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REMEDIAL ACTION PLAN FOR SITE C-2076 TRUMBO POINT BACHELOR OFFICER QUARTERS NAS KEY WEST FL
1/18/2002
BLASLAND, BOUCK AND LEE

Remedial Action Plan

Site C-2076, Trumbo Point BOQ
NAS Key West, Florida
FDEP Facility ID No. 449800230

Reviewed by Amanda Shearer 1/18/02

Department of the Navy
Key West, Florida 33040

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Executive Summary

Site assessment activities for Building C-2076, Trumbo Point Bachelor's Office Quarters, U.S. Naval Air Station Key West, Florida have determined that a localized area of petroleum-impacted groundwater and soil exists at the site. Free product has been detected at this site on several occasions, with the first detection occurring on February 27, 1998, and the most recent detection occurring on November 15, 2001. Actions taken to remove the free product are detailed in this Remedial Action Plan. The depth to water is approximately 3 feet below land surface. Current contaminants of concern for groundwater at this site are naphthalene, total recoverable petroleum hydrocarbons (TRPH), and iron. These contaminants were detected at concentrations exceeding Groundwater of Low Yield/Poor Quality Cleanup Target Levels in groundwater samples collected from monitoring wells MW-5 and MW-8 during an April 2000 sampling event. MW-5 and MW-8 have not been sampled since April 2000.

Based on the remedial alternatives considered, the identified remedial concerns, and the documented site-specific geophysical data, Blasland, Bouck, and Lee, Inc. (BBL) suggests conducting up to four short-term multi-phase extraction (MPE) events. The short-term MPE events should be conducted until sheen/free product is no longer present in any of the wells on site. Subsequently, natural attenuation monitoring should be conducted for a period of one year, unless two consecutive quarterly sampling events have indicated that applicable cleanup target levels have been met. The objective of the monitoring program is to meet the applicable No Further Action criteria in Rule 62-770.680, Florida Administrative Code and obtain a Site Rehabilitation Completion Order.

Based on the proposed remediation strategy, the estimated cost of cleanup through site closure is $220,000.

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1. Introduction and Background Information

Blasland, Bouck & Lee, Inc. (BBL) prepared this Remedial Action Plan to address soil and groundwater quality concerns at Building C-2076, Trumbo Point Bachelor's Officer Quarters (BOQ), U.S. Naval Air Station (NAS) Key West, Florida. The source of petroleum hydrocarbons in the site media is suspected to be from a former underground pipeline from a former diesel aboveground storage tank (AST). The Florida Department of Environmental Protection (FDEP) facility identification number for the site is 449800230.

1.1 Purpose

The purpose of preparing this Remedial Action Plan (RAP) is to address soil and groundwater impacted by petroleum hydrocarbons at concentrations above State allowed target levels.

Pursuant to Contract Number N62467-99-D-2745, the United States Navy (USN) authorized BBL to initiate the first phase of remedial activities (baseline sampling) at the site on March 23, 2000 (Task Order 9). On June 29, 2001, USN authorized BBL to perform well installation, pilot testing, additional sampling, and RAP preparations (Task Order 15 and Mod 1503). This report presents a summary of these activities, results of the groundwater quality assessment, and recommendations for remediation at the site.

1.2 Site Location and Area of Investigation

Building C-2076 is the Trumbo Point BOQ, located in Section 32, Township 67S, Range 25E, as referenced on the Key West, Florida U.S. Geological Survey Topographic Quadrangle Map (**Figure 1-1**).

The site is near the corner of Chevalier Avenue and Ely Street and encompasses much of the parking area south of the west wing of the BOQ building. Most of the area around the site is paved parking area. The USN owns all of the surrounding property to the site. The site topography is level and the elevation of the site is approximately 10 feet above mean sea level (MSL). The site is bounded on the north by Towers Avenue, on the east by Chambers Street, on the south by Chevalier Avenue, and on the west by Building C-2078, Building C-2081 and Ely Street. Within one-quarter-mile radius of the site are the Gulf of Mexico to the north, and Garrison Bight to the east.

Figure 1-2 shows the site layout. A 1,000-gallon diesel above ground storage tank (AST) with secondary containment is on site (C-2076), which is used to fuel the BOQ water heaters. Also on site is an above ground propane tank. A water line and valve pit, where the leak was first discovered, is present near the former propane tank location. An abandoned fuel line reportedly exists on the southern portion of the site, passing near the water valve pit. The exact location of the abandoned line is not known.

1.3 Site History

The Navy first discovered free petroleum product at Site C-2076, Trumbo Point BOQ on February 27, 1998, during a routine inspection of a water line valve pit (PWC, June 1999). Public Works Department (PWD), NAS Key West submitted a Discharge Reporting Form (DRF) to the FDEP on March 3, 1998, which estimated the amount discharged to be less than five gallons. A second DRF was filed for the site on March 11, 1998, after a tightness test was conducted on the underground piping from the diesel AST (C-2076). The cause of the release was indicated to be corroded piping and the product discharged was indicated to be JP-5 jet fuel. One line failed the pressure test and the line was taken out of service.

Approximately 55 cubic yards of contaminated soil and approximately 10 gallons of free product were removed in the vicinity of the valve pit from March 12 through March 14, 1998. The excavation location is shown on **Figure 1-2**. Complete soil remediation was not possible due to the proximity of the building and an active propane gas supply line. A monitoring well was installed in the excavation area and groundwater sample results indicated petroleum hydrocarbon levels greater than the Groundwater of Low Yield/Poor Quality Cleanup Target Level (CTL) for naphthalene at 460 micrograms per liter (µg/L). A Source Removal Report was submitted to the FDEP by the Navy on October 14, 1998.

