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REMEDIAL ACTION PLAN SITE 107 OUTLYING LANDING FIELD BRONSON WITH TRANSMITTAL NAS PENSACOLA FL
10/1/2001
TETRA TECH

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October 8, 2001

Project Number N0401

Joe Fugitt, P.G.
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Florida Department of Environmental Protection
2600 Blair Stone Road
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Reference: Clean Contract Number N62467-94-D-0888
Contract Task Order Number 0112

Subject: Final Remedial Action Plan
Site 1107
Outlying Landing Field Bronson
Pensacola, Florida

Dear Mr. Fugitt:

Tetra Tech NUS Inc. (TtNUS) is pleased to submit the Final Remedial Action Plan for Site 1107 at Outlying Landing Field Bronson in Pensacola, Florida for your review. This report has been prepared for the U.S. Navy Southern Division Naval Facilities Engineering Command under Contract Task Order Number 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,

Joe D. Fleet

(for) Gerald Walker, P.G.
Project Manager

Enclosures

cc: Mr. B. Glover, SOUTHNAVFACENGCOM (1 copy)
Mr. G. Campbell, NAS Pensacola (1 copy)
Ms. D. Wroblewski, TtNUS (cover letter only)
Mr. G. Roof (1 copy)
Mr. M. Perry, TtNUS (unbound copy)
Project Office File

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10/10/01

Remedial Action Plan
for
Site 1107

Outlying Landing Field Bronson
Pensacola, Florida

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

October 2001

Rev. 1
10/10/01

REMEDIAL ACTION PLAN
FOR
SITE 1107

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.
Foster Plaza 7
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0112

OCTOBER 2001

PREPARED UNDER THE SUPERVISION OF:

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TETRA TECH NUS, INC.
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The professional opinions rendered in this decision document identified as Remedial Action Plan for Site 1107, Outlying Landing Field Bronson, Pensacola, Florida were developed in accordance with commonly accepted procedures consistent with applicable standards of practice. Decision documents were prepared under the supervision of the signing engineer and are based on information obtained from others. If conditions are determined to exist differently than those described in this document, then the undersigned professional engineer should be notified to evaluate the effects of any additional information on the project described in this document.

10/8/01

Gregory S. Roof, P.E.
Professional Engineering Number 50842
Tetra Tech NUS, Inc. Engineering Number 7988

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ACRONYMS

ASTM	American Society for Testing and Materials
bls	Below Land Surface
CAR	Contamination Assessment Report
CARA	CAR Addendum
CLEAN	Comprehensive Long-term Environmental Action Navy
COC	Chemicals of Concern
CTO	Contract Task Order
DO	Dissolved Oxygen
˚F	Degrees Fahrenheit
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FL-PRO	Florida Petroleum Range Organics
ft	Feet/Foot
ft^2	Square Feet
GCTLs	Groundwater Cleanup Target Levels
lbs	Pounds
LTTD	Low Temperature Thermal Desorption
MDES	Mobile Dual-phase Extraction System
mg/kg	Milligrams per Kilogram
MWR	Morale, Welfare, and Recreation
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
ppm	Parts-per-Million
RAP	Remedial Action Plan
SCTLs	Soil Cleanup Target Levels
SOUTHNAVFACENGCOM	Southern Division Naval Facilities Engineering Command
SVE	Soil Vapor Extraction
TPHs	Total Petroleum Hydrocarbons

ACRONYMS (Continued)

TRPH	Total Recoverable Petroleum Hydrocarbons
TtNUS	Tetra Tech NUS, Inc.
µg/kg	Micrograms per Kilogram
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOA	Volatile Organic Aromatics
VOCs	Volatile Organic Compounds
yd^3	Cubic Yards

EXECUTIVE SUMMARY

Tetra Tech NUS, Inc. (TtNUS) has completed a Remedial Action Plan (RAP) for Site 1107 at the Outlying Landing Field (OLF) Bronson, Pensacola, Florida, in accordance with the requirements of Chapter 62-770, Florida Administrative Code (FAC). This plan is being submitted to the Florida Department of Environmental Protection (FDEP) for approval.

TtNUS performed the following tasks during the RAP:

- Reviewed the Contamination Assessment Report (CAR) and Contamination Assessment Report Addendums (CARA) [Navy Public Works Center (NPWC) 1997, NPWC 1998, & TtNUS 2001].

- Evaluated remedial alternatives to address the soil and free product contamination.

- Prepared a RAP to remediate the contaminated soil, remove free product, 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 1) identify a method to perform free product recovery in the source area, and 2) select a remedial alternative to reduce hydrocarbon constituents within the soil matrix. This RAP identified soil excavation and disposal as the selected alternative for remedial action at Site 1107. The remedial alternative was selected because it was determined to be the most effective method for the removal of free product and remediation of soil impacted by Bunker C fuel oil. If implemented, it is expected to require approximately three to six months to mobilize and remove soil above soil cleanup target levels (SCTLs). Post remedial action activities specified in 62-770 FAC will require a minimum of 12 months of groundwater monitoring.

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This RAP was prepared by TtNUS for the United States Navy (Navy) Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) 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 soil and free phase hydrocarbons (free product) present at OLF Bronson, Site 1107, Pensacola, Florida as a result of a release of Bunker C fuel at the site (NWPC, 1997).

In June 1997, a CAR for OLF Bronson, Site 1107, Pensacola, Florida was submitted by Naval Air Station (NAS) Pensacola NPWC to FDEP for review. A CARA was completed for the site by NPWC on December 2, 1998, and an additional CARA was completed by TtNUS and submitted to FDEP on January 25, 2001. Following the submission of the TtNUS CARA, the FDEP requested the preparation and submittal of a RAP to address Bunker C Fuel oil released at Site 1107 (NWPC, 1997).

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

1.2 SITE DESCRIPTION

Site 1107 is located 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 support buildings for the airfield. OLF Bronson is now known as the Blue Angel Recreation Park and is used for recreation purposes (NPWC, 1997). Figure 1-1 and Figure 1-2 illustrate the site location and site vicinity, respectively.

OLF Bronson consists of approximately 950 acres of mostly grass and forest. The area surrounding OLF Bronson is sparsely populated. Two small communities, Paradise Beach and Perdido Heights, are

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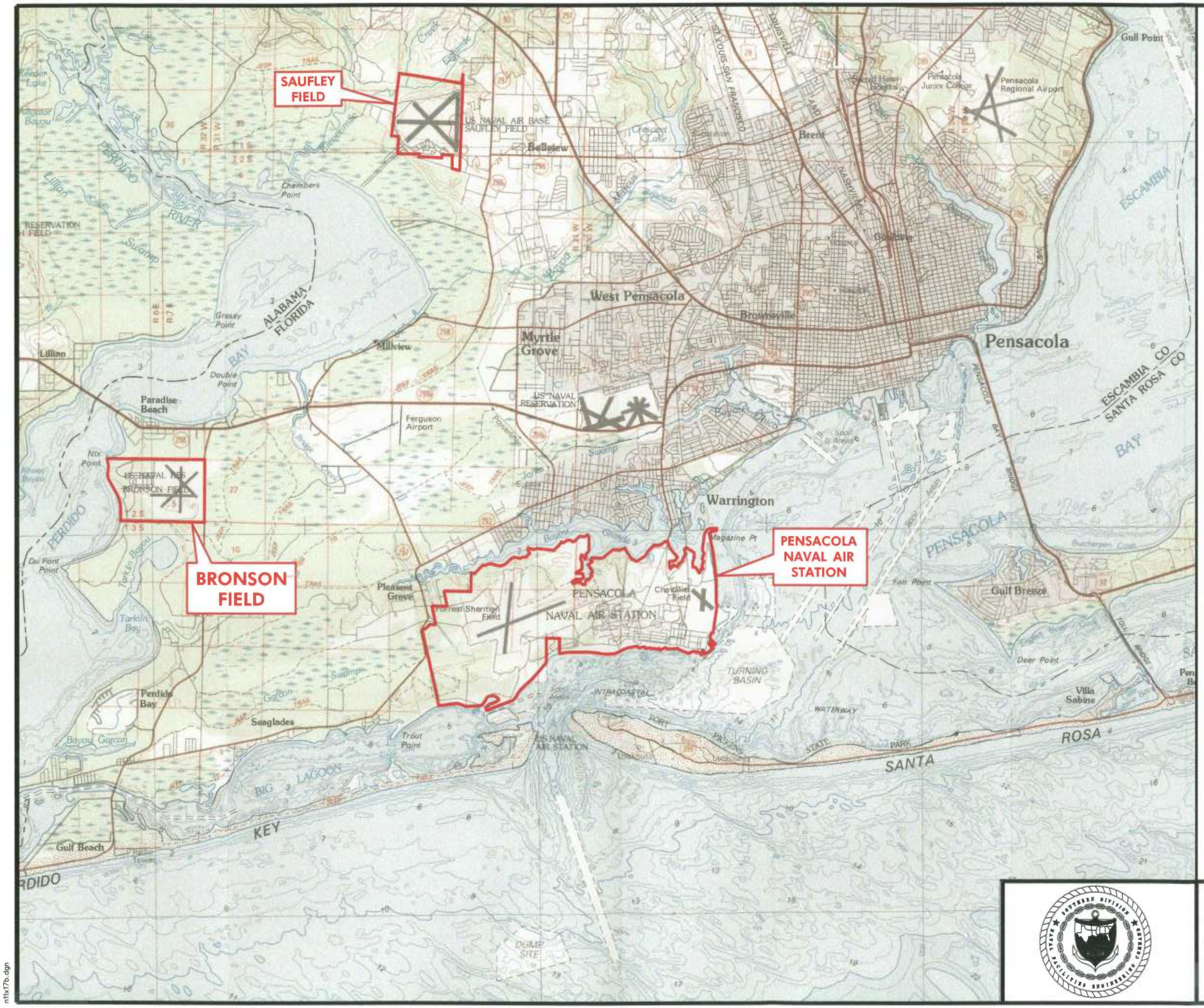

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FIGURE 1-1

SITE LOCATION MAP
UST SITE NO. 1107
REMEDIAL ACTION PLAN

OUTLYING LANDING FIELD BRONSON
PENSACOLA, FLORIDA

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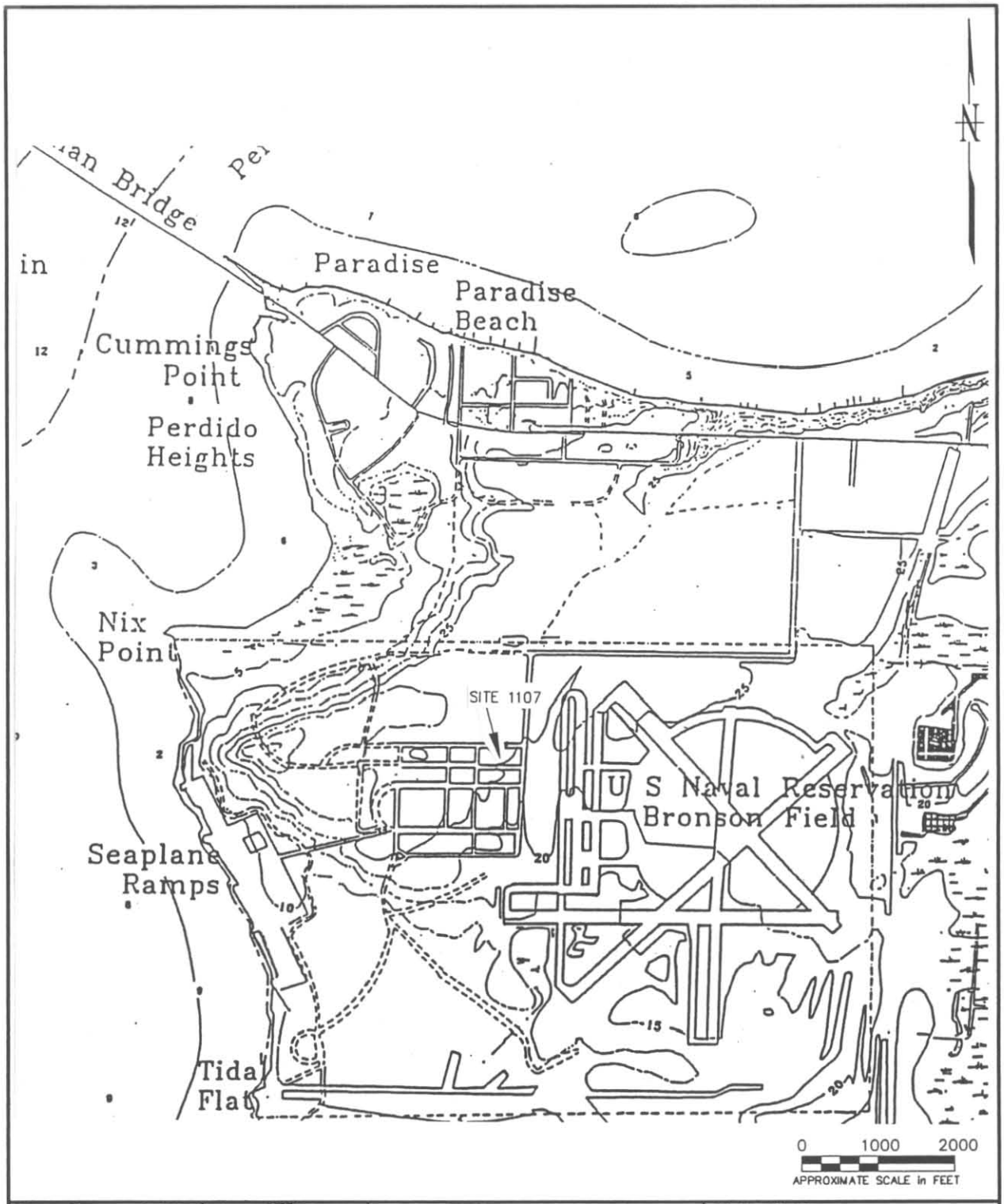

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CHECKED BY DATE			APPROVED BY DATE	
COST/SCHED-AREA			APPROVED BY DATE	
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located approximately one mile to the north of the old airfield. A few houses are located around the perimeter of the old airfield, 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 north, south, and east of OLF Bronson characterize the areas. Perdido Bay is located west of OLF Bronson.

Site 1107 is located at latitude 30° 23' 12" N, longitude 87° 25' 01" W. The underground storage tanks (USTs) removed from the site were previously located on the east side of an existing concrete slab, the remains of Building 1107. To the south, east, and west of the site are dense woods, and to the north is a dirt road running east to west. A large fenced-in scrap yard is located approximately 100 yards to the west, on the north side of the dirt road (NPWC, 1997). Figure 1-3 displays the site plan and former tank locations.

1.3 SITE HISTORY

OLF Bronson was used as an outlying landing field for NAS Pensacola from 1942 to 1950. When first opened in 1942, the 950-acre airfield was originally called Tarklin Field, but in 1944 the name was changed to OLF Bronson. During that time, the base used aviation gasoline, oil products, and solvents. OLF Bronson was closed as an active airfield in late 1950. Helicopters used the area for occasional training until 1995. Presently, all the runways are inactive. All buildings at OLF Bronson have been dismantled and portions of the base have been sold to private parties. Maps of OLF Bronson show Building 1107 was designated as a Boiler House. As of 1997, the only employees at Bronson were Morale, Welfare, and Recreation (MWR) personnel. Duties of MWR personnel at OLF Bronson included operating the campground, minor maintenance of the facility, and teaching sailing and windsurfing (NPWC, 1997).

In September 1993, the NPWC was retained by SOUTHNAVFACENGCOM to remove approximately 35 USTs. On June 14, 1994, during the removal of the five USTs at Site 1107, petroleum contamination was discovered at the site. A Discharge Reporting Form was submitted to FDEP for Site 1107 on June 15, 1994 (NPWC, 1997).

Four USTs at the site were used for storage of heating oil, reported to be Bunker C fuel oil. Three of the tanks had a storage capacity of 1,500 gallons, and one tank had a storage capacity of 3,000 gallons. The fifth UST was a 250-gallon tank used for the storage of butane. The USTs were approximately 50-years old (NWPC, 1997). The Closure Assessment Form for Site 1107 documented the presence of free product and petroleum hydrocarbon levels in the soils at levels greater than 50 parts-per-million (ppm). Analytical results of the groundwater sample collected from a monitoring well during tank closure indicated contaminant levels above regulatory criteria (NWPC, 1997).

