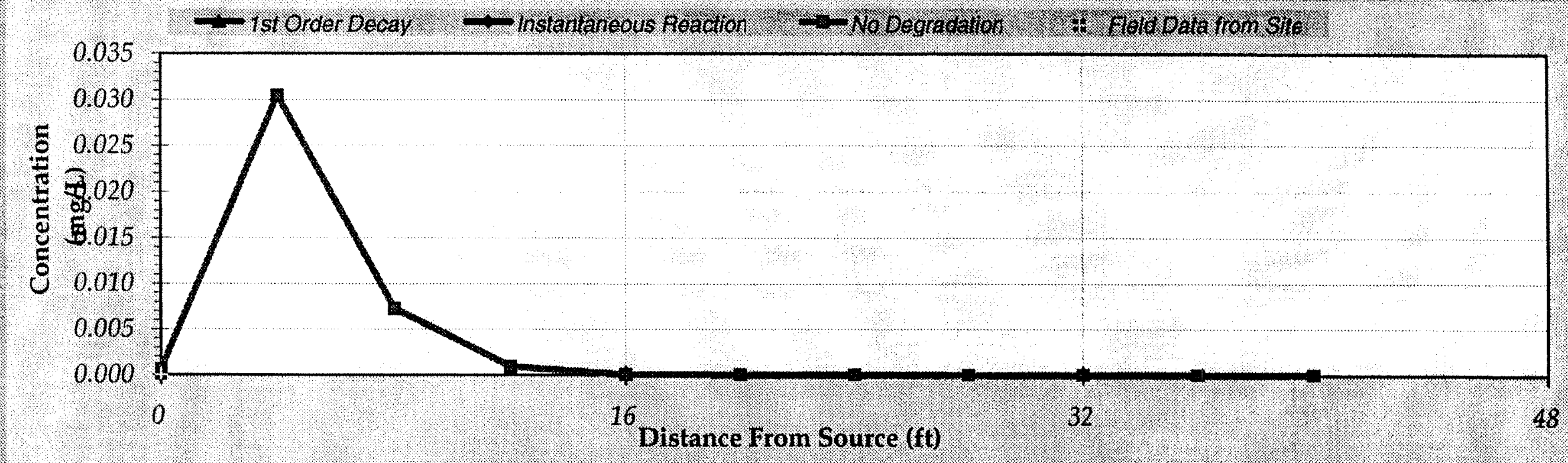
Time: 30.0 Years

Return to Input

Recalculate This Sheet

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	0	4	8	12	16	20	24	28	32	36	40
	Distance from Source (ft)										
No Degradation	0.001	0.030	0.007	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1st Order Decay	0.001	0.030	0.007	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.001	0.030	0.007	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