A site assessment was conducted by PWC Pensacola and a Site Assessment Report (SAR) dated June 1999 was submitted to FDEP. The SAR concluded that the source of the petroleum hydrocarbons was probably diesel, free product existed on site, groundwater petroleum hydrocarbon concentrations exceeded Chapter 62-777, FAC targets, and soil contamination exceeding Chapter 62-777, FAC targets for Commercial/Industrial Use Direct Exposure was not present. Soil analyses did indicate exceedences of Residential Use Direct Exposure targets and organic vapor analysis (OVA) readings exceeded 50 parts per million (ppm). FDEP approved the SAR on July 9, 1999, concurring with the recommendation to prepare a RAP for the site. **Figure 1-2** shows the location of monitoring wells installed for the SAR.

All sources of the petroleum in the site media is uncertain. The diesel AST C-2076 was replaced in 1998 with the current AST and the underground piping was replaced with aboveground piping. Petroleum was noted in the ground during this pipe replacement, as stated above. Also, according to Navy engineering personnel, a gasoline line ran along Chevalier Avenue and branched north into the parking lot of the BOQ, where it split going to the east and west toward buildings. This line reportedly still exists in the ground and may have fed an underground storage tank (UST) that possibly exists in the vicinity of the former propane tank or underneath the BOQ building. (A review by BBL of historical site plans did not reveal the presence of a UST). One additional source for petroleum hydrocarbons on site is that in 1999, diesel fumes associated with a generator in the BOQ building reportedly caused an evacuation. There may have been diesel leaks from the generator piping beneath the building.

2. RAP Data Collection and Analysis

2.1 Baseline Sampling

In April 2000, BBL conducted baseline sampling to determine current groundwater conditions at the site. Ten existing monitoring wells were sampled and all wells were checked for the presence of free product. The baseline sampling data is provided as a complete report in **Appendix A**. The sampling data indicated exceedences of Chapter 62-777, FAC target levels for petroleum constituents in the groundwater on site, including the presence of free product in three wells (MW-14, MW-15, and MW-16), ranging in thickness from a sheen to 2 feet.

2.2 Monitoring Well Installation

Additional wells were installed on site subsequent to the SAR and baseline sampling, in order to further delineate the petroleum hydrocarbon plume in the groundwater and to conduct pilot testing necessary for RAP preparation. These wells were installed on August 21, 2001 by Precision Drilling Inc., under the supervision of a BBL geologist.

Monitoring wells MW-22 and MW-23 were installed on the east and north sides of the BOQ, respectively, to determine if petroleum-impacted groundwater extended under the building (**Figure 1-2**). The wells were installed using a 6.25-inch inside diameter hollow-stem auger to a depth of 12 feet below land surface (BLS). Each well was constructed of a 2-foot section of 2-inch diameter, Schedule 40 polyvinyl chloride (PVC) solid casing connected flush to 10 feet of 2-inch diameter, 0.010-inch mill-slotted screen. The annular space around the well screens was filled to 1 foot above the screened interval using 30/45 graded silica sand filter media during auger removal. Approximately 0.5 feet of bentonite chips were used as a plug to prevent grout from seeping into the filter pack. The remaining annular space was grouted to land surface with a neat cement slurry. The wells were fitted with locking cap and lock and contained within flush-mounted, bolt down, traffic-bearing manholes. Decontamination procedures outlined in BBL's FDEP-approved CompQAP were followed prior to and during the drilling events.

A temporary percolation test well (Perc-1) was installed adjacent to MW-19 to perform a falling head permeability test. Perc-1 was constructed to 6 feet BLS and a 6-inch diameter perforated PVC pipe was placed in the borehole. The perforated pipe was removed following the test, and the borehole backfilled, grouted to the top, and covered with asphalt patch.

Multi-Phase Extraction well MPE-1 was installed at the location shown on **Figure 1-2** for use during the multi-phase extraction pilot test and aquifer performance test. The well was installed in a similar manner to wells MW-22 and MW-23, but was constructed to a depth of 8 feet BLS, with 7 feet of 4-inch diameter, 0.020-inch slotted PVC well screen, connected flush to 1 foot of 4-inch diameter solid riser.

Well completion figures are provided in **Appendix B**.

2.3 Soil Sampling and Analyses

Table 2-1 provides OVA readings of soil samples collected during the installation of Perc-1, MPE-1, MW-22 and MW-23. The water table was encountered at approximately 3 feet BLS on August 21, 2001. The soils in the vicinity of Perc-1 and MPE-1 were a gray brown sand with limestone fragments to a depth of approximately 2 feet BLS, underlain by a tight gray clay from approximately 2 to 5 feet BLS, underlain by a silty, slightly clayey oolitic lime sand to 7.5 feet BLS, underlain by limestone to at least 8 feet BLS, the depth drilled. OVA readings at the location of Perc-1 and MPE-1 exceeded 1000 ppm in the vadose zone, with strong petroleum odors. The soil encountered at MW-22 and MW-23 indicated fine sands to approximately 2 feet BLS, underlain by slightly clayey lime sand to 11 to 12 feet BLS. Hard limestone was encountered at 11 to 11.5 feet BLS in the boring for MW-22. OVA readings at these two locations were negligible. **Figure 2-1** presents OVA readings collected during this monitoring well installation, as well as historical OVA readings.

The drill cuttings from Perc-1 and MPE-1 were drummed and properly disposed of by Rinker. Prior to disposal, a sample was collected from the boring of MPE-1 at a depth of 2 feet BLS (SS-1-2') for analysis for:

a. EPA Method 8021 (benzene, toluene, ethylbenzene, total xylenes, and methyl tert-butyl ether [MTBE])
b. EPA Method 8270 SIM Polynuclear Aromatic Hydrocarbons (PAH)
c. FL-PRO (total recoverable petroleum hydrocarbons [TRPH]), and
d. Rinker Preburn analyses.