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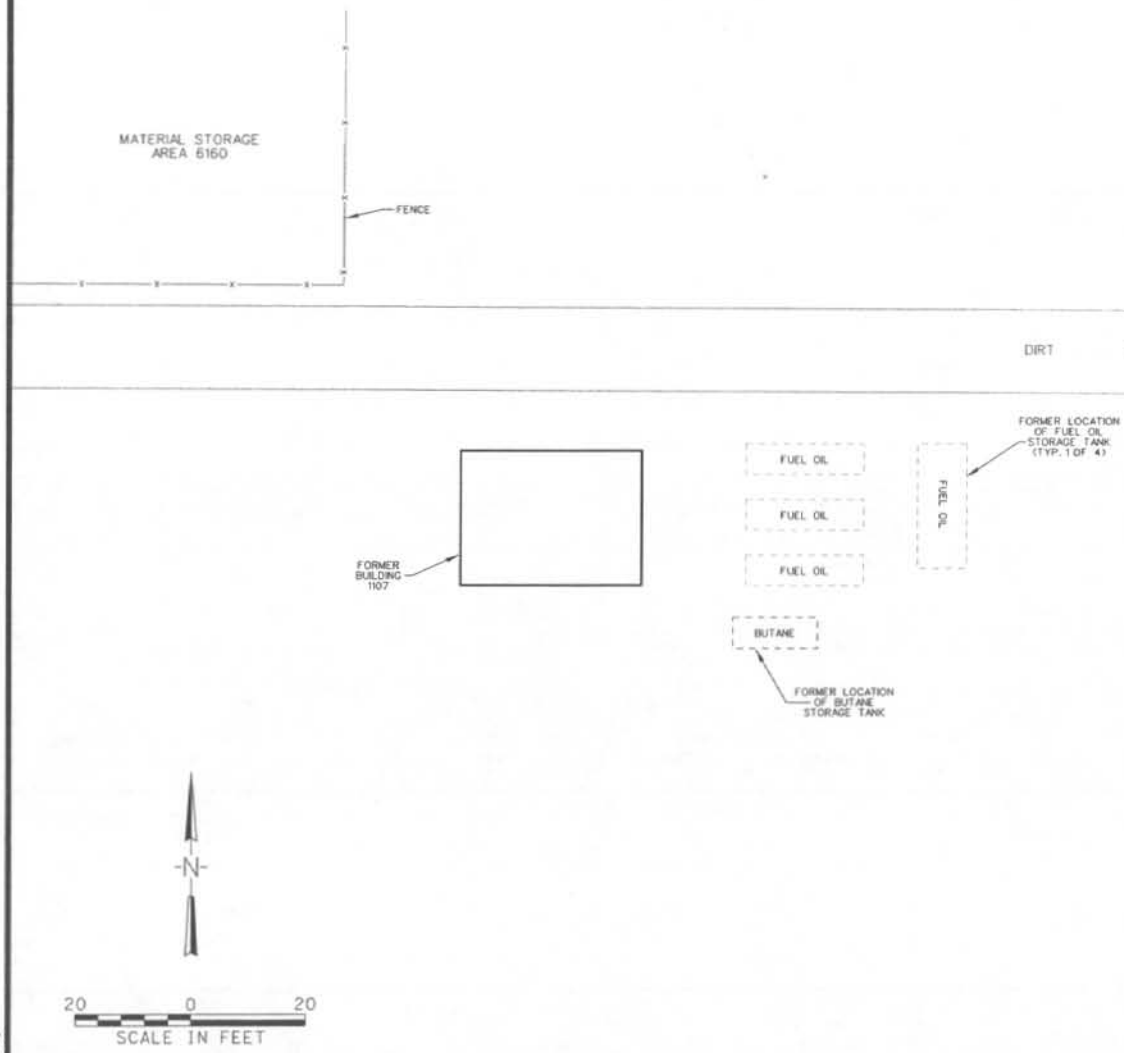

FIGURE 1-3

SITE PLAN
UST SITE NO. 1107
REMEDIAL ACTION PLAN

OUTLYING LANDING FIELD BRONSON
PENSACOLA, FLORIDA

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1.4 REPORT ORGANIZATION

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

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

- Section 2: CAR Findings and Conclusions. Reviews the approved CARA and summarizes the CAR and CARA's findings and conclusions.

- Section 3: RAP Goals. Sets the soil and free product treatment objectives for the remedial system/plan.

- Section 4: Contaminant Distribution. Estimates the mass of contaminants in the soil and groundwater.

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

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

- Section 7: Operation and Maintenance (O&M) and Monitoring. Establishes start-up and 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 June 1997, a CAR for OLF Bronson, Site 1107, Pensacola, Florida was submitted by NAS Pensacola NPWC to the FDEP for review. A CARA was completed for the site by NPWC on December 2, 1998, and an additional CARA was completed by TtNUS and submitted to FDEP on January 25, 2001. The CAR and CARAs were conducted to determine the extent of soil and groundwater contamination at the site. The following is a summary of the findings of CAR and CARAs for Site 1107.

2.1 LITHOLOGIC FINDINGS

The site is underlain by a red/brown fine sand from the surface to a depth of 17 feet (ft), a red/brown fine silty sand with traces of clay at a depth from 17 ft to 30 ft, and white coarse to medium grained sand at a depth of 30 to 35 ft. This soil type extends to at least 35 ft below land surface (bls), the maximum depth drilled during the contamination assessment investigation. Boring logs are located in the CAR and CARAs for Site 1107.

2.2 GROUNDWATER AND AQUIFER CHARACTERISTICS

The CAR indicated that the depth to groundwater ranged from approximately 16 to 19 ft bls, and flows generally to the northwest. TtNUS measured the depth to groundwater in July 2000 during the preparation of the CARA and determined that the groundwater table appeared to be level in the measured area and, therefore, no flow direction was apparent. Depth to groundwater ranged from 19 to 22 ft bls. Table 2-1 presents the groundwater elevations from July 2000, and monitoring well construction data. Figure 2-1 presents the groundwater elevation map from July 2000.

The CAR for Site 1107 stated that because the hydrogeology at the site was found to be generally consistent with other sites at OLF Bronson, slug test information from three other sites at OLF Bronson could be averaged to provide the aquifer characteristics data for Site 1107.

The following aquifer parameters were estimated in the CAR (NPWC, 1997).

Hydraulic conductivity	K	=	0.6130 ft per day
Flow velocity	V	=	0.0088 ft per day or 3.201 ft per year
Effective porosity	n_e	=	0.25 (unitless)

Table 2-1
Top of Casing Elevations, Water Table Elevations, and Total Depths

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

Well ID	Monitoring Well Diameter	Well Depth	Top of Casing Elevation(1)	Thickness of Free Product	Depth to Water	Groundwater Elevation
MW-1	2 inch	NM	48.22	1.8	22.12	27.85*
MW-2	2 inch	23.45	47.96	--	20.15	27.81
MW-3	2 inch	20.52	47.35	--	19.57	27.78
MW-4	2 inch	NM	48.00	2.29	22.28	28.16*
MW-5	2 inch	NM	48.42	--	NM (2)	NM (2)
MW-6	2 inch	23.33	48.65	--	20.78	27.87
MW-7	2 inch	23.8	49.98	--	22.20	27.78
MW-8	2 inch	NM	48.24	sheen	20.44	27.80
MW-9	2 inch	21.46	47.73	--	19.93	27.80
MW-10	2 inch	21.61	48.63	--	20.87	27.76
MW-11	2 inch	21.65	48.88	--	21.07	27.81
MW-12	2 inch	21.86	48.92	--	21.03	27.89
MW-13	2 inch	21.78	47.56	--	19.72	27.84
MW-14	2 inch	21.41	48.10	--	20.23	27.87
DMW-15	2 inch	34.03	49.97	--	21.28	27.79
MW-16	2 inch	24.24	NA	--	21.88	NM

Notes:
(1) Top of casing and groundwater elevations are relative to an arbitrary site reference.
(2) Monitoring well MW-5 was dry.
All measurements reported in feet.
*indicates correction for free product (free product thickness*0.75-depth to water).
NM - not measured
NA - not available

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LEGEND

MW-1	MONITORING WELL
DMW-15	DEEP MONITORING WELL
RW-1	RECOVERY WELL
27.85	GROUNDWATER ELEVATION [1]
NM	NOT MEASURED

1-ELEVATION IN FEET ABOVE MEAN SEA LEVEL

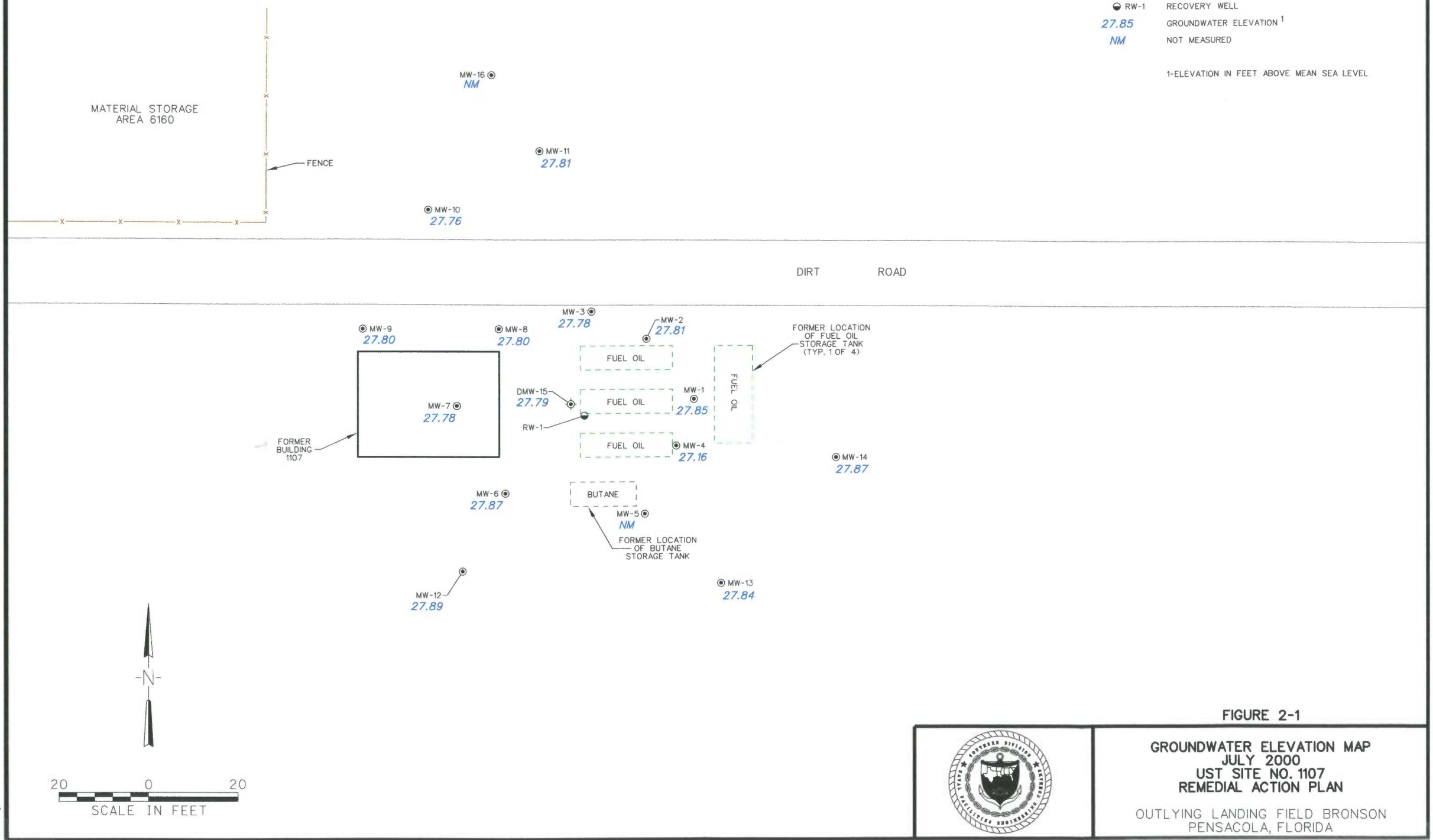

FIGURE 2-1

GROUNDWATER ELEVATION MAP
JULY 2000
UST SITE NO. 1107
REMEDIAL ACTION PLAN

OUTLYING LANDING FIELD BRONSON
PENSACOLA, FLORIDA

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2.3 TANK REMOVAL AND INITIAL REMEDIAL ACTION

NPWC personnel discovered petroleum-impacted soil at Site 1107 during the removal of the four fuel oil USTs and one butane tank located at the site. Approximately 1000 cubic yards (yd^3) of petroleum-impacted soil was removed to the depth of groundwater. The CARA performed by NPWC (NPWC, 1998) states that contaminated soil was removed to approximately 18 ft bls. The excavated soil was stockpiled on-site and eventually treated at a permitted thermal treatment facility and disposed (NPWC, 1997). Figure 2-2 provides a sketch of the site showing the location of the former USTs and the limits of the soil excavation during tank removal with respect to the monitoring wells and soil borings that have been installed at the site. Clean soil was used to fill the excavation and a recovery well was installed at the site in September 1994. The only information provided in the CAR about the recovery well states that approximately one gallon of free product was extracted from the recovery well.

During the tank closure assessment, five soil samples were collected from the sides and bottom of the excavation and were analyzed for volatile compounds using United States Environmental Protection Agency (USEPA) Method 8260. The laboratory analyses of soil samples from the sidewalls of the excavation indicated no contamination (NWPC, 1997). However, laboratory analysis of the soil sample from the bottom center of the excavation indicated the presence of benzene, ethylbenzene, toluene, and naphthalene.

Soil samples collected from the excavated soil stockpiles indicated the presence of volatile organic compounds (VOCs) ranging from 100 micrograms per kilogram (µg/kg) to 12,000 µg/kg, and Total Petroleum Hydrocarbon (TPH) levels of 60,000 milligrams per kilogram (mg/kg) and 67,000 mg/kg.

2.4 SOIL CONTAMINATION ASSESSMENT

The vertical and horizontal extent of petroleum impacted soil in the vadose zone was assessed through soil vapor analysis performed during the field investigations described in the CAR and two CARAs for Site 1107 (NPWC, 1997; NPWC, 1998; and TtNUS, 2001). The CAR soil assessment at Site 1107 consisted of screening the soil for petroleum vapors with an organic vapor analyzer (OVA) during the installation of soil borings and monitoring wells. Eighteen soil borings were installed at the site to a depth of 16 ft bls in February 1996. Fifteen additional soil borings were installed during the installation of monitoring wells MW-1 through DMW-15. Soil samples were collected at depths of 1, 4, 7, 10, 13, and 16 ft bls. During the CAR field investigation, the groundwater table was generally encountered at 15 to 17 ft bls. Results of the CAR field investigation indicated that the flame ionization detector reading from one soil sample exceeded the 50 ppm level for soil and was detected at monitoring well MW-11 at 1 ft bls. Soil boring locations are indicated on Figure 2-2.

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LEGEND

MW-1	SOIL BORING INSTALLED DURING MONITORING WELL INSTALLATION
DMW-15	SOIL BORING INSTALLED DURING DEEP MONITORING WELL INSTALLATION
RW-1	SOIL BORING INSTALLED DURING RECOVERY WELL INSTALLATION
SB-2	SOIL BORING INSTALLED DURING TTNUS CARA
SB-4	SOIL BORING INSTALLED DURING NPWC CARA
B4	SOIL BORING INSTALLED DURING NPWC CAR

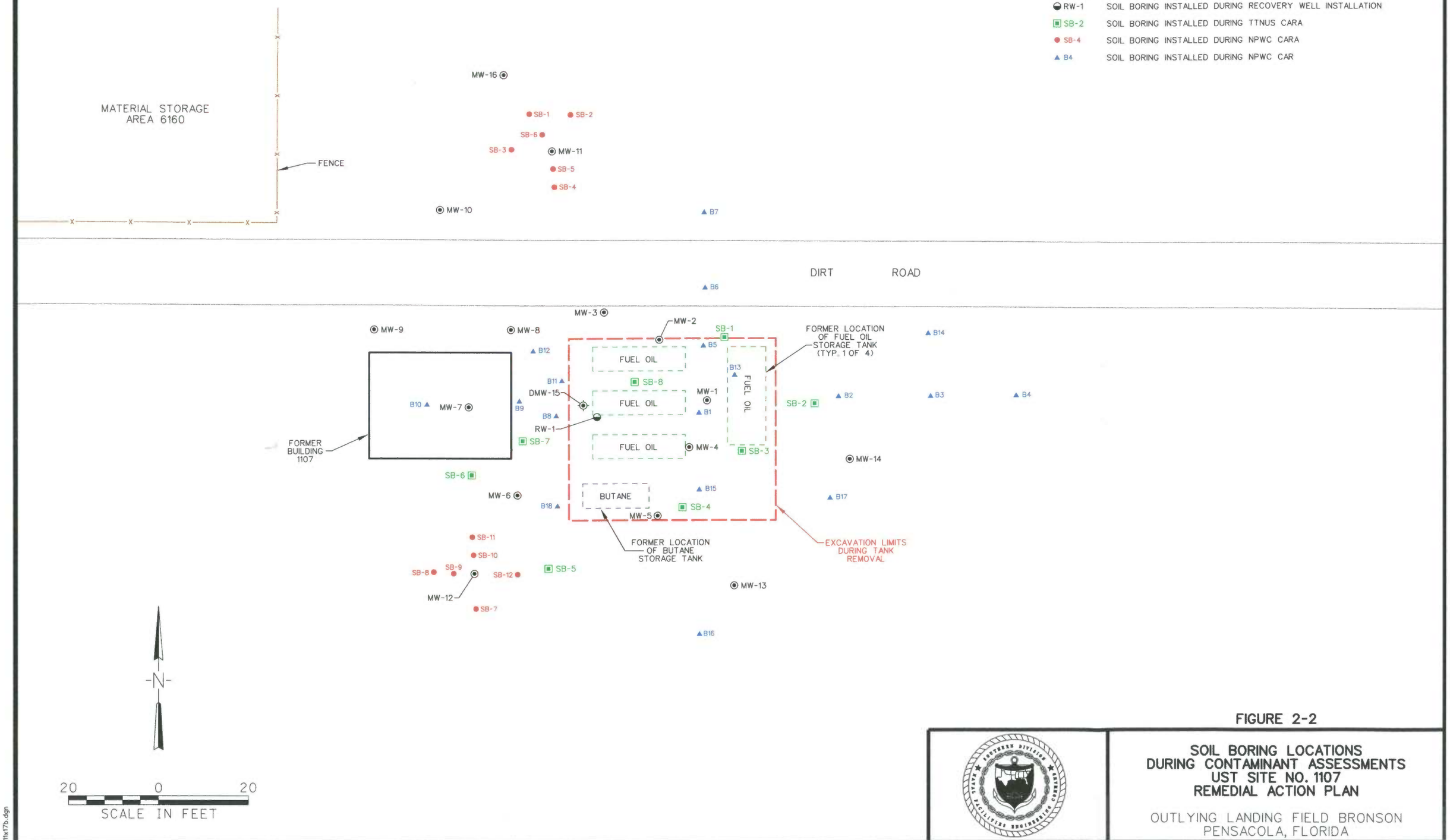

FIGURE 2-2

SOIL BORING LOCATIONS
DURING CONTAMINANT ASSESSMENTS
UST SITE NO. 1107
REMEDIAL ACTION PLAN

OUTLYING LANDING FIELD BRONSON
PENSACOLA, FLORIDA

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During the CARA performed by NPWC (NPWC, 1998) additional soil borings were installed in the vicinity of MW-11 and MW-12. Soil borings SB-1 through SB-6 were installed near MW-11, and soil borings SB-7 through SB-12 were installed near MW-12 to determine the lateral and vertical extent of petroleum-impacted soil. In addition to the headspace analysis, soil samples were collected and shipped to a fixed-base laboratory and analyzed for Volatile Organic Aromatics (VOAs), Polynuclear Aromatic Hydrocarbons (PAHs), and TPHs. Of the 12 soil samples collected in the vicinity of MW-11 and MW-12, none exceeded the 50 ppm level when analyzed with an OVA. Soil samples were collected from SB-5 at 7 ft bls, SB-6 at 4 ft bls, and SB-12 at 13 ft bls and shipped to a fixed-base laboratory and analyzed for VOAs, PAHs, and TPHs. Analytical results of soil samples were below method detection limits for all parameters analyzed.