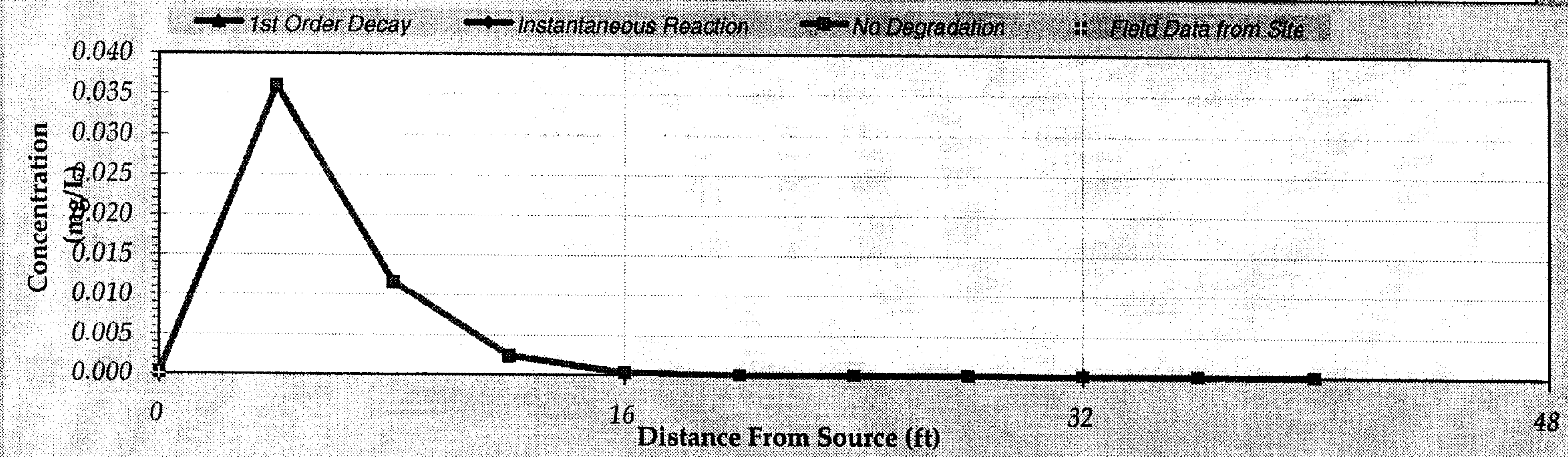
Time:
75.0 Years

Return to Input

Recalculate This Sheet

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	0	4	8	12	16	20	24	28	32	36	40
No Degradation	0.000	0.036	0.012	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1st Order Decay	0.000	0.036	0.012	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.036	0.012	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time:

100.0 Years

Return to Input

Recalculate This Sheet

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence *Version 1.4*

Navy, Pensacola, FL
Site 1159, Lead
Run Name

Data Input Instructions:

115	1. Enter value directly...or
↑ or	2. Calculate by filling in grey
0.02	cells below. (To restore formulas, hit button below).
Variable*	→ Data used directly in model.
20	→ Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	*Vs*	38.9	*(ft/yr)*
or		↑ *or*	
Hydraulic Conductivity	*K*	1.2E-02	*(cm/sec)*
Hydraulic Gradient	*i*	0.00096	*(ft/ft)*
Porosity	*n*	0.3	*(-)*

2. DISPERSION

Longitudinal Dispersivity*	*alpha x*	21.0	*(ft)*
Transverse Dispersivity*	*alpha y*	7.0	*(ft)*
Vertical Dispersivity*	*alpha z*	1.0	*(ft)*
or		↑ *or*	
Estimated Plume Length	*Lp*	700	*(ft)*

3. ADSORPTION

Retardation Factor*	*R*	5527.0	*(-)*
or		↑ *or*	
Soil Bulk Density	*rho*	1.842	*(kg/l)*
Partition Coefficient	*Koc*	180000	*(L/kg)*
FractionOrganicCarbon	*foc*	5.0E-3	*(-)*

4. BIODEGRADATION

1st Order Decay Coeff*	*lambda*	0.0E+0	*(per yr)*
or		↑ *or*	
Solute Half-Life	*t-half*		*(year)*
or Instantaneous Reaction Model			
Delta Oxygen*	*DO*	0	*(mg/L)*
Delta Nitrate*	*NO3*	0	*(mg/L)*
Observed Ferrous Iron*	*Fe2+*	0	*(mg/L)*
Delta Sulfate*	*SO4*	0	*(mg/L)*
Observed Methane*	*CH4*	0	*(mg/L)*

5. GENERAL

Modeled Area Length*	40	*(ft)*
Modeled Area Width*	350	*(ft)*
Simulation Time*	100	*(yr)*

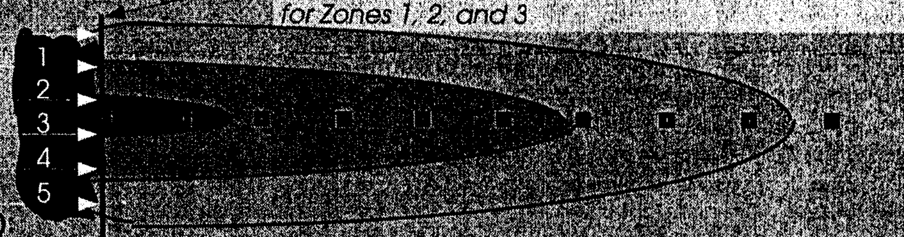
6. SOURCE DATA

Source Thickness in Sat.Zone* 9.5 *(ft)*

Source Zones:

Width* (ft)	Conc. (mg/L)*
30	0.015
130	0.1324
30	0.809
130	0.1324
30	0.015

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Source Halflife (see Help):

6	6	*(yr)*
Inst. React. ↑	↑ 1st Order	

Soluble Mass 2 *(Kg)*
In Source NAPL, Soil

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)											
Dist. from Source (ft)	0	4	8	12	16	20	24	28	32	36	40

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

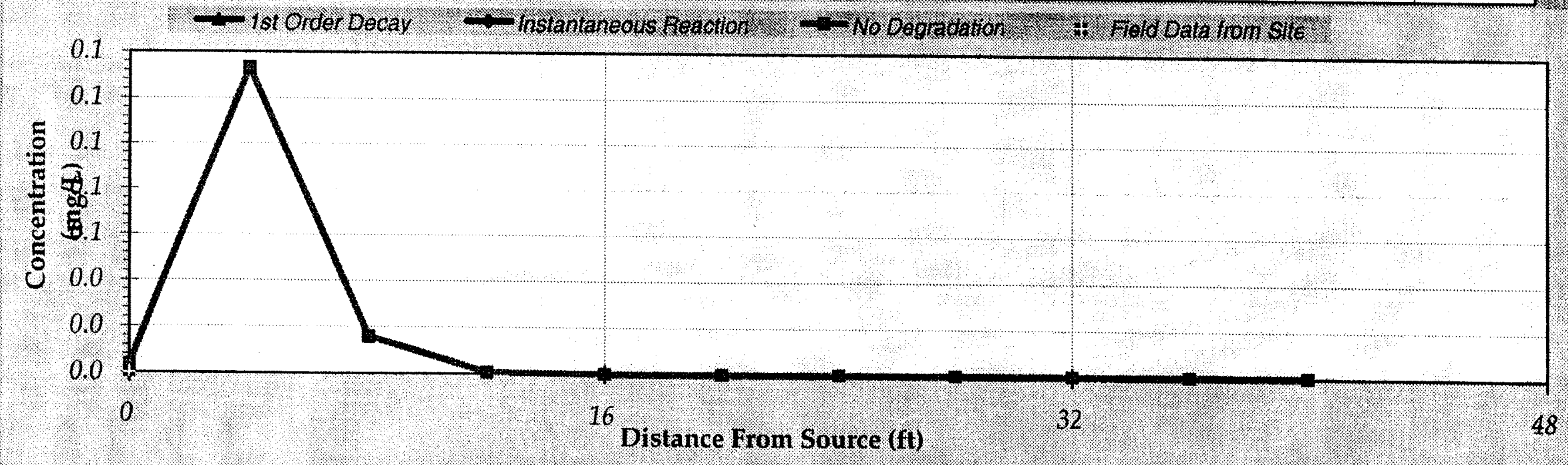
Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	4	8	12	16	20	24	28	32	36	40
No Degradation	0.003	0.133	0.016	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1st Order Decay	0.003	0.133	0.016	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.003	0.133	0.016	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Replay Animation