Table 2-2 summarizes the analytical results for EPA Methods 8021, 8270 SIM, FL-PRO, and Rinker Preburn analyses. The complete laboratory analytical report is provided in **Appendix C.** The results indicated TRPH and arsenic exceeded Residential Direct Exposure and Commercial/Industrial Direct Exposure Soil CTLs (Chapter 62-777, FAC). The CTLs for Leachability Based on Groundwater of Low Yield/Poor Quality were exceeded by TRPH and 1-methylnapthalene.

2.4 Multi-Phase Extraction Pilot Study

BBL conducted a six-hour multi-phase extraction (MPE) pilot study to determine if MPE technology is applicable to this site. The pilot study was conducted using MPE-1. The pilot study consisted of four test conditions, adjusting drop tube locations and applied vacuums for the four test conditions. Depth-to-water measurements and wellhead vacuum readings were collected in monitoring wells located at various radial distances from MPE-1 prior to the MPE pilot study (static) and during the tests. This data was used to determine vapor recovery and groundwater recovery radii of influence of the MPE-1 well under different test conditions. Additionally, three air samples were collected during the MPE pilot study to determine if and what type of emission treatment may be necessary if a permanent MPE system were installed. The laboratory air sample results are included as **Appendix C**. Tables and figures summarizing the collected data are presented in **Appendix D.**

The MPE drop tube location was set to one foot (Test #1) and adjusted to two feet (Test #2) and three feet (Test #3A and #3B) below static water level of MPE-1. MPE-1 applied wellhead vacuum ranged from 65 inches water gauge ("wg) to 220 "wg with a vapor airflow recovery rate ranging from 14 standard cubic feet per minute (scfm) to 27 scfm, respectively. A maximum average groundwater recovery rate of 0.7 gallons per minute (gpm) was recorded during Test #3A of the MPE pilot study.

Based on the plot of wellhead vacuum versus distance and monitoring well drawdown versus distance from the MPE pilot study, the following was determined.

Drop Tube Location (feet below static water table elevation of MPE-1)	MPE-1 Wellhead Vacuum ("wg)	Vapor Recovery ROI (based on 0.1 "wg) (ft)	Groundwater Recovery ROI (based on 1 foot drawdown) (ft)
1	65	Insufficient Data	Insufficient Data
2	125	27	9
3	200	27	12
3	220	27	13

Based on BBL's experience, sites that have been amendable to MPE systems had vapor recovery radii of influence (ROI) of at least 35 feet and groundwater recovery ROI in the 25 feet range. The MPE pilot study conducted at this site show significantly less ROIs and thus a permanent MPE system would be an ineffective alternative for remediating this site.

2.5 Percolation Test

A constant head and falling head hydraulic conductivity test were conducted to help determine hydraulic conductivity of the lithology from 1 to 6 feet BLS for the potential design of a recharge gallery. The tests were performed on Perc-1. The constant head and falling head hydraulic conductivity methodology and results are provided as **Appendix E**.

The constant head hydraulic conductivity test indicated a hydraulic conductivity of 1.52×10^{-4} cubic feet per second per square feet per feet of head (cfs/ft^2 – ft head). The falling head hydraulic conductivity indicated a geometric averaged and arithmetic averaged hydraulic conductivity of 5.44×10^{-6} cfs/ft^2 – ft head and 6.27×10^{-6} cfs/ft^2 – ft head, respectively.

2.6 Aquifer Performance Test

The aquifer performance test methodology and results are provided as **Appendix F**. The pump test results indicated an estimated transmissivity of the upper surficial aquifer on site of approximately 1.81 square feet per day.

2.7 Groundwater Sampling and Analyses

All sampling was performed in accordance with BBL's Comprehensive Quality Assurance Plan (CompQAP) No. 880552G approved by FDEP. The laboratories used for analytical services, Accutest Laboratories and Analytical Environmental Services, Inc., also have approved CompQAPs on file with FDEP.

As stated above, in April 2000, BBL conducted baseline sampling. The complete Baseline Sampling Report is provided as **Appendix A**.

On August 21, 2001, BBL sampled MW-2 (a well downgradient of the plume), MW-5 (a well in the area of maximum concentration), and MW-20 (a well upgradient of the plume) for bioremediation parameters to assess the intrinsic bioremediation/natural attenuation occurring at the site. Discussions of the sampling results are provided in **Section 4.0**. The bioremediation parameters include:

a. RSKSOP-147/175 (Methane) [AccuTest].
b. EPA Method 310.1 (Alkalinity, Total) [AccuTest].
c. SW846 6010B (Hardness, Total) [AccuTest].
d. EPA Method 300/SW846 9056 (Nitrogen, Nitrate) [AccuTest].
e. EPA Method 365.3 (Phosphorous, Total) [AccuTest].
f. EPA Method 160.1 (Solids, Total Dissolved) [AccuTest].
g. EPA Method 415.1 (Total Organic Carbon) [AccuTest].
h. Petroleum Degraders Most Probable Number (Aerobic Microbial Plate Count) [Microbial Insights].

Following the installation of MW-22 and MW-23, these wells were sampled on August 21, 2001, and August 22, 2001, respectively, for:

a. EPA Method 8021 (Volatile Organic Aromatics [VOA], including MTBE).
b. EPA Method 8270 SIM (PAH).
c. FL-PRO (TRPH).

To ensure the presence of formation water in the wells, the water levels and well depths were recorded for the wells, then the monitoring wells were purged of five well volumes until the pH, specific conductance, and temperature had stabilized as measured using a Hydac® water quality instrument. The Hydac® was calibrated according to the manufacturer's directions prior to sampling the purge water. Purging was accomplished using pre-cleaned, dedicated polyethylene tubing and a peristaltic pump operating at a low flow rate of less than 1 liter per minute. Purge water was discharged onto the source area. Once purging was completed, samples were collected. Copies of the field water sampling logs are included in **Appendix C**.