During the CARA performed by TtNUS (TtNUS, 2001), eight additional soil borings were collected. TtNUS completed the eight soil borings (SB-1 through SB-8) to a depth of 20 ft bls using Direct Push Technology. The soil borings were completed to further characterize the extent of free product and collect subsurface soil samples. Four of the eight soil borings completed at the site (SB-3, SB-4, SB-7, and SB-8) were reported to contain soils stained with a viscous, “coal tar” type free product. A single soil sample was collected from each of the eight soil borings and shipped to a fixed-base laboratory for analytical analysis. The soil samples were analyzed for compounds specified in the gasoline and kerosene analytical groups.

Results of the soil analysis indicated that two VOCs exceeded the leachability limits for groundwater as specified in Chapter 62-777, FAC. Ethylbenzene was detected above the leachability criteria in the soil sample from SB-8, and xylenes exceeded the leachability criteria in soil samples from SB-7 and SB-8. Results of the analytical analysis are presented and summarized in Table 2-2.

Eleven PAHs were detected in the soil samples collected from Site 1107. 1-Methylnaphthalene and 2-methylnaphthalene were detected in soil samples from four soil borings (SB-3, SB-4, SB-7, and SB-8) at concentrations exceeding the leachability for groundwater. In the soil sample from SB-8, naphthalene exceeded the leachability criteria. In the sample from soil boring SB-8 benzo(a)pyrene exceeded the direct exposure limit for both residential and industrial areas.

The soil samples were also analyzed for TPHs. Concentrations of TPHs were detected in soil samples from four (SB-3, SB-4, SB-7, and SB-8) of the eight soil borings. All of the detected TPH concentrations exceeded both the residential direct exposure limit (340 mg/kg) and the leachability limit for groundwater (340 mg/kg) from Chapter 62-777, FAC.

Table 2-2
Summary of Analytes Detected in Soil Samples

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

Boring	Depth (ft bls)	Date	Ethylbenzene	Toluene	Xylenes	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene	Benzo(a)pyrene
CAR									
No soil samples collected for laboratory analysis.									
CARA (NPWC)									
SB-5	7	5/2/1998	--	--	--	--	--	--	--
SB-6	4	5/2/1998	--	--	--	--	--	--	--
SB-12	13	5/2/1998	--	--	--	--	--	--	--
CARA (TtNUS)									
SB-3	18-20	8/9/2000	--	--	--	--	**11J**	**9.06J**	--
SB-4	19-20	8/9/2000	--	--	--	--	**8.71J**	**9.82J**	--
SB-7	18-20	8/9/2000	0.175J	--	0.83J	--	**5.9J**	**7.16J**	--
SB-7 dup	18-20	8/9/2000	0.364J	--	**1.74J**	--	**20J**	**23.6J**	--
SB-8	18-20	8/9/2000	**1.62**	0.0513J	**3.12**	**2.38J**	**8.55**	**11.4**	**0.76**
SCTLs									
Residential Direct Exposure			1100	380	5900	40	68	80	0.1
Industrial Direct Exposure			8400	2600	40000	270	470	560	0.5
Leachability for groundwater			0.6	0.5	0.2	1.7	2.2	6.1	8

Notes:
1. All concentrations in micrograms per kilogram (ug/kg), except TPH which is in milligrams per kilogram (mg/kg).
2. Soil cleanup target levels (SCTLs) as provided in Chapter 62-777, FAC.
3. J indicates the presence of a chemical at an estimated concentration.
4. Bold indicates exceedance of regulatory critiera as provided in Chapter 62-777, FAC.
5. -- indicates that analyte was not detected above method detection limit.

Table 2-2 (Continued)
Summary of Analytes Detected in Soil Samples

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

Boring	Depth (ft bls)	Date	Benzo(b)flouranthene	Benzo(g.h.l)perylene	Benzo(k)flouranthene	Flourene	Indeno(1,2,3-cd)pyrene	Phenanthrene	Pyrene	TPH
CAR										
No soil samples collected for laboratory analysis.										
CARA (NPWC)										
SB-5	7	5/2/1998	--	--	--	--	--	--	--	--
SB-6	4	5/2/1998	--	--	--	--	--	--	--	--
SB-12	13	5/2/1998	--	--	--	--	--	--	--	--
CARA (TtNUS)										
SB-3	18-20	8/9/2000	--	--	--	--	--	6.07J	7.86	**19800**
SB-4	19-20	8/9/2000	--	--	--	--	--	--	4.46J	**11400**
SB-7	18-20	8/9/2000	--	--	--	--	--	--	--	**13300**
SB-7 dup	18-20	8/9/2000	--	--	--	3.95J	--	7.36J	9.42J	**16300**
SB-8	18-20	8/9/2000	1.11	0.903	0.444J	--	0.964	2.14J	--	**5540**
SCTLs										
Residential Direct Exposure			1.4	2300	15	2200	1.5	2000	2200	340
Industrial Direct Exposure			4.8	41000	52	28000	5.3	30000	37000	2500
Leachability for Groundwater			10	32000	25	160	28	250	880	340

Notes:
1. All concentrations in micrograms per kilogram (ug/kg), except TPH which is in milligrams per kilogram (mg/kg).
2. Soil cleanup target levels (SCTLs) as provided in Chapter 62-777, FAC.
3. J indicates the presence of a chemical at an estimated concentration.
4. Bold indicates exceedance of regulatory critiera as provided in Chapter 62-777, FAC.
5. -- entry indicates that analyte was not detected above method detection limit.

A soil vapor measurements table was not included in this report because soil vapor measurements exceeding 50 ppm occurred at only one location during the CAR investigation. Table 2-2 summarizes the analytes detected in soil samples from the CAR and CARAs. The analytical results indicate the presence of petroleum-impacted soils at the site exceeding FDEP target levels. Figure 2-3 presents the location of the detected analytes. Based on soil laboratory results, the contaminants appear to be present in the soil from 16 to 20 ft bls.

2.5 GROUNDWATER CONTAMINATION ASSESSMENT

Fifteen groundwater monitoring wells were installed during the CAR investigation (NWPC, 1997). Groundwater samples were collected from monitoring wells in 1996 and 1997 in support of the CAR. The groundwater samples were analyzed for VOA, PAHs, TPHs, ethylene dibromide, and total lead, using USEPA methods 8260, 8270A, Florida Petroleum Range Organics (FL-PRO), 504, and 7421, respectively. A summary of analytes detected in groundwater is presented in Table 2-3 and exceedances are indicated on Figure 2-4.

During the CARA performed by NPWC in 1998 (NWPC, 1998), monitoring well MW-16 was placed 20 ft downgradient of well MW-11. Additionally, monitoring wells MW-1, MW-3, MW-4, MW-6, MW-8, and MW-10 were to be resampled for PAHs and TPHs. The groundwater sample from MW-4 was also to be analyzed for VOAs. During the field investigation to collect groundwater samples, monitoring wells MW-1, MW-4, and MW-6 contained free product, reported to be Bunker C fuel oil. Monitoring wells MW-3, MW-8, and MW-10 were sampled and the groundwater was analyzed for PAHs and TPHs. Results of this portion of the investigation are presented in Table 2-3 and exceedances are indicated on Figure 2-4. It was reported in the CARA that the product found in monitoring wells MW-1, MW-4, and MW-6 is indicative of contamination at the original source area.

During the CARA performed by TtNUS in 2000 (TtNUS, 2001), groundwater samples were collected from 12 of the 16 monitoring wells. Monitoring wells MW-1, MW-4, and MW-8 were not sampled due to the presence of free product. Well MW-5 was dry and, therefore, not sampled. Groundwater samples were analyzed for VOCs, PAHs, Total Recoverable Petroleum Hydrocarbons (TRPH), and lead. None of the detected concentrations exceeded the FDEP Groundwater Cleanup Target Levels (GCTLs). Groundwater analytical detections are presented in Table 2-3.

SOURCE:
LOCATIONS OF ROADS AND FORMER LOCATIONS OF BUILDINGS, TANKS, AND DISTRIBUTION LINES ARE TAKEN FROM N.A.S. DRAWING NO. 23032 DATED JUNE 24, 1944. ALL WELL AND BORING LOCATIONS ARE APPROXIMATE.

LEGEND

SB-2 — SOIL BORING INSTALLED DURING TTNUS CARA

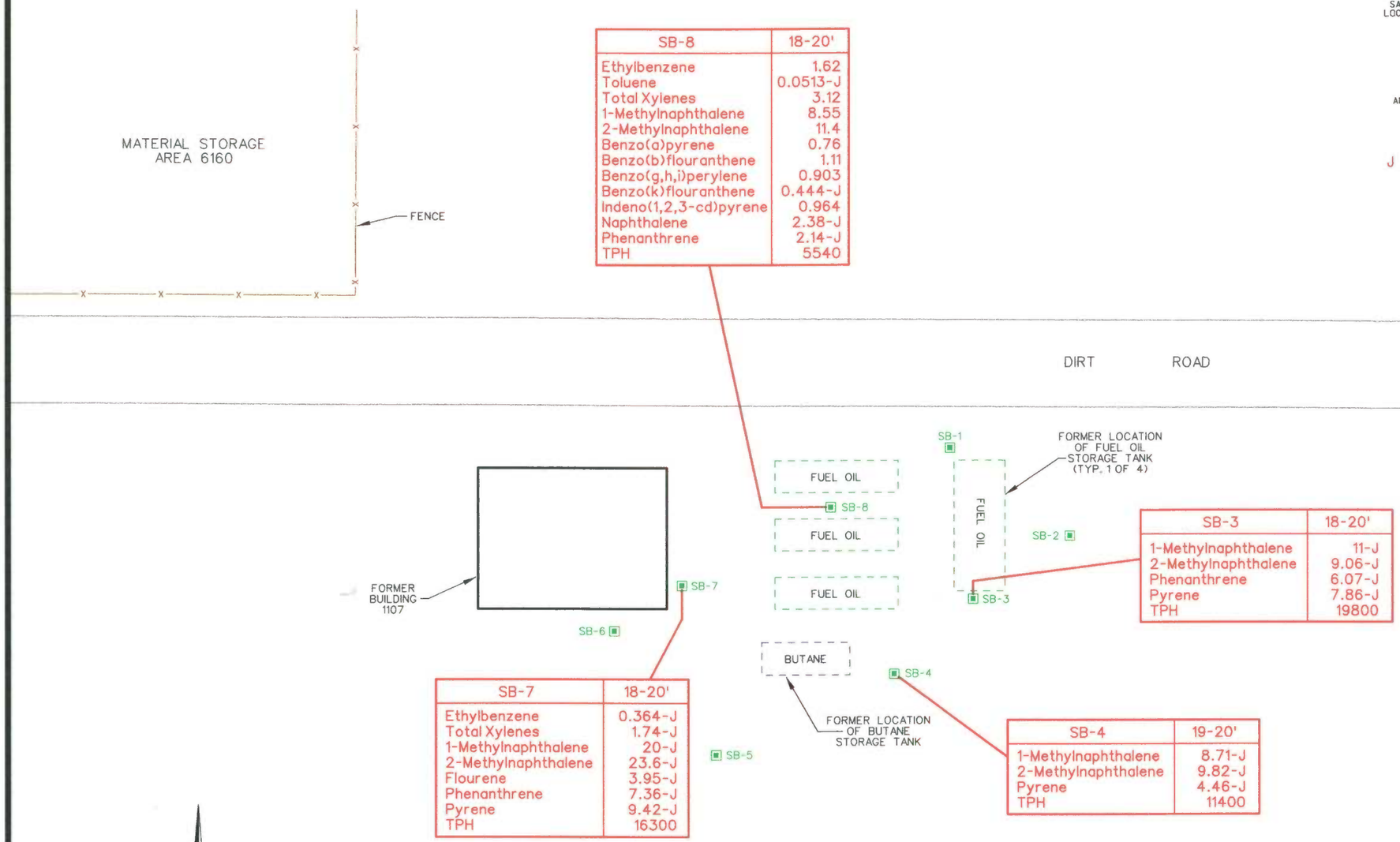
SB-3 (SAMPLE LOCATION)	18-20' (SAMPLE DEPTH [1])
1-Methylnaphthalene	11-J
2-Methylnaphthalene	9.06-J
Phenanthrene	6.07-J
Pyrene	7.86-J
TPH	19800

ANALYTE — ANALYTE CONCENTRATION [2]

J — ESTIMATED CONCENTRATION

1-DEPTH BELOW GROUND SURFACE IN FEET
2-CONCENTRATION IN MILLIGRAMS PER KILOGRAM (mg/Kg)

NOTE:
ALL ANALYTES DETECTED DURING TTNUS CARA.



SB-8	18-20'
Ethylbenzene	1.62
Toluene	0.0513-J
Total Xylenes	3.12
1-Methylnaphthalene	8.55
2-Methylnaphthalene	11.4
Benzo(a)pyrene	0.76
Benzo(b)flouranthene	1.11
Benzo(g,h,i)perylene	0.903
Benzo(k)flouranthene	0.444-J
Indeno(1,2,3-cd)pyrene	0.964
Naphthalene	2.38-J
Phenanthrene	2.14-J
TPH	5540

SB-3	18-20'
1-Methylnaphthalene	11-J
2-Methylnaphthalene	9.06-J
Phenanthrene	6.07-J
Pyrene	7.86-J
TPH	19800

SB-7	18-20'
Ethylbenzene	0.364-J
Total Xylenes	1.74-J
1-Methylnaphthalene	20-J
2-Methylnaphthalene	23.6-J
Flourene	3.95-J
Phenanthrene	7.36-J
Pyrene	9.42-J
TPH	16300

SB-4	19-20'
1-Methylnaphthalene	8.71-J
2-Methylnaphthalene	9.82-J
Pyrene	4.46-J
TPH	11400

N

20 0 20
SCALE IN FEET

FIGURE 2-3

SUMMARY OF ANALYTES DETECTED IN SOIL SAMPLES
UST SITE NO. 1107
REMEDIAL ACTION PLAN

OUTLYING LANDING FIELD BRONSON
PENSACOLA, FLORIDA

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Table 2-3
Summary of Analytes Detected in Groundwater

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

Well	Date	Benzene	Ethylbenzene	Toluene	Xylenes	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene	Phenanthrene	Pyrene	TPH
CAR											
MW-1	3/11/1996	--	--	--	2	--	--	--	--	4	2800
MW-2	3/11/1996	--	--	--	--	--	--	--	--	--	420
MW-4	3/11/1996	**2**	7	12	**41**	**55J**	**180**	**200**	55	50	3700
MW-6	3/11/1996	--	--	--	-	--	--	--	--	6	930
MW-8	3/11/1996	--	--	--	--	--	5	--	--	4	1600
CARA (NPWC)											
MW-1	8/26/1998	Free product	--	--	--	--	--	--	--	--	--
MW-3	8/26/1998	--	--	--	--	4	3	5	--	--	--
MW-4	8/26/1998	Free product	--	--	--	--	--	--	--	--	--
MW-6	8/26/1998	Free product	--	--	--	--	--	--	--	--	--
MW-8	8/26/1998	--	--	--	--	2	7	5	--	--	--
CARA (TtNUS)											
MW-1	7/12/2000	Free product	--	--	--	--	--	--	--	--	--
MW-3	7/12/2000	--	0.98J	--	--	11.5	12.3	14.2	--	--	1650
MW-4	7/12/2000	Free product	--	--	--	--	--	--	--	--	--
MW-6	7/12/2000	--	--	--	--	1.8J	2J	2.2	--	--	843
MW-7	7/12/2000	--	--	--	--	--	--	--	--	--	1860
MW-8	7/12/2000	Free product	--	--	--	--	--	--	--	--	--
MW-9	7/12/2000	--	--	--	--	--	--	--	--	--	278J
GCTLs		1	30	40	20	20	20	20	210	210	5000

Notes:
1. All concentrations in micrograms per liter (µg/l).
2. Groundwater Cleanup Criteria as provided in Chapter 62-777, FAC.
3. J indicates the presence of a chemical at an estimated concentration.
4. Bold indicates exceedance of GCTLs as provided in Chapter 62-777, FAC.
5. -- Entry indicates analyte not detected above method detection limit.