Next Timestep

Prev Timestep

Time: 50.0 Years

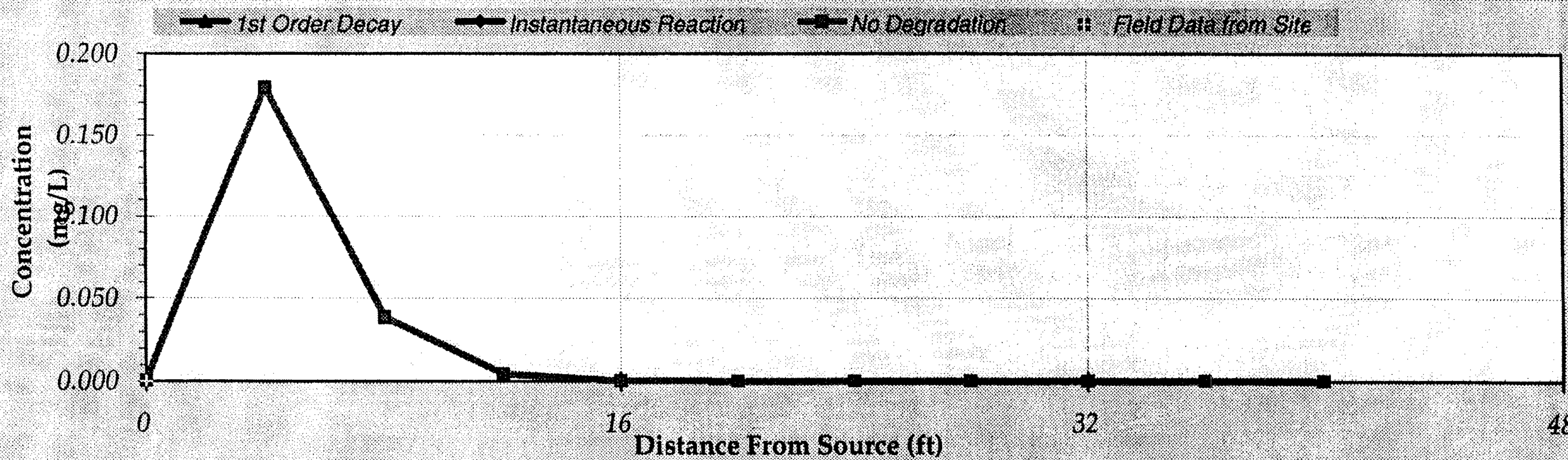
Return to Input

Recalculate This Sheet

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	4	8	12	16	20	24	28	32	36	40
No Degradation	0.000	0.179	0.039	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1st Order Decay	0.000	0.179	0.039	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.179	0.039	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time: 75.0 Years

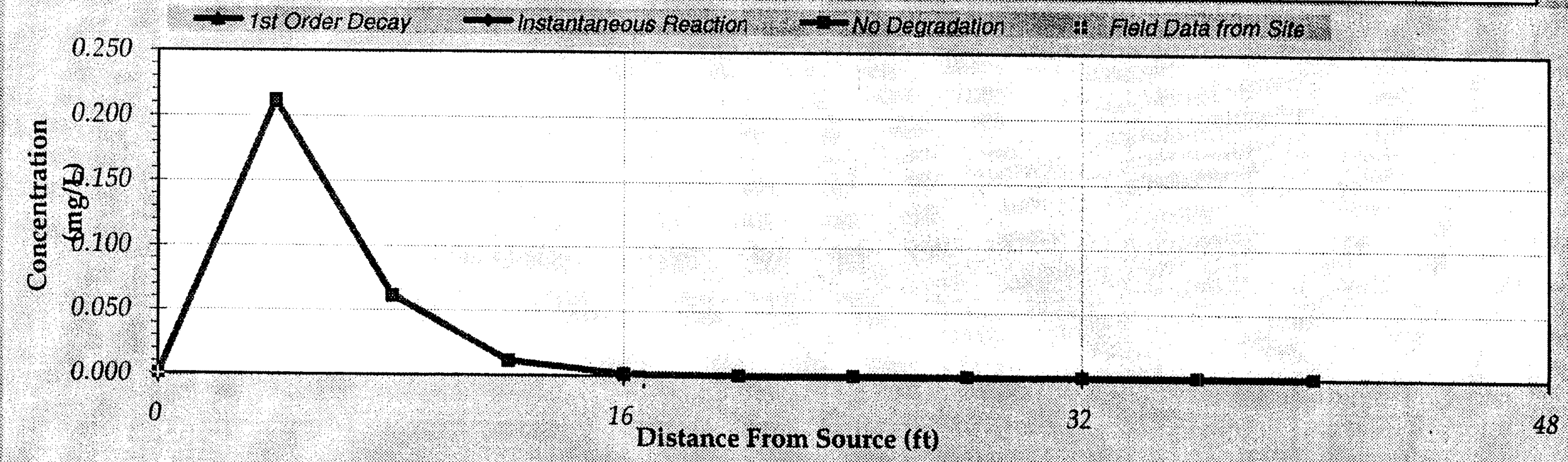
Return to Input

Recalculate This Sheet

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	4	8	12	16	20	24	28	32	36	40
No Degradation	0.000	0.212	0.062	0.011	0.001	0.000	0.000	0.000	0.000	0.000	0.000
1st Order Decay	0.000	0.212	0.062	0.011	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.212	0.062	0.011	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time:
100.0 Years