None of the parameters analyzed were above Chapter 62-777, FAC Class G-I aquifer target levels. The data are summarized on **Figures 2-2** through **2-5** and on **Table 2-3**. The complete analytical report is provided as **Appendix C**.

Following groundwater extraction during the multi-phase pilot testing and the aquifer performance test, samples were collected for laboratory analyses to assess the current concentrations of petroleum constituents in the groundwater. Monitoring wells MW-1, MW-6, MW-12, MW-14, MW-16, MW-19, and MW-20 were sampled on November 15, 2001. An equipment blank was prepared and a duplicate was collected from MW-16 for quality assurance/quality control.

The samples were collected as described above and placed in laboratory-prepared (appropriately preserved) sample containers, stored under ice, and shipped via overnight courier in sealed coolers to the laboratory. The samples were analyzed for the same parameters as for MW-22 and MW-23, with the addition of total dissolved solids for the sample from MW-12.

Figure 2-4 summarizes the groundwater analytical results for PAHs and TRPH in groundwater on April 21, 2000, August 25, 2001, and November 15, 2001 and **Figure 2-5** shows the estimated extent of naphthalene in groundwater as of November 15, 2001.

The results of the most-recent sampling events indicate a substantial decrease in petroleum hydrocarbon concentrations in the groundwater on site since the SAR was prepared. The complete analytical report is provided as **Appendix C** along with the field sampling logs.

2.8 Free Product

BBL personnel discovered free product in three of the monitoring wells on site on April 21, 2000: MW-14, MW-15, and MW-16. The thickness of the product varied from only a sheen in MW-14 to 0.33 feet (about 4 inches) in MW-16 and 2 feet in MW-15. The product appeared very dark and weathered. These three wells are located in the northern portion of the study area, adjacent to the loading docks at the BOQ. The SAR reported that MW-15 had approximately 1.5 inches of free product on April 12, 1999.

Following the groundwater pumping that occurred during the multi-phase pilot testing and aquifer performance testing, only a sheen of free product was noted in two of the wells on site on November 15, 2001: MW-15 and MPE-1.

2.9 Hydraulic Gradient Determination

Top-of-casing of new monitoring wells MW-22, MW-23, and MPE-1 were surveyed relative to existing monitoring wells. All elevations are relative to an assumed elevation of 10 feet MSL. The water levels in all wells were measured on several occasions. April 21, 2000 measurements are recorded in **Appendix A,** along with map and table. September 18 and 19, 2001 measurements are recorded in **Appendix F,** with maps and table.

On November 15, 2001, a complete round of water levels was collected prior to well sampling. Measurements were recorded within an accuracy of 0.01 feet with a water level indicator. Groundwater elevations were determined by subtracting the depth to groundwater from the relative top-of-casing elevation. The water table was encountered on site at a depth of approximately 3 feet BLS. **Table 2-4** presents the groundwater elevation data. A groundwater contour map for November 15, 2001, is provided as **Figure 2-6**. Groundwater flow varies on site, according to the SAR, apparently influenced by tidal changes. During high tide on November 15, 2001, the flow was generally toward the southwest.

3. Remedial Alternatives Evaluation

3.1 Air Sparging with Soil Vapor Extraction

Air sparging and soil vapor extraction has the potential to decrease hydrocarbon contaminant concentrations in the subsurface. Hydrocarbon contaminant mass is directly removed from the groundwater through volatilization and is delivered to the vadose zone. The SVE system removes the contaminant mass in the vadose zone, by creating a negative pressure environment using a vacuum blower. An AS/SVE system is most effective in fine- to course-grained sand exhibiting a homogeneous distribution across the site. However, soil investigations have revealed that, in general, sands exist in the first 2 feet BLS, followed by clay to approximately 7.5 feet BLS, and then followed by limestone below 7.5 feet BLS. Clay greatly impedes the AS/SVE technology. Additionally, the abundance of calcium carbonate from the limestone subsurface significantly increases the chances of biofouling of the AS/SVE wells. The multi-phase pilot study revealed that the site's subsurface limits vapor recovery rate and radius of influence. An AS/SVE system will not cost effectively remediate the impacted groundwater and soil at this site.

3.2 Multi-Phase Extraction

Multi-Phase Extraction utilizes a high vacuum and flow rate system to remove both impacted groundwater and hydrocarbon vapors from the subsurface. A high vacuum/flow rate blower is connected to the extraction well(s). The extracted groundwater and vapor are directed to an air/water separator. The vapors can be discharged to the atmosphere directly or after treatment if required. The recovered groundwater is pumped out of the air/water separator for treatment or storage/disposal. Since MPE simultaneously removes groundwater and vapors from the subsurface, it treats absorbed phase VOAs in the smear zone. However, the benefits of the MPE are realized only if the subsurface is conducive to high flow created by a high vacuum. And as detailed in Section 2.4, the multi-phase pilot test indicated that site lithology significantly limited the effectiveness of this technology. A permanent MPE system will not cost effectively remediate the impacted groundwater and soil at this site.

3.3 Excavation

Excavation has been proven an effective remediation technique for soil remediation. However, a portion of the contaminated soil may be under the existing multi-story building (BOQ). Without significant engineering controls, excavation near the building is not feasible. Additionally, there are several underground utilities that would impede excavation. Therefore, excavation is not a cost-effective remedy.

3.4 Chemical Oxidation

Chemical oxidation of petroleum contaminants through the use of an oxidizing agent such as hydrogen peroxide to create carbon dioxide and water has been shown to be effective in some groundwater systems. A groundwater system consisting of clays causes significant distribution problems. The cost may become excessive due to the need for more chemical oxidant to ensure oxidant contact with the entire plume. Additionally, the chemical oxidation process increases soil temperature, which limits its use around underground structures, tanks, lines, and utilities. Therefore, besides the excessive cost, implementation of chemical oxidation would raise safety concerns. This remedial option is not feasible at this site.