SOURCE:
LOCATIONS OF ROADS AND FORMER LOCATIONS OF BUILDINGS, TANKS, AND DISTRIBUTION LINES ARE TAKEN FROM N.A.S. DRAWING NO. 23032 DATED JUNE 24, 1944. ALL WELL AND BORING LOCATIONS ARE APPROXIMATE.

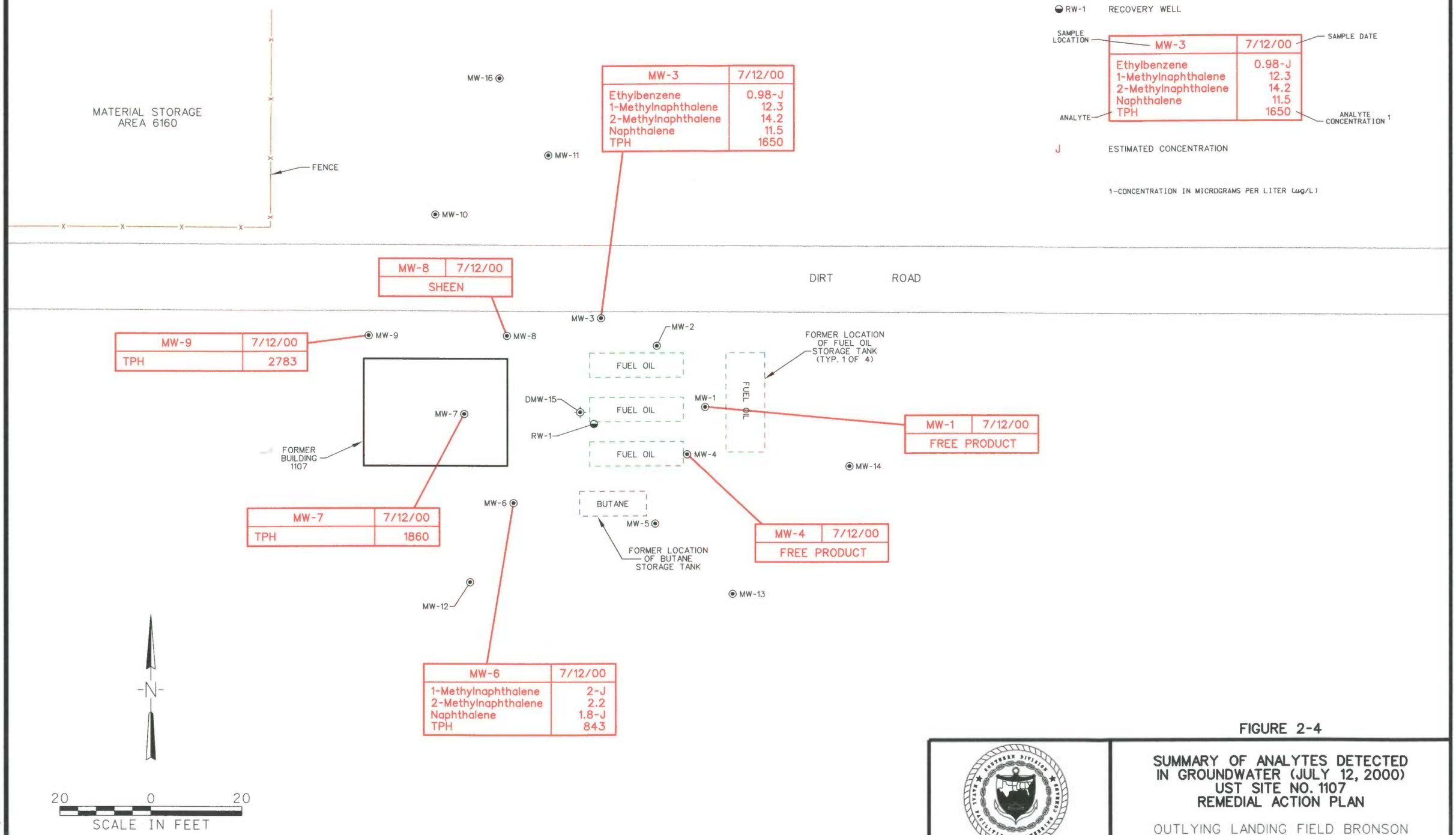

FIGURE 2-4

SUMMARY OF ANALYTES DETECTED IN GROUNDWATER (JULY 12, 2000)
UST SITE NO. 1107
REMEDIAL ACTION PLAN

OUTLYING LANDING FIELD BRONSON
PENSACOLA, FLORIDA

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2.6 FREE PRODUCT RECOVERY

On July 12, 2001, a free product assessment was performed during the CARA (TtNUS, 2001). The free product encountered was described as a very viscous material similar to coal tar product. Free product measurements recorded during the survey indicated monitoring wells MW-1 and MW-4 contained thicknesses of 1.80 ft and 2.29 ft, respectively. Free product sheen was also reported in monitoring well MW-8, but was not measurable. The estimated extent of free product present at the site, as indicated in the CARA (TtNUS, 2001), is presented on Figure 2-5.

2.7 CAR CONCLUSIONS

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

- A coal tar type free product plume is present at the site over a 1,540 square ft (ft^2) area with a thickness up to 2.29 ft.

- Current and historic groundwater flow data indicate flow is typically stagnant in the study area.

- Groundwater samples collected from on-site monitoring wells did not contain analytes at concentrations exceeding FDEP's GCTLs.

- Soil samples from four on-site soil borings (SB-3, SB-4, SB-7, and SB-8) contained analytes that exceeded FDEP's leachability limit for groundwater from Chapter 62-777 FAC. However, with the exception of TPH detected in the sample from monitoring well MW-9, none of the analytes were detected in the groundwater samples collected on site.

- Benzo(a)pyrene was detected in a soil sample from one soil boring (SB-8) at a concentration that exceeded the FDEP's direct exposure limits for both residential and industrial areas.

- The soil contamination appears to be within the "smear zone" from 16 to 20 ft bls and is located in the area of the former fuel tanks.

- In the CARA, TtNUS recommended preparing a RAP for the site.

SOURCE:
LOCATIONS OF ROADS AND FORMER LOCATIONS OF BUILDINGS, TANKS, AND DISTRIBUTION LINES ARE TAKEN FROM N.A.S. DRAWING NO. 23032 DATED JUNE 24, 1944. ALL WELL AND BORING LOCATIONS ARE APPROXIMATE.

LEGEND

MW-1	MONITORING WELL
DMW-15	DEEP MONITORING WELL
RW-1	RECOVERY WELL
SB-8	SOIL BORING
	FREE PRODUCT AREA
1.80	FREE PRODUCT THCKNESS IN FEET

NOTE:
FREE PRODUCT PLUME LOCATION FROM TTNUS 2001.

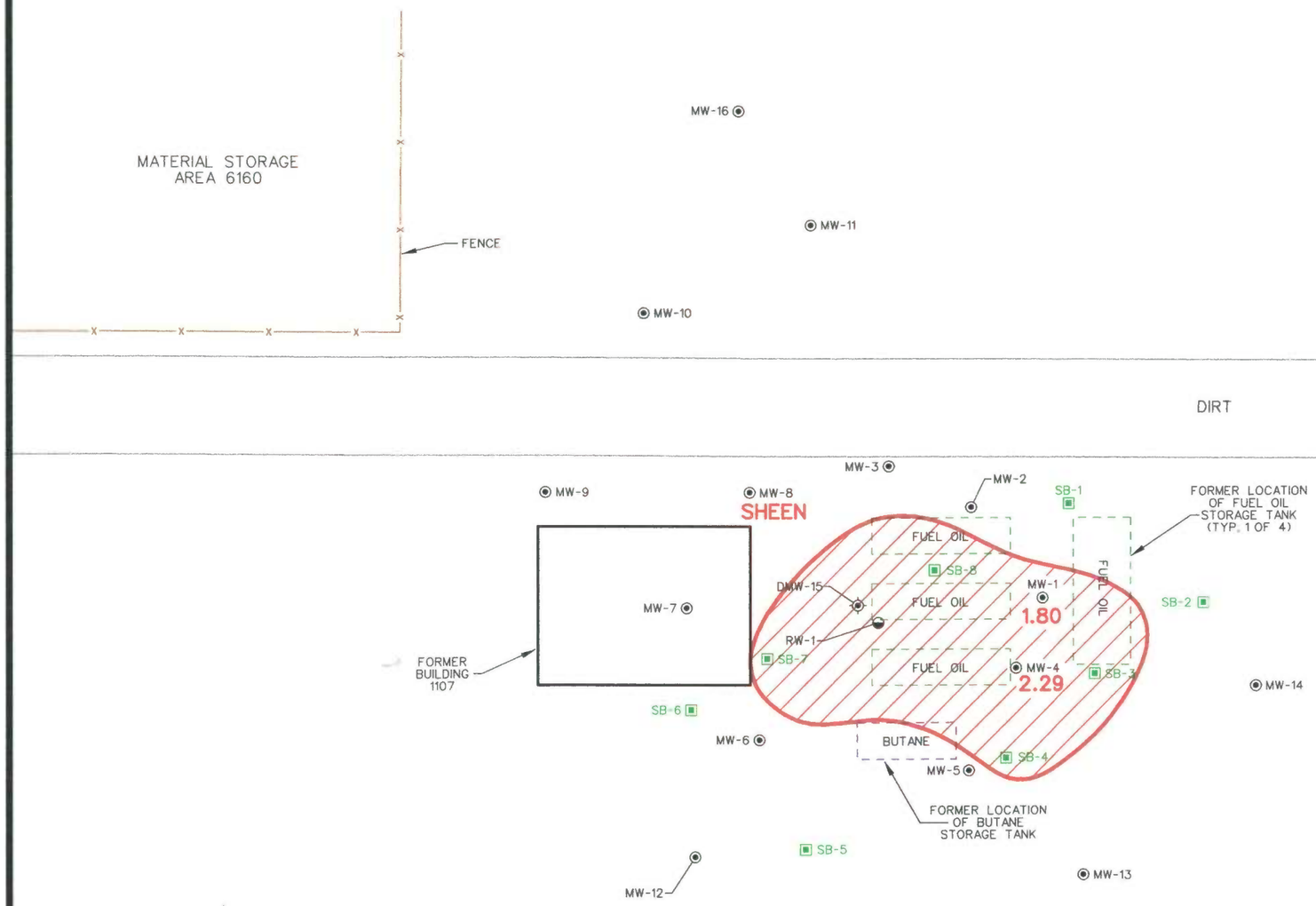

FIGURE 2-5

FREE PRODUCT THICKNESS AND AREA
(JULY 12, 2000)
UST SITE NO. 1107
REMEDIAL ACTION PLAN

OUTLYING LANDING FIELD BRONSON
PENSACOLA, FLORIDA

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2.8 CAR & CARA FINDINGS FOR REMEDIAL ACTION CONSIDERATION

The CAR for Site 1107 stated that the fuel released at the site was Bunker C fuel oil. Bunker C fuel oil is a sticky, black liquid similar in appearance and smell to asphalt sealing compounds and has been used to generally describe thick and sticky residual fuel (Environment Canada, 1996). This description is similar to the “coal tar” like description stated in the CARA (TtNUS, 2001).

At 50 degrees Fahrenheit (°F), Bunker C fuel oil has a consistency of liquid honey or corn syrup. At 32 °F, it barely flows. Bunker C fuel oil, in addition to being used in the majority of large marine diesel engines, is used in power generating stations, industrial boilers and furnaces, and pumping plants. Because Bunker C fuel oil is less dense than water, fresh Bunker C fuel oil will float in water either at or below the surface. As the oil ages or “weathers,” it becomes heavier, but it will still float under most conditions. When the oil comes into contact with sediment, sand, or other soil materials, it may adhere together forming lumps or tar balls.

It is expected that due to the age of the tanks (1940s) and the chemical properties of Bunker C fuel oil, the weathered fuel is affixed to the soil and as a result a minimal groundwater plume is prevalent at the site. The findings of the CAR and CARA support this assumption. In addition, the stained soil samples collected and analyzed during the investigations determined that although some volatile and semi-volatile compounds were detected above residential and leachability SCTLs, the primary contaminant was TPH, which was detected at concentrations well above the SCTL. It is assumed that the fuel oil has weathered and degraded to a point where long chain hydrocarbons (which do not readily degrade) are the most prominent contaminants at the site.

3.0 RAP GOALS

The objective of this RAP is to present a proven, reliable, and cost-effective method to remediate petroleum impacted soil, remove free product, retard plume migration at the site, 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 FAC.

- Select a remedial alternative to reduce hydrocarbon constituents within the soil matrix (smear zone).

The target cleanup concentrations for the soil at the subject site are based on Table II of Chapter 62-777 FAC. The following subsections list the target levels for the site-specific chemicals of concern (COCs).

3.1 SOIL TARGET LEVELS

Table 3-1 presents the soil remediation goals for the site specific COCs based on the exceedances of SCTLs listed in Table II of Chapter 62-777 FAC.

3.1.1 Groundwater Target Levels

The most recent groundwater analytical results of the CARA indicate that dissolved fraction hydrocarbon constituents were not detected above GCTLs within the groundwater matrix. Therefore, remedial action goals for groundwater are not established. After remedial actions have been completed for the site soil, groundwater monitoring will be conducted in accordance with Chapter 62-770 FAC. Groundwater monitoring criteria as listed in 62-777 FAC will be used.

Table 3-1
COCs and Associated Selected SCTLs

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

Site-Specific COCs	Concentrations from Table II*
Ethylbenzene	0.6 mg/kg
Xylenes	0.2 mg/kg
Naphthalene	1.7 mg/kg
1-Methylnaphthalene	2.2 mg/kg
2-Methylnaphthalene	6.1 mg/kg
Benzo(a)pyrene	0.1 mg/kg
TPH	340 mg/kg

***** Concentration is the lower of the residential direct exposure or leachability based on groundwater criteria Table II, Chapter 62-777 FAC.

4.0 CONTAMINANT DISTRIBUTION

4.1 ESTIMATED MASS OF CONTAMINANTS IN SOIL

Data acquired during the contamination assessments determined soil contamination exists within the "smear zone" from 16 to 20 ft bls. The groundwater table was encountered at 19 to 22 ft bls. The lateral limits of the free product plume were estimated based on soil borings performed at the site during the TtNUS CARA, and defined as depicted in Figure 2-5. These limits were also used to determine the volume of impacted soil. The smear zone contamination is conservatively estimated at 6 ft thick (16 ft to 22 ft bls) and covers an estimated surface area of approximately 1,540 ft^2, yielding a total volume of approximately 342 yd^3 of contaminated soil. The average TRPH concentration from the fixed laboratory analysis of soil samples collected at SB-1 through SB-8 in the TtNUS CARA (see Tables 2-2 and 2-3) is approximately 13,268 mg/kg. Based on this information, the estimated quantity of adsorbed hydrocarbons within the smear zone is approximately 14,201 pounds (lbs). Appendix A presents calculations for the estimated mass of impacted soil.

4.2 ESTIMATED MASS OF FREE PRODUCT

Data acquired during the contamination assessments determined the presence of free product within the "smear zone" from 16 to 20 ft bls. The lateral limits of the free product plume have been defined as depicted in Figure 2-5. Based on the assumed lateral limits of the free product plume and specific site characteristics, the total volume of free product was estimated. Multiple free product thickness equations from the guidance document, *How To Effectively Recover Free Product at Leaking Underground Storage Tank Sites* (USEPA, 1996), were used to determine the volume of free product located in the subsurface. Free product quantity estimates ranged from 158 gallons to 4,722 gallons. The equations, which resulted in the smaller quantities of free product, take into account the density of the product. Due to the high density and chemical properties of Bunker C fuel oil, it is expected that the thickness of fuel oil measured in the monitoring wells at the site greatly exaggerate the amount of actual free product located in the subsurface. Due to these factors, it is expected that the lower estimates of product are more accurate. Therefore, it was estimated that approximately 158 gallons of free product is located in the subsurface at Site 1107, based on the De Pastrovich equation. Free product volume calculations are provided in Appendix B. The equation used to determine the amount of free product is one of several equations provided in *How To Effectively Recover Free Product at Leaking Underground Storage Tank Sites* (USEPA, 1996).

Calculating the volume of free product in the subsurface is an estimate, and actual product volumes can vary significantly. The contaminant distribution estimate is based on data obtained during the TtNUS CARA (TtNUS, 2001).

5.0 REMEDIAL ALTERNATIVE TECHNOLOGY SCREENING

TtNUS conducted a screening of available technologies in order to determine the best remedial alternative for the subject site. Potential remedial technologies and process options for soil and free product removal have been identified and evaluated based on their ability to meet clean-up objectives (effectiveness), applicability based on site conditions, feasibility of implementation, reliability, anticipated duration, and cost.