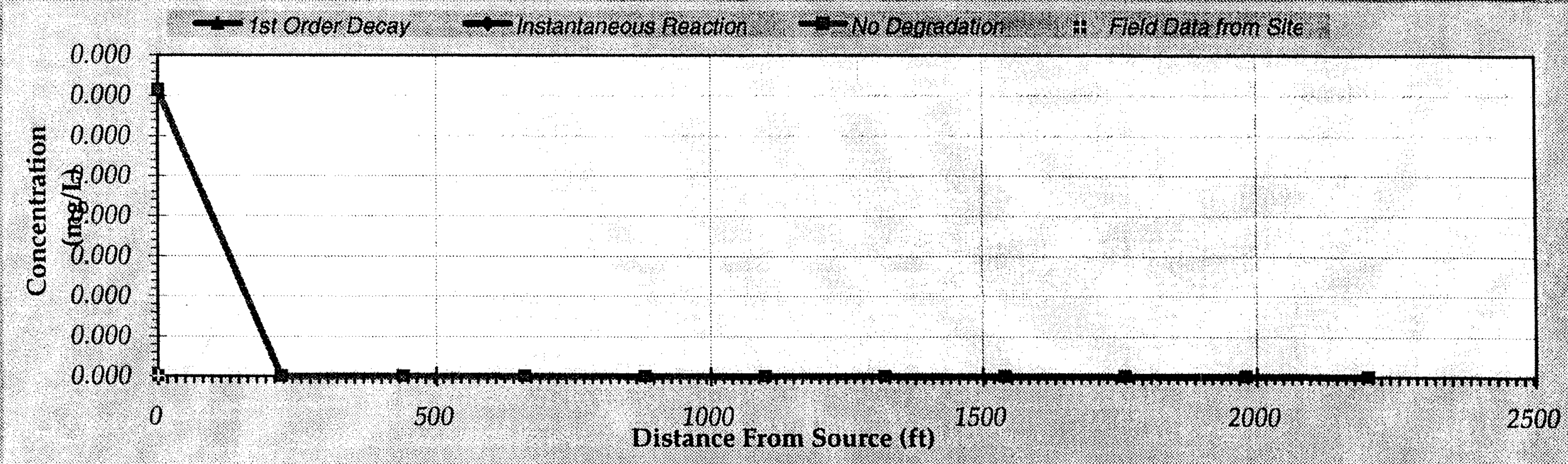
Return to Input

Recalculate This Sheet

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	220	440	660	880	1100	1320	1540	1760	1980	2200
No Degradation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1st Order Decay	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time:

100.0 Years

Return to Input

Recalculate This Sheet

Attachment 1

ATTACHMENT 1
HYDROCARBON CONSTITUENT CONCENTRATIONS IN WATER BASED ON RAOULT'S LAW

Parameter Descriptions:	Units
C_W = Aqueous Solubility of Organic Constituents Dissolved from Product	mg/L
C_F = Concentration of the Constituent in the Fuel	mg/L
K_{FW} = Fuel/Water Partition Coefficient	
P_F = Density of the Product	g/mL
MW_F = Molecular Weight of the Product	g/mol
C_{SAT} = Aqueous Solubility of the Constituent	mol/L
MW_C = Molecular Weight of the Constituent	g/mol
$K_{FW} = (10^3(mL/L)\ p_F)/(MW_F{*}C_{SAT}/(MW_C{*}1000))$	
$C_W = C_F/K_{FW}$	mg/L

Source: "Solubility, Sorption, and Transport of Hydrophobic Organic Chemicals in Complex Mixtures," EPA Environmental Research Brief, EPA/600/M-91/009, Robert S. Kerr Environmental Research Laboratory, ADA, Oklahoma.

Key Assumptions:

MW_F : Molecular Weight of Weathered Product, Source: "A Practical Approach to the Design, Operation, and Monitoring of In-Situ Soil Venting Systems", Shell Development/Shell Oil Company, Houston, Texas.
P_F : Density of the Product, Source: Conoco Material Safety Data Sheet for unleaded gasoline.