3.5 Groundwater Pump and Treat

A groundwater pump and treat system would likely decrease contaminant concentrations, but, in general, the time to clean up and the costs to install and operate the system would be greater than that of other remedial technologies. A groundwater pump and treat system would not likely meet the CTLs within a reasonable time frame or cost at this site.

3.6 Bioremediation

Bioremediation typically involves introducing foreign or new microbes into the subsurface, and increasing the electron acceptors and nutrients available to the microbes. The microbes are usually selected based on their ability to degrade the specific contaminant group. However, foreign microbes or enzymes would most likely fail to degrade petroleum contaminants without sufficient delivery of air and nutrients. Similar to other remedial alternatives, the site lithology limits the practicality of this technology because of the distribution problems caused by clays.

3.7 Intrinsic Bioremediation/Natural Attenuation

It is most often effective and efficient to utilize and enhance naturally occurring biodegrading organisms typically present at most petroleum-contaminated sites. Evaluation of this technology is presented in Section 4.0.

4. Intrinsic Bioremediation/Natural Attenuation Evaluation

4.1 Intrinsic Bioremediation/Natural Attenuation

It appears that intrinsic bioremediation/natural attenuation (IB/NA) is occurring at this site. Evidence to support this is presented below and will serve as documentation justifying that IB/NA is the appropriate cleanup strategy for this site via the "Level 1 Evaluation" presented in the FDEP, BPSS Remedial Action Guideline, BPSS-11.

4.2 Level 1 Evaluation (from Rule 62-770.690 (1) (a) through (e), FAC)

a. Historically, free product has been detected in three monitoring wells, MW-14, MW-15, and MW-16. Free product was detected in these wells during the April 21, 2000 groundwater sampling event conducted by BBL. The thickness of the product varied from only a sheen in MW-14 to 0.33 feet (about 4 inches) in MW-16 and 2 feet in MW-15. During the multi-phase extraction pilot study, 160 gallons of free product/groundwater mixture were pumped from MPE-1, MW-15, and MW-16 into a water tanker for subsequent transportation to a treatment and disposal facility. The non-hazardous waste manifest is included as **Appendix G**. Subsequently, during the November 15, 2001 sampling event conducted by BBL, only a sheen remained in one of the three monitoring wells (MW-15). Therefore, it is anticipated that there is no floating phase-separate product with a thickness greater than the thickness specified in the Department's definition of "free product" of 0.01 feet in any monitoring wells on site. However, to ensure the free product has been removed from the subsurface, BBL suggests that up to four short-term MPE events be performed quarterly in which any wells with free product present will have the free product/groundwater mixture recovered using a 3,000-gallon vacuum truck.

b. Although the analytical results from the soil sample collected from one to two feet BLS (SS-1'-2') on August 21, 2001, exceeds the Leachability Based on Groundwater of Low Yield/Poor Quality for TRPH and 1-methylnapthalene (see **Table 2-2**), it is believed that this contaminated soil does not exist to the extent that it may result in increased cleanup cost since four short-term MPE events will be conducted to remove free product/groundwater mixture in the vicinity of the location of SS-1'-2'. The institutional control provided by the pavement, which covers the site, prevents the exceedance of the Commercial/Industrial Use Direct Exposure CTL for TRPH and arsenic from being a concern since this pavement will protect the public from exposure to the soil during natural attenuation monitoring of the groundwater. If a No Further Action without Conditions cannot be obtained after the proposed one year of IB/NA, the Navy may wish to obtain a NFA with Conditions.

c. Groundwater analytical results appear to indicate that a shrinking plume exists at this site. Comparing figures depicting the extent of the groundwater contamination presented in the *Baseline Sampling Report* (BBL, July 2000) and the figures included in this RAP provides evidence of a shrinking plume.

d. Monitoring wells with multiple sampling events performed were used in determining the exponential decay rate of each contaminant. **Table 4-1** provides the decay rate between the concentrations detected earliest in time and latest in time for each contaminant in each monitoring well, if applicable. Concentrations of contaminants that were below laboratory detection limits for all sampling events performed on a monitoring well were considered not applicable and can be seen as NAs in **Table 4-1**. The average decay rate for each applicable contaminant is presented in the rightmost column. Applicable COCs exhibited negative decay rates, except TRPH. An average of all the applicable COC decay rates was determined to be –0.003296 per day. The decay rate is based on the following expression: $C = C_o e^{kt}$, where C_o is the concentration on the earliest in time sampling event, k is the decay rate, t is the time between the earliest in time and the latest in time sampling event, and C is the concentration on the latest in time sampling event.

e. The decay rates determined in **Table 4-1** were applied to the contaminant concentrations that exceeded the CTL for Low Yield/ Poor Quality at the time of the groundwater sampling to determine the estimated time it will take natural attenuation to reduce these contaminant concentrations to below their respective CTL. These contaminants include the naphthalene and TRPH concentrations (872 μg/L and 146 μg/L, respectively) detected in MW-5 in April 2000 and the iron concentration (5,710 μg/L) detected in MW-8 in April 2000. Using the average decay rate of naphthalene for naphthalene and the average decay rate of all applicable COCs for TRPH and iron resulted in the CTLs being theoretically met 391 days, 325 days, and 195 days, respectively, after the April 21, 2000 sampling event. The April 2000 sampling event is the most recent for MW-5 and MW-8. **Table 4-2** provides the corresponding calendar date that the CTLs should have been theoretically met.