5.1 EVALUATION OF SOIL TREATMENT ALTERNATIVES

Based on the CARA data, a total volume of approximately 342 yd^3 of soils exhibits hydrocarbon concentration in excess of FDEP SCTLs. TtNUS has investigated alternate methods for the removal of hydrocarbons from the soils at the site. The following actions have been identified for remediation of soil and will be evaluated in this RAP:

- Natural Attenuation
- Soil excavation and off-site disposal or on-site treatment
- Bioventing/Biosparging
- Chemical Oxidation

The following technologies have been ruled out and the reasons why are listed below:

- In-situ Soil Vapor Extraction – This technology is applied to sites where the contaminants are primarily VOCs. Diesel fuel, heating oils, and kerosene, which are less volatile than gasoline, are not readily treated by soil vapor extraction (USEPA, 1994).

- Enhanced Bio-Degradation – The effects of enhanced bio-degradation are uncertain on Bunker C fuel oil impacted soils.

The following sections briefly discuss each of these soil remedial actions with respect to their suitability for implementation at this site.

5.1.1 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 either by preventing constituents from 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 microorganisms 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. However, when the materials have low porosity and are relatively impermeable, the rate of oxygen replenishment is reduced and biodegradation effectiveness is decreased. Additionally, less permeable materials are typically finer grained and contain higher percentages of organic carbon. Both of these features favor adsorption and retardation of contaminant movement. In this case, contaminants may remain relatively un-degraded, but in close proximity to the original source.

Anaerobic biodegradation is also a significant attenuation process. Oxygen depletion in the subsurface is characteristic of biodegradation of petroleum hydrocarbons and is a consequence of the rate of metabolic oxygen utilization exceeding the natural capacity for oxygen replenishment. The core of a contaminant plume is typically under anaerobic conditions and only the margins are aerobic. Therefore, even though the rate of anaerobic biodegradation is much slower than aerobic biodegradation (often by a factor of 10 to several hundred), anaerobic processes may dominate the degradation of hydrocarbon contaminants at the source.

Because of the complex interrelationship among these controlling factors, using specific numerical thresholds to determine whether natural attenuation will be effective is frequently not possible. Prior to implementing this alternative, a detailed site investigation is necessary to provide sufficient data on site conditions and hydrocarbon constituents present to evaluate the potential effectiveness of natural attenuation. Once implemented, monitoring of site conditions over time would be performed to confirm

whether or not contaminants are being naturally degraded at reasonable rates. Site data should clearly indicate whether concentrations of soil and groundwater contaminants are being adequately reduced without active remediation. If acceptable contaminant reductions are not achieved, more aggressive remedial alternatives may be warranted.

Under the appropriate site conditions, natural attenuation can reduce the potential impact of petroleum hydrocarbon releases by preventing constituents from being transported to sensitive receptors or by reducing constituent concentrations to less harmful levels. Natural attenuation may also be an acceptable option for sites that have been subject to active remediation and which have substantially reduced concentrations of contaminants. However, natural attenuation alone is not an appropriate option at this site because it is not acceptable for sites with free phase hydrocarbons under the rules of Chapter 62-770 FAC. Also, the rates of natural processes are typically slow and contaminant levels may not be reduced to meet the corrective action goals for years. Due to the continued presence of the petroleum at the site, already given approximately 50 years, it is suspected that natural attenuation would be ineffective. It is unknown how long that natural attenuation would be required to achieve soil remediation to the target cleanup levels. However, for costing purposes an arbitrary number of 10 years was selected. In addition, long-term monitoring is necessary to demonstrate that contaminant concentrations are continually decreasing at a rate sufficient to ensure that potential receptors are not adversely affected. An estimated cost for the implementation of natural attenuation with 10 years O&M is presented in Table 5-1 and Appendix C, Table C1.

5.1.2 Excavation and Off-site Disposal or On-Site Treatment

This alternative consists of the physical removal and on-site treatment or off-site disposal of impacted soils with hydrocarbon constituents exceeding the target cleanup levels. Prior to complete excavation of impacted soils, removal of approximately a 1,540-ft^2 area of soil to the depth of approximately 16 ft bls would be required to access the contaminated zone. Additionally, due to the depth of the excavation, a 1-ft horizontal step-out for every 2 ft of vertical excavation is required to provide a slope for safety measures and in accordance with Occupational Health and Safety Administration (OSHA) regulations. The slope would require an additional area of soil be removed surrounding the excavation. The contaminated soil assumed to be located in the 16- to 22-ft smear zone would be removed. Excavation below the water table (approximately 19 to 22 ft bls) will require dewatering with collection, treatment, and disposal of collected water.

Removal operations can be accomplished using standard equipment, with some modifications due to the depth required for excavation. Following removal and stockpiling of the impacted soil, analysis of samples collected from the excavation sidewalls and bottom will be performed to confirm achievement of

the target cleanup levels. Once confirmatory sampling is complete, the excavation will be back-filled with clean fill material and the site restored to its original condition.

5.1.2.1 Off-site Disposal

The stockpiled soil and other debris generated during excavation will be characterized, loaded, and transported off-site to a permitted facility for treatment and/or disposal. It is assumed that since the soil is petroleum impacted, the soil can be disposed of in a landfill that accepts non-hazardous solid bulk waste, as opposed to a hazardous waste landfill regulated by Resource Conservation and Recovery Act land disposal restrictions. The Perdido Landfill located in the Pensacola region is a nearby Subtitle D Landfill, which will accept petroleum-impacted soil if it passes the toxicity characteristic leaching procedure analysis. Water collected during dewatering would need to be contained, sampled, and disposed in accordance with regulatory guidelines.

5.1.2.2 On-site Treatment

The stockpiled soil can be treated on-site either by biopiles, land farming, or by a mobile low temperature thermal desorption (LTTD) unit. Biopiles and land farming are used to reduce concentrations of petroleum constituents in excavated soils through the use of biodegradation by aeration. While tilling and plowing aerate land farms, biopiles are aerated most often by forcing air to move by injection or extraction through slotted piping placed throughout the pile. Biopiles and land farms have been proven effective in reducing concentrations of nearly all the constituents of petroleum products. While the lighter petroleum products are removed by volatilization, the heavier petroleum products do not evaporate and breakdown as a result of biodegradation. However, higher molecular weight petroleum constituents, such as heating and lubricating oils (i.e., those found at Site 1107) and to a lesser extent in diesel fuel and kerosene, require a longer period of time to degrade (USEPA, 1994). It is expected that the weathered Bunker C fuel oil would require longer time duration for soil cleanup as compared to lighter fuel compounds. Because of the long time period to degrade fuel oils by land farming or biopiles, these two options are ruled out, and it is recommended that LTTD be used for the selected remedial option for on-site treatment.

LTTD, also known as low-temperature thermal volatilization, thermal stripping, and soil roasting, is an ex-situ remedial technology that uses heat to physically separate petroleum hydrocarbons from excavated soils. Thermal desorbers are designed to heat soils to temperatures sufficient to cause constituents to volatilize and desorb (physically separate) from the soil. The vaporized hydrocarbons are generally treated in a secondary treatment unit (e.g., an afterburner, catalytic oxidation chamber, condenser, or carbon adsorption unit) prior to discharge to the atmosphere. Treated soil may be

re-deposited on-site or used as cover in landfills. Thermal desorption systems fall into two general classes: stationary facilities or mobile units. Contaminated soils are excavated and either transported to stationary facilities or mobile units that are used for local treatment on-site. LTTD has proven very effective in reducing concentrations of petroleum products including gasoline, jet fuels, kerosene, diesel fuel, heating oils, and lubricating oils. LTTD is applicable to constituents that are volatile at temperatures as great as 1,200 °F (USEPA, 1994). Due to the Bunker C fuel oil at Site 1107, the recommended LTTD would require a temperature range of 800 °F to 1200 °F. A Rotary Dryer-Alloy LTTD can achieve this temperature range.

The primary advantage of excavation and off-site disposal or on-site treatment by LTTD is the complete removal or treatment of contaminants from the site over a short time duration. Impacted soils can be physically removed from the site in a matter of days, as opposed to the months or years that are required using in-situ treatment alternatives, thus eliminating the potential for dispersion of hydrocarbon constituents to unaffected soil or groundwater during the remedial process. If on-site treatment is performed, the treated soil can be placed back into the landfill, and soil disposal costs are not incurred.

The estimated costs for soil excavation, transportation, and off-site disposal or on-site treatment by LTTD, and site restoration is presented in Table 5-1 and Appendix C, Table C2. It should be noted that the costs calculated for this LTTD alternative include the cost for a typical small LTTD system and does not take into account the rotary dryer-alloy LTTD system. The cost for a rotary dryer-alloy LTTD system is typically higher and actual costs may increase if a large Rotary Dryer-Alloy LTTD unit is the only system available.

5.1.3 Bioventing

Bioventing is an in-situ remediation technology that uses indigenous microorganisms to biodegrade organic constituents adsorbed to soils in the unsaturated zone. Soils in the capillary fringe and the saturated zone are not affected. In bioventing, the activity of the indigenous bacteria is enhanced by inducing air (or oxygen) flow into the unsaturated zone (using extraction or injection wells) and, if necessary by adding nutrients (USEPA, 1994).

When extraction wells are used for bioventing, the process is similar to soil vapor extraction (SVE). However, while SVE removes constituents primarily through volatilization, bioventing systems promote biodegradation of constituents (generally by using lower airflow rates than for SVE). All aerobically biodegradable constituents can be treated by bioventing. In particular, bioventing has proven to be very effective in remediating releases of petroleum products including gasoline, jet fuels, kerosene, and diesel fuel. Bioventing is most often used at sites with mid-weight petroleum products (i.e., diesel fuel and jet

fuel), because lighter products (i.e., gasoline) tend to volatilize readily and can be removed rapidly using SVE. Heavier products (e.g. fuel oils) generally take longer to biodegrade than the lighter products (USEPA, 1994).

Before the installation of the bioventing system it is recommend that all free product present at the site be removed. This system will not be effective unless the free product is removed from the site prior to the installation of the system.

Based upon the soil hydrocarbon concentrations identified in the TtNUS CARA, it is estimated that soil remediation may be achieved in approximately 69 months using bioventing. It should be noted that the estimated time to clean up was determined by equations used for SVE clean up time. SVE clean up calculations were used due to the absence of calculations available for bioventing. Calculations available for SVE clean up time determined a remediation time of 23 months. Since SVE relies on volatilization for remediation and clean up by volatilization occurs at a faster rate than bioventing, the bioventing time was calculated by multiplying the SVE time by three, resulting in an estimated clean up time of 69 months. Estimating the time to clean up by bioventing is difficult to calculate unless a treatability study is performed, and the time to clean up provided here may vary significantly from the actual clean up time. The calculations are presented in Appendix D. An estimated cost of bioventing implementation with six years of O&M is presented in Table 5-1 and Appendix C, Table C3.

5.1.4 Chemical Oxidation

In-situ chemical oxidation requires the injection of proprietary liquid chemical formulations into the contaminated portion of the aquifer. Two reactive compounds commonly used for in-situ oxidation of organic contaminants have been identified as Fenton's reagent and potassium permanganate.

In Fenton's reagent, hydrogen peroxide reacts with ferrous iron to produce the hydroxyl radical, a powerful oxidizer. The hydroxyl radical progressively reacts with organic compounds to produce carbon dioxide and water. If potassium permanganate is used instead of Fenton's reagent, then the potassium permanganate ion, rather than hydrogen peroxide, is used as the reagent. The reaction may result in a temporary exceedance of the secondary groundwater standards for color, total dissolved solids, manganese, and pH. Treatability testing is typically required to verify the effectiveness of in-situ chemical oxidation.

Multiple injection wells would be installed throughout the soil contaminant plume from which the chemical oxidation compounds would be injected. The amount of injected compound and the number of injection wells would be determined by a treatability study. Chemical oxidation would be effective at destroying the

petroleum contaminants at the site. It will be beneficial to remove the free product from the site prior to the injection of chemical oxidation compounds. This will reduce the amount of injected compounds required, and will allow the injected compounds to work more efficiently on the soil matrix. In order for the process to be fully evaluated, a treatability study will be required. An estimated cost of chemical oxidation implementation with one year of O&M is presented in Table 5-1 and Appendix C, Table C4.

5.2 EVALUATION OF FREE PRODUCT REMOVAL ALTERNATIVES

Based on the CAR and CARA data, the total volume of approximately 158 gallons of free product is located in the subsurface at Site 1107 (see Appendix B). It should be noted that this is only an estimate and actual free product volumes may differ significantly from this estimate. TtNUS has investigated various methods for the removal of free product from the site. The following methods have been identified for removal of free product and will be evaluated in this RAP:

- Dewatering during soil excavation.
- Skimming systems.
- Dual-phase extraction.

The following sections briefly discuss each of these free product removal actions with respect to their suitability for implementation at this site.

5.2.1 Dewatering During Soil Excavation

Free product may be recovered prior to and during the excavation dewatering using trash pumps or conventional vacuum trucks. During excavation activities, recovered free product and groundwater in the excavation will be removed. Due to the viscous nature of the aged Bunker C fuel oil, it is expected that most free product will be recovered during excavation activities. The removed product and water from dewatering activities will be treated at or disposed of at an off-site facility.

Free product dewatering is expected during soil excavation activities, and therefore the duration of the excavation phase of the project would determine the time limit for free product removal. Preliminary calculations indicate a remedial time period of 15 days for excavation and disposal. An estimated cost for dewatering is included In Table 5-2, and as part of the Soil Excavation and On-site Treatment or Off-site Disposal Alternative presented in Appendix C, Table C2.

Table 5-1
Soil Remedial Alternatives Cost Summary

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

ALTERNATIVE	CAPITAL COST	ANNUAL O&M	ESTIMATED YEARS OF OPERATION	O&M PRESENT WORTH	TOTAL PRESENT WORTH
Natural Attenuation	$19,000	$152,000 (1) $38,000 (2) $19,000 (3)	10	$292,000	$342,000
Excavation and Offsite Disposal	$172,000	$40,000	1	$40,000	$212,000
Excavation and Onsite Treatment	$219,000	$40,000	1	$40,000	$259,000
Bioventing	$143,000	$75,000	5	$352,000	$544,000
Chemical Oxidation	$262,000	$91,000	1	$91,000	$353,000

Note: See Appendix C for detailed cost estimates for the soil remediation alternatives.
(1) Years 1 - 2
(2) Year 3
(3) Year 4 - 10

Table 5-2
Free Product Remedial Alternatives Cost Summary

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

ALTERNATIVE	CAPITAL COST	ANNUAL O&M	ESTIMATED YEARS OF OPERATION	O&M PRESENT WORTH	TOTAL PRESENT WORTH
Excavation and Dewatering	**	**	15 days	**	**
Passive Skimming/ Bailing	$26,000	$73,000	5	$271,000	$322,000
MDES	$69,000	$11,000	1	$11,000	$88,000

Note: See Appendix C for detailed cost estimates for the free product remediation alternatives.
** Costs included in the excavation alternatives

5.2.2 Skimming Systems

Skimming systems are typically used to collect free product with little or no recovery of water. In general this approach involves using skimming devices to remove product floating on the water table (USEPA, 1996).

Free product removal using skimming equipment is applicable in settings where long-term hydraulic control of the dissolved hydrocarbon plume is not required. In most settings skimmer operations will not control the liquid hydrocarbon plume. The most common use of these systems is inclusion in an interim action where free product has entered open excavations. In general, skimming systems are applicable to settings in which the amount of free product is small and exists in permeable conduits such as utility bedding or buried underground structures. The hydraulic conductivity should be greater than ±10 centimeters per second to ensure a sufficient influx of free product to the skimmer. Skimmers may also be used in conjunction with other free product removal programs such as in monitoring and extraction wells used for water table depression methods (USEPA, 1996).

For long-term operations, skimmers are placed in wells and gravel-filled trenches with sumps. Recovery may be enhanced by the use of hydrophobic gravel packs in wells. Field studies have shown that gravel packs constructed from hydrophobic materials allow for free product to enter wells and sumps more rapidly. Recovery rates for long-term operations are generally very low.

The selection of skimming equipment is based primarily on the size of the recovery installation (well, trench) and expected rate of recovery of free product. Two types of skimming equipment are available. Mechanical skimming equipment actively extracts free product from recovery initiation, whereas passive skimming equipment accumulates free product over time. Mechanical skimming systems rely on pumps (either surface mounted or within the well) or other motors to actively extract free product from the subsurface. Mechanical skimming systems are more often used where larger volumes of free product are present. Passive skimming systems do not actively pump free product; instead they slowly accumulate it over time. There are two basic forms of passive skimmers, filter canisters, and absorbent socks.

Based on the viscosity of the free product, a passive skimming system would likely be used along with hand bailing. Due to the minimal groundwater flow at the site, hand bailing may help induce a groundwater flow toward the recovery wells, and therefore increase the amount of free product recovered at the site. It is expected that due to the viscosity and slow movement of the free product a mechanical skimming system would be inefficient since it would most likely operate for a short period of time before shutting down and then activate again several hours later. This cycle would result in a very small amount of time where the system would actively be removing the free product.

To capture the free product plume, filter canisters would be placed in the wells where free product has been detected (monitoring wells MW-1, MW-4, and MW-8) along with the recovery well located at the site. Additionally, a new well would be installed on the western side of the free product plume to capture free product in this area. To recover additional product, the wells would be hand bailed on a weekly interval when the skimmers are emptied and adjusted.