Concentration of Hydrocarbon Constituents in Water Based on Molar Solubility

Constituent	MW_F g/mol	C_{SAT} mg/L	MW_C g/mol	P_F g/mL	K_{FW}	C_F mg/L	C_W mg/L
Benzene	111.00	1,750	78	0.675	271.04	18,480.0	68.18
Toluene	111.00	535	92	0.675	1045.72	115,500.0	110.45
Ethylbenzene	111.00	152	106	0.675	4240.75	15,400.0	3.63
Xylene	111.00	198	106	0.675	3255.53	92,400.0	28.38
MTBE	111.00	48,000	88.15	0.675	11.17	67,375.0	6033.05
Naphthalene	111.00	33	128.2	0.675	23624.08	5,852.0	0.25

Attachment 2

Attachment 2
Estimated Mass of Dissolved and Adsorbed Contaminants in Saturated Zone

Remedial Action Plan
Site 1159
Naval Air Station Pensacola
Pensacola, Florida

Mass of Soluble Contaminants Calculations

Well Number	Benzene (µg/L)	Ethylbenzene (µg/L)	Toluene (µg/L)	Xylene (µg/L)	MTBE (µg/L)	Lead (µg/L)	TRPH (µg/L)	Impacted Thickness (feet)
MW-1	547	195	1580	909	12.2	99.1	1750	9.5
MW-2	--	44.8	--	83	--	97.8	1210	9.5
MW-4	54.8	52.9	296	262	24.1	136	3210	9.5
MW-18	748	516	5820	3200	30.2	62.9	3720	9.5
MW-20	0.61	1.2	4.6	21.8	--	--	204	9.5
MW-21	--	1	0.94	40.3	--	--	--	9.5
MW-22	--	162	5.3	612	38.6	31.6	1180	9.5
MW-23	225	173	1750	1040	--	189	4240	9.5
MW-27	483	223	2000	1680	--	809	7070	9.5
MW-28	--	238	815	1550	17.5	566	5430	9.5
MW-30	1.2	1.9	--	4.8	--	--	--	9.5
MW-47	301	574	5870	3620	109	46.8	1670	9.5
MW-55	--	344	403	1300	63	70.1	1540	9.5
MW-64	--	14.1	--	32.4	31.1	--	--	9.5
MW-67	3.1	42.6	4.8	140	7.7	9.6	945	9.5
MW-68	--	43.2	--	116	20.6	--	361	9.5

	Benzene	Ethylbenzene	Toluene	Xylene	MTBE	Lead	TRPH
Average Dissolved Contaminant Concentration (µg/L)	147.7	164.2	1159.4	907.0	22.1	132.4	2033.1
Estimated Mass of Dissolved Contaminants based on Average Concentrations (lbs)	4.21	4.67	33.00	25.82	0.63	3.77	57.88
Estimated Mass of Dissolved Contaminants based on Average Concentrations (kgs)	1.91	2.12	15.00	11.74	0.29	1.71	26.31
Maximum Site Dissolved Contaminant Concentration (µg/L)	748.0	574.0	5870.0	3620.0	109.0	809.0	5430.0
Estimated Site Mass of Dissolved Contaminants based on Maixmum Concentrations (kg)	9.68	7.43	75.96	46.84	1.41	10.47	70.26
Aqueous Solubility from product based on Raoults Law (µg/L)	68,180	3,630	110,450	28,380			
Estimated Site Mass of Dissolved Contaminants based on Raoults Law (kg)	882	47	1,429	367			

Estimated GW Volume:

Impacted Area x Thickness x Porosity (n) = $(160{,}000\ ft^2)*(9.5\ ft)*(0.30)*(7.48\ gal/ft^3)$ = 3,410,880 gallons

Estimated Mass of Soluble Contaminants:

$M_{dissolved}$ (lbs) = $C_{dissolved}$ (µg/L) * V_{gw} (gal) * 3.7854 (L/gal) * 2.205E-9 (lb/µg)

where:

$M_{dissolved}$ = mass of dissolved contaminants (lbs)

$C_{dissolved}$ = average dissolved contaminant concentration (µg/L)

V_{gw} = volume of impacted groundwater (gal)