4.3 Other IB/NA Indicators

The results of the petroleum-degrading bacteria analysis using the most probable number (MPN) indicate that aerobic petroleum-degrading bacteria are limited at this site. However, this analysis could only determine aerobic petroleum-degrading bacteria at the site. Anaerobic petroleum-degrading bacteria count must be conducted using anaerobic conditions. BBL believes that the limited aerobic petroleum-degrading bacteria count is consistent with other bioremediation parameters collected at the site. The limited aerobic petroleum-degrading bacteria may be a result of the limited dissolved oxygen at the site. The additional bioremediation parameters seem to indicate that methanogenesis is the process by which the petroleum contaminants are being reduced at this site. Methanogenesis is the conversion of low molecular fatty acids, alcohols, carbon dioxide, and hydrogen to methane gas. It is accomplished by a group of bacteria known as methanogenic bacteria. Methane levels appear to be greatest within the plume and decrease radially from MW-5 (source well), indicating more anaerobic bacterial activity and biodegradation in the plume than outside the plume, which is to be expected. The oxidation reduction potential (ORP) levels are in the range (-124 millivolts to –96 millivolts) expected when methanogenesis is occurring. The slightly acidic pH exhibited in MW-2, MW-5, and MW-20 is indicative of the production of intermediate acidic compounds created by high levels of bacterial activity. Additionally, carbon dioxide, an end product of the metabolism of hydrocarbons, contributes to the lower pH as dissolved carbon dioxide forms carbonic acid. Although it is expected to see high levels of ferrous iron in anaerobic (reducing) conditions, the low levels exhibited in MW-2, MW-5, and MW-20 may be indicative of a subsurface environment with low background levels of ferrous iron. **Table 4-3** and **Table 4-4** summarize the bioremediation parameters and general chemistry data, respectively, from MW-2, MW-5, and MW-20.

5. Recommended Remedial Approach

5.1 Active Remediation

5.1.1 Short-Term Multi-Phase Extraction Events

BBL suggests conducting up to four short-term MPE events utilizing a 3,000-gallon vacuum truck. One MPE event will be conducted each quarter. The free product/groundwater mixture recovery will be concentrated on monitoring wells MW-14, MW-15, and MW-16 and any other monitoring wells containing free product. The free product/groundwater mixture will be transported by vacuum truck to a water treatment facility for treatment and disposal. Monitoring should be conducted during each of the multi-phase extraction events to maintain optimal treatment efficiency. Items to be monitored include:

- depth to water in monitoring well prior to and during free product/groundwater recovery,
- depth to water in surrounding monitoring wells prior to and during free product/groundwater recovery,
- volume of recovered free product/groundwater mixture.

The short-term MPE events should be conducted until sheen/free product is no longer present in any of the wells on site. Subsequently, natural attenuation monitoring should be conducted.

5.1.2 Data Collection and Reporting

The following schedule is proposed for the short-term MPE events:

- Quarter 1: Pre-MPE events groundwater sampling event and 1st MPE event,
- Quarter 2: 1st MPE event follow-up groundwater sampling and 2nd MPE event,
- Quarter 3: 2nd MPE event follow-up groundwater sampling and 3rd MPE event,
- Quarter 4: 3rd MPE event follow-up groundwater sampling and 4th MPE event.

The conduction of an MPE event will be based on the detection of free product in the monitoring wells during each quarterly sampling event. If no free product is detected, that quarterly MPE event will not be conducted.

The monitoring wells to be sampled include MW-2 (a well downgradient of the plume); MW-4, MW-5, MW-6, MW-7, MW-9, MW-14, MW-15, MW-16, and DMW-18 (wells in the area of maximum concentration); and MW-20 (a well upgradient of the plume). These samples will be analyzed for VOAs, PAHs, TRPH, lead, and total iron using EPA Method 602, EPA Method 8270 SIM, FL-PRO, EPA Method 239.2, and SW846 6010A, respectively.

Quarterly reports will be submitted to the FDEP. The reports will document the results of the short-term MPE events and the sampling and data collection performed at the site. Included in the reports will be the measurements of the monitored items listed in **Section 5.1**, water-level measurements (summary table and flow map) acquired prior to the groundwater sampling of the wells listed above, the analytical results, chain of custody records, a table summarizing the analytical results, and site map(s) illustrating the analytical results. A completed Annual Status Report Summary Form will be included in the annual report.

5.2 Natural Attenuation Monitoring

Subsequent to the completion of the short-term MPE events, BBL proposes to conduct one year of monitored natural attenuation, unless two consecutive quarterly sampling events have indicated that applicable cleanup target levels have been met, in which case a Site Rehabilitation Completion Report (SRCR) will be submitted to the FDEP.

5.2.1 Data Collection and Reporting

Quarterly visits will be scheduled, which will include groundwater sample collection. In accordance with Chapter 62-770.690(7)(b), FAC, the monitoring period shall be a minimum of one year, unless two consecutive quarterly sampling events have indicated that applicable cleanup target levels have been met, in which case a SRCR will be submitted to the FDEP. The SRCR may be submitted based on meeting NFA criteria with or without Conditions.

The objective of the monitoring program is to meet the applicable No Further Action criteria in Rule 62-770.680, FAC. The monitoring wells to be sampled include MW-2 (a well downgradient of the plume); MW-4, MW-5, MW-6, MW-7, MW-9, MW-14, MW-15, MW-16, and DMW-18 (wells in the area of maximum concentration); and MW-20 (a well upgradient of the plume). These samples will be analyzed for VOAs, PAHs, TRPH, lead, and total iron using EPA Method 602, EPA Method 8270 SIM, FL-PRO, EPA Method 239.2, and SW846 6010A, respectively. This information will be compared to the previous groundwater analytical results to determine if natural attenuation is still occurring at the site and to determine if a SRCR can be submitted to the FDEP.