Since there is a minimal groundwater flow at the site and due to the chemical characteristics of the contaminant, it is expected that the free product levels in the monitoring wells would persist for one to two years. However, this time calculation does not include desorption factors. Experience with passive skimming systems at sites with similar lithology and similar fuel oil contaminants indicate that adsorbed petroleum hydrocarbons within saturated zone soils continually leach into groundwater prolonging remedial time periods. This leaching process cannot be predicted accurately. In addition, since there is a minimal groundwater flow at the site free product flow may also be retarded. Cost calculations, therefore, were prepared using a more conservative remedial time period of five years for the passive skimming system. An estimated cost for installation of a passive skimming system and five years of operation is presented in Table 5-2 and Appendix C, Table C5.

5.2.3 Dual-phase Recovery

The approach of dual-phase recovery is to extract free product and vapor by vacuum enhanced pumping techniques. Dual-phase systems recover free product and facilitate vapor-based unsaturated zone cleanup through each well point (USEPA 1996). This approach has several 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 and mobile free product are collected simultaneously.

There are two main conceptual approaches to dual-phase recovery, although they differ only in the vertical positioning of the pump intake. 1) Recovery of free product and water by a single vacuum/liquids pump. 2) Extraction of free product, air, and water with a single pump and a vacuum extraction point set at the air/product interface. This technology is commonly referred to as “bioslurping.”

Dual phase extraction can be applied using either an in-situ system or via specialized mobile vacuum trucks. The use of mobile vacuum trucks is a variation of multi-phase extraction/dual-phase extraction, and also known as aggressive fluid vapor recovery, mobile multi-phase extraction, or mobile dual-phase extraction system (MDES). In this RAP the technology will be referred to as MDES. Permanent dual-phase extraction systems typically involve large capital costs for equipment and installation. Permanent dual-phase recovery systems are also typically used for long-term operations. MDES allows sites with

small amounts of free product to be remediated via dual-phase extraction with low capital cost. MDES is the proposed dual-phase extraction technology for Site 1107. Due to these factors, the site constraints listed in Section 3.2, and reduced costs. A mobile vacuum truck equipped for MDES would also eliminate the need for an on-site remedial system. The vacuum pressures provided by the vacuum truck may provide a large radius of influence, thereby effecting a larger area. Additionally, the dual-phase system can be connected to multiple wells at one time. Based on phone conversations made between TtNUS and an MDES subcontractor, a radius of influence for extraction wells could range from 20 ft to 200 ft. However, due to the site conditions and the fuel contaminant, the radius of influence will be assumed at the low range of 20 ft.

Dual-phase recovery systems are most applicable in medium to low permeability media or thin (less than 0.5 ft) saturated thickness (with water table depths of 5 to 20 ft), settings in which conventional pumping approaches or trenches are inappropriate or ineffective, and free product plumes that are located under paved or sealed surfaces (USEPA, 1996).

To accomplish free product removal with MDES, monitoring wells MW-1, MW-4, and MW-8 and a new well, installed on the western side of the free product plume, would be used as the extraction wells. Based upon the use of MDES at similar sites in Northeast Florida and moderate free product levels, it is estimated that free product recovery may be achieved with six MDES events. The estimated time duration of this remedial technology was estimated at one year (Appendix D). An estimated cost of MDES implementation with one year of O&M is presented in Table 5-2 and Appendix C-6.

5.3 COST COMPARISON AND RATIONAL FOR SELECTION

A table comparing the estimated cost of remediation of soil and free product at the subject site using the combinations of the evaluated alternatives is provided in Table 5-3. A table comparing the advantages and disadvantages of each remedial alternative is presented in Table 5-4. Based on a review of the advantages, disadvantages, costs, and TtNUS project experience at sites with similar conditions, TtNUS recommends the excavation and disposal alternative to remediate the soil and dewatering to address free product contamination at this site.

Excavation and disposal provides the highest degree of overall protection to human health and the environment by providing an immediate reduction in risk and hydrocarbon concentrations. The equipment and controls needed for excavation and disposal are reliable, easily operated, commonly available, and typically require minimal O&M cost. Minimal permitting is required for the implementation and operation of soil excavation and disposal. In addition, excavation and disposal will also provide a shorter duration to achieve cleanup standards and goals compared to the other alternatives.

Table 5-3
Cost Comparison for Combined Soil and Free Product Remedial Alternatives

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

COMBINED ALTERNATIVE	TOTAL PRESENT COST
Natural Attenuation and Passive Skimming/Bailing	$664,000
Natural Attenuation and MDES	$430,000
Soil Excavation and Disposal	$212,000
Soil Excavation and Onsite Treatment	$259,000
Bioventing and Passive Skimming/Bailing	$866,000
Bioventing and MDES	$632,000
Chemical Oxidation and MDES	$441,000

Note: See Appendix C for detailed cost estimates for the soil and free product remediation alternatives.

Table 5-4
Comparison and Rational for Selected Remedial Alternatives

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

MEDIA	TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING COMMENT
Soil	Natural Attenuation	Low capital costs. Easy to implement.	Uncertain remedial time. Long-term O&M.	Eliminate – Free product present.
	Bioventing	Uses readily available equipment; easy to install. Is cost competitive: $45-140/ton of contaminated soil.	Uncertain clean-up time for soil contaminated with Bunker C fuel oil. Requires almost complete removal of free product prior to implementation. Cannot always achieve very low cleanup standards. Requires treatability study.	Eliminate – would require a delayed installation until free product removed. Uncertain effectiveness to clean-up time on Bunker C fuel oil.
	Excavation and Off-Site Disposal	Source removal, short remediation time (weeks), and clean backfill.	Site conditions require special engineering and precautions. High price, transportation of contaminated soil off premises.	Retain– although difficult to excavate, cheaper and assured effectiveness.
	Excavation and On-Site Treatment	Source removal, short remediation time, treated soil tested before backfilling and soil stays on-site.	High price of treatment.	Eliminate – More cost effective to dispose of soil. On-site treatment by LTTD is typically effective when > 1,000 yd^3 of soil.
Free Product	Chemical Oxidation	Very effective on all petroleum products. Short remediation time. In-situ treatment.	High price of treatment. Requires treatability study. Requires removal of most free product prior to injection.	Eliminate – not cost or schedule effective.
	Skimmers and Hand Bailing	Relatively low cost.	Long term removal time. Effectiveness uncertain.	Eliminate – long term removal required.
	Dewatering During Excavation	Relatively low cost	Requires excavation to 21 to 22 ft bls.	Retain – if soil excavation alternative selected.
	Dual-phase Extraction by Mobile Unit	Easily implementable with mobile vacuum trucks.	Uncertain effectiveness on Bunker C fuel oil.	Retain – if chemical oxidation, natural attenuation, or bioventing alternatives are selected.

6.0 REMEDIAL SYSTEM DESIGN

The preferred remedial alternative presented in this RAP was selected based on it being the most cost and schedule effective method for recovery and/or treatment of hydrocarbons within the vadose zone at the site. It is also the only technology that provides a short-term reduction in risk. The potential remedial technologies and process options for soil remediation and free product removal were identified and screened, and the results were presented in Section 5.0. The selected alternative is soil excavation and offsite disposal with free product collection during dewatering.

6.1 TECHNOLOGY DESCRIPTION AND SYSTEM DESIGN

Major components of soil excavation and disposal/treatment include the following:

- Site preparation (pre-excavation activities).
- Excavation and transportation to off-site location.
- Backfill and compaction.
- Site restoration and/or grading.

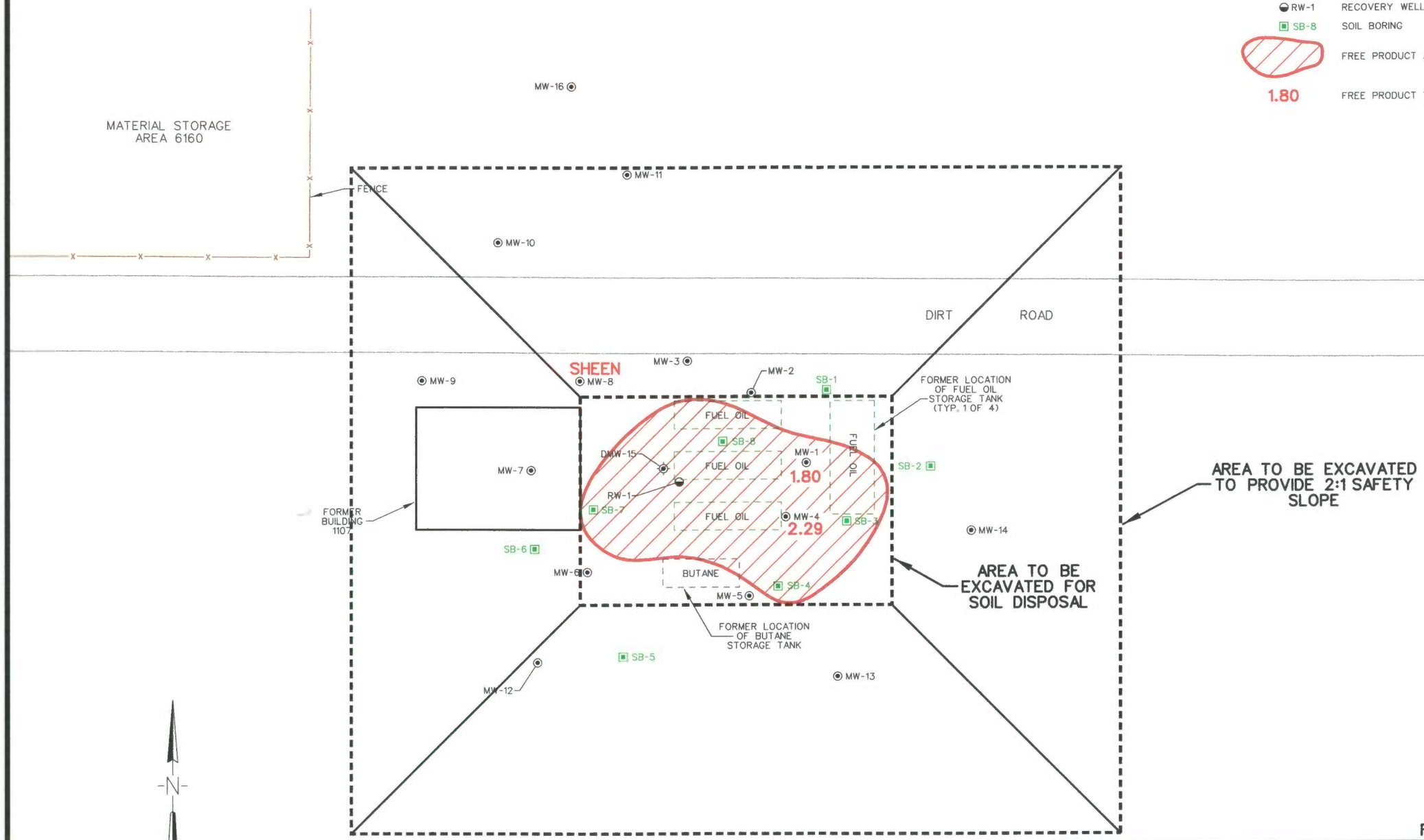
Figure 6-1 presents the boundaries of the excavation area. As indicated on Figure 6-1, the soil located between 16 and 21 ft bls within the inner boundary marked (soil to be excavated and disposed), should be considered petroleum-impacted soil. Since the contaminated soil is located at 16 to 21 ft bls, only the contaminated soil will be disposed off-site. The uncontaminated soil above should be returned to the excavation as backfill. Additional soil should be excavated to provide the safety sloping required to achieve the required depth as indicated on Figure 6-1. Based on the soil plume boundary and an average thickness of 16 ft to 22 ft bls, (22 ft bls, as a result of over-excavation 1 ft below the water table) the estimated volume of soil to be disposed is 342 yd^3 (see Appendix D).

6.1.1 Site Preparation (Pre-Excavation Activities)

Due to the presence of free product at the site, it is recommended that a manual free product recovery method (hand bailing) be performed on a bi-weekly basis until the proposed excavation is conducted. Recovered free product should be contained in a 55-gallon drum and disposed or treated. The hand bailing may reduce the amount of free product encountered during soil excavation.

Rev. 1
10/10/01

SOURCE:
LOCATIONS OF ROADS AND FORMER LOCATIONS OF BUILDINGS, TANKS, AND DISTRIBUTION LINES ARE TAKEN FROM N.A.S. DRAWING NO. 23032 DATED JUNE 24, 1944. ALL WELL AND BORING LOCATIONS ARE APPROXIMATE.



LEGEND

MW-1	MONITORING WELL
DMW-15	DEEP MONITORING WELL
RW-1	RECOVERY WELL
SB-8	SOIL BORING
	FREE PRODUCT AREA
1.80	FREE PRODUCT THCKNESS IN FEET

FIGURE 6-1

EXCAVATION BOUNDARIES
UST SITE NO. 1107
REMEDIAL ACTION PLAN

OUTLYING LANDING FIELD BRONSON
PENSACOLA, FLORIDA

n1x17b.dgn

CAD FILE NO./DATE: k:\dgn\navy\pensacola\bronson\ 0401b009.dgn/8-2-01
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Prior to excavation activities, the limits of excavation should be surveyed and staked in the field. The designated areas should be flagged and boundaries will be established by florescent yellow caution tape to define the exclusion zone.

Prior to beginning any excavation activities or any intrusive work, the designated areas should be checked for any substructures, utility lines, and other potential interference. A professional survey to verify locations of site utilities was not conducted for this report; however, active or inactive subsurface obstructions may include electric lines, piping for sewer, gas distribution, etc.

Monitoring wells within the limits of the excavation are to be abandoned prior to excavation or removed during excavation activities. If the monitoring wells are abandoned, they should be abandoned by grouting from the bottom of the well to approximately 2 ft bls with bentonite-cement grout. The grout should be pumped from the bottom of the borehole to the top by pressure grouting using a tremie pipe. The total depth of the well should be sounded prior to sealing, and the level of grout should be monitored during pumping with a weighted tape to insure complete placement of the grout. The grout level should be checked 24 hours after emplacement and refilled to replace any losses due to settling. In addition, all local and state regulations shall be followed for well abandonment.

The following wells are to be abandoned: MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, MW-9, MW-10, MW-12, MW-13, MW-14, and MW-15.

The existing concrete foundation from Building 1107, considered clean construction debris, is to be demolished and disposed of in accordance with standard practices.

The contractor shall prepare all required planning documents, such as an erosion and sediment control plan, Health and Safety Plan, Removal Action Plan, and Soil Disposal Plan, and also obtain all necessary permits.

6.1.2 Excavation and Off-site Transportation

Soil excavation should be within the area shown on by Figure 6-1. Soil excavated from 16 to 22 ft bls in the depicted area should be handled as petroleum contaminated soil. Additional excavation will be required to provide the two-to-one slope as required by OSHA. However, shoring may be used in lieu of the 2-to-1 slope. Excavation will be conducted using standard earthmoving equipment. All operators should be certified to be in compliance with 29 Code of Federal Regulations 1910.120 health and safety requirements. Visual and OVA headspace analysis should be used to determine the soil contamination extent at set intervals during the excavation. It is assumed that due to the age of the petroleum that

visual observation of the petroleum impacted soil may be necessary. Excavation to a depth approximately 1 ft below the groundwater table may be required to implement free product removal where free product is encountered. Free product that is exposed in the open excavation should be recovered to the extent practicable by using high vacuum suction, product absorbing socks, and over excavation.

Excavated soil that is contaminated with TPHs (greater than 50 ppm or observed stained by visual observation) should be loaded directly into trucks or roll-off boxes to facilitate immediate site removal and delivery to an FDEP permitted off-site disposal facility.

The excavation should have sides sloped or be shored in accordance with applicable standards to prevent unstable conditions during excavation that could pose hazards to personnel. Stormwater run-on and run-off controls should be implemented to prevent migration of sediment or contaminated stormwater during site activities.

The limits of excavation shown on Figure 6-1 are representative of the footprint of the free product and soil contaminant plume. The soil in the excavation area is described as silty sand and the sides of the excavation should naturally slope. Excavations shall be cut back and sloped to allow for safe entry into the excavation in accordance with OSHA regulations. Open excavations shall be protected with suitable barriers, such as, temporary fences. The tops of the excavation shall be provided with a berm of clean soil to minimize the amount of run-on that can enter the excavation.

Since it is assumed that OVA headspace analysis and visual observations will not accurately confirm the complete removal of contaminated soils, a mobile lab should be set up on-site during the excavation of contaminated soil. The soil analysis by the mobile lab should be used to screen excavated soils during removal of the contaminated area to assure the complete removal of petroleum impacted soil. Confirmatory soil samples should be provided to the lab from the sidewalls of the excavation to confirm the removal of petroleum-impacted soil. Final confirmatory soil samples should be shipped to a fixed base laboratory and analyzed for the gasoline and kerosene analytical group. At a minimum, confirmatory soil sampling should be performed in accordance with the Florida regulatory guidelines provided for UST removals.

Free product floating on the groundwater table at the bottom of the excavation shall be removed. Collected water, free product, and materials will be disposed of off-site.

If it is necessary to temporally stockpile contaminated soil, the stockpile will be provided with erosion and sedimentation control such as silt fences or hay bails. Captured sediment from the contaminated soil stockpiles must be treated. Contaminated soil and treated soil stockpiles will be placed on an

impermeable surface, or liner, 5-mil thickness minimum. Stockpiles will be graded to promote flow toward the excavation. Water and free product seeping out of stockpiles of contaminated soil must be captured for treatment or disposal. Stockpile locations selected by the contractor are subject to review and approval.