APPENDIX E

FDEP REMEDIAL ACTION SUMMARY FORM

DEP Form # 62-770.900(4)	
Form Title: Remedial Action Plan Summary	
Effective Date: September 23, 1997	

Remedial Action Plan Summary

Site Name Site 1159, Outlying Landing Field Bronson
Location Pensacola, Flordia
Media Contaminated: ☑ Groundwater ☐ Soil

FDEP Facility ID No. 179300938
Current Date / /
Date of Last GW Analysis 7 / 11 / 0

Type(s) of Product(s) Discharged:
☑ Gasoline Analytical Group
☐ Kerosene Analytical Group (Diesel)
- Estimated Petroleum Mass (lbs):
  - Groundwater 58
  - Saturated Zone Soil 1620
  - Vadose Zone Soil ____
- Area of Plume 160,000 (ft^2)
- Thickness of Plume 9.5 (ft)

Groundwater Recovery and Specifications:
- No. of Recovery Wells 5
  - ☑ Vertical ☐ Horizontal
- Design Flow Rate/Well 1.0 (gpm)
- Total Flow Rate 5.0 (gpm)
- Hydraulic Conductivity 33 (ft/day)
- Recovery Well Screen Interval 10 (ft)
- Depth to Groundwater 10 to 20 (ft)

Method of Groundwater Remediation:
☐ Pump-and-Treat
- ☐ Air Stripper
  - ☐ Low Profile ☐ Packed Tower
- ☐ Diffused Aerator
- ☐ Activated Carbon
  - ☐ Primary Treatment ☐ Polishing

☐ In Situ Air Sparging
- No. of Sparge Points ____
  - ☐ Vertical ☐ Horizontal
- Pressure ____ (psi)
- Design Air Flow Rate/Well ____ (cfm)
- Total Air Flow Rate ____ (cfm)

☐ Biosparging
- No. of Sparge Points ____
  - ☐ Vertical ☐ Horizontal
- Design Air Flow Rate/Well ____ (cfm)

☐ Bioremediation
- ☐ In Situ ☐ Ex Situ

☐ Other ____

Method of Groundwater Disposal:
☐ Infiltration Gallery ☑ Sanitary Sewer
☐ Surface Discharge/NPDES ☐ Injection Well
☐ Other ____

Free Product Present ☑ Yes ☐ No
- Estimated Volume 242,000 (gal)
- Maximum Thickness 1.0 (in)
- Method of Recovery (check all that apply):
  - ☐ Manual Bailing ☐ Skimming Pump
  - ☑ Other Bioslurping

Method of Soil Remediation:
☐ Excavation
- Volume to be Excavated ____ (yds^3)
- ☐ Thermal Treatment ☐ Land Farming On Site
- ☐ Landfill ☐ Bioremediation
- ☐ Other ____

☑ Vapor Extraction System (VES)
- No. of Venting Wells 22
  - ☑ Vertical ☐ Horizontal
- VES - Applied Vacuum ____ (wg)
- Design Air Flow Rate 85 (cfm)
- Design Radius of Influence 40 (ft)
- Air Emissions Treatment
  - ☐ Thermal Oxidizer ☐ Catalytic Converter
  - ☑ Carbon ☐ Other ____

☐ Soil Bioventing
- No. of Venting Wells ____
  - ☐ Vertical ☐ Horizontal
- Design Air Flow Rate ____ (cfm)

☐ In Situ Bioremediation
☐ Other ____

Natural Attenuation:
- Method of Evaluation
  - ☐ Rule 62-770.690(1)(e), F.A.C.
  - ☐ Rule 62-770.690(1)(f), F.A.C.

Estimated Time of Cleanup: 3,650 (days)
- Method of Estimation
  - ☐ Pore Volumes (no. of pore vols. = ____)
  - ☐ Exponential Decay (Decay Rate) ____ (day^{-1})
  - ☐ Groundwater Model
  - ☑ Other RAP Engineering calculations

Estimated Cost:
- Est. Capital Cost (incl. install.) $ 515,000.00
- Est. O & M Cost (per year) $ 117,000.00
- Est. Total Cleanup Cost $ 1,782,000.00