Quarterly reports will be submitted to the FDEP. The reports will document the results of the sampling and data collection performed at the site. Included in the reports will be the water-level measurements (summary table and flow map) acquired prior to the groundwater sampling of the wells listed above, the analytical results, chain of custody records, a table summarizing the analytical results, and site map(s) illustrating the analytical results. A completed Annual Status Report Summary Form will be included in the annual report. When natural attenuation meets the NFA criteria that groundwater concentrations of chemicals of concern are below site CTLs as stated in Rule 62-770.680, FAC, three soil borings will be conducted. If soil analytical results show that "excessively contaminated" soil no longer exists on the site, a SRCR will be submitted to the FDEP recommending site closure without conditions. In the event that soil remains "excessively contaminated", the Navy may exercise its right to request a NFA with Conditions and a subsequent SRCR with Conditions will be submitted to the FDEP.

5.3 Estimated Cost of Cleanup

Based on four short-term multi-phase extraction events performed quarterly, followed by one year of monitored natural attenuation the estimated cost of cleanup through site closure is **$220,000**. This cost is broken down as follows:

One Year of Quarterly Events (includes four MPE and groundwater sampling events with quarterly reports)	$118,000
One Year of Natural Attenuation Monitoring (includes four groundwater sampling events with quarterly reports)	$65,000

Site Rehabilitation Completion Report	$8,000
Abandon Wells and Demobilize	$29,000
	$220,000

6. References

Blasland, Bouck & Lee, Inc., July 2000, *"Baseline Sampling Report, Site C-2076, Trumbo Point BOQ, NAS Key West, Florida."*

Public Works Center (PWC), NAS Environmental Department, Pensacola, Florida, June 1999, *"Site Assessment Report, Site C-2076, Trumbo Point BOQ, NAS Key West, Florida."*

U.S. Geological Survey, *Key West, Florida*: 7.5-minute orthophotomap (topographic) series, 1971.

Wong, Jimmy H.C., et al. 1997. Design of Remediation Systems.

Figures

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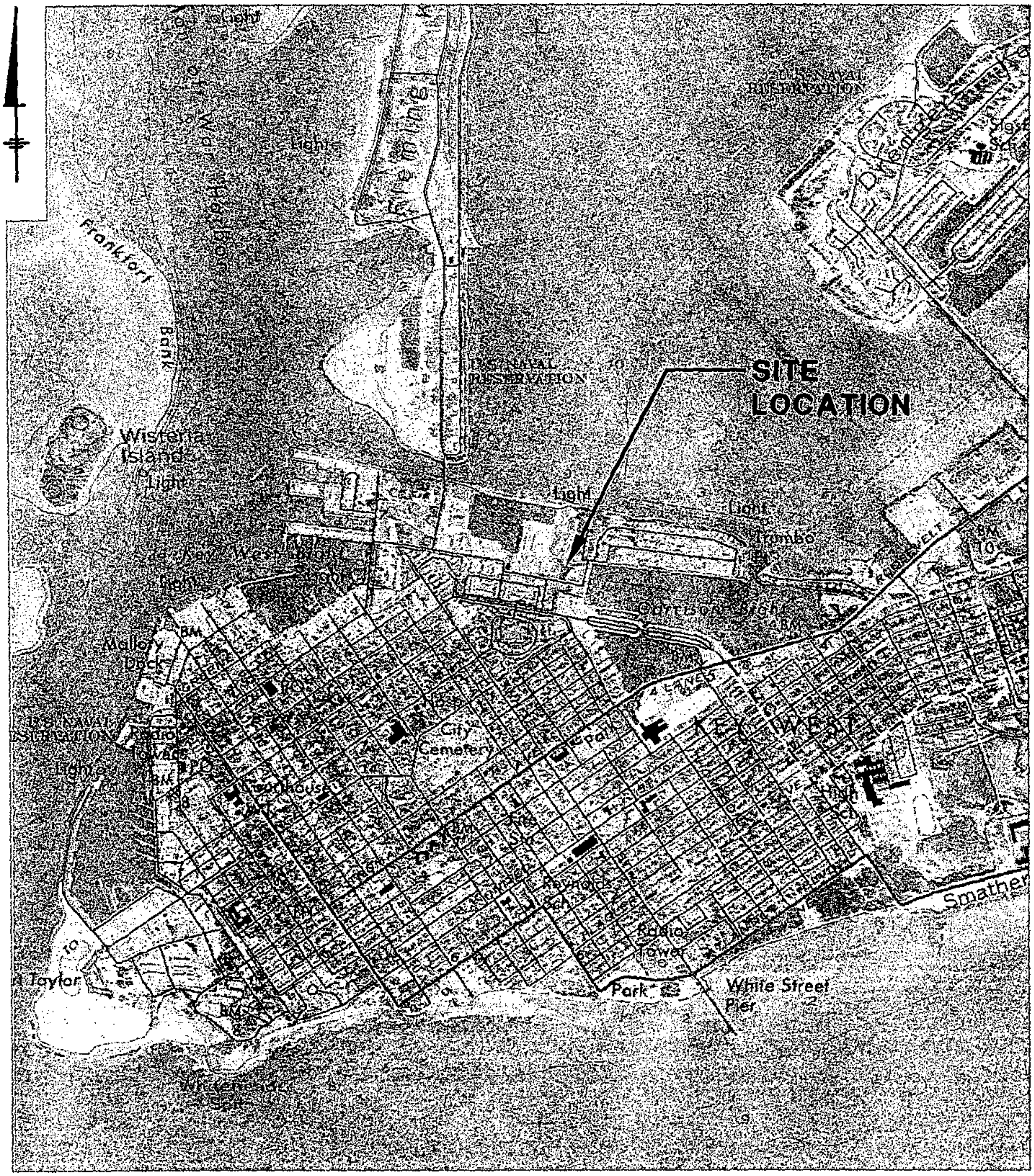
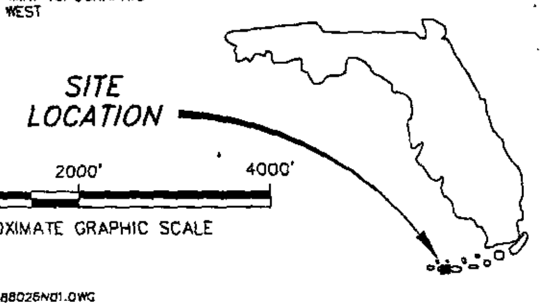