The total volume excavation to allow sloping and removal of contaminated soil is estimated to be 4506 yd^3. Based on the actual water table at the time of excavation, these volumes may vary.

6.1.3 Site Restoration

Backfill of excavated areas may be performed simultaneously with excavation if the confirmatory sampling has determined that the excavation in the particular area is complete. All water from the excavation during soil replacement should be removed as necessary to accommodate compaction. To minimize recontamination of the backfill soil by groundwater, a low (i.e., less than 0.5 percent) organic content soil will be used as backfill material. Backfill material will be well-graded granular soil consisting of silica sand or other approved materials. Backfill will contain less than 0.5 percent organic carbon as measured in accordance with American Society for Testing and Materials (ASTM) D2074-87. Moisture-density testing will be in accordance with ASTM D698-91. Certification that the barrow source is free of petroleum hydrocarbon contamination is required from the borrow source prior to delivery. Backfill material will be placed in 12-inch lifts and compacted to 90 percent standard Proctor density. Compactive effort should be no less than four passes of the earth-moving equipment. Approximately 340 yd^3 of backfill material should be required. If excavation and backfill operations are performed simultaneously, a separation distance should be maintained between the toe of the slope for excavation and the toe of the slope for backfill to prevent or minimize cross-contamination by direct contact with free product or excessively contaminated soil. After all disturbed areas of excavation have been successfully backfilled, the site should be graded to drain. The excavation should be graded to match surrounding elevations, and the grade will be sloped from the center outward so that runoff will flow away from the backfilled area. The slope should be blended into the surrounding areas, and the grade changes should be gradual. If necessary, prior to backfilling an appropriate amount of 1½- to 2-inch diameter crushed stone may be provided as a bottom layer in order to stabilize saturated material resulting from groundwater encroachment into the open excavation.

Following completion of the excavation, backfill, and site restoration, groundwater monitoring wells that were abandoned or destroyed during remedial activities should be replaced as determined necessary to complete the post-remedial groundwater monitoring. A final survey shall be performed to identify the limits of excavation, final grading elevations, and new monitoring well locations. An as-built site plan should be prepared for the excavation project area. A completion report consistent with the requirements

of Chapter 62-770.300 FAC should be provided summarizing volumes removed, disposed, replaced, site activities, and confirmatory soil sampling results.

7.0 POST REMEDIAL ACTION MONITORING

The following sections establish procedures for the post-remedial action monitoring required by Chapter 62-770 FAC.

7.1 DESIGNATION OF MONITORING WELLS

Groundwater samples will be collected from all remaining and new monitoring wells on a quarterly basis as selected necessary for post-remedial action monitoring. The monitoring shall occur for a minimum of four quarters. Samples will be analyzed for the Gasoline and Kerosene Analytical Groups as described in Chapter 62-770 FAC.

7.2 MONITORING PLAN

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

- To monitor the overall effectiveness of the remedial action in reducing hydrocarbons in groundwater.
- To verify that the contaminant plume has not migrated beyond its current location.
- To comply with Chapter 62-770 FAC.

The proposed monitoring plan includes the following and is summarized in Table 7-1.

- Measurements of groundwater levels in the monitoring wells to determine groundwater flow after remedial activities. Measurement will be performed using a water level indicator.

- Sampling and laboratory testing of groundwater from the selected monitoring wells to document remediation of the groundwater plume will be performed quarterly. The groundwater samples will be analyzed for the Gasoline and Kerosene Analytical Group.

- The results of quarterly sampling will be reported every quarter in a monitoring report.

TABLE 7-1

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

Monitoring/Sample Location	Parameters	Frequency/ Reporting
Monitoring Wells	Water Levels and Dissolved Oxygen (OH), pH, Oxidation Reduction Potential (ORP), Conductivity, Turbidity, Temperature	Quarterly
Monitoring Wells	Kerosene Analytical Group	Quarterly

7.3 STATUS/MONITORING REPORTS

A summary of remedial activities shall be included in the first quarterly monitoring report. The remaining quarterly reports shall include results on groundwater monitoring activities as required in Chapter 62-770 FAC. The first status/monitoring report shall summarize all remedial activities and shall contain at a minimum the following information:

- Startup date.
- Total volume of soil excavated.
- Total volume of soil disposed.
- A copy of all waste manifests.
- Confirmatory sampling analytical results.
- Analytical results for soil that was disposed.
- Volume of free product and groundwater recovered and disposed.
- Hydrocarbon constituent concentrations in groundwater as measured from monitoring wells, together with water table elevations.
- DO, ORP, pH, temperature, conductivity, and turbidity in the groundwater monitoring wells during sample collection.
- A figure indicating soil excavation area.
- A figure indicating the location of all existing and replaced monitoring wells after excavation is complete.
- Recent groundwater contour and contaminant maps.
- Conclusions as to the effectiveness of the remedial activities and recommendations on further monitoring and operations of the system.

The other three quarterly monitoring reports shall contain at a minimum the following information:

- Hydrocarbon constituent concentrations in groundwater as measured from monitoring wells, together with water table elevations.
- DO, ORP, pH, temperature, conductivity, and turbidity in the groundwater monitoring wells during sample collection.
- A figure indicating the location of all existing and new monitoring wells from which samples were collected.
- Recent groundwater contour and contaminant maps.
- Conclusions and recommendations on further monitoring and operations.

REFERENCES

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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.

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.

APPENDIX A

SOIL CALCULATIONS

TABLE A1

ESTIMATED MASS OF CONTAMINANTS IN VADOSE ZONE SOIL MATRIX

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

INPUT:

Estimated Impacted Area	**1,540**	**ft^2**
Estimated Average Impacted Thickness	**6**	**ft**
Estimated Impacted Volume	**9,240**	**ft^3**
Average TPH Concentration (a)	**13,260**	**mg/kg**

CALCULATIONS:

Estimated Mass of Impacted Unsaturated Soil	**486,777**	**kg**
Estimated mass of hydrocarbons in soil	**14,201**	**lbs**

(a) Arithmatic mean of laboratory analysis of soil sample detections from SB-1 through SB-8.
(See Table 3 in the TtNUS January 2001 CARA)

NOTES

TPH - Total petroleum hydrocarbons
mg/m^3 - milligram per kilogram

Estimated Mass of Impacted Unsaturated Soil = impacted volume (ft^3) x (1 yd^3/27 ft^3) x (1.4 tons/1 yd^3) x (1016 kg/ton)

Estimated mass of hydrocarbons = hydrocarbon concentration (mg/kg) x impacted volume (ft^3) x (1 yd^3/27 ft^3) x (1.4 tons/1 yd^3) x (1016 kg/ton) x (kg/10^6 mg) x (2.2 lb/kg)

PREPARED BY: _____ **CHECKED BY:** _____

Date

APPENDIX B

FREE PRODUCT VOLUME CALCULATIONS

Table B-1
Estimating Thickness and Volume of Free Product

Remedial Action Plan
Site 1107, 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 = 62.48 cm
ρ_ω = 1 gm/cm^3
ρ_o = 0.974 gm/cm^3

$$\mathbf{H_f} = \frac{62.48(1 - 0.974)}{0.974} = \underline{1.668 \text{ cm}}$$

Assumptions:
- density of Bunker C fuel oil 0.974 gm/cm^3 (USEPA 1996)
- product measured = average of MW-1 and MW-4

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 = 1540 ft^2 (TtNUS, 2001)
Actual thickness of product in subsurface = 1.668 cm or 0.055 feet (see above)
Effective porosity = 0.25 (NPWC, 1997)

Volume of product area = area x thickness
1540 ft^2 x 0.055 ft = 84.70 ft^3

Free product volume = volume of product area x effective porosity
84.70 ft^3 x 0.25 = 21.18 ft^3

Gallons of free product = free product volume x 7.4794 gallons/ft^3
21.18 ft^3 x 7.4794 gallons/ft^3 = 158.38 gallons

Total volume of free product in subsurface = **<u>158 gallons</u>**

APPENDIX C

ESITMATED ALTERNATIVE COSTS

Table C-1
Natural Attenuation Alternative

Site 1107, Outlying Landing Field Bronson
Remedial Action Plan
Pensacola, Florida

Estimator: JDF
Checked by:

COST SUMMARY TABLE (costs rounded to nearest $1000)

DIRECT COSTS		
Institutional Controls		$5,000
Total Direct Costs		$5,000
INDIRECT COSTS		
Health and Safety, HASP		$6,000
Engineering and Administration, SAP		$8,000
Total Indirect Costs		$14,000
Total Capital Costs (Direct + Indirect)		$19,000
OPERATIONS AND MAINTENANCE		
Total Costs for One Natural Attenuation Groundwater Monitoring Event		$11,000
Total Reporting Cost for One Reporting Event		$8,000
Total Operation & Maintenance Cost Per Event (Monitoring & Reporting)		$19,000
Quarterly Natural Attenuation Groundwater Monitoring and Reporting (First Two Years)		$152,000
Semi-Annual Natural Attenuation Groundwater Monitoring and Reporting (Third Year)		$38,000
Present Cost of Sampling for First Three Years		$190,000
Annual Natural Attenuation Groundwater Monitoring & Reporting (Years Four through Ten)		$133,000
PRESENT WORTH OF O&M (7%, 7 yrs)	($102,396)	$102,000
Present Cost of First Three Years Plus Present Worth for 7 Years		$292,000
Total Capital and O&M Costs		$311,000
Contingency (10%)		$31,000
TOTAL COST		**$342,000**

Table C-1 (Continued)
Natural Attenuation Alternative

DIRECT COSTS	Quantity	Unit	Unit Cost	Total Cost
Institutional Controls				
Prepare Deed Restrictions or LUCIPs	1	ls	$5,000	**$5,000**
TOTAL DIRECT COSTS				**$5,000**
INDIRECT COSTS				
Health and Safety Plan for Monitoring Activities				
Labor:				
H&S Supervisor	16	hrs	$60	$960
Mid-level Geologist/Scientist	40	hrs	$45	$1,800
Word Processor	16	hrs	$35	$560
CADD	32	hrs	$40	$1,280
Editor	8	hrs	$60	$480
Copying: 50 pgs x 25 copies	1250	page	$0.10	$125
Binding/shipping, 25 copies	25	ea	$20	$500
Total HASP				**$5,705**
Sampling and analysis Plan (SAP) for Monitoring Activities				
Labor:				
Jr.-Level Geologist/Scientist	80	hrs	$45	$3,600
Senior Geologist	16	hrs	$80	$1,280
ODC's, Production Support (editing, copying, binders, etc.)				
Word Processor	16	hrs	$35	$560
CADD	32	hrs	$40	$1,280
Editor	8	hrs	$60	$480
Copying: 50pgs x 25 copies	1250	page	$0.10	$125
Binding/shipping, 25 copies	25	ea	$20	$500
Total SAP				**$7,825**
TOTAL INDIRECT COSTS				**$13,530**

Table C-1 (Continued)
Natural Attenuation Alternative

OPERATION AND MAINTENANCE	Quantity	Unit	Unit Cost	Total Cost
Groundwater Monitoring for Natural Attenuation per Event				
Assumptions:				
Duration of NA alternative = 10 yrs				
Use of existing wells				
Quarterly first two years, semi-annual third year, and annual thereafter for duration of treatment period.				
Labor				
1 technician, 1 geologist, 2 days per sampling event @10 hour days	40	hrs	$75	$3,000
Car rental: two days per event	2	ls	$50	$100
Total labor:				$3,100
Lab analysis:				
Volatile Organics, Method 8260, assume 16 wells, 4QC	20	ea	$80	$1,600
PAHs, Method 8310, assume 16 wells, 3 QC	19	ea	$135	$2,565
TRPH (FLPRO) assume 16 wells, 3 QC	19	ea	$120	$2,280
Total lab analysis:				$6,445
Expendables and Equipment				
Gloves (2 boxes per event)	2	box	$10	$20
Teflon tubing (400 feet per event)	400	ft	$1.45	$580
Silicon tubing (50 feet per event)	50	ft	$1.55	$78
Shipping and supplies (tape, bubble wrap, ice)	1	ls	$250	$250
Pumps for purging wells, 2 pumps, 2 days rental	4	days	$35	$140
First Aid kit	1	ls	$50	$50
Rental of Horiba U-22 meter for conductivity, Oxidation-Reduction Potential, pH, dissolved oxygen, turbidity, and temperature.	2	days	$60	$120
Oil water interface probe	4	days	$25	$100
Disposal of purge water, assume nonhaz., drums	2	ls	$150	$300
Total expendables and equipment rental:				$1,638
Total Costs for One Natural Attenuation Groundwater Monitoring Event				**$11,183**
Reporting for Each Monitoring Event				
1 Jr. Level Geologist	100	hrs	$45	$4,500
1 Senior Geologist	16	hrs	$80	$1,280
Production:				
Word Processing	12	hrs	$35	$420
Technical Expert	6	hrs	$75	$450
Editor	8	hrs	$60	$480
CADD operator	9	hrs	$40	$360
Reproduction: 100 pgs @ 20 copies	2000	pg	$0.10	$200
Shipping/Binding: 20 reports	20	ea	$20	$400
Total Reporting Cost for One Monitoring Event:				**$8,090**
TOTAL OPERATION & MAINTENANCE (MONITORING & REPORTING PER EVENT)				**$19,273**

Table C-2
Excavation and Disposal or Onsite Treatment Cost

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

Estimator: JDF
Checked By:

COST SUMMARY TABLE (costs rounded to nearest $1000)

DIRECT COSTS	
Site Preparation and Mobilization	$21,000
Workplan & Health & Safety Plan	$6,000
Field Sampling & Oversight	$13,000
Summary Data Report	$7,000
Excavation Activities	$51,000
Offsite Disposal of Soil	$23,000
Onsite Treatment by LTTD	$62,000
Site Restoration and Demobilization	$7,000
One Year of Post-Remedial Action Quarterly Monitoring	$40,000
Reporting, Site Activities and Monitoring Report	$9,000
Costs for Excavation and Offsite Disposal	$177,000
(Sum of Direct Costs minus Onsite Treatment)	
Indirect Costs	
Contingency (@20%)	$35,000
Total Costs for Excavation and Offsite Disposal	**$212,000**
Costs for Onsite Treatment by LTTD	$216,000
(Sum of Direct Costs minus Disposal Cost)	
Indirect Costs	
Contingency (@20%)	$43,000
Total Costs for Excavation and Onsite Treatment	**$259,000**

Table C-2 (Continued)
Excavation and Disposal or Onsite Treatment Cost

DIRECT COSTS	Quantity	Unit	Unit Cost	Total Cost
Site Preparation and Mobilization				
Silt fencing/signs/misc. materials	1	ls	$5,000	$5,000
Decontamination pad	1	ls	$1,000	$1,000
Pressure washer (assume base will provide decon water)	15	day	$20	$300
Pick-up truck	3	wk	$350	$1,050
General site mob/demob	1	ls	$1,000	$1,000
Site clearing of trees (Dozer D7 with U-blade, including operator)	24	hr	$136	$3,264
Wood Chipper	1	ls	$2,000	$2,000
Foreman (3 weeks * 50 hr/week) Assume 10 hour days	150	hrs	$50	$7,500
Foreman oversight for the entire field event, prep, excavation, demob, etc..				
Total For Site Preparation and Mobilization				**$21,114**
Site Sampling & Oversight				
Workplan & Health & Safety Plan				
Jr. Level Engineer	40	hrs	$45	$1,800
Sr. Scientist	16	hrs	$90	$1,440
Word Processor	16	hrs	$35	$560
CADD	32	hrs	$40	$1,280
ODCs	1	ls	$500	$500
Total for Workplan & Health & Safety Plan				**$5,580**
Field Sampling & Oversight				
Jr. Level Geologist	150	hrs	$35	$5,250
ODCs	1	ls	$1,000	$1,000
Analysis RCRA 8 metals, VOCs 8260, TRPH FLPRO, PAHs 8310	20	ea	$300	$6,000
Sampling equipment	1	ls	$1,000	$1,000
Total for Field Sampling & Oversight				**$13,250**
Summary Data Report				
Jr. Level Engineer	20	hrs	$45	$900
Senior Scientist	8	hrs	$80	$640
Mid-level Engineer	60	hrs	$60	$3,600
Word Processor	16	hrs	$35	$560
CADD	32	hrs	$40	$1,280
ODCs	1	ls	$500	$500
Total for Summary Data Report				**$7,480**
Excavation				
Excavation of Soil:				
(assume two trackhoes 10 hrs/day, one for 10 days, the other for 15 days)				
Trackhoe operator labor included in costs				
2.5 CY, Track Loader	100	hrs	$125	$12,500
2.5 CY, Track Loader	150	hrs	$125	$18,750
Common fill for backfill (load and haul) includes spreading and compaction	342	yd^3	$8	$2,736
Dewatering (Assume vacuum truck onsite for 10 days, collection, transport, and disposal of contaminated water)				$5,000
Mobile lab for confirmatory sampling	5	day	$1,250	$6,250
Two laborers	200	hrs	$25	$5,000
Compaction tests	1	ls	$1,000	$1,000
Subtotal for Excavation				**$51,236**

Table C-2 (Continued)
Excavation and Disposal or Onsite Treatment Cost

Offsite Disposal of Soil				
Transportation, and disposal of contaminated soil to a Subtitle D Facility	479	ton	$47	$22,513
Cost derived from quote from Andy Adams of Waste Transportation & Disposal Services				
(1-800-901-0081) cost quoted was $46.50/ton with treatment at an offsite soil burner.				
Subtotal for Offsite Disposal of Soil:				**$22,513**
Onsite Treatment of Soil by LTTD				
Permitting/Engineering for Site	1	ea	$37,131	$37,131
(permitting site with treatability studies, interface with regulators)				
Minimum Mob/Demob Charge for Small Portable LTTD Unit	1	ea	$5,304	$5,304
Direct firing, Rental and Operations Cost to treat soil	428	ton	$23	$9,827
Front end loader with operator				
(for moving soil)	150	hr	$65	$9,729
Subtotal for soil treatment by LTTD				**$61,991**
Site Restoration and Demobilization				
Hydroseeding	0.5	acre	$400	$200
Demobilization of Equipment	1	ls	$1,000	$1,000
Drill and install 8 - 2" PVC monitoring wells, each 25 feet deep	200	ft	$26.59	$5,318
Subtotal Site Restoration and Demob:				**$6,518**

Assumption:
No repair to current dirt road beyond backfill w/compaction specified herein. No replacement of slab to west of contaminated area.

Table C-3
Bioventing Cost Alternative

Site 1107 Outlying Landing Field Bronson
Remedial Action Plan
Pensacola, Florida

Estimator: JDF
Checked By:

COST SUMMARY TABLE (costs rounded to nearest $1000)

DIRECT COSTS		
Site Preparation		$35,000
Bioventing Well System Installation		$14,000
Piping and Equipment		$31,000
Total Installation labor		$19,000
Treatability Study		$20,000
Total Direct Cost		$119,000
INDIRECT COSTS		
Engineering and Design (20%)		$24,000
Total Indirect Costs		$24,000
Total Capital Costs (Direct + Indirect)		$143,000
OPERATIONS AND MAINTENANCE		
Administrative O&M		
Sampling and Analysis Plan (SAP) for Monitoring Activities		$9,000
Annual Groundwater Monitoring (4 quarters)		$24,000
Reporting, Site Activities Report/System Operation Report		$9,000
Total Administrative O&M, annual		$33,000
PRESENT WORTH OF O&M (7%, 5 yrs)	($200,910)	$201,000
Present worth O&M + SAP		$210,000
Treatment System O&M		
System Maintenance		$31,000
Utilities		$11,000
Total Treatment System O&M, annual		$42,000
Present Worth of Treatment System O&M (7%, 4 yrs)	($142,263)	$142,000
Present Worth O&M (Administrative + Treatment System O&M)		$352,000
Total Capital and O&M Cost		$495,000
Contingency (10%)		$49,000
TOTAL COST		**$544,000**

Table C-4
Costs for Chemical Oxidation

Remedial Action Plan
Site 1107 Outlying Landing Field, Bronson
Pensacola, Florida

Estimator: JDF
Checked By:

COST SUMMARY TABLE (costs rounded to nearest $1000)

DIRECT COSTS		
Chemical Oxidation Injection System	$	182,000
Treatability Study	$	37,000
Total Direct Costs	$	218,000
INDIRECT COSTS		
Engineering and Design (20%)	$	44,000
Total Indirect Costs	$	44,000
Total Capital Costs (Direct + Indirect)	$	262,000
OPERATIONS AND MAINTENANCE		
Administrative O&M	$	15,000
Groundwater Monitoring (Annual)	$	40,000
Monitoring Reports (Annual)	$	36,000
Total Administrative O&M (annual)	$	91,000
Total Capital and O&M Cost	$	353,000
TOTAL COST		**$353,000**

Table C-4 (Continued)
Costs for Chemical Oxidation

DIRECT COSTS	Quantity	Unit	Unit Cost	Total Cost
Chemox Injection System				
Chemox injection	1	ls	$146,021	$146,021
(Cost inferred from Geo-Cleanse International, Inc. cost estimate) See Appendix H				
Mobilization/demobilization, drillers and equipment	1	ls	$1,000	$1,000
Install injection wells via Hollow Stem Auguring (HSA) methods (25 ft bls)	30	well	$863	$25,890
Misc. equipment and supplies	1	ls	$2,000	$2,000
Per diem, 3 drillers, 6 days ea.	18	dy	$100	$1,800
Decon, drillers	18	hr	$100	$1,800
Oversight, engr or geologist, 6 days, 12 hrs per day	72	hr	$45	$3,240
Total Chemox Injection System Cost:				$181,751
Treatability Study	1	ls	$36,505	$36,505.25
(Cost 25% of Chemox injection cost)				
TOTAL DIRECT COSTS				**$218,256**
Indirect Costs				
Engineering and Design (20%)				$43,651.25
TOTAL DIRECT COSTS				$261,908
Health and Safety Plan for Monitoring Activities				
Labor:				
H&S Supervisor	16	hrs	$60	$960
Mid-level Geologist/Scientist	80	hrs	$45	$3,600
Word Processor	16	hrs	$35	$560
CADD, 8 hrs/figure, 4 figures	32	hrs	$40	$1,280
Editor	8	hrs	$60	$480
Copying: 50 pgs x 25 copies	1250	page	$0.10	$125
Binding/shipping, 25 copies	25	ea	$20	$500
Total HASP				**$7,505**
Sampling and analysis Plan (SAP) for Monitoring Activities				
Labor:				
Jr.-Level Geologist/Scientist	80	hrs	$45	$3,600
Senior Geologist	16	hrs	$80	$1,280
ODC's, Production Support (editing, copying, binders, etc.)				$0
Word Processor	16	hrs	$35	$560
CADD, 8 hrs/figure, 4 figures	32	hrs	$40	$1,280
Editor	8	hrs	$60	$480
Copying: 50 pgs x 25 copies	1250	page	$0.10	$125
Binding/shipping, 25 copies	25	ea	$20	$500
Total SAP				$7,825
TOTAL INDIRECT COSTS				**$15,330**

Table C-4 (Continued)
Costs for Chemical Oxidation

OPERATION AND MAINTENANCE	Quantity	Unit	Unit Cost	Total Cost
Groundwater Monitoring for Chemical Oxidation Alternative				$7,423
Total costs for quarterly groundwater monitoring				**$7,423**
REPORTING, Site Activities Report:				
Total report/modeling cost:				**$8,690**
(See Table C2)				

Table C-5
Passive Skimming/Bailing Alternative

Site 1107, Outlying Landing Field, Bronson
Remedial Action Plan
Pensacola, Florida

Estimated by: JF
Checked by:

COST SUMMARY TABLE (costs rounded to nearest $1000)

DIRECT COSTS		
Free Product Removal/Skimming System		$9,000
Total Direct Costs		$9,000
INDIRECT COSTS		
Health and Safety, HASP		$8,000
Sampling and Analysis Plan		$9,000
Total Indirect Costs		$17,000
Total Capital Costs (Direct + Indirect)		$26,000
OPERATIONS AND MAINTENANCE		
Treatment System O&M		$26,000
Annual Groundwater Monitoring		$40,000
Quarterly Status Reports (annual)		$7,000
Total Annual O&M		$73,000
PRESENT WORTH OF O&M (7%, 5 yrs)	($270,613)	$271,000
Total Capital and O&M Cost		$297,000
Contingency (10%)		$25,000
TOTAL COST		**$322,000**

Table C-5 (Continued)
Passive Skimming/Bailing Alternative

Free Product Recovery by Passive Skimming/Hand Bailing

INITIAL COSTS	Quantity	Unit	Unit Cost	Total Cost
Free Product Removal/Skimming System				
Skimmer, 1" Diameter, 47" L, 0.10 gal capacity	5	ea	$367	$1,835
Estimated by Material Storage Building (for storage of drums & equipment)	1	ea	$3,038	$3,038
Checked b Labor				
1 Technician	10	hrs	$35	$350
1 Jr. level Engineer	10	hrs	$45	$450
Sub-total for Skimming System				$5,673
Additional Well Installation				
Mob/demob	1	ea	$500	$500
2" PVC Monitoring well installation	25	ft	$22	$557
IDW (1 drum each for soil cuttings and well development)	2	ea	$150	$300
Well completion	1	ea	$65	$65
Labor				
1 Technician (well installation)	8	hrs	$35	$280
1 Jr. level geologist (well installation)	8	hrs	$45	$360
1 Technician (well development)	8	hrs	$35	$280
Sub-Total For Well Installation				$1,562
Sub-Total For Initial Costs				$7,235
Engineering and Design (20%)				$2,170
Total for Initial Costs				**$9,405**
Treatment System O&M (Annual)				
System Maintenance				
Labor:				
Technician, 30 hrs per month	360	hrs	$30	$10,800
Sr. Engineer, 2 hours per month	24	hrs	$90	$2,160
Project Mgr, 8 hrs per month	96	hrs	$100	$9,600
Purchase drums for product storage	4	ea	$50	$200
Recovered product drum disposal, 4 per year	4	ea	$150	$600
Truck ($50 each trip, 4 trips a month or 48 trips a year)	48	ea	$50	$2,400
		ls	$200	$0
Total Annual O&M				**$25,760**
Sampling and Analysis Plan				
For costs See Table C-3				
Total Costs for Sampling and Analysis Plan				**$8,825**

Table C-5 (Continued)
Passive Skimming/Bailing Alternative

Groundwater Monitoring	Quantity	Unit	Unit Cost	Total Cost
For costs See Table C-3				
Total cost for groundwater monitoring				**$7,463**
Quarterly Status Reports				
(assume four status reports each year)				
1 Jr. Level Geologist 16 hrs	64	hrs	$45	$2,880
1 Senior Geologist 4 hrs	16	hrs	$80	$1,280
Technical Expert 2 hrs	8	hrs	$75	$600
CAD Technician	8	hrs	$40	$320
Production:	1	ls	$100	$100
Word processing 8 hrs	32	hrs	$35	$1,120
Editor 2 hrs	8	hrs	$60	$480
Total Annual Costs for Status Reports				**$6,780**

Table C-6
Mobile Dual-Phase Extraction (MDES)

Site 1107, Outlying Landing Field, Bronson
Remedial Action Plan
Pensacola, Florida

Estimator: JDF
Checked by:

COST SUMMARY TABLE (costs rounded to nearest $1000)

DIRECT COSTS	
Free Product Recovery Via Mobile Dual-Phase Extraction	$49,000
MDES Costs for Oversight and Free Product Monitoring	$6,000
Total Direct Costs	$55,000
INDIRECT COSTS	
Health and Safety, HASP	$6,000
Engineering and Administration, SAP	$8,000
Total Indirect Costs	$14,000
Total Capital Costs (Direct + Indirect)	$69,000
OPERATIONS AND MAINTENANCE	
Status letter Reports	$3,000
Reporting, Final Site Activities/System Operation Report:	$8,000
Total O&M costs	$11,000
Total Capital and O&M Cost	$80,000
Contingency (20%)	$8,000
TOTAL COST	**$88,000**

Table C-6 (Continued)
Mobile Dual-Phase Extraction (MDES)

Free Product Recovery by MDES

DIRECT COSTS	Quantity	Unit	Unit Cost	Total Cost
Free Product Recovery Via Mobile Enhanced Multi-Phase Extraction				
8 hour MDES event	6	ea	$3,165	$18,990
Off-gas treatment	6	ea	$1,500	$9,000
Over time for MDES rig	6	hrs	$450	$2,700
Oily water removal, 6 events @ 2100 gal/event	12600	gal	$0.16	$2,016
Sub-total for initial costs				$32,706
Labor OH (30%)				$9,812
Engineering and Design (20%)				$6,541
Total Direct Costs				**$49,059**
MDES Costs for Oversight and Free Product Monitoring				
Oversight by staff engineer during MDES event (10 hrs per event)	60	hrs	$45	$2,700
Free product monitoring by technician	36	hrs	$30	$1,080
(Assume 4 hrs once every two weeks for 6 month project duration)				
Rental of free product interface probe	30	day	$25	$750
Truck	30	ea	$50	$1,500
Total				**$6,030**
HASP				**$6,000**
(See Table C-1)				
SAP				**$8,000**
(See Table C-1)				
Status Letter Reports				
(assume two reports, one after two events and one after the four events)				
1 Jr. Level Geologist 16 hrs	32	hrs	$45	$1,440
1 Senior Geologist 4 hrs	8	hrs	$80	$640
Technical Expert 2 hrs	4	hrs	$75	$300
CAD Technician	4	hrs	$40	$160
Production:	1	ls	$100	$100
Word processing 8 hrs	16	hrs	$35	$560
Editor 2 hrs	4	hrs	$60	$240
Total				**$3,440**
REPORTING, Final Site Activities/System Operation Report:				
1 Jr. Level Geologist	100	hrs	$45	$4,500
1 Senior Geologist	16	hrs	$80	$1,280
Technical Expert	6	hrs	$75	$450
Production:				
Word processing	12	hrs	$35	$420
Editor	8	hrs	$60	$480
CADD Operator,	8	hrs	$40	$320
Reproduction: 100 pgs @ 20 copies	2000	pg	$0.10	$200
Shipping/binding: 20 reports	20	ea	$20	$400
Total report cost:				**$8,050**

APPENDIX D

ESTIMATED REMEDIAL TIME CALCULATION

Table D1
Estimated Remedial Time
Bioventing System

Remedial Action Plan
Site 1107, Outlying Landing Field Bronson
Pensacola, Florida

INPUT DATA

Density of Air at Standard Conditions (1 atm and 68 F)	**0.075**	**lbs/ ft3**
Vacuum Extraction Flow Rate	**50**	**scfm**
SVE Operation Time	**24**	**hour**
Average TPH Concentration in Soil (a)	**13260**	**mg/kg**
Estimated Mass of Impacted Unsaturated Soil (b)	**486,777**	**kg**
Estimated Mass of TPH in Unsaturated Soil (b)	**15,216**	**lbs**
Estimated Mass of Impacted Saturated Soil (b)	**14,201**	**kg**
Estimated Mass of TPH in Groundwater (b)	**10**	**lbs**
Estimated Volume of Impacted Soil	**9240**	**ft^3**
Soil Porosity	**0.25**	
Target Cleanup Level for TPH in Soil	**340**	**mg/kg**

CALCULATIONS

Estimated TPH Concentration in Saturated Soil	**320**	**mg/kg**
Estimated Total TPH Concentration in Saturated and Unsaturated Soil	**13,579.7**	**mg/kg**
Estimated Air Extraction Volumetric Flow Rate	**72,000**	**ft^3/ day**
Estimated Air Extraction Mass Flow Rate	**5,400**	**lbs air/day**
Estimated Total Mass of TPH in Saturated and Unsaturated Soil	**15,226**	**lbs**

(a) Based on the fixed laboratory analysis of soil samples from SB-1 through SB-8 (TtNUS, 2000)
(b) Based on the calculations performed in Appendix B.

NOTES
These are calcualtions used for SVE remedial times and do not necessarily reflect actual bioventing clean-up.
scfm = Standard cubic feet per minute
mg/kg = Milligram per kilogram
TPH = Total Petroleum Hydrocarbons

Estimated TPH Concentration in Saturated Soil = mass of TPH in saturated soil (lb) x (454 g/lb) (1000 mg/g)/ mass of impacted saturated soil (kg)
Estimated Air Extraction Volumetric Rate = flow rate (scfm) x 60 minutes x operation hours
Estimated Air Extraction Mass Flow Rate = density of air (lb/ft3) x daily volumetric extraction rate (ft3/day)

APPENDIX E

FDEP REMEDIAL ACTION SUMMARY FORM

Remedial Action Plan Summary

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

Site Name Site 1107, Outlying Landing Field Bronson
Location Pensacola, Florida
Media Contaminated: ☐ Groundwater ☑ Soil

FDEP Facility ID No. _____
Current Date 8 / 3 / 1
Date of Last GW Analysis 7 / 12 / 1

Type(s) of Product(s) Discharged:

☐ Gasoline Analytical Group
☑ Kerosene Analytical Group (Diesel)
- Estimated Petroleum Mass (lbs):
  - Groundwater _____
  - Saturated Zone Soil _____
  - Vadose Zone Soil 14,201
- Area of Plume 1,540 (ft^2)
- Thickness of Plume 16 to 22 bls (ft)

Groundwater Recovery and Specifications:

- No. of Recovery Wells _____
  - ☐ Vertical ☐ Horizontal
- Design Flow Rate/Well _____ (gpm)
- Total Flow Rate _____ (gpm)
- Hydraulic Conductivity _____ (ft/day)
- Recovery Well Screen Interval _____ (ft)
- Depth to Groundwater _____ (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 158 (gal)
- Maximum Thickness 27.5 (in)
- Method of Recovery (check all that apply):
  - ☐ Manual Bailing ☐ Skimming Pump
  - ☑ Other Excavation and Dewatering

Method of Soil Remediation:

☑ Excavation
- Volume to be Excavated 342 (yds^3)

☐ Thermal Treatment ☐ Land Farming On Site
☑ Landfill ☐ Bioremediation
☐ Other _____

☐ Vapor Extraction System (VES)
- No. of Venting Wells _____
  - ☐ Vertical ☐ Horizontal
- VES - Applied Vacuum _____ (wg)
- Design Air Flow Rate _____ (cfm)
- Design Radius of Influence _____ (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: 180 (days)
- Method of Estimation
  - ☐ Pore Volumes (no. of pore vols. = _____)
  - ☐ Exponential Decay (Decay Rate) ____ (day^{-1})
  - ☐ Groundwater Model
  - ☑ Other 6 months to mobilize & excavate

Estimated Cost:
- Est. Capital Cost (incl. install.) $ 170,000.00
- Est. O & M Cost (per year) $ 40,000.00
- Est. Total Cleanup Cost $ 212,000.00