SOURCE: USGS 7.5 MIN. TOPOGRAPHIC
QUADRANGLE: KEY WEST
REVISION: 1971
COUNTY: MONROE



0 2000' 4000'

APPROXIMATE GRAPHIC SCALE

X: NAS-TP.JPG
P: STD-PCZ\AP
12/4/01 TAM-54-JAR
880\88026\001\C2076\88026N01.DWG

NAVAL AIR STATION KEY WEST
KEY WEST, FLORIDA

SITE C-2076 – TRUMBO POINT BOQ

SITE LOCATION

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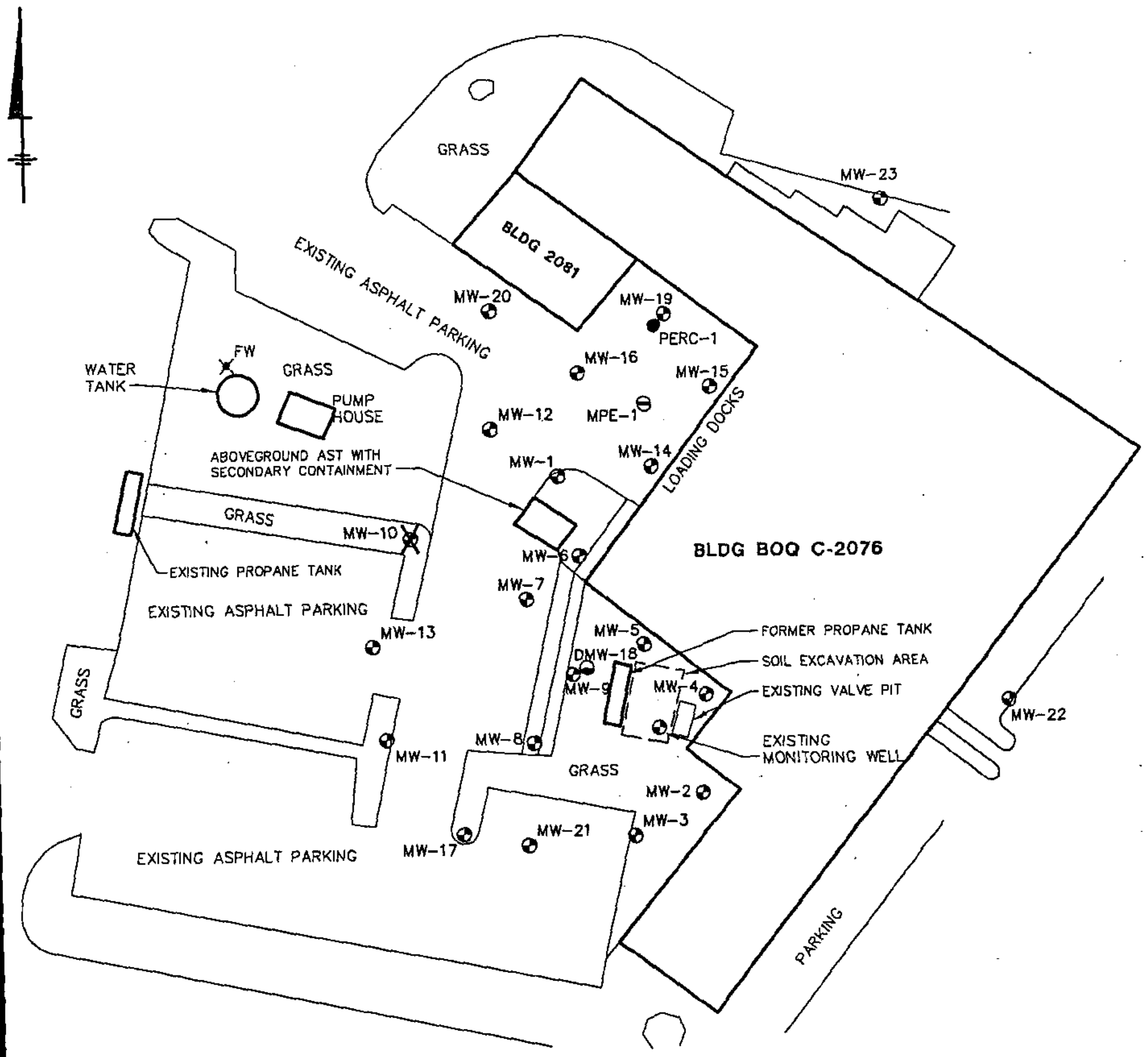
FIGURE
1-1



0 50' 100'

GRAPHIC SCALE

LEGEND

- SHALLOW MONITORING WELL
- DEEP MONITORING WELL
- FIRE PROTECTION WELL
- MISSING/DESTROYED WELL
- MULTI-PHASE EXTRACTION WELL
- TEMPORARY PERCOLATION TEST WELL

NAVAL AIR STATION KEY WEST
KEY WEST, FLORIDA

SITE C-2076 – TRUMBO POINT BOQ

SITE LAYOUT

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FIGURE
1-2

SOURCE: Base map digitized from map 'MONITORING WELL LOCATION MAP' provided by PUBLIC WORKS CENTER, PENSACOLA, FLORIDA. Date June 1999. Scale 1"=40'.

P: STD-PC2\AP
12/7/01 TAM-54-JAR
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